ENVIRONMENTAL FINANCIAL ASSURANCE: CURRENT COVERAGE, INSTITUTIONAL CHALLENGES, AND ALTERNATIVE FINANCIAL GUARANTEE ARRANGEMENTS

by

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Abstract

Mining activities provide comprehensive socio-economic benefits to a nation. There are, however, varying degrees of environmental risks and financial liabilities related to mining. Governments expect mine operators to rehabilitate the environmental condition of disturbed lands once they complete their extraction activities. In the event of insolvency or bankruptcy, regulators also require them to establish that they possess adequate, financial assurance to ensure that mandatory reclamation and closure requirements are performed in accordance with the approved mine closure plans before initiating their mine operations.

Such an approved '*hard*' financial assurance instrument is typically held by the government or in trust by a third-party in escrow until the end of mining and only released when closure and reclamation operations are completed, which in some cases could be decades into the future or sometimes never. Financing these obligations come with a set of other challenges. Requiring a mining company facing both financial difficulties and unsettling market conditions, an epidemic of current times, to take on tens of millions or even hundreds of millions of dollars in '*hard*' financial liabilities only increases the possibility of its financial collapse and potential reclamation failure.

The dissertation focuses on the evaluation of a proposed structured finance mechanism that is expected to offer greater access to required funds from the capital markets and one that aims to assist government regulators with their regulatory compliance, oversight, and enforcement efforts. Even though securitisation has demonstrated the ability to take an illiquid asset or group of such assets, and through financial engineering, transforming it into a marketable financial security for sophisticated investors to invest in, it has yet to be applied to the securitisation of financial assurance requirements. The available financial assurance funding tools and options are also assessed.

The dissertation is expected to deepen the discussion surrounding seeking more effective and readily accessible environmental financial assurance instrument solutions for the

resource extractive industries. No literature evidence seems to exist to support any earlier study on the prospect of such a financial assurance-backed securitised mechanism. It is therefore of interest to investigate its potential.

Lay Summary

Government regulatory agencies mandate mine operators, before initiating their operation activities, to establish that they possess adequate financial resources, through receipt of acceptable listed forms of financial assurance. Such a request is demanded from a mine operator in the event of bankruptcy or insolvency, to ensure that mandatory reclamation and closure obligations are adequately performed following the approved mine closure plans upon completing their mining economic activities.

The dissertation focuses primarily on the question of whether financial assurance backed securitised instruments could be suitable alternatives to the growing issues surrounding financing constraints for mining companies.

The analysis deepens the discussion surrounding the use of effective and accessible financial assurance instruments within the extractive industries, particularly as it relates to mining but not exclusively. The dissertation constitutes a timely and unique addition to the literature on financial assurance from both a funding and regulatory perspective.

Preface

The academic research described herein was conducted under the principal supervision of Dr Scott Dunbar at the Norman B. Keevil Institute of Mining Engineering, University of British Columbia.

To the author's knowledge, this work is original, except where acknowledgements and references are made to previous work. Neither this nor any substantially similar dissertation or thesis has been or is being submitted for any other degree, diploma or other qualification at UBC or any other academic institution.

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List of Abbreviations

ABS	Asset-Backed Security
AUM	Assets Under Management
BC	British Columbia
CAC	Command and Control
CAD	Canadian
CCSP	Crown Contaminated Sites Programme
CDO	Collateralised Debt Obligation
CDO^2	Synthetic CDO
CDS	Credit Default Swap
CE	Credit Enhancement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLN	Credit-Linked Note
CLO	Collateralised Loan Obligation
CMBS	Commercial Mortgage-Backed Security
CRA	Credit Rating Agency
CSR	Corporate Social Responsibility
EFA	Environmental Financial Assurance
EFABS	EFA-Backed Security
EIM	Economic Incentive Mechanism
ESG	Environmental, Social, and Governance
FA	Financial Assurance
FABS	FA-Backed Security
FDI	Foreign Direct Investment
FEH	Factor Endowment Hypothesis
FIS	Fuzzy Inference System
FL	Fuzzy Logic
ICR	Interest Coverage Ratio
IFC	International Finance Corporation
IMCC	Interstate Mining Compact Commission
IMF	International Monetary Fund
MBS	Mortgage-Backed Security
MEM	Ministry of Energy and Mines
MF	Membership Function
NGO	Non-Governmental Organisation
OAGBC	Office of the Auditor General of British Columbia
OBS	Off-Balance Sheet
OECD	Organisation for Economic Co-operation and Development
OTC	Over the Counter

PHE	Pollution Haven Effect
PH	Porter Hypothesis
PHH	Pollution Haven Hypothesis
PPP	Polluter Pays Principle
R&C	Reclamation and Closure
R&D	Research and Development
RMBS	Residential Mortgage-Backed Security
RMCE	Regulatory Monitoring, Compliance, and Enforcement
SCC	Supreme Court of Canada
SIB	Social Impact Bonds
SPV	Special Purpose Vehicle
SRI	Socially Responsible Investing
UNEP	United Nations Environment Programme
UNEP FI	United Nations Environment Programme Finance Initiative
US	United States of America
USD	US Dollar
US EPA	US Environmental Protection Agency

Acknowledgements

Working on my PhD and writing this dissertation has been a great pleasure, and a real labour of love, for me. The only regret that I have is that I did not further my studies a bit sooner as intended. The years of financial industry knowledge and experience gained, coupled with my educational background; however, benefited my research efforts.

I am grateful for the respect, guidance, and advice provided to me by Dr Scott Dunbar, Dr Dirk van Zyl, Dr Nadja Kunz, and others at UBC's Keevil Institute throughout my efforts to produce and improve this dissertation and all through my studies in the PhD programme. I wish to extend special thanks to Dr Dunbar for his assistance and guidance with my research efforts over the years. I am also thankful to Dr Knud Sinding for his input in the early stages of my research since it helped shape it. A special thanks goes out to Carmen Jensen as well for the chance encounter that brought me to UBC to pursue my PhD studies.

My sincere appreciation also goes out to a number of my colleagues[1] from the Segal Graduate School of Business at Simon Fraser University (SFU) for their insights and support over the years. As well, to Dr Ana Maria Fuertes from Cass Business School, City, University of London, and to Brian Eales from London Metropolitan University for their inspiration since I was their student.

I owe a debt of gratitude to everyone else who helped me progress through the PhD programme or who helped me improve my dissertation. From proof-reading, editing, offering valuable advice and guidance, I appreciate the support provided by them.

Thank you to the many dedicated people at CAIA (Chartered Alternative Investment Analyst) Association, CIM (Canadian Institute of Mining, Metallurgy and Petroleum),

[1] Especially Dr Christina Atanasova, Elsie Christopher, Dr Andrew Gemino, Dr Brenda Lautsch, Dr Kamal Masri, Dr Jijun Niu, Dr Jan Simon, and Dr Mark Wexler.

CIM MES (Management and Economics Society of CIM), and PRMIA (Professional Risk Managers' International Association) as well who have inspired me over the years.

A special thanks are also due to my parents (Manuel Ferreira da Costa and Maria Irene Lopes da Costa), family, and friends[2] who encouraged my academic pursuits.

I am forever thankful to my wife, Silvia Piccioni, most importantly, and above all, for her encouragement and support over the years while I endeavoured to pursue my career and academic ambitions.

Muito obrigado à todos vocês! Boa saúde!

[2] In particular, Tony Birch, Bill Carbonneau, Mike Church, Byron Jung, Mark Richards, Jaspal Singh, and Susannah Skerl.

Dedication

This dissertation is dedicated to all concerned mining stakeholders around the world. I hope that in some small way it will be of benefit to their ongoing mine reclamation and closure efforts and struggles.

It is also dedicated to all mature students, like me, who must continuously worry about the many little things while trying to achieve big things.

> *Anyone who stops learning is old, whether at twenty or eighty. Anyone who keeps learning stays young. The greatest thing in life is to keep your mind young.*
>
> — Henry Ford

> *Ancora imparo.*
>
> — Michelangelo di Lodovico Buonarroti Simoni (Michelangelo)

— José Carlos Lopes da Costa
(Carlos da Costa)

Chapter 1: Introduction

We are seeing that surety bonding is becoming more expensive and less available.

— Anna Zubets-Anderson
Vice President – Senior Analyst, Moody's Investors Service

The mining sector is an essential contributor to the Canadian economy (MAC, 2018). The Mining Association of Canada cites that mining contributed CAD$97 billion[3] to the country's Gross Domestic Product (GDP) in 2017 (MAC, 2018). The industry accounted for 19 percent of the value of goods exported that year. Canada's value of mineral production was CAD$43.9 billion in 2017. Extractive sector companies as well reported payments of more than CAD$9.3 billion to the government that year. The metals and mining sector is also central to the world's economy. The global top 40 mining companies, which represent a majority of the entire industry, reported $600 billion of revenue in 2017 (Statista, 2018).

Activities in the mining sector range from exploration, production, and project decommissioning. Such actions are accompanied by various types and levels of environmental risk and, if not well managed, can result in a substantial expenditure to the public. Environmental risks related with such projects can include the release of toxic and hazardous substances; effects on vegetation, wildlife, and fisheries (biological resources); and the impact of climate change that exacerbates the effects of mining on water and wastewater quality, flows, and containment controls. The result of such catastrophes may require substantial financial commitments or investments to decommission and ensure reclamation of a mine site or facility as history has illustrated various times in Canada and around the world (Sheldon et al., 2002; Poulin and Jacques, 2007; Otto, 2009).

[3] In Canadian (CAD) dollars. Hereinafter, unless otherwise stated, all dollar-denominated values are expressed in US dollars (USD).

Environmental reclamation provides the right to reclaim property in the event of default, fraud or other irregularities. Mining and metals companies' exposure to fraud and corruption[4] is now more prevalent as a result of cost-cutting measures in the sector and expansion into new territories. Fraud and corruption in the mining, oil, and gas industries keep some developing nations poor and props up brutal regimes. There is a growing global sentiment that governments and corporate entities must end the confidentiality and bring deals, profits, and environmental costs into the open.

Governments and regulators possess a selection of tools and options to manage such risks, including:

- strategic environmental assessments;
- environmental assessments of proposed projects; and
- regulations and laws to control the release of pollutants during operations, and for the reclamation and deactivation of mine sites at the end of their operating lives.

These tools also include environmental liability limits and various forms of regulatory approved '*hard*' and '*soft*' financial assurance[5,6]. While such instruments are accessible to government and regulators, the responsibility is on mine operators to meet the financial costs associated with mine closure, reclamation, and any damages resulting from accidents.

Synonyms such as '*rehabilitation*,' '*restoration*,' and '*re-cultivation*' are often used to denote '*reclamation*.' Although they are used interchangeably, differences between them exist (Lima et al., 2016). The objective of reclamation is to return affected areas as near as

[4] From Kazakhstan to Angola to Uganda, investigations by Global Witness (2019) show how secrecy in this extractive sector entrenches corruption and props up kleptocratic regimes. Experts estimate that in Nigeria alone a staggering $400 billion of oil revenue has been stolen or misused since 1960.

[5] Financial assurance (FA) and environmental financial assurance (EFA) are interchangeably used in the dissertation.

[6] Financial assurance instrument forms, two forms of guarantee: '*hard*' security (e.g., cash deposit, letters of credit, bond, and trust), typically held in escrow, and '*soft*' security (e.g., corporate guarantee, FA discounts, financial test, and other permitted forms).

possible to their ecological and economic value; however, it does not aim to return them to the original state (UNEP, 1983; UNDP, 2018; Teck, 2019). From industry's perspective, the goal of reclamation is to enhance and conserve biodiversity, care for the environment, and turn lands where mining has ensued over to new and productive uses (Teck, 2019).

Munshower (1983) defines reclamation as follows:

> *Reclamation includes all aspects of the environment; it is not restricted to soils and vegetation. Although the disturbed area cannot be returned to its exact pre-mining condition, it can be rehabilitated. It can be returned to a useful function in the ecosystem of which it is a part. In all cases, however, the most economical means of attaining the reclamation goals is to develop a suitable reclamation plan prior to actual land disturbance.*

As can be understood from this statement, reclamation is not considered a simple post-mining operation since best management practices are expected to be progressive and incorporated within all stages of mining. It commences with pre-mining planning, continues through the exploitation stage and also lasts through operations, and ends with post-mining land use. To eliminate the damaging impacts of mining, mine reclamation and closure (R&C) responsibilities, from planning to implementation, is significant to the mining industry, communities, and countries.

Ken Bocking, Principal at Golder Associates Inc., points out that mine closure, and even environmental reclamation, is a relatively new concept in Canada (Hiyate, 2018). "*I started (in mine closure) in 1992. Why? Because that's when the law came in Ontario*," Bocking said. "*Until that time, basically mines would live out their useful life, and then many of the operators just walked away*." Mine operators now need to possess a well-thought-out, approved closure plans and are required to deposit government-approved FA upfront, and held in escrow by the regulator or a third-party, so that there is adequate funding in place for approved R&C obligations, as outlined in their closure planning if they abandon such responsibilities. However, the industry has not implemented closure at many Canadian mine sites: "*There's not very many mines that have been completely closed to the point* *where the company can walk away, and the land can be returned to the Crown*," Bocking noted (Hiyate, 2018). "*So, I think that's where it needs to go next*."

The significant growth in overall clean-up cost liabilities signals an urgent need for reform in the mining sector (Hiyate, 2018). "*It's the single most important thing that our industry does*," said Douglas Morrison, President and CEO of the Centre for Excellence in Mining Innovation, at the Progressive Mine Forum in Toronto, Canada, in late October 2018 (Hiyate, 2018). "*Nobody in the public could care less what our productivity levels are, what the return on investment is. They absolutely care what we do with our waste streams – wastewater and solid waste. This is where our industry interacts with the public.*"

"*The reality is when you look at mine closure in the overall life cycle of a mine, it's actually the longest phase of a mine*," said Steven Woolfenden, Director of Environment for IAMGOLD Corp. (Hiyate, 2018). "*I'm managing some legacy sites that are 30, 40, and 50 years old, and there is no end to that management – it will be in perpetuity*." The cost, he added, is often underestimated. Woolfenden goes on to state, "*Most people really don't pay much attention to it because when you do the costing on mine closure, it's pushed so far out and discounted so much that it doesn't really impact it. But when you get there, and you actually have a closed mine, it costs you a lot of money.*"

Financing such mandatory R&C commitments has a particular set of challenges, including:

- uncertainty of their actual costs;
- the types of standard, non-standard or unacceptable forms of EFA to the regulator;
- '*hard*' financial guarantee (financial assurance) is typically held by the government or in trust by a third-party in escrow until the end of mining and only released when closure and reclamation operations are completed, which in some cases could be decades into the future or sometimes never;
- insufficient financial assurance funding;

- inconsistencies and unclear regulations[7], inadequate enforcement of laws;
- cessation of treatment of polluted mine drainage due to corporate dissolution or bankruptcy; and
- unplanned ongoing treatment obligations of mine discharge water (Miller, 2005; Sassoon, 2008).

Such regulatory vagueness and incompleteness often lead to higher R&C costs and different regulatory interpretation.

Environmental financial assurance is a mechanism that governments and regulators utilise to help shield taxpayers from the possible financial liabilities of environmental protection, clean-up, closure, and reclamation, in accordance with the approved reclamation plan, for a variety of natural resource development projects of the public and private sector in the possible event of bankruptcy or insolvency by the company in question. Such financial security is characteristically required from projects associated with the deterioration of public infrastructure facilities (e.g., transportation, water, power and energy, telecommunications, and health) and other '*white elephant*' infrastructure[8] (e.g., abandoned Olympic venues, World Cup stadiums, and shopping centres worldwide), industrial hazardous waste, municipal solid waste, the transport of oil & gas, energy projects, nuclear, and mining. Absolute cost limits are applied in specific sectors to cap or limit the total financial amount that a corporate entity may be liable for in the event an adverse incident arises, without proof of fault. These absolute liability caps are applied in Canada and other countries (Boyd, 2001; Sassoon, 2009).

Such a financial guarantee is a critical component of the reclamation and post-closure process since it can be used to cover the expenditures of mandatory R&C obligations should

[7] Regulatory bodies and regulations around the world display considerable heterogeneity (Richer La Flèche et al., 2016).

[8] A *white elephant* is an idiom for a valuable but burdensome possession. When applied to finance, it is used to describe anything that is expensive to maintain, unprofitable, and impossible to sell. In other words, white elephant is the name given to undesirable investments that are more trouble than they are worth.

the mine operator be unable or unwilling to do so. The mining sector is vulnerable to significant technical risks and fluctuations in metals prices, and many companies have gone bankrupt or insolvent, sometimes before mine reclamation or closure activities are completed. Because closing a mine can often cost tens to hundreds of millions of dollars, regulators require a dependable source of funds to pay for the environmental reclamation of a mine site as well as the required oversight by government officials. Since closure obligations are the responsibility of the mine operator, these costs are not included in the budgets of regulatory agencies, nor are they expected to be (Miller, 2005).

Regulators need FA that is readily accessible to ensure that mine reclamation occurs. Should a company default on its closure commitments, these liquid funds would be required immediately to maintain and operate mine facilities, such as water treatment plants.

The financial assurance should be protected (on an arm's length basis) from frivolous legal challenges and the prying reach of opportunistic individuals and regulatory agencies. Given the large size of most FA, a surety provider stands to gain financially by collecting interest on the surety bond amount while unsuccessful legal challenges are debated in the courts (Alter and Houston, 2009). Finally, the reclamation liability cost estimate, upon which the environmental financial assurance is based on, must be accurate and up to date. Unfortunately, errors in these computations, whether legitimate or not, have required millions of dollars of taxpayer funding to close bankrupt mines.

Demanding financial sureties for large mines is an accepted practice in developed countries[9], although opinions differ regarding the form of financial assurance. Governments have employed several financial vehicles to meet FA requirements. These instruments commonly take two types: independently guaranteed EFA and financial assurance guaranteed by mining companies. Because mine operators can and do go bankrupt, non-governmental organisations and governments require '*hard*' forms of FA, in-full and

[9] Countries such as Australia, Canada, South Africa, and the United States of America (US).

up-front, that are independent of the mine operator, usually in the form of cash deposits, letters of credit, surety bonds, bank guarantees, trust funds, insurance, or some combination of these instruments. These funds are deposited held, in escrow, in advance of a mining activity and are until the end of mining and released when reclamation operations are completed (Gerard, 2000). The financial coverage provided by such instruments could be based on the relative risk of the mining activity and the potential loss of the environmental services. However, the mining industry, along with other sectors, such as energy, has found it increasingly difficult to obtain such surety coverage for mining operations (Learn, 2016).

Legislation and regulations identify the variety of financial security instruments that are permitted. Government regulators hold or have access to these escrowed funds during the lifetime of a project. The responsibility for restoring land that has been mined to a natural or economically usable state (mine reclamation) rests principally with the host jurisdiction.

The environmental financial obligations stemming from mining projects can run into tens or hundreds of millions, and in some instances, billions of dollars due to post-closure issues (CCSG Associates, 2001). EFA is an appropriate safeguard since it makes available the necessary funding requirements for future environmental liabilities to be funded for by a mine operator. The escrowed funds provide for financial expenditures stemming from projects with long lifespans where risks related to decommissioning and their associated costs may not be realised for several decades into the future. In conjunction with a sound regulatory, oversight, and enforcement framework, they can act as a potent stimulus to industry to minimise environmental impacts as a core part of its operations.

Post-closure issues have often been overlooked in mine closure planning, especially at the mine planning stage. These issues are usually categorised as monitoring and maintenance, water treatment, and catastrophic events (US EPA, 2011). Monitoring and maintenance issues include geotechnical inspections of tailings dams and waste rock facilities, long-term water quality sampling, and minor repair work such as re-grading the slopes of dams and waste dumps and re-vegetation where initial seeding or planting have failed. If water treatment is necessary, extensive financing will be required after the mine has closed. Long-term water treatment along with water treatment plant replacement activities can significantly increase the cost of mine closure, which is why some advocate not allowing the development of mines that require perpetual water treatment (Stantec Consulting, 2016). If a mine operator were to abandon its mine site without providing adequate funding for continuous water treatment, governments would be forced to pay treatment costs.

Financial assurance is not generally required for catastrophic events such as floods, earthquakes, tailings dam failures[10], or the sudden onset of acid mine drainage after mine closure (US EPA, 2011). These adverse exposures can include major environmental accidents costing billions of dollars for compensation, containment, and clean-up (e.g., the Mount Polley mine disaster (2014) in British Columbia (BC), Canada; the Samarco (Brazil's Samarco Mineração S.A.) dam collapse disaster (2015) in Bento Rodrigues, a sub-district of Mariana, Brazil; the Texas Silver Mine[11] storage ponds spill[12] (2016) in southern Queensland, Australia; and the recent Brumadinho dam collapse[13] (2019) in the state of Minas Gerais, Brazil). Where similar incidents have occurred, taxpayers have often been responsible for a large part of the clean-up costs.

The BC First Nations Energy and Mining Council recently called on the British Columbia provincial government to close a policy gap that permits mining companies not to provide

[10] Following January 2019's tailings dam disaster at Vale S.A.'s Córrego do Feijão mining complex, the Responsible Mining Foundation released a statement highlighting the results of its *2018 Responsible Mining Index* report related to miners' tailing dams. As per the report, many of the world's leading mining companies are reluctant to acknowledge how effectively they are addressing the risks of tailings dam failure and seepage (RMI, 2018; Ruiz Leotaud, 2019).

[11] Not to be confused with the Texas silver mine, Rio Grande Mining Co., in Shafter, Texas, that was acquired by Vancouver-based Aurcana Corp. in 2008.

[12] An internal government document disclosed it could cost up to AUS$10 million to rehabilitate the mine site (Willacy, 2016b). The government holds just AUS$2 million from the former owners in financial assurance for the site.

[13] Vale's (Vale S.A.) second dam disaster in Brazil in less than four years is a blow to the mining industry (Lewis, 2019a). Brazil is still grappling from the 2015 collapse of a larger dam, owned by the Samarco Mineração S.A. joint venture between Vale and BHP (Lewis, 2019a).

EFA to pay for the costs of such mine disasters (Hoekstra, 2019). FA is already required in Canada for pipelines, tankers, offshore drilling, rail lines, and nuclear power plants.

Following the devastating Brumadinho tailings impoundment failure, a group of 96 institutional investors (representing more than $10.3 trillion assets under management (AUM)), led by the Church of England Pensions Board and Sweden's public pension fund, wrote to 683 extractive companies seeking greater disclosure on the management of tailings storage facilities (Church of England, 2019a; Church of England, 2019b; Jamasmie, 2019). Such religious organisations and institutional investors are the most prominent shareholders of public, corporate entities. These institutional investors are important actors in corporate governance and in prompting company management to improve performance (Wagemans et al., 2013).

Controversy surrounding monitoring is generally related to several issues (MEM, 2016):

- monitoring data is almost always collected by the mine operator;
- mine operators consider some of the monitoring data to be confidential[14], especially information that is not explicitly required by regulatory authorities (e.g., in practice the details of reclamation liability costing are kept confidential unless a corporate entity releases it independently); and
- the public is usually not permitted to access the mine site to collect samples.

[14] For instance, the *Mining Act, R.S.O. 1990, Chapter M.14* (the Mining Act) and its regulations offer the framework for the Ministry of Northern Development Mines to support and regulate safe, transparent, and environmentally responsible mining practices in Ontario (MNDM, 2018). Part VII of the *Mining Act and Regulation 240/00* set out the prerequisites for FA to be provided, along with the Certified Closure Plan, in a separate appendix with the Closure Plan. Part VII also sets out the constraint that commercial or financial information provided to support the amount or form of financial assurance is to be kept confidential.

Confidentiality only applies to the background and supporting materials used to '*establish*' the FA (MNDM, 2018). Details about the amount or type of FA are not confidential (MNDM, 2018). The idea behind the confidentiality provision seems to be to protect the underlying financial information that would be explicitly needed to establish the corporate financial test form of FA (MNDM, 2018). The posting does not include the following confidential information (MNDM, 2018): i) liability cost estimates comprising of actual quotes from identified contractors or vendors used to support cost estimates for reclamation work and ii) financial information related to proprietary technology or processes used in reclamation. The other types of EFA do not require similar potentially sensitive information about the company's financial status.

The Ministry of Northern Development and Mines oversees support of economic development in the Northern Ontario region and for mining in the Canadian province of Ontario.

Nevertheless, mine operators typically seek to comply with the monitoring requirements specified by regulatory agencies (Garcia, 2008). All stakeholders consider compliance with monitoring requirements to be necessary.

A regulatory framework and the financial assurance established according to regulations are utilised to manage and monitor environmental risks of extractive activities. For mining, financial assurance provides a contingency fund to cover the inherent economic liabilities associated with mine decommissioning and reclamation, in accordance with the approved reclamation plan. The magnitude of the environmental reclamation that needs to be carried out will impact the amount of EFA required and the cost of the work that needs to be completed. For example, ecological land reclamation[15] would usually be considerably more expensive than merely containing mine waste in tailings ponds and would consequently require higher levels of environmental financial assurance.

Financial assurance is an illustration of the polluter pays principle (PPP) in action since during the planning stage a mining company must cover all expected financial costs associated with reclamation, environmental protection, and longer-term protection of a closed mine site (Gerard, 2000; Ambec and Ehlers, 2016; Cooter and Ulen, 2016).

Sound management of EFA requires some additional critical information, such as the term of the mine operator's licence or permit, the calculation of the approved financial assurance amount, the type of allowable FA mechanism, and the security's expiry date. These details are crucial for monitoring the continuing adequacy of the EFA in place. In the absence of such material, regulators will be unaware if the financial securities held are appropriate and enough to cover the total expenditures associated with decommissioning the facility and its

[15] The goal of mine reclamation is to return affected areas as near as possible to a natural or economically usable state. It does not aim to return them to the original state (UNEP, 1983; Government of British Columbia, 2019).

surroundings to conditions comparable with those that existed before mining operations were initiated. Timely inspections are necessary to ensure that EFA held is adequate.

Despite many environmental regulators throughout the world having established adequate systems to obtain environmental financial assurance, there still exist areas for continued development. Many mine operators within a host territory often do not have requirements that are essential for the ongoing management of financial assurance. Notwithstanding the economic benefits that mining brings to a country, the adverse environmental impacts of the industry due to such inefficiencies can be significant.

In British Columbia, Canada, through its Mines Act, owners, agents, or managers of a mining project must submit plans for the environmental reclamation of the watercourses, land, and cultural heritage resources affected by mining activity as a requirement to obtain a Mines Act permit prior to the initiation of mine construction and production (OAGBC, 2016). Regardless of this regulatory approach, adequate reclamation of lands is not always pursued by mine operators (the National Orphaned and Abandoned Mines Initiative (NOAMI) database is littered with examples). Such a scenario can occur at abandoned mines, where mineral claims have returned to the government upon approval of all regulatory requirements but where additional work may still be required at the disturbed lands to avoid pollution, human health risks, and property damage.

A 2006 study undertaken by Castrilli (2007) considered a levy on industrial production as a funding approach that could help solve orphaned/abandoned mines clean-up problems; similar to the OSM (Office of Surface Mining) levy on coal production. Castrilli studied several jurisdictions that implemented this mechanism or were considering it. The standard characteristics of these programmes include the establishment in law of a government entitlement to impose a tax or fee on an industry sector, which the funds would be deposited into a dedicated fund reserved solely for orphaned/abandoned mine clean-up.

The supply of financial assurance providers has declined in past years due to multiple factors in the surety industry, the casualty insurance industry and broader property, and the mining industry itself (Learn, 2016). Citing sharp price increases, reclamation surety companies have withdrawn from the market over the past years and, as a result, mine operators claim that obtaining the suitable EFA required for operations has become significantly costlier. Subsequently, the mining sector has proposed that the government expand the selection of FA offerings that it is willing to accept; though, those proposals, usually '*soft*' security, could potentially have the government and, consequently, taxpayers bearing higher default risk (Hein et al., 2016; Learn, 2016; Harmon, 2017; Richards, 2017; Lavoie, 2018). In some circumstances, for instance, such as mine sites where the company's financial strength materially exceeds the estimated liability, a regulator may accept less than full security. As disclosed in the latest available reclamation liability cost estimates data (see Appendix A) to the BC government, for instance (MEM, 2016). The regulator reviews the liability status of such mine sites and reduces bonding liability shortfalls over time, as determined by regulator analysis. Such '*financial strength materiality*' consideration allows the chief inspector the discretion to accept less than the full value of the financial surety required for reclamation and closure commitments. A discrepancy of such monetary significance not only places the public at considerable financial risk, but it also provides an economic, competitive advantage (subsidy) to large mining corporate entities over their competitors who paid in full.

A disappointing performance by Canadian mining companies over the last few years has also taken a toll on the entire global industry, which makes matters even worse (Friedman, 2019). Many executive leaders are reporting that traditional avenues of finance have dried up, with North American investors fleeing to better-performing sectors, such as cannabis and technology (Hoffmann, 2019). "*It is clear that the industry as a whole is not in good shape*," Barrick Gold Corporation's (Barrick Gold) chief executive officer, Mark Bristow, told analysts in May 2019, describing mining as antiquated (Friedman, 2019). The contraction of Canada's mining industry was outlined at a recent conference (Hoffmann, 2019). Oreninc, a research and advisory firm, tracked approximately 1,400 Canadian-listed mining companies, with market valuations of less than CAD$1.5 billion and more than CAD$100 million, and observed that they are raising less money and forging fewer deals (Hoffmann, 2019). The *State of Mining Finance 2019* report, produced by Oreninc and the Prospectors & Developers Association of Canada, also paints a gloomy picture of mining and exploration companies' capacity to attract financial capital, citing metal price weakness in 2018 as a leading driver behind the growing decline (Els, 2019; PDAC, 2019).

The potential for corporate entities to default on FA needs to be addressed with greater detail. Historically, such EFA defaults have occurred in mining situations throughout remote, lightly populated regions of northern Canada where the abandonment of industrial extraction sites without reclamation has been common, if not the norm (Foote, 2012). As Foote (2012) denotes, Samis et al. (2005), for example, reported on fifty northern Canadian lakes that were either entirely or partially eliminated, or approved for elimination, during the 1985-2000 era because of placer mining, diamond mining, or oil sands operations. The legacy of abandoned/orphaned mine sites, with the accompanying environmental liability, the financial costs of clean up, and human health concerns are a serious concern facing Canada and other jurisdictions around the world (Tremblay, 2006).

One of the objectives of the dissertation is to produce new knowledge surrounding financial assurance. It introduces a structured finance-based EFA-backed securitised mechanism which is inspired by available forms of creative alternative financing — commercialising life settlements (life insurance policies) (Anderson, 2009), biomedical research innovations, student loans, and intellectual property assets through financial securitisation[16] techniques, for example. The proposed securitised mechanism is essentially a customised asset-backed security (ABS), with elements of a mortgage-backed security (MBS) structure, backed by a pool of underlying exposures that are homogeneous in terms of asset type (FA obligations).

[16] Securitisation permits originators of financial assets to obtain liquidity and relatively cheap finance, diversify their investor base, secure off-balance-sheet financing, and replace the risks associated with the ownership of financial assets with income from servicing arrangements and residual interests.

1.1 Research Problem, Purpose, Objective, Scope, and Methodology

1.1.1 Statement of the Problem

> *We securitise auto loans, credit cards, student loans, life settlements, mortgages, intellectual property assets, and even cancer drugs (to name a few). Why not securitise financial assurance obligations as well?*

While governments hold millions of dollars in financial assurance securities, estimates for total liability are often much more substantial. In British Columbia, the government holds approximately CAD$900 million in financial securities; however, estimates for total liability are CAD$2.1 billion, which could result in a potential funding shortfall of approximately CAD$1.2 billion (OAGBC, 2016). Because of this deficit and the risk that mine sites are orphaned or abandoned before proponents fulfil their reclamation requirements, the Government of British Columbia stands to benefit from considering alternative and sound approaches to the collection of financial assurance from the mining industry.

Similarly, in 2016 the Department of Environment and Heritage Protection of the Queensland Government (DEHP) commissioned an enquiry by the Business Centre Coal into the suitability of the FA system in the Australian state's coal mining sector. DEHP published the *Report of the Targeted Compliance Program: Financial Assurance for Queensland Coal Mines (TCP 15-009)*. It found that AUS$4.54 billion is held in EFA in the coal sector (Horn, 2016; Willacy, 2016a). By examining the FA held at 15 mine sites across Queensland, the TCP report observed a shortfall that if extrapolated to all coal mines in Queensland would total AUS$3.2 billion. The 2016 report also found that 19 percent of the EFA put forward by the industry was incorrect and too low (Horn, 2016). Queensland senator, Larissa Waters, claimed mining companies had been dodging their responsibilities (Horn, 2016).

Since the recent global financial crisis of 2007-2009, mine operators have found it increasingly more problematic to satisfy financial guarantee obligations required by regulators with the typical FA mechanisms of choice because of surety providers' large-scale departure from the minerals and metals markets. The troubled surety bond market and the corresponding implications for the mining industry received widespread attention. Anna Zubets-Anderson, a senior analyst at Moody's, comments that "*We are seeing that surety bonding is becoming more expensive and less available.*" (Learn, 2016).

Besides the poor track record surrounding reclamation collection from mine operators – conflicting, incomplete, and vague environmental regulation can lead to unnecessary higher R&C costs and contradictory interpretation of financial reclamation requirements. Such ineffectiveness and inadequateness can also leave little room to determine optimal levels of financial reclamation for each mine site (Berger et al., 2011).

While governments across the world use multiple techniques to manage environmental risks, the focus of the dissertation is financial assurance securities. It investigates if a more effective EFA mechanism can be devised, through innovative social-based[17] structured finance, that can handle the costly shortcomings of both the current FA offerings and the governmental regulations surrounding environmental clean-up.

The alchemy of structured finance (in practice, most references to structured finance imply securitisation – the terms are often used interchangeably), generally, relies on the principle that there is an arbitrage in risk-reward tranching and that the sum of the parts is different from the whole. If markets are efficient, market prices reflect the true value of the underlying pool of asset(s). If something gets underpriced, there is a profit opportunity. The incentive provides the arbitrage mechanism to make sure that prices rise/fall to the correct level. The purpose of permitting such arbitrage opportunities, provided by inefficient pricing

[17] EFA-backed securitisation can be considered a form of social finance since EFABSs (EFA-backed securities) would be designed to generate financial returns while including measurable positive social and environmental impact. Social finance is a technique for managing money that provides a social dividend and an economic return (Varga and Hayday, 2016).

of EFABSs, along with greater transparency on FA requirements, could become a more efficient deterrent effect on mine reclamation and closure negligence rather than relying on just governmental regulation to ensure standards continually being met (a conceivable, capital markets' response, complement to regulatory oversight and enforcement).

The usage of market instruments rather than relying on regulation sounds modern and flexible, and hence politicians increasingly argue that environmental policy should be market-oriented instead of merely relying on top-down regulation by government (Faure et al., 2006). Economic instruments (or market-based instruments) are currently prevalent, at least in the literature, but increasingly at the policy level as well (i.e., carbon financial instruments were traded on the now-defunct Chicago Climate Exchange, which was linked to carbon trading measures under the Kyoto Protocol). Many policy analysts interested in environmental policy have, for several years now, advanced the increasing use of these market-based instruments, more particularly as a reaction to regulation (Faure et al., 2006). Regulation is, in that respect, often referred to as a '*command and control'* (CAC) approach.

1.1.2 Research Purpose, Objective, and Scope

If we knew what it was we were doing, it would not be called research, would it?

— Albert Einstein

The purpose of the dissertation is to deepen the discussion regarding the application of EFA instruments in the mining sector, predominantly, where a mining project's life followed by reclamation efforts extend well into multiple decades or even in perpetuity. Vagueness about reclamation success and the open-ended nature of the regulatory demands can be disconcerting. Such economic liabilities translate into stock values and place significant pressures on regulatory bodies in government to relax environmental regulations.

Financial assurance is required for mining, petroleum and gas, and other activities (e.g., infrastructure, nuclear, chemicals, and livestock farming). When assessing such EFA requirements, regulatory authorities are expected to take into consideration the amount of risk that environmental impairment will result; the probability that action will be necessary to rehabilitate, restore or protect the environment; and the environmental record of the holder of the lease.

Adequate, flexible, and suitable FA are necessary elements required for greater mine closure efficiency. It offers a level of confidence to stakeholders that sufficient financial resources to meet closure requirements will be accessible; however, there is a pressing need to guarantee that it is applied promptly and that it is transparent, effective, and satisfactory to all concerned stakeholder parties, and consistent.

Although most stakeholders agree that systematic monitoring and enforcement is critical to ensuring that mining projects proceed in compliance with the legal framework, and thus that the risks and opportunities of projects are distributed appropriately, these central activities are frequently neglected (Marshall, 2001; World Bank, 2005; Marcin and Ruder, 2007; OAGBC, 2016). In part, at times due to the lengthy time-horizon associated with mine R&C requirements related to a specific mining project[18]. Regrettably, regulatory monitoring and reporting requirements often tend towards being static, especially when a mine project's lifecycle is lengthy. Such oversights need to reflect their evolution both in terms of the mining operations as they unfold and any environmental site reclamation activities as they are implemented. Lacks in capacity, transparency, and government monitoring incentives all contribute to inadequate monitoring, compliance, and enforcement practices. Amendments to regulations after a permit have been granted presents a problematic circumstance as well in the sense that mining operational parameters[19] all depend on a financial calculation incorporating compliance cost.

[18] The lack of importance for mine site reclamation in the early stages of a mining project can be likened to the '*retirement problem*' or '*funeral dilemma*,' as outlined in concepts and methodologies from the behavioural and social sciences.

[19] Mine cut-off grade reserves, mine design, and mine planning.

One can argue that a mining company contributes to its liabilities over time due to ongoing mining operations, and it removes obligations by executing reclamation initiatives. The concern is who is keeping track of such information as it relates to continuous regulatory monitoring and reporting activities? The principal-agent dilemma (agency problem) involves the government (the principal) and the mine operator (the agent) (Miller, 2005a).

One dilemma is that lax regulatory policy and challenges undermining monitoring, compliance, and enforcement requirements create a lower cost and, therefore, higher accounting profits and government revenues, but also more significant long-term environmental impact. Stringent policy, conversely, substantially prevents mines from being developed at all due to high compliance cost. Another concern is that government may be tempted to make reclamation and closure obligations stricter after the mine has been established. Such actions can impact the economic calculations upon which the mine development decision was based.

Any regulated industry is at risk of engendering the concept of regulatory capture (Stigler, 1971). Conversely, regulation surrounding reclamation finance depends significantly on input from the activities to be regulated. Such a problem needs to be addressed in any plan to develop alternative EFA instruments for dealing with long-term mine closure issues.

Existing environmental management guidelines and policies invariably refer to the need to remediate, reclaim, rehabilitate, restore, or some combination thereof, of the mining site after closure (Lima et al., 2016). The use of words like '*remediation*,' '*reclamation*,' '*rehabilitation*,' and '*restoration*'; however, are used interchangeably in the scientific literature, government reports, and policy documents (Li, 2006).

Surety bonding, as an EFA example, is often used to impose contractual and regulatory provisions. Typically, an agent (or a third-party) posts a bond as an assurance of compliance, and it is released when the undertaking is satisfied. For instance, in the mining industry regulation regularly requires post-mining site reclamation. The surety is posted to ensure this is satisfied. If compliance is incomplete or insufficient, the company forfeits the financial bond, and the collected proceeds are employed to finance reclamation efforts.

Despite the promise of surety mechanisms for environmental reclamation issues (Costanza and Perrings, 1990), standard forms of FA mechanisms (e.g., cash, irrevocable letters of credit, and surety bonds) entail trade-offs that limit their scope and effectiveness (Shogren et al., 1993). The utilisation of surety bonding to mid- and long-term, and in general, environmental reclamation and closure projects have been narrow and the success mixed (Boyd, 2002). Therefore, investigating the potential effectiveness of alternative EFA mechanisms to regulate mid- and long-term mining projects are expected to be of significant interest to public policy and stakeholders – it is the focus of the dissertation.

Structured finance may save the day – a bold statement to make but one that the dissertation investigates. An alternative EFA-securitised[20] framework is presented, one that will not necessarily shift the financial assurance obligations surrounding mine closure to other parties (such as consulting and advisory providers or credit rating agencies (CRA)) to manage and oversee but rather to ease the financial burden by spreading the initial upfront deposit costs in a similar manner as a mortgage or loan does while incorporating an asset-backed securitisation framework around it. The investigation of a possible FA alternative, flexible with time horizon, which could conceivably overcome regulatory oversight and enforcement shortcomings, and the restrictions surrounding trust funds and other conventional EFA instruments is expected to spawn further research initiatives.

Since such a securitised mechanism would be customised financial solutions and their numbers could be small, and too costly to provide sufficient statistical evidence, a

[20] Securitisation is a form of off-balance sheet (OBS) financing which comprises of pooling of financial assets and the issuance of financial securities that are repaid from the cash flows generated by these assets (Baig and Choudhry, 2013).

traditional empirical analysis cannot be implemented. The dissertation, thus, offers a conceptual framework that was tested based on some specific and relevant parameters[21]. The utilisation of fuzzy logic (FL) as a modelling tool is fitting since it is, in part, conceptually easy to understand, flexible, tolerant of imprecise data, it can be built on top of the experience of experts, and based on natural language. The framework is tested by applying a fuzzy inference system (FIS) methodology approach.

The FL methodology is applied to attempt to infer and study the potential key attributes leading to the possible success of securitisation deals possessing FA obligations as their underlying pool of assets. The model attempts to understand from the observed data and the fuzzy logic analysis if the likelihood of success of an EFA-backed securitised mechanism is feasible, conceptually, through the possible identification of some key attributes.

1.1.3 Methodology and Research Questions

> *Securitisation markets are a key funding channel for the economy, increasing the availability and reducing the cost of funding for households and companies by opening up investment opportunities to a wider investor base, diversifying risk across the economy and freeing up bank balance sheets to lend.*

— Jonathan Hill
European Commissioner for Financial Stability, Financial Services and Capital Markets Union
Eurofi Financial Forum 2015

> *As complexity rises, precise statements lose meaning, and meaningful statements lose precision.*

— Dr Lotfi Zadeh
Professor Emeritus, EECS, UC Berkeley

[21] Using the latest available reclamation liability cost estimates data, which was obtained from the *2014 Mine Reclamation Securities in BC for Metal and Coal Mines* report (see Appendix A).

Credit constraints continue to be particularly critical for resource extraction companies due to ongoing economic restrictions (McGee, 2018). While the rules on regulatory capital requirements under the Basel III Accord do not seem to have a significant positive impact on lending conditions for mining, oil & gas companies, the ongoing situation of credit markets continues to exert its negative effect in the long run for these industries. Such restrictive market conditions are due to the contraction of financial resources for resource-based projects which impact EFA obligations requirements (Chiesa, 2018). The lack of funding from the credit markets for such capital-intensive companies is particularly critical.

There has been a rising interest in new financial tools that may help ease financial constraints on FA obligations, at least in principle. The question of whether tools based on financial assurance obligations may be effective alternatives to the problem of financing constraints for mining companies engaged in progressive reclamation activities appears to be significant and of considerable interest for both regulators and researchers. One way to leverage such obligations could be to securitise them.

EFA-backed securitisation can be considered a form of social finance since it would be designed to generate financial, inflation-adjusted, returns while including measurable positive social and environmental impact. Social finance is an approach that sees social and economic issues as two sides of the same coin (Varga and Hayday, 2016). It can be described as an investment made to achieve (i) a beneficial and quantifiable impact on society and the environment; and (ii) an economic return (Echenberg, 2015). The appetite for social finance is growing across the world (US SIF Foundation, 2016; Responsible Investment Association, 2017).

Publications in the field of FA obligations outstanding, as it relates to mining, have been constrained by the lack of available public data and by the high level of secrecy surrounding such required financial obligations by mine operators (MEM, 2016).

A wide range of issues limits the suitability and diffusion of EFA-backed securitisation. First, they are complex instruments of financial engineering, which involve high structuring costs. Second, estimating the value and risk profile of a portfolio of FA assets would be a challenge for the development of these proposed solutions. Lack of generally accepted methodologies for the valuation of R&C costs and the high degree of uncertainty to which financial assurance value is subject to would strongly affect the confidence in FABS[22] instruments. To the author's knowledge, no other research has been conducted on such securitised instruments. The dissertation provides a unique approach that adds value to the research landscape surrounding the search for more effective and readily accessible financial assurance instrument solutions for the resource extractive industries.

Securitisation financing, in general, is a challenging area of study. In particular, literature and available data on FA-backed securitised financial instruments are non-existing. The research in this field could be constrained by the limited number of such securitisation deals (*if any*), by the lack of existing data, and due to the high level of secrecy surrounding existing transactions. Consequently, a conceptual framework was developed and tested. It was explored by using a fuzzy set model that includes key attributes leading to the potential success of securitisation deals having financial assurance obligations as their underlying pool of assets. The framework consists of a set of independent crisp inputs that are converted to linguistic variables that are assumed to explain the possible outcomes that such a securitised offering may have in the mining sector.

Through simulation, the model is tested on two portfolio samples based on the latest available reclamation liability cost estimates data (see Appendix A). It highlights the potential for securitisation for each observed FA obligations portfolio. The model attempts to infer from the observed data and the FL analysis if the likelihood of success of an EFA-backed securitised mechanism is feasible, conceptually, through the possible identification

[22] FABS (FA-backed security) and EFABS are interchangeably used in the dissertation.

of some key attributes. There is, however, no evidence available on this topic that directly supports or refutes the observed conclusions outlined in the dissertation.

The securitisation-based conceptual framework provides the basic structure from which the research questions – and, therefore, the methodological approach to answer the questions – are drawn. Critical issues that the dissertation addresses include:

- Can securitisation provide a reliable, regulatory approved, financial assurance funding source to the mining sector, among others, for reclamation and closure obligations in the advent of diminishing surety providers?
- Can environmental financial assurance obligations potentially be securitised?
- Can key attributes be identified that may influence the likelihood of success of a financial assurance-backed securitised mechanism?

The dissertation addresses whether obstacles exist that could hinder EFA-backed securitisation from becoming a successful means of financing reclamation requirements as it has proved to be for other unmarketable, and even intangible, assets.

An explanation as to why financial assurance-backed securitisation remains an untapped niche market could be due to what can be described as an integrated risk analysis. That is, there exists a set of interdependent (therefore, combined) risks that are present in such a securitisation process (e.g., underlying asset risk, legal risk, regulatory risk, commercial risk, credit risk, counterparty risk, and country risk) that would dictate its overall market success. Securitisation works to diversify such residual risks once the underlying assets have been pooled. If the associated risks of each pooled asset are not highly correlated, tranching allows the issuer to exploit the risk diversification effect of pooling to create a highly-liquid and low-risk security.

Despite the analysis undertaken, the market potential for EFA-backed securitisation will remain uncertain until case studies have been completed, and conclusive results are observed. Future case studies in multiple jurisdictions are being planned to examine the possible likelihood of such market potential.

1.2 Academic and Industry Significance

Regulatory monitoring, compliance, and enforcement (RMCE), which are essential to ensuring that mining projects advance in accordance with the legal framework, are often neglected even more so in some jurisdictions with slow economic growth (Dean et al., 2009). Structured finance can potentially play a role in strengthening RMCE requirements through the adoption of new and innovative forms of FA instruments which would possess built-in monitoring, compliance, and economic enforcement mechanisms that are both cost-effective and efficient.

The author is optimistic that the dissertation could spawn a sound financial mechanism for a new form of, inflation-hedging, financially innovative tool that could be well-received by concerned stakeholders, including institutional investors (Deacon et al., 2008; Canty and Heider, 2012; Perrucci and Bénaben, 2012). The proposed EFA-backed securitisation mechanism is an enhanced, hybrid-form, of a general trust fund (e.g., Mine Rehabilitation fund, Abandoned Mine Land fund, or Abandoned Mine Reclamation fund) that is incorporated into an ABS framework (with some features similar to an MBS).

Such financial innovation could also positively impact the effectiveness of regulatory legislation (to govern how RMCE are conducted) and possibly lead to tax code updates, and securities regulation reform in some jurisdictions, and the creation of employment opportunities. It could also provide greater data exposure surrounding reclamation monitoring and liability costing to stakeholders. More importantly, it could ensure timelier reclamation should a mine operator be unable or unwilling to perform the required environmental R&C actions by promptly providing the necessary funding.

The importance of the global financial sectors in influencing the environmental and social quality of resource-related project initiatives is already broadly recognised. Almost two decades have passed since the World Bank included provisions to guarantee that any project financed by the Bank or the related International Finance Corporation (IFC) anywhere in the world must consist of appropriate standards of mine reclamation and closure responsibilities, including the nature and amount of financial assurance in its *Pollution Prevention and Abatement Handbook* (Peck, 2011).

After the financial crisis of 2007-2009, the term financial engineering mutated into a curse for many financial market participants. Securitisation unfairly became '*taboo*' for many investors, credit agencies, and regulators alike. Despite the allegations of the overuse and misuse of securitisation, stemming from manipulation, fraud, and other abuses, in the commercial, industrial and residential market, and in other markets, it is an essential and indispensable structured finance technique for financing significant ventures.

Fusing portfolio theory with securitisation, in the extractive industries, could spawn into some viable mid- to long-term EFA alternatives. Such a structured finance method can be utilised to assist in funding something as crucial as reclamation obligations when standard forms of FA with their inherent limitations, including monitoring, compliance, and enforcement, may not always be the appropriate option. If the life expectancy of a mining project and the required amount of time needed to effectively clean-up and reclaim the mine property is several decades, or more, into the future, this is especially so.

Similar to an MBS, the proposed financial assurance securitised mechanism is a collection of a type of asset (financial assurance) combined into a group, divided in tranches of different credit quality and therefore of varying subordination, and evaluated using weighted average characteristics. The size and diversification of each financial assurance pool are expected to decrease investment risk for the investor to the point where the expected, inflation-adjusted, returns are predicted to outweigh the risks for the high-quality[23] and to, some extent, the mezzanine tranches as well. These appealing features should attract the attention of many types of sophisticated investors, for both their social financing, returns potential, principal protection features, and inflationary hedging properties.

Anticipated investors for such an EFA securitised mechanism offering could include insurance companies, pension funds, money managers (including exchange-traded funds, ethical funds, and the like), sovereign wealth funds[24], and sophisticated individual investors. Such investors, with access to sizable amassed fortunes, are continuously seeking new investment opportunities with acceptable levels of risk and return to enhance their alpha returns[25] from their pool of diversified investments.

The proposed securitised mechanism would be considered socially responsible investing (SRI) (i.e., socially conscious, sustainable, '*green*' or ethical investing). By its definition, it is an investment strategy which seeks to consider both social/environmental good and financial return to bring about a positive change in the context of successfully meeting specific environmental reclamation, closure, and long-term liabilities objectives in the metals and mining sector but not necessarily exclusively (OECD, 2006; Marlowe, 2014). There is a growing interest in such social investments, among institutional investors and others, globally (Berry and Junkus, 2013; Marlowe, 2014; Auer and Schuhmacher, 2016).

[23] All the combined tranches in a securitised mechanism make up what is referred to as the deal's liability structure or capital structure. They are commonly paid sequentially from the most senior to most subordinate (and typically unsecured), although specific tranches with the same security may be paid simultaneously. In this context, it relates to circumstances where two or more securities are uniformly managed without any act of preference. The senior (high-quality) tranches possess the highest credit quality with the lowest yield. Subsequently, the mezzanine tranches are next in line with lower credit quality and higher yield, while the subordinate (subprime) or equity tranches receive residual tranches and are of least credit quality with the highest yield. For instance, senior tranches may be rated AAA, Aaa, AA+, Aa1, AA, Aa2, or A, while a junior (subordinate), unsecured tranche may be rated BB or Ba2.

[24] Two of the top 15 sovereign wealth funds (SWFs) worldwide, with a combined value of over $7.09 trillion (as of November 2018), by AUM, are i) Government Pension Fund Global — Norway ($1.06 trillion) and ii) China Investment Corporation — China ($941.4 billion) (Statista, 2019). Preqin (2018) states that SWF assets jumped (13 percent year-on-year) to $7.45 trillion in March 2018 — a size comparable to that of the entire alternative assets industry.

[25] The active return, in excess of a specific market index, of an investment.

The tranched issuances within the proposed EFA securitised mechanism, which could be viewed as a next-generation form of social impact bonds (SIB), would each possess a different risk profile and financial return (Herrera, 2015). A feature for such transactions would entail higher usage of credit ratings by issuers. The ratings offer a market signal as to the credit quality of the particular asset. For instance, such a SIB tranched EFA obligations-based issuance could possess the following tranches and interest rate pay-outs: senior tranche (A%), mezzanine tranche (A% + B%), and equity tranche (A% + B% + C%) (listed from least to most risky). With a tranched SIB, if the SIB issuer were unable to pay the owed interest to the investor, the equity tranche holders would consequently take the first loss, followed by the mezzanine, and then senior tranches. Such a tranched SIB-based securitised mechanism could expand the potential social impact investor base since they would provide a more extensive array of risk profiles (and thus, interest rates) in the same issuance. Such features could make the mechanism appealing to social investors.

One of the crucial factors to the possible success of the proposed EFA-backed securitised instrument will be the use of an additional layer of RMCE that will rely on early indicators of potential failure of a mining company. Empirical research on environmental enforcement confirms that effective monitoring helps to discourage regulatory violations (Cohen, 1998). Multiple independent third-parties will be investigated to determine if such impartial (non-political) entities can provide value to the good governance (transparency and accountability) process at a reasonable cost to assist regulators in the surveillance responsibilities. These entities include consulting and advisory providers, credit rating agencies, and agencies of the United Nations, such as the United Nations Environment Programme (UNEP), through their United Nations Environment Programme Finance Initiative (UNEP FI) (Peck, 2011), and the Bank's Oil, Gas and Mining Unit.

Another objective of the dissertation is to investigate if the proposed enhanced, positive-sum, reclamation mechanism framework can indeed be developed for market use given the findings of the research (Klein, 1991; Wright, 2000; Wright, 2006).

1.3 Dissertation Outline

The dissertation contains five chapters, references, and appendices. The first chapter briefly describes the background to the analysis presented in the dissertation and outlines the framework within which it is set. It describes the government requirements for EFA for environmental risks in approved mine R&C requirements, its significance, and the scope of the dissertation. The second chapter provides a literature review of the general concepts underlying financial assurance and the limitations and challenges regarding mine reclamation security. A short discussion is also presented on how financial innovation can play a part in ongoing efforts to mitigate environmental risks.

The third chapter offers a background surrounding the regulatory approved funding mechanisms available to mine operators for reclamation efforts, and it outlines key issues that concern various stakeholders relating to EFA. The section also provides a brief insight into some of the critical institutional arrangements for mine closure planning and characterisation of current mining reclamation security (financial assurance) regulation for many mining jurisdictions around the world. The fourth chapter includes a framework overview of the proposed FA-based securitised mechanism. It also describes and explains the methodologies applied, and it discusses the benefits and drawbacks of asset-backed securitisation, which the EFABS mechanism is partially based on, to critical stakeholders.

Several critical potential determinants leading to the possible success of securitisation deals having financial assurance obligations as their underlying pooled asset are also studied. A conceptual framework is proposed and tested by applying a Mamdani fuzzy inference system-based methodology. In the fifth and final chapter, conclusions, contributions, and recommendations for future research are presented. Finally, the references are then listed, and appendices are located at the end of the dissertation.

Chapter 2: Literature Review

You never let a serious crisis go to waste.

— Rahm I. Emanuel
Former Chicago Mayor

Mining activities characteristically involve the displacement of large volumes of rock and soil, resulting in various degrees of environmental degradation. Mine reclamation entails restoring these disturbed areas to a previous natural resource setting, such as forest or agricultural land uses while minimising environmental impacts. Financial assurance for mandatory reclamation and closure requirements, which is held in escrow, is designed to serve as an insurance policy, of a sort, to provide adequate funding, when required, to government regulators to deal with clean-up, closure, and reclamation expenditures, in accordance with the approved R&C plans, if a mine operator is unable or unwilling to fulfil such duties (Peck and Sinding, 2009; Malone and Winslow, 2018).

Multinational companies must conform to increasingly rigorous domestic regulations and may adopt voluntary practices that exceed regulations. There is some confusion that free-market policies applied to attract mining investment have led economically developing nations to weaken their environmental regulations. The subject is still heatedly debated (Gallegos and Regibeau, 2004). There continues to be no consensus among researchers whether environmental law adversely or favourably impacts a company's behaviour. Some of them argue that mining companies are low-cost seekers and, consequently, minimise activities when they are up against strict environmental standards (i.e., pollution haven hypothesis). Others stress the role of clean natural resources and pioneering technologies in the production process (factor endowment hypothesis (FEH) and Porter hypothesis (PH)) (Gallegos and Regibeau, 2004). According to this view, environmental regulation should govern a company's activities. Consequently, the relationship between these aspects will produce different results, such as a cleaner environment in the host country than anticipated by the pollution haven hypothesis (PHH). Empirical research has determined that strict environmental policy is just one determinant in location decisions, and a negligible one, compared to other country factor endowments such as quality of infrastructure and the accessibility to low-cost country sourcing (Jaffe et al., 1995; Tole and Koop, 2010). Geology is a dominant factor that influences it.

PHH expects that rigorous environmental regulation in developed countries lead to the repositioning of pollution-concentrated production away from high-income nations toward economically developing nations, where regulations are comparatively weaker. If these lower regulatory standards in developing nations can be considered as an additional source of comparative advantage, it is reasonable to be troubled that governments could try to attract foreign direct investment (FDI) by aggressively undercutting each other's regulations, and consequently turning developing nations into pollution havens (Neumayer, 2001; Zeng and Eastin, 2011). Conversely, capital or export inflows can also be discouraged by stricter environmental regulations (Taylor, 2005).

FEH deviates from PHH by hypothesising that factor endowments, and not just differences in environmental legislation and regulations, are the core incentives for trade patterns (Temurshoev, 2006). Trading economies will specialise in production where comparative advantage is evident – this infers that nations, where capital is abundant, will export capital intensive (dirty) products. Conversely, countries, where access to capital is limited, will witness a decrease in pollution levels given the reduction of the pollution-producing industries. The impacts of open-trade on the environment are contingent on the distribution of comparative advantages across countries (assuming resource endowment).

The Porter hypothesis assumes that stringent regulations have the potential to encourage efficiency while promoting innovation that supports greater competitiveness (Porter and van der Linde, 1995).

Substantial empirical research has been carried out in seeking for confirmation for pollution haven practice amongst companies (Neumayer, 2001; Zeng and Eastin, 2011). These studies have come up with different conclusions. Dean et al. (2009) examined pollution haven behaviour by assessing the determinants of location preference for equity joint ventures in China. The study results concluded that weak environmental standards attract highly-polluting industries funded through Taiwan, Hong Kong, and Macau. Chung (2014) also found evidence for the pollution haven effect (PHE) in the pattern of Korean FDI over 2000-2007. A similar finding was observed when Korean imports were analysed. Eskeland and Harrison (2003) examined the pattern of FDI in four developing countries and found minimal indication to support PHH.

Levinson and Taylor (2008) observed that environmental policy and regulation had a revealing impact on trade flows that adheres with the PHH, after taking into consideration unobserved endogeneity and heterogeneity of pollution reduction cost measures. In contrast, Costantini and Mazzanti (2010) illustrated that environmental policies, coupled with innovation activities, promote competitive advantages of green exports. They also trigger greater efficiency in the production process, consequently turning the concept of environmental protection initiatives as a production expenditure into a net benefit.

In the last two decades, a growing number of countries have become increasingly aware of environmental issues, and many of them have taken adequate measures to regulate and to protect their environment (United Nations, 2015). Voluntary standards have also been employed by mine operators to achieve and maintain their social licence to operate (SLO).

Since the 1990s economically developing countries have implemented environmental regulations and established administrative structures to enforce these laws; regulatory and legal reforms have enhanced environmental rights and legal protection of the environment in Latin American and African countries (United Nations, 2015). National courts of justice ultimately enforce the implementation of such regulations.

At the global level, environmental standards have also been strengthened. Environmental treaties include the United Nations Conference on Environment and Development (1992); the Control of Transboundary Movements of Hazardous Wastes within Africa and the Bamako Convention on the Ban of the Import into Africa (1993); the International Convention to Combat Desertification in those Countries Experiencing Serious Drought or Desertification (1994); the European Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (1998); the United Nations Conference on Sustainable Development (2012); and the United Nations Sustainable Development Summit (2015).

The perceptions of mining companies working abroad also dispel the belief that environmental regulations are more stringent in developed countries than in developing nations. According to the Fraser Institute, a Canadian public policy think tank, more mine operators avoid investing in Latin America due to constraints or uncertainties from environmental regulations than would avoid investing in Canada for this reason (McMahon and Cervantes, 2012). Nevertheless, regulatory uncertainty is an issue since environmental regulations that lack clarity and stability can bring about different understandings, higher compliance costs, and increased political interference (World Bank, 2005).

The primary approaches to environmental policies and regulation are direct regulation, via command and control, and market alternatives (economic incentive mechanisms (EIM)). Under CAC, the authority (regulator) will specify how polluters are to behave. In contrast, Oates (1996) defines economic incentives as a system (i.e., EIM) through which the authority creates economic incentives for abatement activity but leaves polluters free to decide their responses to these inducements.

The basic concept of CAC is that it is the task of the regulator to gather the information required to decide upon actions to control pollution, and then to demand potential polluters to take specified actions. Thus, the difference between the two methodologies is mostly defined based on the amount of government involvement regarding the specific conduct of polluters.

Both CAC and EIM have been discussed in the literature (Baumol and Oates, 1988; Oates, 1996; Hackett, 2006; Castellucci and Markandya, 2012; Máca et al., 2012; Steinberg and VanDeveer, 2012; Wiesmeth, 2012; Callan and Thomas, 2013; Phaneuf and Requate, 2017). Cornwell and Costanza (1994) compare CAC and EIM approaches, and some aspects have been adapted to the mining sector. The command and control approach consists of creating and enforcing laws and regulations, and of setting objectives, standards, and technologies that agents must comply with. The economic incentive mechanism offers incentives that promote the desired behaviour while permitting companies the ability to act on their knowledge of their mitigation and production costs. Such a mechanism decentralises the decision-making process to protect mine sites and their disturbed surroundings. It also relies on performance objectives instead of a pre-established course of action.

Regarding government intervention, Ogus (1994) categorised several regulatory instruments concerning the degree of intervention. The least interventionistic instruments are economical and information provision instruments, while the most interventionistic instrument is prior approval. Between these two extreme instruments lie environmental standards. The classification of the economic incentives approach typically embraces the use of pollution taxes and subsidies, deposit-refund systems (e.g., financial assurance), marketable emissions permits, and liability rules.

Economic analysis specifies that current methods of environmental protection, mostly based on CAC strategies, are ineffective and frequently provide disincentives for costs reduction (Cornwell and Costanza, 1994). The central reasons are:

- increasing reservations in calculating closure costs;
- costly and lengthy litigation processes;
- homogeneous treatment of mine operators;
- significant information burden on the regulatory agency (selecting the best technology and enforcing penalties for noncompliance);
- the minimal motivation for the development of innovations that can encourage improvements and cost reductions;
- regulatory avoidance rather than regulatory compliance; and
- the ambiguous statutory language that permits companies to build convincing legal arguments that show that mounting requirements are unattainable.

The regulatory approach of the CAC instrument has been subject to criticisms as well. They can be summarised as follows (Faure et al., 2006):

- A traditional command and control system focuses on a permit or licensing system. Within this system, permits traditionally set emission standards, in the oil & gas sector, but these often disregard the effect of the aggregate level of emissions on the environmental quality of the receiving environmental medium.
- It requires high levels of information and enforcement costs. If the controls are too strict, costs will be too high. If conversely, the level of control is too low, the damage costs for society as a result of environmental pollution will be too high.
- It has often been argued that the CAC approach has, in many cases, failed to generate adequate inducements for polluters to decrease their pollution levels.
- It cannot equalise the marginal pollution costs of pollution control among different polluters that produce the same pollution. The reason has to do with the fact that a command and control approach is often too general and too unspecific.

- Under a CAC approach, polluters will only pay the prevention costs required to comply with the regulatory standard. However, polluters under this method will not necessarily be required to pay for the costs of residual damages associated with the pollution that they have produced in conformity with the standard.

Considerable disadvantages in the traditional CAC approach thus exist, which can be summarised by the fact that the regulatory standard is often too general and not flexible or differentiated enough. An optimal environmental policy would require flexible, market-based, instruments, such as the proposed FA-backed securitised mechanism. It, on the one hand, will provide more flexibility (taking into consideration the individual prospects for optimal pollution abatement by each polluter) and, alternatively, it will offer optimal incentives towards environmental technological innovation and not merely compliance with a regulatory standard.

The legal structure governing mining activities in most provinces and territories, in Canada, and states, in the United States, are, in most instances, well defined by statutes and regulations. Mining in these jurisdictions and other countries presents progressively complex cost and compliance issues. Government enforcement regimes, worldwide, tend to be costly, and host governments, which have many social or geopolitical matters to address and enforce, cannot, at times, be relied upon to act against the mining industry in the name of environmental standards (Marcin and Ruder, 2007). Lack of proper monitoring, compliance, and enforcement capabilities can impede the willingness of a mining company to improve its environmental performance standards even in well-established mining jurisdiction such as BC, Canada (Marshall, 2001; Marcin and Ruder, 2007; OAGBC, 2016).

The view of environmental surety bonds as a form of financial assurance is rooted in the theory of '*materials-use fees*,' first developed in the early 1970s. Several economists advocated programmes where governments would collect a materials-use fee from the industry when they could be found responsible for releasing harmful substances into the environment (Solow, 1971; Bohm and Russell, 1985). The cost would be refunded to parties who can verify that they had disposed of materials, with the generosity of the refund varying according to the chosen disposal method (Solow, 1971). As this early work on the topic suggests, the collection of EFA by regulators is grounded in the PPP, in turn, underpinned by the notion of strict liability, which holds that agents responsible for damages compensate all other affected parties (Becker and Stigler, 1974; Cropper and Oates, 1992; Gerard, 2000; Ambec and Ehlers, 2016).

2.1 Review of Mine Reclamation Security

A methodology to evaluate mine reclamation FA was developed by the Environmental Law Alliance Worldwide (ELAW). ELAW (2010) comments that the following three factors are essential in suitable financial assurance:

- reclamation and closure plans should contain a commitment by the mine operator to pay for reclamation and closure expenditures during the active phase and the closure phase of the mining project;
- it is essential to make available this financial commitment before the commencement of any mining activities and in an irrevocable form; and
- the mine closure plans should indicate an adequate amount of funds that the mine operator would pledge, in escrow, to pay for reclamation and closure expenditures (these costs would be updated periodically to reflect any changes in site conditions or requirements in the order or approval, and, subsequently, the posted financial assurance requirement would be adjusted accordingly).

2.1.1 Surety Bonds: Limitations and Challenges

There are several possible complications associated with surety bonding (Shogren et al., 1993; Boyd, 2002; Mooney and Gerard, 2003; Boyer and Porrini, 2008). Shogren et al. (1993) list moral hazard, liquidity constraints, and legal restrictions on contracts as possible shortcomings related to performance bonds in environmental regulation. Collecting financial assurance through environmental bonds mitigates the adverse impacts of resource depletion, providing enforcement through market-based incentives leading to low-cost land reclamation (Bohm and Russell, 1985; Peck and Sinding, 2000). The literature also includes a countervailing perspective; however, stressing the restrictions and key trade-offs associated with EFA policies. A summary of the various limitations and critiques follows.

Bonding is expensive, both in terms of the associated transaction costs and of the liquidity constraints imposed on companies at the onset of the project. Jose et al. (1996), Nobanee et al. (2011), Al-Shubiri and Aburumman (2013), and Takon (2013) all discussed the cash conversion cycle and the continual requisite for free cash flows to ensure the liquidity of a mine operation. A perception of such applies to mining given the substantial amount of initial cash outlay on capital costs that are accumulated and the expectation of early positive cash flows by investors, and subsequently by mine operators. If the company cannot guarantee positive cash flows on the onset of a project, its riskiness would rise, which would then increase its cost of capital.

As is the case with liability, surety bonding becomes more expensive as complexity increases, hence restricting its effectiveness. If the costs of monitoring, compliance, and enforcement are minimal and the mine operator poses an insignificant default risk, then mandatory, hard forms, FA requirements may perhaps be a real cost to such companies. One consequence if bonding is costly is that there could be less of the regulated mining activity and possibly fewer corporate entities involved within the host jurisdiction.

A surety bonding obligation can also tie up the operating capital funds of a company, imposing liquidity constraints on them. Such restrictions become more binding as the deposit amount increases. The use of a third-party provider, such as a surety provider, is one method to reduce but not eliminate the liquidity constraint (Gerard, 2000).

A possible drawback on the reliance of liability rules and bonding as deterrence mechanisms is the potentially long latency period between the mining company's operational activities and the potential harm afflicted (e.g., a spill or leak of a cyanide-containing solution, toxic substances, and the realisation of the leakage) (Shavell, 1986; Ringleb and Wiggins, 1990). Two issues could subsequently arise. For long-term horizons, this is an issue since the responsible party may become insolvent before the damage arises. For surety bonds, the limitation of having financial capital tied up for such long periods is a concern.

As is the case with liability rules, the lengthy expectancy period between the company's operational activities and the potential harm can present complications for bonding mechanisms. Not only is it conceivable that responsible parties will become insolvent before the damage arises, but the bonding obligations could also tie up considerable, and possibly much-needed, financial capital indeterminately. Due to increasing ambiguity as time horizons expand, financial assurance providers are less likely to underwrite surety bonds over time horizons where there exists considerable uncertainty. Mining projects require clearly defined time frames and levels of responsibility.

The refundability of the bonds is an effective means to encourage socially efficient environmental outcomes only if it reflects the social cost of misbehaviour (Gerard, 2000). Risk-pooling policies such as insurance have emerged as a potential complement to surety bonding as part of a broad environmental policy (Poulin and Jacques, 2007). Similarly, a policy mix of an environmental bond and a modified Pigouvian tax has been advocated to help achieve both risk-sharing and efficiency objectives (Farzin, 1993; White et al., 2012).

Concerns regarding the imposition of liquidity constraints on mine operators also give rise to the possibility of utilising insurance as either a complement or substitute to surety bonds (Shogren et al., 1993; White et al., 2012). Some researchers suggest that the availability of insurance products would relieve the liquidity constraint connected to bond rules (Shogren et al., 1993). In the absence of private options for insurance[26], a jurisdiction-sponsored institution providing insurance products might be considered an alternative FA mechanism for addressing the liquidity concerns implicit to an environmental surety bonding scheme.

A further constraint of environmental bonds is that they often reflect minimum R&C costs (Peck and Sinding, 2009). Under circumstances of imperfect monitoring, the practical value of a surety bond should be set to reflect both the value of evasion and the possibility of detection (Shogren et al., 1993). In other words, this model of environmental policy holds that, when set at an adequate level, such financial assurance bonds can escalate the costs of dodging to a level that brings into line company behaviour with social preferences for environmental quality (Shogren et al., 1993). When these bonds are set too low relative to the gains from avoidance on environmental responsibilities, the costs of doing so would not be adequate to penalise poor performance in reducing environmental reparations. Parties liable for environmental damages would then be able to shift the related risks to the rest of society at a low cost (Costanza and Perrings, 1990).

In conjunction, uncertainty restricts the ability of decision-makers to request the appropriate surety bond level from relevant parties where the range and probability of the future effects of present actions are unknown. It is not possible to calculate an expected value for the outcome of those actions (Costanza and Perrings, 1990). Coming up with a fair estimate of reclamation liability ex-ante is problematic, particularly with the continuing possibility of catastrophic environmental events.

[26] Likely due to information asymmetries and self-selection bias (Akerlof, 1970).

Another shortcoming of common financial assurance mechanisms in some jurisdictions, where regular updates of FA are mandatory, is that they do not sufficiently deal with time value of money (TVM). The average life of a typical mining project is often well in the decades, and the importance of having a nominal EFA returned at the end of the mine production period is insignificant from a mine operator's standpoint (Igarashi et al., 2014). The concern boils down to one of investing the financial assurance obligations in an interest-bearing security or bank account, so that accrued interest is accessible to cover the increasing costs of reclamation efforts over time (Otto, 2009; OECA, 2015).

TVM should not be confused with inflation (Rudawsky, 1986). Under inflationary conditions, the value of future income will be less than that of the same revenue at present, due to a general rise in the price level. Nevertheless, the inflationary effect does increase and magnify the time value of money. Changes in price levels do not create the TVM; they only influence its magnitude for any given time frame.

A more economically rational system would require an FA mechanism, at the start of mine development, such as the interest-bearing securitised one that is proposed in the dissertation. The proposed system would offer some appealing options for increasing the incentive of mine operators to perform the R&C obligations. One possibility is to share the accrued interest on the mechanism between the host jurisdiction and the mining company.

The influence of private interest in environmental law has been addressed, specifically in the literature concerning the issue of instrument choice. The selection of FA instruments that can be utilised to control environmental pollution was specified, indicating that the research suggests under what kind of circumstances a particular type of policy instrument would be optimal. In practice, these '*economic prescriptions*' are not always followed. The effect of lobbying on instrument selection has also been analysed in many papers (Hahn and Noll, 1983; Hahn, 1989a; Hahn, 1989b). Hahn points out that policy instruments are seldom used in the way that is suggested by economic theory.

Bearing in mind the advantages and disadvantages of the various approved FA instruments, it can be concluded that there is no single instrument that can be used for all circumstances. The proposed financial assurance-based securitisation mechanism would be just another tool that government regulators worldwide would possess at their disposal. More importantly, it may be more efficient to use a hybrid system that combines more than one instrument. In such instances, Oates and Baumol (1996) concluded that the protection of the environment could be best pursued by using a combination of various regulatory instruments, namely the grouping of CAC and EIM measures.

2.1.2 Setting the Surety Bond Amount

Setting the amount of the surety bond is a central dimension of bonding requirements. Due to the costs involved on the side of the mine operator and the probable public liabilities, it is often a contentious issue. Gerard (2000) proposes a simple model to demonstrate that companies with deep pockets can be expected to abide by regulatory requirements even if the financial sum of the bond posted is less than the expected compliance costs. In many instances, regulators and corporate entities cooperate on several projects, and the frequent interactions and reputation effects, especially in today's world of increasing active mobile social users, act as a check on opportunistic behaviour. Furthermore, since companies are responsible for reparations or risk reduction, then defaulting on a surety bond will only result in ensuing litigation. A consequence of these liability rules and reputation effects is that the mine operator's financial position should be a factor in determining if a bond is appropriate. Another result is that rather than setting surety bond amounts at the worst-case scenario, compliance can be encouraged even if bond requirements are lower than expected R&C costs.

2.2 Role of Securitisation in Modern Economy

> *It is widely agreed that when used appropriately, securitisation can increase the availability of credit and reduce the cost of funding. As a funding tool, it can contribute to a well-diversified funding base. As a risk transfer tool, it can also act to improve capital efficiency and allocate risk to match demand.*
>
> — European Securities and Markets Authority, June 2016

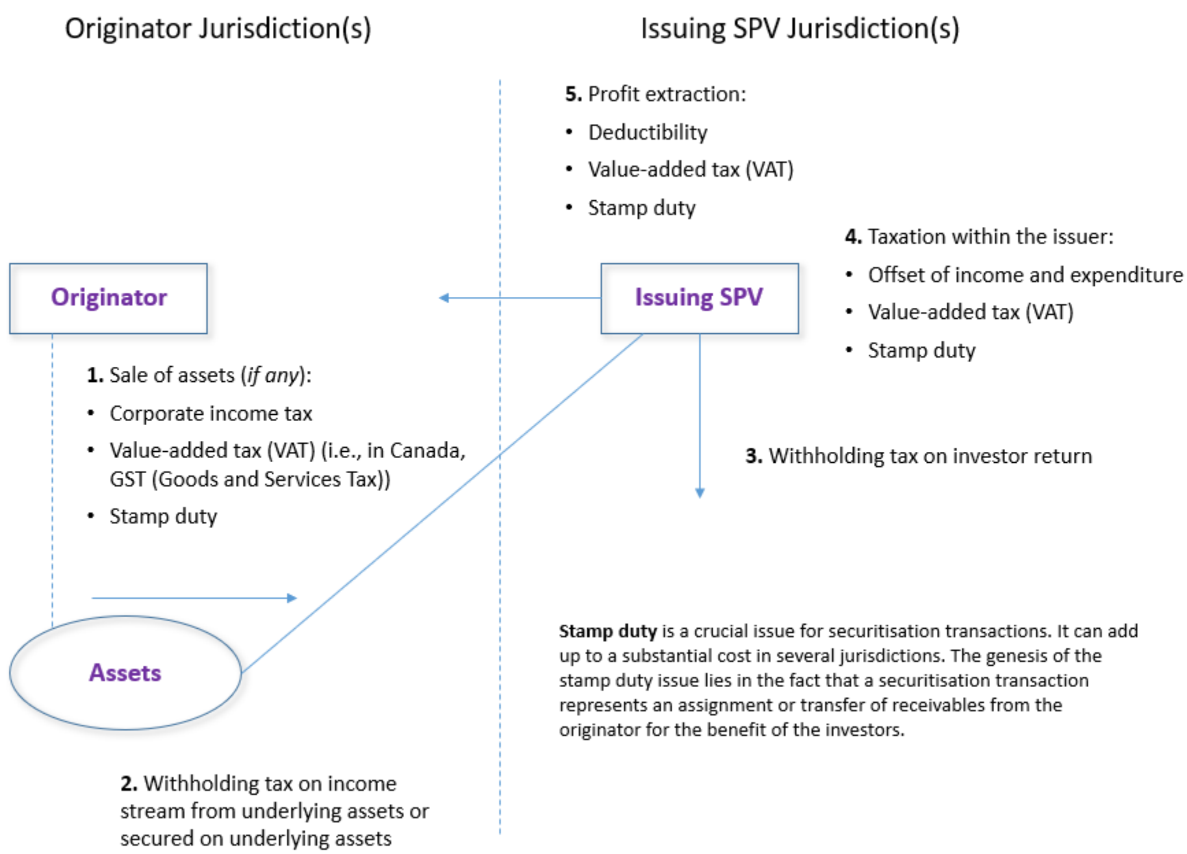
Securitisation usually only thrives in economies with developed capital markets. Constraints on lack of information about the borrowers, transferability, and freedom of the parties to design both the terms and form of transfer of the loans are not conducive to creating markets in loans and ABS instruments (Hu, 2011; Buchanan, 2017).

Securitisation arose due to the inefficiencies of the bank-dominated money markets (Hu, 2011; Buchanan, 2017; Deku and Kara, 2017). Benefits from securitisation include protection from interest rate risk and sometimes repayment risk, increased liquidity, and a more efficient flow of capital from investors to borrowers. It may allow institutions to attract long-term funds more economically than would be possible with more conventional financing tools. Additionally, securitisation can offer the originator with a new source of fee income from originating and servicing the securitised assets (Hu, 2011). Furthermore, most banks (i.e., originator) pay corporate income taxes, but securitisation vehicles (i.e., SPVs) do not – a further source of revenue.

Tax issues, however, would arise for such securitisation transactions, these include: i) whether the transfer of assets from the originator to the SPV will be treated as a sale or a loan; (ii) the degree to which the SPV itself would be taxed; and (iii) the degree to which the investors who purchase the financial assurance securities will be taxed. The tax consequences of the transaction would be especially important for the originator. By understanding the tax treatment of the transaction, all parties involved would be able to make informed choices as to whether structuring such a securitisation deal would be worth the time, effort, and expense.

In general terms, the tax issues on securitisation can be broken down into five main categories, which in turn can be separated into those issues in the originator jurisdiction(s) and those in the issuing SPV jurisdiction(s). This is illustrated in Figure 2.1, showing a traditional (though simplified) securitisation structure.

Figure 2.1: Categorisation of Tax Issues Affecting Securitisation



The tax analysis in the originator will commonly seek to ensure that tax neutrality (*at worst*) is obtained as a result of the securitisation transaction. To summarise the main elements observed in Figure 2.1:

1. **Sale of Assets:** In many securitisation structures, the originator sells the assets to an SPV, at an arm's length, potentially giving rise to corporate income tax, VAT, and transfer tax implications. These are largely issues in the home jurisdiction of the

originator and, certainly in respect of commonly securitised assets, should be broadly well-known and manageable. Often (*though not always*) they are issues for the originator which do not affect the rating process.

2. **Withholding Tax on Income Stream:** In many jurisdictions withholding tax may potentially arise on the income produced by the underlying assets (or secured on the underlying assets where the funds reach the originator in secured loan form in structures, such as whole business securitisations for example where there is no actual sale of underlying assets). This depends on several factors including the nature of the income, and the status of the originator, the SPV, and the source of the underlying income (e.g., mortgage borrowers in the case of a mortgage securitisation). This (potential) withholding tax cost is a key determinant of the securitisation structure as a whole and to the type of assets commonly securitised.

   Where withholding tax is not imposed by a particular jurisdiction, or at least not in respect of the relevant asset class, the location of the securitisation SPV, including whether to locate onshore or offshore, is left to be determined by other factors.

   Issuing SPV Jurisdiction**:** In the issuing SPV, the main focus is on the reliability of cash flows, including taxation (or, typically, its virtual absence), so as to maintain the integrity and the rating of the SPV. These factors are, of course, driving factors behind the ability to raise cheaper finance than would otherwise be available.

3. **Withholding Tax on Investor Return:** Commercially, interest paid on the notes issued by the SPV must not carry withholding tax. This is generally achieved fairly readily but depends on the tax jurisdiction of the SPV, the nature of the bonds issued, double tax treaties, and specific withholding tax exemptions.

4. **Taxation Within the Issuer:** The securitisation SPV will typically be a corporate entity in its own right (and therefore, in many jurisdictions without a special securitisation regime, a corporate taxpayer). Given the need for a high degree of certainty regarding the tax liability of the special purpose vehicle, the offset of income and

expenditure should be clear and predictable. Canada, for example, has complex offset rules and, where such difficulties are encountered, one option for Canadian originators would be to locate the securitisation SPV in a jurisdiction with more straightforward offset rules or indeed in a tax favoured jurisdiction. This has often not been possible, mainly for withholding tax reasons.

5. **Profit Extraction:** Regardless of the ability, or otherwise, to effectively offset expenditure against income in the SPV, the structure should allow the originator to extract profit from the special purpose vehicle in a tax-efficient way. There are various means of doing this with perhaps the most common being the payment of deferred consideration by the SPV to the originator in respect of the original acquisition of the securitised assets.

One key purpose of the EFA-securitised mechanism is to offer additional sources of funds for financial assurance financing while encouraging *lower* interest rates and longer-term EFA financing. Under such a structure, as the financial assurance holders make their periodic payments, these funds are channelled to the investors. The mine operators are generally unaffected by, and may even be unaware of, the securitised transaction.

Environmental protection regulation, in combination with effective supervision and enforcement stemming from the efforts of the regulators and features of the proposed securitised mechanism, is expected to reinforce or enhance trust in the financial assurance system within which the relationship between the regulator and mine operator arises, by enhancing trust in the regulatory context. In this regard, such trust is complementary to the confidence of environmental law and regulation.

Securitisation may also increase the liquidity of a portfolio by making it possible to package and sell these otherwise sometimes low-liquid pooled assets in an established secondary market (Davidson et al., 2003). Greater diversification may be attained since an investment institution can hold the same dollar value of a particular type of investment.

Protection from interest rate risk exposure is also beneficial to long-term institutional investors, such as mutual funds, pension funds, and insurers (Hu, 2011). Securitisation offers a more efficient flow of funds from investors to companies that require financial resources for the development of their new and existing projects or services. Many institutional investors prefer to invest in long-term instruments, such as 10- to 100-year high-quality market (HQM) corporate bonds, since they characteristically generate a consistent and healthy income stream (Girola, 2007; USDT, 2007; Girola, 2011; Federal Reserve Bank of St. Louis, 2017).

Securitisation links the long-term funds of corporate entities with relatively long-existing assets, thus permitting more capital to flow into the markets. Sherris and Wills (2008) discussed that longevity risk is one of the remaining frontiers challenging modern financial markets. The authors considered how financial markets and financial product innovations can be efficiently and effectively utilised to mitigate the risk and to reflect on lessons from the insurance-linked securities market that could be used to fund such a risk in the financial markets successfully.

Securitisation may offer a comparatively inexpensive funding source when a company's overall credit rating is lower than the one on its receivables (Hu, 2011). For instance, a publicly-traded mining company with experienced leadership guidance seeking investment to conduct exploration work in an area with proven results may be rated BB by Standard and Poor's. The bonds issued by the company are backed by a well-structured portfolio which could possess a stand-alone credit rating of A1 (one of the top scores that a CRA can assign to an issuer or insurer). The mine operator would subsequently reduce its borrowing cost rate considerably by securitising its assets (Baig and Choudhry, 2013).

Securitisation can, therefore, be characterised as a form of financial innovation that better (efficiently and effectively) utilises the markets, especially in an unstable economic environment (Sassoon, 2009).

2.3 Local Contemporary Issues

> *The notion that reclamation sureties are not adequately assessed in BC and companies don't have to put up full reclamation sureties upfront, as they have to do in Alaska and many other countries in the world, means BC can't continue saying it is world-class in terms of their mining sector.*
>
> — Heather Hardcastle
> Director, Salmon Beyond Borders

Over the past few decades, increasing recognition has been observed that mining activity can bring adverse environmental, community, and social impacts. Such opinions have emerged in research studies, industry and stakeholder accounts, and government reports, each of which point with wavering force to the toxic legacy of mine sites (OAGBC, 2002; Keeling and Sandlos, 2009; Keeling, 2010; OAGBC, 2016; Keeling and Sandlos, 2017). In BC, Canada, the Office of the Auditor General of British Columbia (OAGBC) raised the issue of mine reclamation in a 2002 report relating to the management of contamination on provincial lands.

The 2002 report pointed to contaminants remaining on former mining sites on private and public areas in the province. It argued that the extent to which these substances are found in soil and water sometimes threatens both environmental sustainability and human health. OAGBC (2002) suggested that the province identify a leading ministry to oversee a government framework for managing contaminated sites; develop a process of collecting information enough to decide where scarce resources should be allocated for R&C obligations; and establish a management accountability framework to measure progress in managing contaminated mine sites (Stewart and Johnstone, 2007).

The province, in response, established the Crown Contaminated Sites Programme (CCSP), a system of managing tracts of land needing environmental reclamation (Stewart and Johnstone, 2007). As per the recommendation of the Auditor General, the CCSP is now overseen by the Ministry of Forests, Lands, and Natural Resource Operations, which manages the reclamation of contaminated provincial lands for which government is liable (CCSP, 2016). Where poor mine site reclamation is deemed to pose substantial risks to either human health or environmental sustainability, mineral claims may return to the government before the discharge of the conditions of a mining permit (CCSP, 2016). These are the mine sites managed under the CCSP. Contaminated sites include abandoned and orphaned mines but may also consist of ones contaminated by other causes (CCSP, 2016). However, the Office of the Comptroller General Public Accounts 2016/17 report points out that mining sites encompass the majority (about 75 percent) of contaminated sites in the programme (OCG, 2017). In 2015, the CCSP drew CAD$192 million from consolidated revenue to remediate lands and carried CAD$508 million in liability for contaminated sites (CCSP, 2016).

Despite this policy framework, inadequate reclamation efforts of mine sites have remained a concern and have resurfaced as a topical issue in the province triggered by single events[27]. It has also invigorated apprehensions over the severity of the environmental risks associated with mining. Such catastrophic events have spurred widespread discussion concerning the long-term environmental management practices at mine sites, including an independent review which concluded that similar circumstances, as the Mount Polley mine disaster, should be expected to recur every five years in the province (IEEIRP, 2015). The BC First Nations Energy and Mining Council concluded that 35 First Nations communities stand to be affected by similar tailings breaches in northern BC alone (FNEMC, 2015). According to

[27] Such as the 2014 Mount Polley mine spill, which is considered one of the biggest environmental disasters in Canadian history and one of the largest dam failures in the world in the past fifty years (Hoekstra, 2018).

some observers, this event prompted a more cautious approach to the permitting process on the part of the mines branch at the province's Ministry of Energy and Mines (MEM).

On May 3, 2016, the Auditor General of British Columbia, Carol Bellringer, issued her audit (Fry, 2016; OAGBC, 2016). It looked at whether the MEM and the Ministry of Environment's compliance and enforcement activities of the mining sector are shielding the province from significant environmental risks. In her report – *An Audit of Compliance and Enforcement of the Mining Sector* – she stated (Fry, 2016; OAGBC, 2016):

> *Almost all our expectations for a robust compliance and enforcement programme were not met. ... The compliance and enforcement activities of both the Ministry of Energy and Mines and the Ministry of Environment are not set up to protect the province from environmental risks.*

Significant gaps in resources, planning, and tools in both ministries are observed in the findings. For instance, the departments possess inadequate staff levels to handle a growing number of permits, and staff work with incomplete and cumbersome data systems. Consequently, monitoring and inspections of mines were unsatisfactory to make certain mine operators observed the requirements. Furthermore, some companies have yet to provide the government with adequate FA deposits to handle possible R&C costs if a mine operator fails to cover its financial guarantee obligations (OAGBC, 2016). The province is underfunded by over CAD$1.2 billion, a liability that could potentially fall to BC taxpayers[28].

Much of the FA securities held by the regulator are illiquid, and if companies seek restructuring under the Companies' Creditor's Arrangement Act, RSC 1985, the held assets may not be accessible for mine site reclamation (Allan, 2016). Reviews of current policy conclude with several recommendations for reform. These include the creation of a pooled reserve fund; an extension of EFA for the risks of unexpected events; a general escalation in the FA requirements demanded of mine proponents; the creation of an independent

[28] Underfunding for the clean-up of mines rose to CAD$1.273 billion in 2015, increasing the level of financial risk to taxpayers above what it was the previous year (Hoekstra, 2017).

compliance and enforcement branch at the MEM; and increased organisational transparency concerning the mine permitting process (Allan, 2016; OAGBC, 2016).

Besides the poor reclamation record, the lack of practical reclamation standards of the mining industry has become increasingly problematic (OAGBC, 2016). The Health, Safety and Reclamation Code for Mines in British Columbia (BC Ministry of Energy and Mines, 2017) establishes permitting, reclamation and closure standards for surface mine operators to reclaim and restore the land, but it has been criticised as being vague and inadequate (OAGBC, 2016). Vagueness and inadequacy as they pertain to:

- particular code definitions;
- the uncertainty of R&C costs;
- incomplete definitions of outcomes;
- unforeseen challenges that crop up in the mining project plans; and
- lack of agreement surrounding the completion of reclamation activities given that uncertainty defines every mining project since no two projects are identical.

Conflicting, incomplete, and vague environmental regulation can lead to unnecessary higher R&C costs and contradictory interpretation of financial reclamation requirements. Such ineffectiveness and inadequateness can also leave little room to determine optimal levels of financial reclamation for each mine site (Berger et al., 2011). Moreover, if mine operators wish to minimise the possible shock stemming from inadequate allocated funds, these companies should do more to mitigate such vagueness. They are likely to undertake only the level of reclamation that is required by law, even when greater reclamation efforts would produce more net benefits to society (Berger et al., 2011).

Given the scope of mining in BC, Bellringer’s report highlighted the seriousness of more regulatory enforcement. The environmental risks of extraction are growing in the province, but compliance and enforcement are declining (Fry, 2016). The risks are material as evidenced by the Mount Polley mine disaster, which occurred during the 2016 audit. "*To avoid such failures, business, as usual, cannot continue*," says Bellringer (Fry, 2016).

Since the Auditor General's 2016 report being released, BC has tried to increase the amount of financial assurance it holds, says an Ecofiscal study (Ecofiscal Commission, 2018). "*However, the province still holds only CAD$1 billion in financial assurance against a CAD$2.1 billion clean-up liability*," it says.

"*Financial assurance in British Columbia is stronger in theory than in practice*," says the Ecofiscal report, which observed that the broad authority given to the Chief Inspector of Mines to set the amount of FA that companies must post before digging, is used more to boost economic activity than to deal with compensation or to discourage corporate entities from selecting environmentally-risky choices. "*In practice, the government has not required stringent assurance. As a result, the province does not hold sufficient financial assurance to cover its potential reclamation liabilities*," it says (Lavoie, 2018).

The province of Québec stands out as possessing the most stringent EFA requirements in Canada and, according to a recent Fraser Institute annual survey of mine operators, is also one of the top jurisdictions in the country and globally for mining as it has simultaneously modified rules and regulations to encourage investment (Stedman and Green, 2018).

Lead researcher, Jason Dion, stated every jurisdiction has its pros and cons, but BC's FA choices are inconsistent with the PPP (Ecofiscal Commission, 2018). Dion said it is a choice the province has made since the initial stages of mine construction are very capital intensive, implying projects may be less viable if BC demanded '*hard*' financial assurance in full and up-front. Such methods of bonding are costly ex-ante for the mine operators.

In September 2010 an environmental think-tank stated that Albertans could be on the hook for billions of dollars to pay for oil sands clean-up, signalling the obligation works out to as much as CAD$6,300 per person. In their report (Landry, 2010), the Pembina Institute pointed out that inadequate information exists about the exact cost of land reclamation. It warned that a fund set aside to cover for clean-up and reclamation supposedly might be significantly underfunded. It also states (Lemphers et al., 2010):

> *Alberta requires all oil sands mine operators to post a security deposit to fund reclamation in the event an operator is unable or unwilling to pay for reclamation, ... However, because of the lack of transparency about the true costs of reclamation, the public doesn't know if the current security deposits are adequate.*

The Pembina Institute report further remarks that the Alberta government has placed around CAD$820 million aside in its Environmental Protection fund for nearly 69,000 hectares of disturbed land, a dollar amount that appears low (Lemphers et al., 2010).

On July 6, 2015, Alberta's Auditor General, Merwan Saher, stated Alberta might not be demanding oil sands companies to provide sufficient funds to guarantee their massive mines are cleaned up at the end of their life (Weber, 2016). "*If there isn't an adequate programme in place to ensure that financial security is provided by mine operators* ... *mine sites may either not be reclaimed as intended*, *or Albertans could be forced to pay the reclamation costs*," states a report by Saher (Weber, 2016).

Alberta Environment Minister, Shannon Phillips, in response, said the government agreed with Saher's concerns and accepted his recommendations. The Mine Financial Security Programme was instituted in 2011 and as of 2016 holds security deposits from eight oil sands mines and nineteen coal mines (Weber, 2016). The fund holds CAD$1.6 billion to cover about CAD$21 billion in future liabilities (Weber, 2016).

In the last 50 years, Alberta's oil sands companies have only received reclamation certificates for about 0.1 percent of the total land disturbed (Lothian, 2017). Industry reports it has put reclamation efforts into about seven percent of land affected by tailings — but it has not yet received final regulatory certification to confirm that.

A recent report by the Alberta Liabilities Disclosure Project (ALDP), a coalition of Alberta landowners, researchers and former regulators, suggests the financial liabilities surrounding cleaning up all of the old and unproductive oil & gas wells in Alberta is several times more than the Alberta Energy Regulator which had estimated clean-up at around CAD$18.5 billion (Montgomery, 2019). The ALDP cost estimate for remediation is as much as CAD$70 billion to clean up more than 300,000 orphan oil & gas wells in Alberta (Bakx, 2019; Graveland, 2019; Jones, 2019). The number of wells in the province scheduled to be remediated is approximately 3,000. There are, however, more than 100,000 unproductive oil wells that will need to be cleaned up. Alberta's oil & gas liabilities have been mounting for decades, with reported estimates ranging from CAD$58 to CAD$260 billion (ALDP, 2019). Only CAD$1.5 billion is held in securities to shield Albertan taxpayers from the likelihood of being left to pay the financial expenditures (ALDP, 2019). "*Fiscally and environmentally, this is a ticking time bomb*," stated lead researcher Regan Boychuk (Graveland, 2019). Could mining be headed for the same problem?

Alberta's Auditor-General recently launched an investigation into the growing problem of orphan wells as the province struggles with underfunded environmental liabilities in the oil & gas industry that have climbed into the tens of billions of dollars (Jones, 2020). The Alberta energy regulator will soon unveil sweeping changes to how it regulates its old oil & gas infrastructure, including a complete overhaul of an environmental liability rating scheme it now considers a '*flawed system*' (Morgan, 2020). The liability management ratios are a faulty measure because they allowed companies in good financial health to avoid posting security bonds and other security for environmental remediation. However, when their finances begin to deteriorate, they are asked to post surety bonds and security — precisely at a time when they have a difficult time finding the needed funds to do so.

When deliberating on financial assurance issues, one should not only look at traditional assurance offerings but also at other forms of financial security. One of the intentions of the dissertation is to provide further analysis of different financial arrangements that could become a conceivable substitute or complement to alternative forms of regulatory approved '*hard*' financial assurance securities. Consideration should be given to innovative types of financial security, provided they meet specific criteria that protect a host government's interests and objectives.

2.4 Along Comes Financial Engineering

> *You have reclamation obligations growing for an industry and companies that are actually contracting.*
>
> — Anna Zubets-Anderson
> Vice President – Senior Analyst, Moody's Investors Service

> *Securitisation is no more evil than a shovel but if you hit someone in the head with a shovel, they still die.*
>
> — Sean Sheerin
> Senior Quantitative Policy Analyst, Federal Reserve Bank of New York

An alternative FA-backed mechanism that is expected to satisfy the requirements of R&C is presented. Specifically, the dissertation examines the potential application of a securitised mechanism that is flexible and robust enough to possibly address short-, mid-, and long-term financial and regulatory requirements surrounding mine reclamation.

Despite the promise of mainstream financial assurance mechanisms for environmental issues (Costanza and Perrings, 1990), such instruments entail trade-offs that limit their scope and effectiveness (Shogren et al., 1993; Cornwell and Costanza, 1994; Weersink and Livernois, 1996; Mooney and Gerard, 2003). The application of FA instruments such as surety bonding to environmental projects has been narrow, and the success mixed (Boyd, 2002). Consequently, examining the potential effectiveness of an alternative EFA mechanism within the framework of regulating mining projects is of direct interest to public regulatory policy in mining and other extractive resource industries as well[29].

Securitisation arises when a financial institution (e.g., bank) transforms its illiquid assets (e.g., mortgage assets on its books), traditionally held until maturity, into marketable securities (Baig and Choudhry, 2013). In a typical securitisation transaction, the originating bank assigns a pool of financial assets with fixed or practically fixed cash flows to a special purpose vehicle (SPV), a bankruptcy-remote entity that in turn finances the purchase through the issuance of securities backed by the pool. The transfer of assets must meet the requirements of a true sale, where the transferor (e.g., the originating bank) relinquishes control over the financial assets and can consequently eliminate the assets from its balance sheet. The implication is that the money raised in the securitisation transaction does not need an offsetting liability to be presented on the originator's balance sheet — the cash merely depicting the proceeds of the sale of the pool of financial assets to the SPV. Securitisation thus provides an originator with a diversified means of funding, usually at a lower borrowing cost[30].

To reduce credit risk for investors, thus increasing the credit rating of the ABSs, and to mitigate adverse selection complications arising from issuers having more information regarding the credit quality of the underlying pooled assets than do the investors, the SPV obtains credit enhancements (CEs) (Baig and Choudhry, 2013). They usually come from the originating financial institution (e.g., bank) and can comprise of both contractual and non-contractual arrangements. Examples of explicit recourses, or contractual agreements, include retaining interests in the transferred assets such as subordinated securities and

[29] Although the dissertation mainly focuses on the mining industry, such an EFA-backed securitised mechanism possesses promising implications in other sectors such as oil & gas, chemicals, nuclear, infrastructure, and livestock farming.

[30] Securitisation enables an originator to raise funds at a lower cost than if it, with its associated risks, had borrowed the funds. The originator accomplishes this cost-saving for two reasons. The first reason is that by not having to borrow from a bank intermediary (or other financial institution) of funds, it avoids the bank's profit mark-up. It also accomplishes a cost-saving since the interest rate payable on the securities issued by an SPV is generally lower than the interest rate that would have to be paid on corporate securities issued directly by an originator. The interest rate savings reflects the creditworthiness of financial assets sold to SPVs in securitisation transactions which should be easier to understand and value, if not safer, than the actual creditworthiness of originators with all their related business and other risks.

credit-enhancing interest-only strips and furnishing standby letters of credits to the securitisation structures. Implicit recourses, or the non-contractual arrangement, include (Kothari, 2006; Hu, 2011; Buchanan, 2017): (i) selling assets to the SPV at a mark-down from the price detailed in the securitisation documentation; (ii) purchasing assets from the SPV at an amount more significant than fair value; (iii) swapping performing assets for non-performing ones in the SPV; and (iv) funding CEs beyond contractual requirements. The provision of implicit recourse breaches the true sale condition, but it allows issuers to preserve their reputations for consistent credit quality over recurrent sales.

The literature explains that securitisation offers a means of diminishing bank risk (Greenbaum and Thakor, 1987; Pavel and Phillis, 1987; Hess and Smith, 1988). Such financing innovation has been both acclaimed as the engine of the advancement of society and criticised for being the cause of the weakness of the economy (Segoviano et al., 2013). Only the inventiveness and credit requirements of the parties to any securitisation place limits on what can be securitised. An example is the efforts of MIT Sloan School researchers and the Dana-Farber Cancer Institute.

In examining the problem of medical research risk, such studies (e.g., investigations to search for cancer treatments) are unusual investments in that they are usually costly, often costing several hundreds of millions of dollars, and many of these projects end up not being profitable at all. Those that do make money may earn a great deal of it, but the financial returns would be realised only many years later, typically ten years or more. Fernández et al. (2012) and Fagnan et al. (2013) outlined financial engineering techniques to facilitate such medical research. They suggested a large fund with the proficiency to appraise projects and select a large, diversified group of projects over a long period. The large size of the proposed fund and diversification could be keys to success. An assorted group of research ideas (portfolio) is essential since a group of projects with comparable methods may all fail or succeed, making the portfolio very risky. The issue lies finding suitable project methods that are unrelated enough to create uncorrelated outcomes.

Fagnan et al. (2013) and Fagnan et al. (2014) contended that such a cancer megafund would differ from a standard venture capital fund in both funding methods and size since a significant fraction of the funding would need to come from the long-term bond market. Financial instruments, such as bond insurance (credit default swaps (CDSs)) and tranching (securitisation), could structure the risk to different types of investors, and thus attracting a more extensive range of investors.

Their study showed how securitised consumer healthcare expenses loans could spread the cost of medical therapies over several years, offering more patients access to costly medical treatments while generating positive returns to investors (Dana-Farber Cancer Institute, 2016; Montazerhodjat et al., 2016). If financial engineering can distribute the monetary risk of medical research, then it can play a part in curing cancer. A similar argument can be made for the proposed EFABSs.

Securitisation has become an essential method for financial institutions[31], corporate entities, and governments to pool assets and sell them to investors (Watson and Carter, 2006; Slaughter and May, 2010). The history of securitisation has revealed that this form of financing has expanded to new categories of assets, not only home mortgage financings from where it originated in the 1970s in the United States (Stone and Zissu, 2012; Deku and Kara, 2017). With new types of assets successfully securitised during past decades, the question arises whether such a form of financing can be utilised for any or all assets that are capable of accumulating revenues over time.

Securitisation issuance in the United States alone, including agency and non-agency MBSs and ABSs, totalled $2.2 trillion in 2016 (SIFMA, 2017a). It amounted to $1.2 trillion in the first half of 2017 (SIFMA, 2017b). Morgan Stanley Investment Management estimates that the global securitised market is nearly $9.8 trillion in size, with the US securitised market

[31] Including the IFC, a member of the World Bank Group.

representing 86 percent (Morgan Stanley, 2018). Putting it into perspective, Canada's GDP in 2018 was $1.65 trillion; leaving Canada placed 10th in the ranking of GDP of the 50 countries observed by the International Monetary Fund (IMF) (IMF, 2018). Moreover, the notional amount of outstanding over the counter (OTC) derivatives contracts was $542 trillion at end-June 2017 (BIS, 2017) while the notional principal of exchange-traded futures and options amounted to $33.7 billion at end-December 2017 (BIS, 2018).

Further statistics show that securitisation provided $13.1 trillion in financing and funded more than fifty percent of US household debt in 2019 (SFA, 2020). Through securitisation and structured finance, more families, individuals, and businesses have access to essential credit, seamlessly and at a lower price.

Slaughter and May (2010) and the Economist (2014) comment that securitisation continues to demonstrate its usefulness to the world of business, as also observed by student loan asset-backed securities (SLABS). SLABS are securities consisting of numerous student loans pooled together. They deliver scheduled coupon payments much like an ordinary bond. The selling of student loan asset-backed securities allows lenders to move their credit risk to several investors. In theory, this permits for a more efficient loan market and creates better means for students to finance their education.

Student loan finance and the assessment of related risk evolved dramatically since the 1980s (Maurice and Goyal, 2012). Historically, student loan financing relied in no small extent on tax-exempt public financing sources (Maurice and Goyal, 2012). Today, tax-exempt issuers are equally likely to access taxable markets as they are tax-exempt funding sources as the demand for financing has increased over time, and tax-exempt cap allocation (the amount of volume capital that was approved) has not risen to meet the needs for all issuers. Often the same issuer will tap both markets in the same transaction. Whether taxable or tax-exempt, the risk profile is essentially the same for the Family Federal Education Loan Programme backed student loan financings (Maurice and Goyal, 2012).

Issuers consistently employ the same securitisation financing techniques, or repackaging of student loans, as a dominant financing vehicle.

In April 2018, Social Finance, Inc. (SoFi), a fintech company, from San Francisco, California (Ryabkova, 2017), announced that it had just completed $2.6 billion in loan securitisations in the first quarter of 2018, a 35 percent increase over the previous-year period and its largest-ever quarterly ABS issuance volume (SoFi, 2018). Ashish Jain, SVP of Capital Markets at SoFi, noted, "*Volatility returned to the credit markets this quarter, but investors continued to show a strong appetite for our securitisations, which allowed us to compete for several large transactions. We are especially pleased that our investor base has continued to expand as more institutions recognise the strength of SoFi as a top ABS issuer of prime consumer credit*." With this positive quarterly performance, SoFi remains a top-ten ABS sponsor, ranking seventh among all sponsors as of March 31, 2018, behind Sprint, General Motors, Ford, Santander, Ally Financial, and Citibank, and first among all online lenders (SoFi, 2018). SoFi plans to capitalise on its niche of loaning to '*not rich yet*' borrowers with student debt (Wiltermuth, 2017).

These examples provide a strong incentive to pursue the underlying research surrounding financial assurance-backed securitisation given the similarities of both mechanism forms, and that of others stemming from other unmarketable and intangible assets. Specifically, these financing innovations are a catalyst for the research focus of the dissertation on FA-backed securitisation. The development of such a securitised mechanism can be considered a viable and perhaps significant disruptive financial innovation akin to what blockchain[32] or smart contracts may become unless suppressed by ill-considered regulatory or legislative actions (Vora, 2015). Financial innovations regularly respond to regulation by circumventing regulatory restrictions that would otherwise limit activities in which the public wishes to

[32] Applying blockchain, a form of distributed ledger technology, in securitisation, offers opportunities for reinvention. The substantial space in the financial industry is at an early stage in the advancement of blockchain for structured finance, but blockchain, together with smart contracts, promises to transform many activities in the securitisation lifecycle (Cohen et al., 2017; Deloitte, 2017).

engage (Calomiris, 2009). As such, financial innovation disseminates into forward-thinking financial capital markets around the world – its adoption is expected to grow.

The understanding of the dynamics that fuelled the last wave of financial innovation is premised on the development of the financial sector. Financial innovation became the primary tool for banks and corporations to fund their operations and to be competitive on a worldwide scale. In recent times, these theorems have found fertile soil in the unrestricted utilisation of new structured finance schemes, and in the general euphoria that permeated financial markets, characterised by excessive liquidity, low-interest rates, and a willingness to innovate to satisfy high demands.

2.4.1 Innovation through Securitisation

Amore et al. (2013), Beck et al. (2016), and Lauretta (2018) demonstrated that there exists a strong relationship between finance and technological innovation.

Research studies on the US subprime mortgage crisis of 2007, such as those of Mian and Sufi (2009), Keys et al. (2010), and Dell'Ariccia et al. (2012), suggest the cause was the association between the lax lending standards and the securitisation process of the time. Financial engineering and its toolkit of derivatives received a bad reputation during the financial crisis. Along with financial products such as MBSs and collateralised debt obligations (CDOs), derivatives allowed savers—including individuals and pension funds—to purchase payments on mortgage securities from investment banks that acquired the rights to those loan payments from mortgage lenders. Many analysts faulted the housing bubble and/or the severity of the subsequent crisis on lax regulation and the misuse of these financial instruments, rightly or wrongly. Both fans and foes of financial engineering must acknowledge that this discipline, like other financial tools, multiplies one's power to do harm or good. It, however, solves economic issues with mathematical techniques, which commonly involves trading and distributing risk.

Mallick and Sousa (2013) expressed how fluctuations in financial distress conditions can describe output fluctuations. Other researchers have highlighted the presence of the finance-growth nexus (Greenwood et al., 2010; Creel et al., 2015) and revealed that financial innovation coupled with deregulation had fostered a rapid development of the financial system but consequently amplified economic instability and complexity (Dosi et al., 2013; Grydaki and Bezemer, 2013; Brunnermeier and Sannikov, 2014).

There are few academic studies expressly focused on the concept of financial innovation; the studies from Levine (2005), Klein and Olivei (2008), and Lerner and Tufano (2011) outline and model financial innovation using an approach that correspondences with the concept of innovation applied in the industrial sector. From the studies, it is evident that researchers focused their attention primarily on a more general and vaguer concept of financial innovation, examining its influence on financial depth and its ensuing effects on economic growth. Thus, further study is required since the role of financial innovation remains unclear and not adequately modelled.

2.4.2 Fuzzy Logic and Alternative Methods

Since EFABSs would be considered customised financial assurance solutions and their numbers are expected to be small, and costly, to support statistical evidence and inference, a traditional empirical analysis could not be implemented. Therefore, a conceptual framework was developed and tested on the latest available reclamation liability cost estimates data (see Appendix A) to the BC government (MEM, 2016). Two cases of securitisation transactions based on this data were referred.

The theoretical framework consists of a set of independent crisp inputs that are converted to linguistic variables which are assumed to explain the potential outcomes that a FABS may experience. The identification of possible key attributes of failure and success of an EFABS, and their level of influence compared to the other variables observed, was based on:

- the analysis of existing literature, on financial assurance obligations information derived from the mentioned reclamation liability cost estimates data;
- discussions with industry specialists in structured finance and the mining sector; and
- personal, professional experience.

Several attributes leading to the probable success or failure of securitisation deals having EFA obligations as its underlying pooled asset are studied. The Mamdani-type FIS-based methodology is applied to explore such a potential. The degree of success of financial assurance-backed securitisation deals is measured by one concluding crisp output value generated by the applied Mamdani model. The level of success is in part based on the selected input-crisp values.

Fuzzy logic has been employed in many applications such as industrial control, engineering, military operations, medicine, pattern recognition and classification, reliability, economics, management, and business studies to model systems which are difficult to define precisely (Zadeh, 1976; Wang and Hwang, 2007; Minola and Giorgino, 2008). Mamdani (1977), Sugeno (1985), Bojadziev and Bojadziev (1997), Tanaka (1997), and Von Altrock (1997) demonstrated that it could be applied to industrial, business, and financial applications.

A Fuzzy logic method is a useful tool to represent and analyse qualitative information and to deal with complex phenomena (Minola and Giorgino, 2008; Nounou et al., 2013). Furthermore, it is an appropriate methodology for investigating several problems characterised by unreliable data, imprecise measures, ambiguous language, and unclear decision rules (Karadogan et al., 2008).

It is worth mentioning that alternatives to FL models exist that employ more traditional probabilistic methods. These approaches include decision trees, which represent a traditional approach to decision-making that deals with uncertainty and has been widely utilised in financial applications (Chambers and Lu, 2007; Han et al., 2014). Decision trees are major components of philosophy, finance, and decision analysis. Decision tree analysis is often preferred due to its simplicity, descriptive, transparency, and predictive power. Fuzzy decision trees, in particular, combine the leverage of such classic decision trees along with the benefits of FIS systems, which include the ability to deal with uncertainty and imprecision in data.

To exploit the advantages of path-based modelling utilised by decision trees to determine the degree of potential success of EFA-backed securitisation, without bearing the computational cost of calculating billions of paths, a method of randomly sampling from all available paths exists. These paths could also have been simulated using a Monte Carlo technique as an alternative to fuzzy logic. Monte Carlo methods involve randomly selecting paths to approximate the results of a full path-wise evaluation. Such methods were introduced by Hertz (1979) to finance. Boyle (1977) pioneered the use of simulation in financial derivative valuation.

These alternative models to the observed Mamdani FIS type have been applied in the literature, but they possess some limitations. Monte Carlo simulation is only useful in circumstances where data and analytic models are unavailable. Rubinstein and Kroese (2016) explained that the utilisation of such a simulation method is appropriate when:

- the observed system is too complicated;
- it is too expensive or impossible to obtain data;
- it is difficult to validate the mathematical experiment; and
- the analytical solution is challenging to obtain.

Decision trees also possess certain inherent limitations (Zorman et al., 1997). They include:

- the dependability of the information in the decision tree depends on feeding the precise internal and external data at the onset;
- a small change in the data (i.e., computing probabilities of different possible branches – it requires a higher degree of accuracy) can cause a significant change in the structure causing instability;
- the decisions contained in the decision tree are based on expectations, and unreasonable expectations can lead to errors and flaws in the decision tree;
- decision trees are prone to errors in classification, owing to differences in perceptions, and the limitations of applying statistical tools;
- computing probabilities of different possible branches, determining the best split of each node, and picking optimal combining weights to prune algorithms contained in the decision tree can be problematic; and
- data that is perfectly divided into classes and uses only elementary threshold tests may require a large decision tree.

A comparison of these models is expected to be examined in future studies.

Chapter 3: Issues in the Use of Financial Assurance

Progress is impossible without change.

— George Bernard Shaw

3.1 Funding Mine Closure

Mining is a short-lived activity, with mines operating from anywhere between a few years to several decades. An essential measure of the mining industry's ability to contribute meaningfully to sustainable development is its long-term environmental performance, which involves timely and detailed planning for mine closure and beyond. What happens after a mining operation is closed, and the impact this has on the local community and environment, influences the competitiveness of the mining operation. An essential component of this planning in some host mining jurisdictions is the consideration of how closure measures will be funded and who should fund it remains a topical issue since the need for financial assurance is explicit.

Funding R&C obligations have consequently become a necessary cost and the foremost concern regarding mine decommissioning and reclamation. The nature of the various expenses surrounding mine closure is discussed by du Plessis and Brent (2006) who considered existing mine closure cost calculation models in South Africa. The cost of mine closure can vary immensely as a World Bank and IFC publication points out (Sheldon et al., 2002). Funding these environmental costs is a growing concern in mine closure and continues to play a fundamental role in feasibility and investment into the extractive industries. The issue lies on whom should the responsibility of these environmental expenditures fall on?

Various models have been introduced throughout the world, and the choice is dependent on the legislative provisions of the host jurisdiction where mining operations are carried on (Sheldon et al., 2002). There are three primary sources of such funding: host state, third-parties, and the mining company itself (Sheldon et al., 2002).

The first model is where the obligation of the mine closure expenditures rests on the host country through taxing its citizens or the mining companies themselves (Mathews, 2016). Jurisdictions are seldom the source of such funding obligations as such costs ultimately rest on the taxpayer, which may upset investors due to the unreliability or the possible corruption of the host nation (Mathews, 2016).

In the second one, a mining R&C fund is established in a jurisdiction where its local mining companies contribute to it to meet the EFA requirements (Government of Western Australia, 2013). A mine operator would pay a contributory payment to the fund throughout the life of its local mine. It would not only pay to its reclamation and closure requirements but in effect also to the R&C obligations of other member mines. The underpinning of such a fund is the PPP since mine operators are often described as being raiders of resources generally due to the absence of sustainable legacies left behind after mine closure (Tilton, 1995; Cordato, 2001).

It is now a common practice in modern mine closure planning to possess details of the estimated mine R&C costs and the type(s) of financial assurance vehicles the mine operator will utilise for environmental reclamation and mine closure purposes (Robertson and Shaw, 2006; Heikkinen et al., 2008; Pavlović and Tomislav, 2012; Holmes et al., 2015). The financial assurance instrument(s) of choice is determined by the government regulators of the jurisdiction within which mining operations are carried on (Frilet and Haddow, 2013).

Increasing environmental concerns has led governments to tighten regulatory controls, and the selection of approved FA suitable for mine R&C plans requirements. The question of reclamation and funding is a crucial one for the mining industry, government authorities, the general public, and other stakeholders, and one that Appendix B examines.

Mine operators, today, often try to predict rather than engage in costly R&C obligations determination exercises since they can at times '*walk away*' from a mine operation after minimal closure activities. Such an abandoning scenario, however, does not appear to be valid for a single modern major mine. In every instance, mining company officials and regulators have failed to acknowledge the hard realities of mine reclamation (e.g., acid drainage is a particularly costly and challenging problem to rectify). Operators cannot simply '*walk away*' from mines that are generating acid drainage. Even where mines do not possess acid drainage issues, clean-up is often more complicated than estimated and takes longer than projected, becoming extremely costly. In response, where mining activities occur, many governments have enacted regulations that in some form require reclamation and closure plans to address issues associated with existing mining operations. All these regulations comprise, at least nominally, of a financial assurance provision.

Existing regulatory methods have been verified during the past decade. As newer mines have reached the closure phase — with some companies defaulting or otherwise going bankrupt — regulatory agencies have occasionally been forced to conduct reclamation and closure tasks, to comply with current environmental regulations, and to incur costs for performing those activities. In general, existing financial assurance is lacking, as demonstrated by these experiences with modern mines:

- the magnitude of disturbance and contamination, and in particular the long-term threat of pollution of water resources, is more significant than previously predicted;
- the potential is real for bankruptcies, insolvencies, and other circumstances that lead to a default on required reclamation and closure obligations;
- costs associated with such defaults are much higher than expected;

- regulatory agencies' costs for conducting R&C tasks at a mine are usually higher than projected by mining companies; and
- as a result, financial assurance is generally inadequate, or in some cases, the intended funds are unavailable (as in the case of self-guarantees).

The relative scarcity of surety bonds for mine operations is an effect of historically underestimating risk for many modern large-scale mines. Such a problem could have a severe impact on the environment, and as well to a government's budget. Further discussion is found in Appendix C. In addition to these governmental responses, there has been a market response, which is discussed in Section 3.2.4.

Another necessary aspect that should be taken into consideration when estimating reclamation and closure costs is to understand for whom the assessment is being prepared (Brodie, 2013). Freeman (2010) proposed a broad definition of what constitutes a stakeholder, and he remarked that "*any group or individual who can affect or is affected by the achievement of an organisation's objectives*."

Estimation for internal use assumes that the work would be performed under the guidance of the mine manager, which would maximise the use of existing equipment and staff, and thus the unit cost for all required R&C work would be completed at the lowest permissible total price. Brodie (2013) cited that the moderately low cost to the high productivity of equipment and familiarity of the workforce working on the mine site is expected to lead to a low contingency expenditure. No capital cost relating to the use of equipment would be administered in this circumstance since it would be regarded as a sunk cost.

Closure and environmental cost estimations by the mine operator is generally prepared and submitted by the company in support of its proposal for providing financial assurance security (Brodie, 2013). According to regulations, costs based on third-party contractors performing all the work should be included, with no concession for salvage value. The contingency cost for FA purposes would be like the internal estimate as both cost valuations were based upon the expectations that mine development would proceed as planned.

Estimation by the regulator reflects its adverse anticipation that the company could abandon the mine site. The assessment is prepared when the regulatory agency addresses the degree of uncertainty in the mine closure plans. The contingency cost in such a circumstance may be higher as very few mines are developed precisely to the initial plan's specifications without any revisions. There are also plans based on technological advancements, which could yield different results than projected (Brodie, 2013).

According to Brodie (2013), the worst-case approximation is usually developed when non-governmental organisation (NGO) stakeholders want to thwart the mine development due to the explanation that financial constraints surpass the company's security. Grant Thornton (2003) observed that most countries use the worst-case-scenario approach rather than the most probable scenario method when determining the amount of financial assurance.

Posted financial assurance signals to regulators that a company possesses the financial capacity to meet its environmental obligations, thus reducing the environmental risk exposure of regulators should it default or go bankrupt. Traditionally, however, there has been an ongoing disagreement between the government and the industry regarding the level of EFA requirements (Hawkins, 2008; Malone and Winslow, 2018). While most governments recognise the benefits that mining brings to an economy and their country, they want to make sure that local mine operators are financially capable of closing and remediating the mine and its surrounding disturbed lands (Brodie, 2013). Regulators believe that the more FA they have access to, the higher the likelihood to minimise taxpayers' burden due to possible bankruptcy losses by ensuring that a dependable third-party has access to enough funding that is segregated from the rest of the mining operations. Such precautionary measures are taken in the event of bankruptcy and the subsequent right to seized assets by creditors who are stakeholders or shareholders of the bankrupt entity.

Nonetheless, mine operators argue that both the EFA security and the further regulatory burden can result in a rising cost of doing business and the exposure taken by the regulatory agency and government in the event of a bankrupt company can be reduced by less costly measures (Brodie, 2013). Further discussion is found in Appendix D.

3.2 Current State of Reclamation

The legacy of mining, globally, is a two-sided coin. On one side, the mining industry has provided significant employment opportunities to many, social services (e.g., built schools, hospitals, sewage treatment facilities, public transit, senior residences, and community centres) in areas surrounding a mine, and generated secondary economic activity, tax revenues and paid royalty, and helped in satisfying the worldwide insatiable appetite for mineral resources. Conversely, it has produced many orphaned mine sites; led to long-term environmental threats and devastating disasters – some of the most publicised environmental catastrophes are linked to this industry (it created and imposed short- and long-term clean-up and R&C responsibilities onto the taxpayer's shoulders). Much of the damaging legacy is derived from mines that were approved under previous environmental regulatory eras. Existing mines that were and are being developed or continued under the current regulatory environment have also contributed to this legacy.

In many mining jurisdictions throughout the world, little consideration is still given to R&C responsibilities of mine sites let alone to long-term environmental reclamation efforts. Disappointedly, reclamation often begins at the end of mining, when the company may not have the necessary funds or incentive for mine reclamation and closure responsibilities. Without an adequate, approved form of FA, the R&C cost obligations go unfulfilled. Environmental degradation is a result of such negligence.

As global public awareness strengthens along with participatory engagement, it is increasingly important that the credibility of reclamation practices, environmental regulation and its enforcement, and the type(s) of financial assurance instruments deployed be established and reliable. Such views relate not only to the environmental policies and actions of these practices but also to how society perceives environmental clean-up and reclamation (Peck and Sinding, 2009).

Environmental reclamation is an increasingly significant feature of the public ongoing perception and perspective of the mining industry. The extent of reclamation activity appears to be directly interrelated to a society's aspiration to find other land uses from altered landscapes (Cao, 2006). Existing mining practices are reliant on these environmental practices to preserve the integrity of the surrounding countryside and the various types of life disturbed due to ongoing mining operations. There is also a continuing necessity to examine how effective current reclamation practices and financial assurance fit into a mining regulatory framework, especially when a mining project's life is often long-lasting.

3.2.1 Little Money, Inadequate Enforcement

Impacts on Company Decision-Making

Financial responsibility makes sure that the expected costs of environmental risks appear on a company's financial statements. If new investments imply potential future environmental costs arising, financial obligation raises the impact of such expenses to its decision-making. To self-insure, mine operators must be comparatively deep-pocketed, which suggests that they will internalise expected environmental liabilities. Shallower-pocketed companies usually cannot self-insure and must consequently purchase rights to financial assets from third-parties. When these parties, such as banks and insurers, arrange for capital in this way, they are concerned with the prospect that future costs will consume their money. As a result, there is a strong incentive for the providers of capital to observe environmental safety to shield themselves against moral hazard (Fanga and Moscarini, 2005). To protect against adverse selection, financial funds providers can also base the cost of their capital (e.g., their premiums) on visible attributes of the companies to whom they provide the funds (Faure, 2007; Dionne and Harrington, 2013). For example, more favourable capital cost rates can be supplied to mine operators with solid risk management and safety programmes. Additionally, EFA coverage may be denied to companies which fail to exhibit adequate levels of safety. By these means, the capital markets that fulfil the demand for environmental financial responsibility generate incentives to decrease environmental risks.

Mine Reclamation and Closure

The global trend in the past few decades demonstrates that governments from mineral-rich countries require mine operators to develop a timely mine R&C closure plans (Otto, 2009). These companies are usually expected to reclaim their sites themselves. Within these regulations, mine operators are also directed to establish adequate FA (Otto, 2009).

The following reasons justify the need for financial assurance (Otto, 2009):

- mine closure implies that no further revenue will come from the mine;
- premature closure can arise due to unanticipated volatility on mineral prices or other circumstances, or in the company becoming insolvent or going bankrupt; and
- inadvertent events may adversely impact the environment; even far-after reclamation is duly completed as per required by the regulations.

Government regulatory agencies set multiple conditions and requirements based on the amount of FA required for mine R&C obligations. For instance (Miller, 2005):

- various jurisdictions in Australia decide the necessary amount of financial assurance on a case-by-case basis, and in Texas, such financial requirements are established by the mine's permit conditions;
- in India, a fixed sum per hectare of a mining site is required, and Botswana and Suriname need funding from a company for closure as an ongoing expenditure; and
- Ontario, New Brunswick, and Arkansas demand EFA to cover the entire cost of mine R&C, while Québec requests monetary funds to cover 70 percent, Nevada requires 40 percent, and Ghana expects between 5 to 10 percent of the projected clean-up costs to be handed over at the start of a mining project.

Financial assurance is designed to function as an insurance policy to supposedly offer adequate funding to the government to cover the reclamation expenditures if a company is incapable or reluctant to perform its reclamation obligations (Peck and Sinding, 2009). These reclamation liability cost estimates and the collected EFA funds, regrettably, often fall short of actual R&C costs (Chambers, 2005). For example, the British Columbia Auditor General's 2016 report stated there is a shortfall of over a billion dollars in BC (Hoekstra, 2016). The Ministry of Energy and Mines estimated its financial security deposits for major mines were under-secured by more than CAD$1.2 billion. The latest information available to the BC government (see Appendix A) comes from 2014 data (MEM, 2016).

The data offers the first public mine-by-mine breakdown, as BC legislation permits such reclamation estimates information to be kept confidential by companies (MEM, 2016). Inflation adjustments are also not compulsory, and a no-victim-compensation scheme is not required (MEM, 2016). The BC government asked the mines to provide the breakdown, which they agreed to do. It shows the provincial government possesses financial securities of CAD$450 million from Teck Resources Ltd. (Teck Resources) against total reclamation costs of nearly CAD$1.187 billion. That leaves an underfunded liability of CAD$736 million.

Minister Bill Bennett (BC Minister of Energy and Mines and Minister Responsible for Core Review) stated most of the CAD$1.2 billion the government failed to collect was from Teck Resources and Barrick Gold, both of which are large multinational, public, corporate entities with plenty of financial resources. "*Those companies aren't going anywhere*," he said. Such an attitude of '*too big to visualise*' implies that British Columbia could be subject to the mining equivalent of the financial moral hazard that is '*too big to fail*' (Goodlet, 2010; Gormley et al., 2015). Such companies enjoy the '*too big to fail*' status.

In the 2007 financial crisis, many kinds of prominent financial institution failed or were saved only by government intervention: investment banks – Lehman Brothers and Bear Stearns; large financial conglomerates – Royal Bank of Scotland and Citigroup; smaller retail banks – Sachsen Landesbank and Northern Rock; public agencies – Freddie Mac and Fannie Mae; America's largest insurer – American International Group; diversified banks – Fortis; and specialist lenders – Hypo RE. Taxpayers were held footing the bills.

'*Too big to fail*' is too senseless of an idea to keep. The main objective of regulation is to protect the public, not endorse the interests of a particular company or even industry. Moreover, it is impractical for government regulators to avert business failure and undesirable to seek that purpose (Moosa, 2010).

Teck Resources was one of the worst-hit companies when coal prices plunged in the global commodity price shocks during the second half of 2014. Its shares peaked at CAD$62.22 apiece in January 2011 and fell to CAD$3.65 in January 2016. The diversified natural resources public, corporate entity lost CAD$2.5 billion in 2014, driven mainly by impairment charges. Barrick Gold shares plummeted to a 25-year low, as low as $7.82, on the New York Stock Exchange, on July 2015 as falling gold prices put pressure on the mining sector (Owusu, 2015; Rocha, 2015). Gold's tumble posed problems for debt-laden Barrick Gold.

Mining companies often face the correlated market and credit risks associated with the cyclical nature and volatility of commodity pricing. Such cyclicality and variability have long been recognised. The recent 2014 commodity downturn, however, was different. It was longer and more painful than past cycles due to multiple reasons, including a structural shift in the demand for coal, copper, and other base metals. When Moody's (2016) downgraded Teck Resources' rating to B3 on February 23, 2016, it noted that "*This rating action reflects Moody's view that there has been a fundamental downward shift in the mining sector with the downturn being deeper and the recovery longer than previously expected*, *resulting in increased credit risk and weaker metrics for Teck as well as the global mining sector*." All four credit rating agencies[33] downgraded Teck Resources to non-investment grade, junk bond status, during the 3rd quarter of 2015 (Thomson Reuters, 2015).

A decrease in share value and non-investment grade credit rating can make it increasingly difficult for a company to raise capital and arrange credit facilities. Moreover, when a public, corporate entity drops down to a non-investment grade, junk bond status, they are often referred to as '*fallen angels*.' As many institutional investors, such as insurers and pension funds, are barred from owning sub-investment-grade debt, money managers would have to dump their holdings of these fallen angels, leading to a sharp fall in their bond prices. As a result, downgraded issuers such as Teck Resources could struggle to find buyers for their pending and future bond and stock issuances.

A form of systemic risk[34] that may arise from such a potentially massive business failure is far from theoretical given the interdependency of Teck Resources' R&C efforts due to the company's multiple mining operations (Allan, 2016). These funds generated from one ongoing mine project are expected to cover the R&C closure costs of another one. Allan (2016) suggests that the overall success of R&C efforts by Teck Resources is co-dependent

[33] Moody's Investors Service (Moody's), Standard & Poor's, Fitch Ratings, and DBRS.

[34] Systemic risk became a key contributor to the worldwide financial crisis and global recession of 2007-2009. The term '*too big to fail*' is frequently used to describe companies which pose a systemic risk and as such, receive preferential treatment from the government, which often leads to '*moral hazard*' situation.

on the '*domino*' business success of the pool of mine operations that it possesses. Equally concerning is the potentially anti-competitive nature of such a permitted form of '*soft*' security. It could inversely impact the competitiveness of small and midsize mining projects that are required by regulation to demonstrate '*hard*' financial assurance for mine closure.

Barrick Gold has put up financial security of CAD$6.5 million on total estimated reclamation liability costs of CAD$218 million (MEM, 2016). In another instance, the BC government has an underfunded liability of CAD$73 million on estimated reclamation costs of CAD$79 million for Switzerland-based Glencore. Imperial Metals has a CAD$10.5 million underfunded responsibility on total reclamation costs of CAD$29.5 million. Peace River Coal possesses a CAD$67 million underfunded liability, and Thompson Creek Metals has a CAD$29.2 million underfunded liability.

In releasing her 2016 BC Auditor General report, Carol Bellringer stated the shortfall implies taxpayers could be on the hook if a company cannot pay for cleaning up a closed mine (MEM, 2016). It concluded that in addition to an unfunded reclamation liability, British Columbia had assumed responsibility for reclaiming abandoned mines, putting taxpayers on the hook for a further CAD$275 million. The Auditor General's team also examined the Imperial Metals' Mount Polley tailings dam failure[35], which happened during their two-year review (Fry, 2016).

Bellringer said their examination differed from other investigations as it did not focus on the mechanics of how the dam failed, but whether it was related to compliance and enforcement (Fry, 2016). She said they determined the province's regulators did not ensure the mine was built to design specification, noting an independent engineering panel appointed by the government of BC found that had it been built to specifications, it would

[35] The BC First Nations Energy and Mining Council recently called on the BC provincial government to close a policy gap that permits mining companies not to provide financial assurance to pay for the costs of a mine disaster (Hoekstra, 2019). "*BC has a polluter-pays policy under its Environmental Management Act, but that's not the reality on the ground,*" said Allen Edzerza, the mining lead for the BC First Nations Energy Council.

not have failed. "*To avoid such failures, business, as usual, cannot continue*," says Bellringer. Her report also stated that CAD$730 million of the underfunded liability is for mines that require water treatment, which contravenes the Ministry's policy of needing full security on mines that require long-term water treatment (OAGBC, 2016). The report mentions that Québec and Alaska require total funding of project reclamation from miners.

Some of the explanations for the discrepancy in mine closure expenditures relate to the inability or the strategic reluctance of effectively forecasting financial expenses deep into the future at times (Chambers, 2005). Mining companies calculate the liability cost estimates with the viewpoint that they will be the ones dealing with the clean-up and reclamation obligations. Conversely, environmental regulatory agencies approach the same matter believing that they might need to take responsibility for such mine closure efforts due to the inability or unwillingness of the mining entity. Consequently, the requirement for financial assurance can be viewed as an effective economical monitoring, compliance, and enforcement mechanism. These opposing viewpoints can, and often do create significant discrepancies in the assessment of mine closure costs (Chambers, 2005).

In some jurisdictions, financial institutions have offered FA for mine abandonment and closure in the form of a surety bond or insurance policy[36]. Due to the number of mines that any individual insurer is capable of insuring versus the adverse possibility of a high payout, many insurance providers ceased covering this form of activity (Chambers, 2005). The increasing lack of assurance coverage led to the use of cash or its equivalent, which can be desirable from a regulator's perspective. However, such financial instruments can significantly impact a mining company's balance sheet, cash flow, borrowing capacity, and even its credit rating (Miller, 1998).

[36] Also, for abandoned oil wells. Such wells can contaminate water and soil, leak greenhouse gases, and put nearby residences at risk of harmful gases and explosions, according to a study by the C.D. Howe Institute, *All's Well that Ends Well: Addressing End-of-Life Liabilities for Oil and Gas Wells* (Dachis et al., 2017).

Another issue relates to the actual mine closure standards necessary to meet regulatory requirements. That is, what level of environmental reclamation is required to fulfil a regulator's expectations to obtain a closure certification? Through the integration of observable criteria for the mine closure expectations with the financial assurance requirements, which should be agreed upon by all stakeholders, future surprises are expected to be limited. Such decisions are best developed early in the mining operations planning and development stage, so stakeholders will possess all the pertinent information needed to make the necessary choices (Miller, 1998).

Including EFA requirements into licenses and new permits is straightforward; however, how do regulators handle mine sites that have been abandoned some time ago and those mines that are still productive but mature? According to Mackasey (2000), placing the same financial assurance expectations on such established mines may prove financially burdensome and harmful to its very existence.

Robertson et al. (1998) observed that the interest of a mining company in the jurisdiction where its mining operations exist usually comes to an end with the execution of a mine closure plans. Such a blueprint is often concentrated upon objectives such as resource extraction optimisation, attainment of planned environmental goals and termination of ongoing financial obligations as rapidly and as cost-efficient as possible (Laurence, 2003). It is said that a mine operator often possesses a shorter perspective than that of the environmental impacts for which it is responsible for (Strongman, 2000).

Mine owners, strategically, strive to avoid dealing with financial obligations as far into the future as legally permitted since they dislike possessing unresolved liabilities on their balance sheets. They attempt to avoid dealing with their reclamation costs for as long as they are legally allowed to offer them the opportunity to dispose of their mine sites at a suitable time for them (Strongman, 2000). Such a procrastinated stance is in stark contrast with the plans of the succeeding land caretakers and related stakeholders since they are far more concerned about continued sustainable use of the land (Strongman, 2000).

In August 2013 the IMCC (Interstate Mining Compact Commission) surveyed outstanding obligations related to bonding across the United States (IMCC, 2013), and it was observed that some mining companies in various states reported difficulty in obtaining financial assurance in the form of surety bonds for their mine operations (Kuipers, 2000).

It is correct to remark that EFA is progressively costly[37], and cash equivalents are even pricier than surety bonds; however, the explanations provided by mine operators for this upsurge pricing trend do not necessarily explain the issue(s). Financial assurance providers that offer financial guarantees are responding, as anticipated in a market economy, to higher and more complex levels of risk. Events have shown, repeatedly, that the total disbursement, timeframe, and magnitude of reclamation have been significantly underestimated by the environmental regulators who determine the bonding amounts (Kuipers, 2000). Because of the increasing magnitude of bankruptcies (Els, 2016), surety providers have been forced to make substantial payouts in recent years, which could explain why the industry increased its overall rates. Agents of financial assurance providers outline that mine reclamation surety bonds are often riskier than other forms of investments that they hold in their portfolios (Kuipers, 2000). Such surety bond returns are highly skewed with limited upside. As a result, it is much more challenging to diversify risks in a bond portfolio than in an equity portfolio.

When a mining company borrows money from an FA provider, it obligates itself to repay the financial assurance loan at a future agreed upon date, and if it cannot meet this obligation, the debt holders gain control over the corporate entity. These holders would have a claim on the company's assets, and this claim is enforced by the legal system. In a way, debt

[37] British Columbia Mines Minister, Bill Bennett, referring to the Auditor General Carol Bellringer's 2016 report, an Audit of Compliance and Enforcement of the Mining Sector, pointed out that financial security for reclamation costs in the province had doubled in the last decade (Fry, 2016; Hoekstra, 2016).

holders and equity holders own the company together, but the debt holders' investment typically has a limited upside and downside while the equity holders' investment has unlimited upside and downside. A payoff of such signifies that the creditors (e.g., surety provider) are short a put option written on the assets of the borrowing company (Merton, 1974). Companies with higher debt ratios may be tied to higher defaults and thus, greater credit risk (Merton, 1974).

The Merton Model, a structural model, based on the Black-Scholes option pricing model (Black and Scholes, 1973), describes such scenarios – it can be used for equity valuation and credit risk management (Merton, 1974). Merton expresses owning equity stock in a company as equivalent to simultaneously owning a European call option and selling a put option on the company's assets, with the strike price being the value of the company's debt. Merton sees default as arising from the value of the company's assets falling short of the amount of debt at maturity.

Overall, the global speculative-grade corporate defaults rose by more than 30 percent in 2016 and reached the highest level since 2009, stated Moody's Investors Service in their report, entitled *Corporate Default and Recovery Rates, 1920-2015*, which covered more than 20,000 corporate issuers (Els, 2016). According to Moody's, in 2015, companies defaulting on corporate bonds or loans compared to 2014 close to doubled, with the total value jumping to $97.9 billion.

What is different compared to the global financial crisis of 2007-2009 is that defaults in this credit cycle are uncommon in that they are sector-specific (Els, 2016). Oil & gas represented for 32 percent of all defaults and metals & mining around 14 percent, the second-largest contributor among non-financial sectors (Els, 2016). Metals & mining also suffered the highest default rate in 2015 at 6.5 percent, followed by oil & gas at 6.3 percent.

In its 2013 annual report, Molycorp Inc. (Molycorp) stated that the US Environmental Protection Agency (US EPA) declared its plan to launch a new FA programme for hard rock mining, extraction, and processing facilities under the Federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (commonly referred to as the Superfund law). Such a strategy may require mining companies to establish additional financial bonds or other forms of sureties (Molycorp, 2013; US EPA, 2016). At that time, Molycorp could not predict the effect of any such requirements on their operations, and those of mining companies, in general. Asset Retirement Obligations[38] for accounting purposes can be, and frequently are, larger than the number of financial surety bonds placed with local regulatory authorities (Molycorp, 2013).

The Superfund law is a United States federal law intended to clean up sites contaminated with hazardous substances and pollutants (US EPA, 2016). It sanctions federal natural resource agencies, primarily the EPA, US states and Native American tribes to recuperate natural resource damages caused by hazardous substances; however, most states usually use their versions of CERCLA. Financial assurance may identify parties responsible for the contamination, and may either require them to clean up the mine sites or it may take on the clean-up on its own using the Superfund trust fund and expenditures recovered from polluters by requesting the US Department of Justice to intervene.

It should be mentioned that Molycorp, in the summer of 2015, filed for bankruptcy with a plan to restructure its outstanding debt of $1.70 billion after the dive in prices for its products plunged (McCarty and Casey, 2015; Miller and Zheng, 2015). Molycorp emerged as the property of Oaktree Capital Management and was subsequently reorganised as Neo Performance Materials (Topf, 2015; Brickley, 2016).

[38] Asset Retirement Obligation cost estimate is a legally defined term meant for financial reporting by the US and some other jurisdictions (Parshley et al., 2009). Such assessments must be prepared each year as part of the annual financial reporting requirements and must be adjusted to reflect any increases stemming from new development work or reductions resulting from completed mine closure work that occurred in the fiscal year.

When Pegasus Gold Inc., located in Montana, filed for bankruptcy in 1998, the cost of the clean-up fell on the US taxpayer. The expenses kept growing (Jacobson and Custer, 2017; Preston, 2017; AbandonedMines.gov, 2018). To stop such future abuses, the Obama administration moved to mandate hard rock mining operations to demonstrate they possess the financial capacity to clean up future pollution. The administration rule was meant to support cash-strapped Superfund clean-ups of areas polluted by hazardous waste and was aimed at minimising the prospect of taxpayers having to foot the clean-up bill in such disastrous circumstances in the future. Now the Trump administration, cheered by many mine operators, moved to transfer the financial liability of cleaning up back to federal and state agencies (Jacobson and Custer, 2017; Preston, 2017). Critics claim that the US president's EPA rule change exploits taxpayers for mine clean-up.

In early December 2017, Scott Pruitt, EPA administrator, dropped the Obama-era rule, asserting modern mining practices, in addition to other US state and federal requirements, made the financial responsibility rule unnecessary. He stated, "*Additional financial assurance requirements are unnecessary and would impose an undue burden on this important sector of the American economy and rural America, where most of these mining jobs are based*." (US EPA, 2017).

3.2.2 Response from Industry

Miller (1998) states that the mining industry agrees that financial assurance is about the protection of stakeholders' interests through environmental regulation. They are also aware that dropping or volatile commodity prices and unanticipated technical difficulties can render a viable project uneconomic. For a single-mining corporate entity with finite financial resources, the outcome can be disastrous.

The consensus is that most of the industry agrees that if the reclamation expectations and regulations for mine abandonment and closure are adequately defined, and a company possesses an established track record as an accountable mine operator, FA should not be required. He goes on to mention that mine operators would prefer financial assurance that could be attained at nominal or no cost (Miller, 1998). In place, it would include financial statements and financial strength/stress tests, asset pledges, or corporate self-guarantees – examples of '*soft*' forms of financial assurance.

Mining companies specified that a corporate guarantee should be an acceptable form of EFA in circumstances where (Miller, 1998):

- there is a low probability of default;
- clean-up and reclamation expenditures are established by an acceptable third-party;
- the reclamation process is expected to be short-term; and
- the company possesses the financial capacity to meet all its mine closure financial obligations sufficiently.

In circumstances where the above conditions cannot be met, then '*hard*' FA instruments such as cash or its equivalent should be required – this might include newly established mining companies or ones with a restricted record of performance (Miller, 1998).

The mining sector agrees that no single FA method exists that best suits all mining operations circumstances and environmental regulators should possess a toolkit with various forms of financial assurance instruments at their disposal for mine reclamation closure purposes (Miller, 1998). Having such a selection that could be tailored for specific needs based on the length of time needed to retire a mine site, the probability of a company defaulting on their reclamation obligations, and the extent and type of closure activity accomplished to date serves the collective interest of all stakeholders (Miller, 1998).

An SMI-CSRM (Sustainable Minerals Institute's Centre for Social Responsibility in Mining at The University of Queensland) paper concluded that the financial liability of financially assuring mine R&C obligations should be measured and analysed in relation to the overall tax burden to boost much-needed mining investment and to permit rational and efficient exploitation of mineral resources (Dondo, 2014). The cost of the required FA would need to be evaluated considering the overall tax burden for mining investments. Internalising costs in the companies will decrease the tax base and consequently the state revenues, but it may also impact the country's ability to attract investments. The research was conducted from the Argentine context, where large scale mining is a relatively recent development in the nation. Dondo (2014) further remarks that government regulators should also be aware of the relationship between resource efficiency and higher costs, since raising capital expenditure can increase the cut-off grade of the mining projects, resulting in smaller mines or shorter life, or leaving some projects unfeasible (Peck and Sinding, 2009).

Remediating Abandoned Mine Sites

Governments absorb most of the financial expenditures associated with classifying and remediating abandoned mine sites, but it is taxpayers who ultimately pay the costs.

Over the last 30 years, most Canadian provinces and territories, along with the country's federal government, have made attempts to have fitting reclamation and closure plans in place and to make sure sufficient funding for reclamation is available when a mine is permitted (CCSG Associates, 2001). Unfortunately, mine sites are seldom, if ever, returned to their natural or economically usable state. Consequently, financial assurance is often insufficient or inaccessible when it is required.

There are a limited number of innovative programmes for recovering the R&C costs from mining companies that benefited from not providing adequate funding for reclamation.

However, these still need considerable government investment (CCSG Associates, 2001), and, at present, have only a voluntary commitment from the mining industry.

There is some support from mining companies in the reclamation of old and abandoned mine sites where they wish to search for new mineral deposits, as in the Sullivan underground zinc-lead-silver mine in Kimberley, BC, and the Kam Kotia mine site located 35 kilometres northwest of Timmins, Ontario. There are also mine sites such as the Faro mine, in Yukon, and Yellowknife, Northwest Territories, where the federal government accepted financial responsibility for previous perpetual environmental liabilities to entice interested parties in re-mining the site.

The reworking of tailings is not a new concept. Leonida (2015) comments that the abandonment and closure of mining areas are seldom as a result of the overall consumption of a reliable resource, but instead due to diminishing financial returns based on metal prices, or political, social, and environmental restrictions resulting to an unprofitable scenario per resource unit. Miners have traditionally reworked earlier mine wastes as commodity prices have changed or new technologies have been developed, in an attempt to recover commodities lost to former inefficiencies, or due to other economic drivers. However, the reclamation of mine tailings to help in restoration has only recently been considered a possible answer as the pressure on the mining industry for proactive mine closure planning has risen. Nevertheless, even if the ore potential can be established and the technology will recover adequate amounts of metal, there may still be little motivation to re-mine many old mining districts. Concerns include new mining ventures being held financially accountable for past mining legacy, not counting any further disturbance, and the sheer remark of metal value from such old sites could result in legal action from bankruptcy trustees or property owners who will lay claim to any recovered ore value.

The Canadian Broadcasting Corporation (CBC) News reported on May 2012 that Canada's environmental commissioner's 2012 report identifies four mine sites as possessing the highest reported financial liabilities in the country – although it does not reveal the exact financial details, which is said to be classified information (CBC News, 2012).

In Canada, there has been a minimal investigation into how the expenditures of remediating abandoned mine sites can be internalised to the mining companies and principal persons that have primarily profited from their mining activities (CCSG Associates, 2001).

Clark et al. (2000) stated that complete mine closure for orphaned mine sites, currently operating mines, and new mines remain the main obstacle for practically every mining country in the world. To take on the obligation to close abandoned mines and to ensure that current operating and new mines are properly closed usually involves the assistance of a diverse group of stakeholders, new and advanced methods of financing mine closure, and significant changes in government policy and legislation in most mining countries to guarantee post-mining continual development.

In recent years the legacy of orphaned mines, their related environmental, financial obligation and social issues, and the prospecting development options for nearby communities has led to increased social awareness on mine closure planning (Smith and Underwood, 2013). In many jurisdictions' regulatory requirements, mining practice and procedures have advanced to reflect the concerns of stakeholders, and some mine operators have implemented organisational practices and policies and have implemented various forms of technologies (including biotechnology) that enables resource extraction to occur while reducing environmental impact (Smith and Underwood, 2013; Shore, 2014).

3.2.3 Effectiveness of Mine Reclamation and Funding

Each provincial government, in Canada, regulates its respective mining industry, and they have all established and passed regulations and legislation for the supervision of provincial mining activities and site closure. The Canadian federal government has also established acts and regulations that oversee mine closure and is accountable for these mining activities on First Nation Reserves and in the Northwest Territories and Nunavut. These jurisdictions all demand that mine closure plans are developed, and adequate funds are easily accessible for mine reclamation purposes by the company before mining operations commencing (Mackasey, 2000). Progressive R&C work is completed by the mine operator in accordance with the approved closure plans, which must be continuously amended and approved by the appropriate government agencies (Mackasey, 2000).

Each level of government in Canada has legislation in place to offer reclamation financial assurance in the event a mining company is incapable of doing so (Mackasey, 2000). If an operator declares bankruptcy before the closure of its mining operations, the overseeing government agency will employ the security deposit funds to cover the costs associated with clean-up and reclamation and for the mine site closure (Noble, 2006). If the operator correctly handles its R&C obligations, the security deposit is refunded to them (Noble, 2006). That way, even if the corporate entity goes insolvent, the taxpayer is sheltered from having to cover such mine closure expenditures. According to Munso (2009), for one single project, abandoned mine R&C costs can reach several hundred million dollars or even much more. For instance, for the abandoned Faro mine in Yukon, the reclamation cost of its toxic tomb is expected to top well over CAD$1 billion (Giovannetti, 2017) and the poisonous dust buried under Yellowknife's Giant Mine that is costing taxpayers over CAD$2.37 billion to remediate (Thomson, 2018).

As part of Canada's federal budget for 2019, the Canadian government outlined its CAD$2.2 billion abandoned mine sites remediation programme in the Northwest Territories and the Yukon, naming 89 sites that will receive tax funding to clean up these sites over the next 15 years (Parizot, 2019) – this list includes Faro mine[39].

[39] The mines that will secure funding are the Cantung, Giant, and Great Bear Lake mines in the Northwest Territories (Parizot, 2019). In addition, the Clinton Creek, Faro, Ketza River, Mount Nansen, and United Keno Hill mines in the Yukon.

There are some mining operations, which are abandoned, where the mine owner(s) merely disappear(s) from the country. For example:

- the owners of Nunavut's first and only diamond mine, Jericho mine, vanished after the company went bankrupt. Nunavut diamond mine owners owe CAD$2 million for clean-up costs (CBC News, 2013).
- South Africa's Department of Mineral Resources (DMR) holds a list of 6,000 derelict and orphaned mines, which became the government's responsibility over the years when the former owners vanished. While the DMR slowly rehabilitates these mines – at a rate of about ten per year – mining companies continue to discreetly walk away from their operations once they have become economically unprofitable (Olalde, 2016).

Encouraged by the mining industry and other interested groups, governments are keen to endorse local economic development through mineral extraction and to keep regulations to a minimum – often viewed as a method to attract investment (CCSG Associates, 2001). Substantial tax breaks and subsidies are also established to entice mining operations to continue, even when their operators do not believe it to be an economically viable strategic decision to do so. Such actions are widely cited as an example of regulatory capture (Haselipa and Hilson, 2005; Grant, 2011). The Faro mine, in the Yukon, is a case in point.

Proper mine reclamation cost assessments are essential pieces of information that permit a mine operator and the jurisdiction regulatory agency supervising mining operations the capability to decide the amount of the financial assurance that should be put forth before mining operations commence. Such material information should be periodically reviewed by both the agent (mining company) and the principal (regulatory agency) and updated regularly, and this financial veil of secrecy should be lifted for public knowledge and information in the stakeholders' interest. It should also be made easily accessible within a company's annual report for all interested parties to review.

It is also difficult to discover the cumulative reclamation, long-term site monitoring, and financial R&C costs of ongoing mining companies. In particular, how reclamation liability cost estimates are calculated since the discrepancies in some instances are mind-boggling (OAGBC, 2016). For example, and as earlier noted, in the BC Auditor General's 2016 report, the 2014 data shows the provincial government holds financial securities of CAD$450 million from Teck Resources for its various coal mines and its large Highland Valley Copper mine against estimated reclamation costs of CAD$1.187 billion (OAGBC, 2016). That leaves an underfunded liability of CAD$736 million. Barrick Gold, which possesses several shuttered metal mines in BC, including the Eskay Creek gold and silver mine in northern BC, has put up the financial security of CAD$6.5 million on total projected reclamation costs of CAD$218 million. Such a low-ball value signifies that the regulator holds an underfunded liability of CAD$212 million (97 percent of the total reclamation cost).

Such material regularly must be pieced together from annual reports and other sources if it indeed is documented. Notes of material to the financial statements may exist, but they are not necessarily easy to locate and may be vague or incomplete.

3.2.4 Endangered Surety Bond Market

Since the recent global financial crisis, operators in the mining industry, and other sectors, including oil & gas, have found it progressively problematic to satisfy financial guarantee obligations required by regulators with the typical financial assurance mechanisms of choice because of surety providers' large-scale departure from the natural resources markets. The latest financial credit crunch and the tightening of the surety bond market have prompted such extractive companies to seek and post substitute forms of financial collateral. Such a turn of events has had negative consequences for the mining and energy sectors (Learn, 2016). The troubled surety bond market and the corresponding implications for the mining industry received widespread attention.

These problems stemmed from the convergence of several events, which include the most recent financial crisis and the subsequent commodities market crash. The ensuing erosion in financial capital, due to such circumstances and stemming from tighter lending regulations, triggered longer-term conservatism in the underwriting market, which is still felt today by many mine operators in the form of higher premiums. The assurance industry has recognised that surety bonds are now comparatively high-risk investments – especially when dealing with mine operators with multi-decade projects in their portfolios. Consequently, many are either limiting or cancelling their existing bonds with mining and oil & gas companies and refusing to issue new ones. The last market correction of 2007 has increased the surety industry's rates and made it more risk-averse.

Another concern, according to Robert Duke, general counsel of The Surety and Fidelity Association of America, is that selling surety bonds to mine operators is already a niche market in which perhaps only a few dozen financial companies operate (Learn, 2016). The shortage may get worse, as Anna Zubets-Anderson, a senior analyst at Moody's, said, "*You have reclamation obligations growing for an industry and companies that are actually contracting*" (Learn, 2016). Zubets-Anderson goes on to mention, "*We are seeing that surety bonding is becoming more expensive and less available.*" Bob Kenney, president of First Surety Corp., indicated the market for surety bonds is also tightening for many in the broader energy sector (Learn, 2016).

The Supreme Court of Canada (SCC) released its verdict in *Orphan Well Association, Alberta Energy Regulator v. Grant Thornton Limited and ATB Financial* on January 31, 2019, which could tighten access to much-needed debt financing even further. The case concerned the receivership and bankruptcy of Redwater Energy Corp. (Redwater Energy). The dispute in

Redwater Energy centred on the renunciation of uneconomic oil & gas wells, pipelines, and facilities that are subject to provincial abandonment and remediation liabilities.

The company's receiver (and later trustee in bankruptcy) challenged the applicability of the provincial regulatory regime administered by the Alberta Energy Regulator. It argued, among other things, that the provincial regulatory regime frustrated the legislative purposes of the federal Bankruptcy and Insolvency Act and that dual compliance with federal and provincial legislation was not possible. It also indicated that preventing receivers from renouncing uneconomic assets, including oil & gas wells, would result in receivers and trustees refusing to take on such mandates and would frustrate statutorily mandated efforts to realise on oil & gas assets of insolvent companies.

The SCC's decision could have profound effects on lending to oil & gas companies at a time when the industry is experiencing severe setbacks (DeSereville, 2019; Maerov et al., 2019; Morgan, 2019; Restructuring Roundup et al., 2019). In reaching its verdict, the SCC noted that the effect of its judgment is to enforce the supremacy of the polluter pays principle; such a goal is equally laudatory and sacrosanct (Collins et al., 2019; Johnson, 2019; Restructuring Roundup et al., 2019). The case has been one of the most closely watched by the Canadian oil & gas industry in decades.

Such a verdict implies that super-priority administrative claims would take precedence over all other administrative claims, including seniority debt, when a corporate entity is insolvent. The priority of creditor rankings under the Bankruptcy and Insolvency Act in Canada classifies all kinds of claims against a debtor. It prioritises them according to specific rules depending upon, among other things: when the claim arose, whether it is unsecured or secured and whether it should be entitled to some especially elevated status of the payment in accordance with various policy considerations and particular interest concerns identified by the Office of the Superintendent of Bankruptcy Canada (Department of Justice, 2019; ISED, 2019). Secured claims possess the highest priority so long as the value of collateral securing a claim is larger than the face amount of the obligation, the secured creditor's rights will be relatively unchanged by a bankruptcy case. Unsecured claims fare worse except in rare situations where unsecured creditors receive a pro-rata distribution from a bankruptcy estate that contains inadequate assets to satisfy all creditor claims.

Government regulators may now contend that regulatory obligations have been leapt to a super-priority status (DeSereville, 2019; Maerov et al., 2019; Morgan, 2019; Restructuring Roundup et al., 2019). Where those financial obligations surpass the value of the estate, and the transfer of assets is subject to regulatory control, it is uncertain whether those assets could be sold in a bankruptcy process. It is therefore uncertain whether there would be a point to a bankruptcy process in those circumstances. Such an SCC decision may have profound repercussions, possibly limiting the capacity of oil & gas producers to establish credit and impairing the effectiveness of the bankruptcy system where debtors have significant regulatory obligations (DeSereville, 2019; Maerov et al., 2019; Morgan, 2019).

Secured lenders, such as banks, may soon be unwilling to advance monetary funding to any oil & gas company for fear that the regulator may in effect confiscate the secured lenders' interest in their borrower's assets (Collins et al., 2019; Johnson, 2019; Krüger et al., 2019). Consequently, credit for all corporate entities in the affected industries could become costlier and less accessible, stunting economic growth and causing more financial failures and distress (Krüger et al., 2019; Restructuring Roundup et al., 2019). The Redwater Energy verdict is expected to generate increased financial difficulties for junior and intermediate producers in an already challenging credit market (Restructuring Roundup et al., 2019).

Borden Ladner Gervais LLP (BLG) expects that trustees[40] are likely to be prevented from disclaiming uneconomic assets and selling economic ones (Krüger et al., 2019). Instead, trustees will now be obligated to sell assets in bundles or perform abandonment and

[40] Receivers and trustees are referenced as '*trustees*' (all the stakeholders, they include the Crown, Alberta's Orphan Well Association (OWA) and Energy Regulator (AER), producers, receivers, lenders, surface rights holders, and bankruptcy trustees) in the upstream oil & gas production sector (Collins et al., 2019).

reclamation obligations as conditions of selling economic assets. Where environmental liabilities exceed the total valuable assets, BLG expects fewer asset sales in ongoing engagements, as well as fewer appointments of trustees and receivers by creditors in the first instance.

Moody's Investor Services says high court support for the Alberta Energy Regulator's ability to force a bankruptcy trustee to pay out well-abandonment obligations before paying back creditors is credit negative for energy companies (Kilpatrick, 2019). Such an impact may well extend beyond the regulated oil & gas industry to other sectors such as mining (DeSereville, 2019; Lewis, 2019b; Maerov et al., 2019; Morgan, 2019). Moody's also states the ruling is credit negative for banks and other creditors but adds it is unclear how it will affect different industries and provinces going forward (Kilpatrick, 2019).

SCC's verdict in *Orphan Well Association, Alberta Energy Regulator v. Grant Thornton Limited and ATB Financial* could add strength to the arguments raised in the dissertation in favour of the application of securitisation to meet the regulatory requirements surrounding financial assurance. Securitised mechanisms are typically made bankruptcy-remote (under the control of an arm's-length trustee, the SPV). The SPV is usually set up in a manner that ensures that it is operationally distinct from the originator (Hahn et al., 2015).

The Canadian federal government also unveiled a new piece of legislation, Bill C-69, the Impact Assessment Act (an overhaul of the Federal Environmental Assessment Act). The C.D. Howe Institute (C.D. Howe) has warned this controversial legislation, which the Canadian government introduced in 2018 to overhaul federal environmental assessments for major mining projects, threatens to dampen investment in the already depressed natural resources sector even further (Bishop and Sprague, 2019; C.D. Howe Institute, 2019; Webb, 2019). Investment in Canada's mining and oil & gas sectors are disproportionately down compared with other jurisdictions (Bishop and Sprague, 2019). C.D. Howe blames Canada's sclerotic regulatory regime.

Morgan (2018) comments that the proposed legislation under consideration lacks clarity and decisiveness since it does not define guidelines and rules. Instead, it uses terms left to the interpretation of the reader, which could potentially adversely impact the reclamation success of a given site. It will force stakeholders into massive financial spending commitments before even applying to the regulator for consent, all due to lack of absolute clarity of rules or requirements. Bill C-69 will permit the government to serve some role as the regulator, thus sanctioning political influence into a decision that should be made by a regulator. The Environment Minister would ultimately have the final say on any approval of a pipeline (Morgan, 2018).

The Fraser Institute also warned that oil & gas and mining projects would be needlessly exposed to political risk, which in turn could limit the ability of proponents to finance projects on a cost-effective basis. Canadian Senator and lawyer, Douglas Black, also questioned if Bill C-69 is an attempt to kill the oil sands in Alberta (McNeil, 2018). Martha Hall Findlay, president of the Canada West Foundation, said, "*In all of my involvement for decades now, I've never heard the phrase* '*sovereign risk*' *associated with Canada, and that is now a regularly used term.*" (Bennett, 2019).

C.D. Howe further argued that Bill C-69 is flawed and stated that the legislation for impact assessments must specify considerations for assessing projects that can be scoped and applied with reasonable consistency and predictability (Bishop and Sprague, 2019). It also commented that legislation must preserve the role of independent and expert lifecycle regulators in leading assessments.

The Fraser Institute has further stated that eliminating the existing test for public involvement will throw the door open for interventions from groups far from any future project, potentially adding a considerable amount of time for taking testimony on a proposed project (Green, 2018a; Green, 2018b). The Institute also warned that Bill C-69 would mean environmental assessments could take longer and be more subjective and political, which might potentially lead to conflicting, incomplete, and vague environmental regulation.

3.3 Financial Assurance Rules

A key mining standard of environmental law and regulation is that pollution costs are expected to be borne by their creators (Vagstad and Kirsch, 2002). Regulations and laws give this principle form by demanding polluters to pay for property, natural resource damages, and health and unperformed reclamation requirements. Regrettably, many environmental obligations, despite being well defined in theory and law, are not always met (OAGBC, 2016). Outright abandonment, insolvency, and bankruptcy are disturbingly common techniques by which polluters evade responsibility for environmental costs.

Financial assurance rules are intended to address this policy issue. These rules require probable polluters to demonstrate, before the fact, their financial resources are adequate to deal with environmental damage that may arise in the future. Thus, EFA acts as a central complement to liability rules, reclamation and closure obligations, and other environmental and closure compliance requirements (Miller, 2005).

3.3.1 Underperformed Obligations and Unrecoverable Liabilities

Theoretically, polluter cost internalisation is practically undeniable as a guiding principle for environmental regulation (Gerard, 2000; Boyd, 2001; Miller, 2005; OAGBC, 2016). Cost internalisation by responsible parties yields the most equitable means of casualty remuneration, where the alternatives are no compensation provided by public funds or simply no compensation. Polluter cost internalisation also encourages prevention, risk reduction, and innovations to diminish environmental harm. Because of that, with few exemptions, most environmental regulations make polluters responsible for damages stemming from commercial activities that harm public health or that cause property or ecological disasters.

The relevance of cost internalisation in law and regulation does not always correspond by its successes in practice (Gerard, 2000; Boyd, 2001). Even the most certain legal requirements can vaporise when presented to an absent, insolvent or bankrupt polluter.

Consider the inferences of bankruptcy. In the US bankruptcy code, debtors are sheltered from creditors by the automatic stay provision of which implies that both public and private environmental claims can be discharged in bankruptcy (Howard, 2015). Outstanding environmental liabilities are only partially recoverable upon bankruptcy occurring if they are retrievable at all. To compound the matter, companies may deliberately increase the prospect of insolvency by divesting themselves of capturable assets to externalise costs. In industry sectors where liability costs can be high, a corporate entity's business organisation and its decision-making strategies regarding capital investment and retention decisions may be influenced by the incentive to externalise liabilities (Howard, 2015). For example, it might shelter assets overseas through a shell company such as an SPV legal entity, where it serves as a vehicle for business transactions without the shell entity itself having any significant assets or operations.

Environmental cost recovery can also be crushed if a polluter has legally dissolved its operations before the realisation of performance or liabilities of obligations; however, there are limits to such a strategy. A liable company that is sold does not instantly escape liability since they will be transferred to the purchasing company. If assets are retired over time or sold piecemeal, however, such environmental costs can more effectively be externalised. This prospect is enhanced by the nature of many environmental obligations and risks, which frequently materialise only over a period of years or possibly decades. Company closure can be a questionable tactic to avoid future requirements. Regardless of the strategy used to circumvent liability and reclamation obligations, the absence of a solvent defendant defeats the capability of victims or governments to collect compensation. Insolvency undercuts an environmental law's ability to discourage environmental injuries in the first place.

3.3.2 Scale and Scope of Unrecovered Environmental Costs

Non-recoverable environmental obligations are more than an imaginary likelihood. Over the past decades, countless numbers of environmentally damaging mining operations have been orphaned or have avoided liability by declaring insolvency.

3.3.3 Benefits of Assurance

Reclamation obligations and liability rules lead to polluter cost internalisation, in theory; however, liability, many administrative requirements, and any other after-the-fact obligations or penalties suffer from a significant fault. Since the financial commitments or damages arise only after environmental damages have occurred, polluters can escape cost internalisation through prior dissolution or bankruptcy declaration (Faure and Grimeaud, 2000; Boyd, 2001; Miller, 2005). Financial assurance rules are meant to counter this weakness. Moreover, EFA essentially safeguards that the expected financial costs of environmental risks appear on a company's financial statements.

Financial assurance can also foster timely, relatively low-cost public access to compensation, which can be favourable when a swift response allows for the minimisation of environmental damages. When assurance is held by a public trustee, such as a regulatory agency, it reduces the public transaction costs related to collecting payment. Even when liability is confidently established, the prospect of postponement, appeal, and uncertainties associated with penalty collection can muddle the actual transfer of funds from defendants to victims and resource trustees. Specific financial assurance instruments permit practically instant access by regulators to reserved funds – this shifts the responsibility of the regulator to the accuser. Instead of the regulator having to substantiate that reparation is due and seek the funds, the burden falls to the polluter to establish that they are not legally liable (Faure and Grimeaud, 2000).

3.3.4 Alternatives to Assurance

Perhaps the most substantial incentive for financial assurance requirements arises from the contemplation of the alternatives. Since R&C costs never cease to exist, someone must ultimately pay but who…? Two choices exist, the extension of environmental costs to polluters' business partners or the externalisation of these costs to society. The externalisation of such costs to society is objectionable since it undermines deterrence and the capacity to compensate victims (Faure and Grimeaud, 2000; Monti, 2002). The extension of liability to corporate partners is a more difficult circumstance, but it too highlights the desirability of EFA.

The law regularly extends financial liability to the business partners of absent or bankrupt defendants. The incentive for extending liability is identical to that for financial assurance, as seen in the insurance industry where compensation and deterrence are served by the internalisation of financial costs (Faure and Grimeaud, 2000). Corporate entities exposed to their business partners' financial obligations will diligently monitor those partners' safety. Such partners also provide a source of compensation that can be sought out if required.

Under CERCLA, an acquiring company takes on the liabilities attached to a property possessed by the seller (Price, 1984; Buckley, 1990). Accountability is also extended from mine operators of disposal facilities to the original generators of the waste (Price, 1984) and legal responsibility can be applied without reference to fault or the liable mine operator's proportional contribution to the environmental damage.

Financial assurance is preferable to extended liability for a multiple of reasons. Foremost, the extension of financial responsibility does not ensure cost internalisation given there may be no business partners from whom to seek reparation or if such partners may themselves be in receivership. Secondly, joint or multiple environmental obligations entail significant transaction costs related with ex-ante contracting between mutually liable entities and the resolution of ex-post claims for contribution among jointly responsible offenders (Price, 1984; Buckley, 1990). Lastly, extended liability can impact production decisions (Price, 1984).

3.4 Politics and Costs of Assurance

Regulated communities typically oppose new or strengthened financial assurance rules (Peck and Sinding, 2009). New regulations produce dismal expectations of higher insurance rates, the possible departure of insurers and surety providers from the market, and the potential demise of extractive companies who are unable to meet new financial assurance requirements (Faure and Grimeaud, 2000; Boyd, 2001). Amendments to mining regulations have often prompted opposition based on their adverse impact on small mine operators (Boyd, 2001). Should such uncertainties call into question FA's social desirability? It should be mentioned that much resistance can be accredited to an underlying cynicism and distress of increased financial liability as opposed to fear of financial assurance requirements themselves (Faure and Grimeaud, 2000; Boyd, 2001; Dondo, 2014).

3.5 Scope of Assurance Rules

Financial assurance is an elegantly simple concept where its central purpose is to protect public finances in the event a mining company becomes bankrupt or fails to carry out its legal commitments related to the normal activities of its project(s), including mine decommissioning and reclamation. EFA requires operators to demonstrate the availability of financial resources to conduct closure and environmental activities. Such simplicity highlights a set of crucial design issues.

Issues of the proper scope of financial assurance requirements relate to the obligations and liabilities that are covered by EFA and the dollar value of coverage or bonding that must be demonstrated. Tension often arises between the objective to maximise the scope of FA, to maximise deterrence and compensation, and the need to reduce compliance costs by minimising EFA requirements (Faure and Grimeaud, 2000). Issues surrounding the effectiveness of a regulatory approved EFA mechanism is also often questioned by concerned stakeholders (Marcus, 1997; Faure and Grimeaud, 2000). One approach for liable parties to decrease their financial burden and their financial risks is to reduce the amount of security they provide as financial assurance. A significant obstacle inherent in environmental regulation is that they require regulators, who usually possess limited enforcing resources, to monitor and ensure the financial mechanisms' security is financially adequate over long periods (Marcus, 1997).

3.5.1 Appropriate Coverage Levels

To internalise costs and subsequently to ensure environmental obligations are sufficiently performed, financial assurance regulations need to provide a mine operators' capacity to internalise costs in the future. Financial coverage requirements should be satisfactorily high enough to validate the performance of the required obligation or internalisation of future environmental expenditures. An opportunity cost will arise if coverage requirements are greater than the required levels since they would be excessive given that a company's capital would be tied up without it yielding any additional social benefit (Grimeaud, 2000). Conversely, coverage requirements lesser than the required levels are also detrimental since they would not ensure cost internalisation, and thus yield an insufficient level of deterrence and compensation (Grimeaud, 2000). As in insurance economics, FA rules mandate coverage up to some finite dollar value, even if there is no actual upper limit to the likely damages arising from an operation (Zweifel and Eisen, 2012).

3.5.2 Determining the Required Assurance Levels

Regulators and corporate entities rarely know with confidence what actual costs will ultimately be since such reclamation liability cost estimates are subject to negligent, deliberate, or inadvertent error. Financial obligations related to pollution disasters are even more challenging to predict. Given such uncertainties, the calculation of the necessary financial assurance amounts can be problematic.

A variety of approaches are utilised to determine coverage requirements. In some circumstances, these obligations are determined on a case-by-case basis, which considers the specific risks posed by a mining operation. In other situations, greater procedural formality is imposed via established estimation approaches. To further complicate matters, cost estimates frequently change considerably over time (EY, 2017). EFA amounts must also be adjusted accordingly for cost inflation, expansion of operations, and changes in a mine site's environmental conditions (Cheng and Skousen, 2017).

The Pennsylvania Department of Environmental Protection points out that a surety bond, in general, is not a suitable financial instrument for safeguarding the long-term treatment of a post-mining pollution discharge since it is finite and fundamentally incapable in keeping up with inflation (PA, 2007). In Pennsylvania, every five years, when a mining permit is renewed, the permittee must make available additional financial assurance to keep pace with inflation and changing site conditions. Due to the general term and given it is highly improbable that the bond will ever be released, many permittees will be unable to obtain the obligatory assurance to meet their legal obligations. As a substitute to bonds, Pennsylvania's Surface Mining Act permits the Department of Environmental Protection to establish alternative FA mechanisms that meet the objectives and purposes of the bonding programme. One alternative tool created by the Department is a trust fund (PA, 2007).

Accordingly, the estimation of required coverage amounts places a substantial burden on the regulator to assess the quality of the values and estimation methods. Under some regulatory programmes, a fixed schedule of requirements is imposed across an entire industry (Boyd, 2001). Overall, though, regulatory agencies may possess a high degree of difficulty in determining suitable financial assurance levels (Boyd, 2001). Several legal cases highlight the procedural challenge. For instance, in *Leventis et al., v. South Carolina DHEC, et al.*, the Sierra Club persuasively argued that the state environmental agency neglected to estimate and assess acceptable clean-up, closure adequately, and reclamation financial assurance amounts for a hazardous waste disposal facility (Boyd, 2001).

3.5.3 Auditing Self-Estimated Assurance Requirements

While regulators can perform cost estimation themselves, such evaluation is time-consuming and costly. In some circumstances, mine operators are asked to develop their environmental liability cost estimates as a basis for their EFA obligations. Absent of adequate oversight, these valuations may prove to be low. After all, low-balling assessments of future environmental requirements is a good approach for companies to minimise their costs of financial assurance. A low approximation translates into lower coverage obligations and, therefore, lower compliance costs. Therefore, audits, ideally conducted at regular intervals, by certified third-parties, as the dissertation is proposing, are imperative to ensure that adequate financial assurance is put in place. It should be noted that an advantage of fixed assurance schedules is that they minimise this auditing burden.

Absent of a suitable audit process, it is ill-advised to permit mine operators to assess the amount of their EFA obligations. There is evidence that companies regularly underestimate R&C requirements while conforming to assurance regulations (US EPA, 2001). One US EPA study found that 89 of 100 facilities submitting landfill liability cost estimates miscalculated their closure expenditures and thus posted low levels of EFA (US EPA, 2001). Furthermore, the US EPA (2001) report stated that the total amount of the under-estimates was substantial, estimated at $450 million, just for those 89 facilities. Because the usefulness of financial assurance rules hinges in large part on having enough financial guarantee funding, and since the level of EFA is often based on liability cost estimates, verification of such estimates should be an essential regulatory priority.

The US White House released its fiscal 2019 budget in February 2018, where it outlined the administration's budgetary priorities. It included cuts to programmes like Medicare and food stamps, and leaner budgets across federal agencies, including the US EPA (Davis, 2018). It also cut several programmes and shifted many environmental responsibilities to the states. Moreover, funding to the states has been reduced. Among the programmes that were cut or modified at EPA and other agencies is the elimination of thousands of federal EPA jobs and environmental projects at the state level, educational institutions, and government contractors; cuts in funding for Superfund clean-ups; and increased funding for fossil fuel development on public lands and waters (Dennis et al., 2018).

3.5.4 Adequacy of Coverage Levels

The best test to determine if coverage levels are adequate is the degree to which mine operators' EFA obligations are met over the decades. Because many current financial assurance rules are somewhat recent, and cover obligations that arise over decades, it is challenging to draw definite conclusions concerning the sufficiency of coverage levels for longer-term projects since overall patterns of cost recovery have not been identified yet.

Financial assurance levels are an exception since such an obligatory funding commitment mechanism has been required for decades, and there is enough evidence that mining surety bond levels have been inadequate and continue to remain so. A finding that is of interest observed that reclamation standards, which regulate bond amounts and the conditions for the release of bonds, were not well documented and are commonly subjective and problematic to measure (US EPA, 1997). Such an observation highlights the significance of standardised, audited reclamation liability cost estimates and performance standards.

Another issue relating to the sufficiency of surety bond amounts arises from the usage of trust funds as an EFA mechanism (GAO, 2005). If a fund is fully funded at its inception, then coverage should be satisfactory, provided that the required coverage amount is acceptable. Some programmes, however, permit mine operators to pay funds into a trust fund over time. Note that if an operator becomes insolvent before a trust is fully funded, the actual amount of available coverage will be subsequently deficient. Partly funded trusts are common (GAO, 2005).

3.5.5 Confiscation Concerns Arising from Assurance

Some mining advocates have raised concerns that EFA may enhance a regulator's ability to confiscate private property (Shogren et al., 1993; Tan, 2007). It should be mentioned that many surety bonds are so-called '*penal bonds*' where they authorise the forfeiture of the whole bond amount for failure to perform as agreed (US EPA, 2010). Consequently, even though the performance failure may have a comparatively small cost associated with it, a more considerable bond sum can be collected by the government (US EPA, 2010) – this is by design, though, and is agreed upon mutually by the parties before the fact. Consequently, penal bond collections represent less a worrisome form of confiscation, and more of a penalty used to encourage compliance with performance standards.

3.5.6 Liability Limits and Assurance Coverage Requirements

Financial assurance requirements, even if based on sound estimation procedures, may be surpassed by the final costs of reclamation or liability. If so, the mine operator's liability may be limited to the assured amount since the company may have no other accessible funding to cover environmental claims. Legally, conversely, its obligation is not generally defined by the amount of required FA (Auditor General of Canada, 2012). It would be liable for any environmental damages it causes, regardless of the amount of mandatory assurance.

From a public policy perspective, the alternative of liability limits reflects a trade-off. For one thing, truncated impairment awards reduce uncertainty, which can be anticipated to decrease the costs of assurance and thus may encourage the development of markets for third-party assurance products. Furthermore, from a regulated company's perspective, liability limits discipline the regulator's pursuit of claims the polluter operator may feel are unsupported. Consequently, liability limits may encourage political resistance to FA requirements. Conversely, these benefits to the regulated community must be weighed alongside the downside of capped liability. Specifically, that environmental costs above the limit will be uncompensated by responsible parties.

3.6 Security of Assurance Mechanisms

Financial assurance rules should be judged on their capacity to offer adequate compensation when environmental obligations come due (Faure and Grimeaud, 2000; Halland et al., 2015). It is consequently essential to comprehend the manners in which the efficiency, or security, of FA can be derailed. In some instances, companies may blatantly fail to abide by coverage requirements (Faure and Grimeaud, 2000; Boyd, 2001; Miller, 2005; Halland et al., 2015). In other situations, third-party FA providers may themselves be incapable of delivering on financial obligations due to their insolvency (Halland et al., 2015). The financial mechanisms utilised to establish compliance may be flawed, by design or negligent regulatory oversight (Halland et al., 2015). In this respect, self-bonding is a particularly perplexing compliance mechanism (Hein et al., 2016; Harmon, 2017; Richards, 2017). Lastly, government regulators may neglect to oversee EFA instruments effectively, and therefore, permitting secured funds to be released prematurely (Halland et al., 2015).

3.6.1 Compliance Evasion

A feature of financial assurance regulations is that they create an incentive for third-party assurance providers to monitor the performance and environmental safety of the mine operators whose financial obligations they underwrite or guarantee (Faure and Grimeaud, 2000; Boyd, 2001). Such a measure can lessen some of the enforcement liability on regulatory agencies. An enforcement burden that is not relieved, though, is the requirement to guarantee that companies conform to the EFA requirements themselves. Like any regulation, FA requirements require monitoring and penalties mechanisms to encourage compliance (Faure and Grimeaud, 2000).

3.6.2 Assurance Evasion through Bankruptcy

Financial assurance rules decrease the risk that corporate entities with environmental obligations will be insolvent when the requirements come due. In some instances, though, EFA is imposed, or higher amounts must be posted, while a company is already insolvent (US EPA, 2001) – this creates a clash between bankruptcy law and FA requirements. Boyd (2001) offers an illustration, environmental clean-up costs, once it is insolvent, could be a dischargeable entitlement under the bankruptcy code. With the code as a buffer, mine operators have attempted to elude EFA requirements by appealing that assurance-related costs are dischargeable obligations (Boyd, 2001). Nevertheless, courts have held that financial assurance costs, including the mandatory posting of FA or increased assurance amount to cover R&C costs, are not money rulings under the bankruptcy code and fit within the regulatory powers' exception to the automatic stay (Boyd, 2001).

3.6.3 Assurance Provider Insolvency

Sureties, insurers, and banks can themselves become insolvent, thus jeopardising the accessibility of EFA instruments. Regrettably, there is no insurance against an underwriter's financial failure unless they possess reinsurance. Regulations typically guard against the likelihood of insurer insolvency by securing ratings for the underwriter, necessitating US Treasury certification of bond issuers or, at least, requiring some form of licensing for financial institutions who offer EFA (US EPA, 2010). Nevertheless, assurance provider insolvencies are common (US EPA, 2010).

A concern when underwriters become insolvent is that their former customers must seek out FA elsewhere and on short notice at times. For financially healthy clientele this is not usually an issue. When mine operators in need of EFA are undergoing financial difficulties of their own, though, a replacement can prove problematic. In some instances, new assurance may not be accessible. When a financial assurance provider fails abruptly, and a company with FA obligations is in financial distress, regulators face a severe dilemma (US EPA, 2010). Officially, non-compliance with EFA regulations is grounds for an injunctive action, which could include mining operations closure. Such a penalty can be a prevailing compliance motivator if a corporate entity is financially healthy. When it is near insolvency, though, closure yields no real environmental benefit, since it starves the mine operator of cash flow that could be employed to finance monetary obligations, improve its capability to secure alternative assurance, and evade bankruptcy (US EPA, 2010).

3.6.4 Defences, Exclusions, and Cancellation

For EFA to be capable such instruments should not contain exclusions or defences that might hinder the host regulator's ability to collect financial obligations (Boyd, 2005; US EPA, 2008). It is also critical that such financial instruments not be quickly withdrawn by providers if substantial environmental costs develop. In most circumstances, insureds and insurers willingly settle on coverage exclusions and cancellation terms (Boyd, 2005).

3.6.5 Monitoring, Administration, and Record-Keeping

Host regulators must supervise FA instruments in a variety of ways (US EPA, 2001). First, the initial establishment of an approved assurance mechanism must be confirmed, typically by inspection of a coverage contract from an approved underwriter (US EPA, 2001) but, equally important, the continuing soundness of financial assurance contracts must be established.

Regulatory rules themselves can assist in simplifying the regulator's responsibilities and for instance, necessitating letters of credit to renew themselves automatically thus relieving regulators of one of the duties – the necessity to validate annual renewals. Sound bookkeeping and monitoring of instruments are critical to ensuring that the EFA contracts will be binding and offer adequate funding in the future.

An issue is the release of financial assurance funds by providers without regulatory approval (US EPA, 2001). Regulations, in such an instance, requires the government regulator to be the sole recipient of the financial assurance (US EPA, 2001). Changes in trust agreements or bank accounts can arise over time, FA providers themselves can restructure or merge, and records need to be updated to reflect changes in the EFA instruments (US EPA, 2001). Minimally, administrative procedures and regulatory requirements need to place prominence on essential record-keeping to facilitate the legal and financial maintenance of FA instruments (US EPA, 2001). The fact that regulators are characteristically not contract lawyers, accountants or even financial assurance experts complicates such an undertaking.

Another burden that government regulators face is the decision to release EFA funds after a mine operator’s reclamation, closure, post-closure, and other requirements are satisfactory met. Such a decision entails engineering and scientific expertise instead of financial judgement; however, the administrative challenge is evident. The quality of R&C efforts can be problematic to evaluate (US EPA, 2001). Mine operators possess the right to challenge a regulatory agency’s decision of if their posted FA should be released. Litigation over such issues is frequent in some instances, and it adds to administrative costs (US EPA, 2001).

3.6.6 Self-Demonstration and Corporate Guarantees Issues

Self-assurance and corporate guarantees permit selective mine operators to pass a set of accounting tests as an alternative to having to secure suitable financial assurance. When a company self-guarantees, its financial status is utilised to fulfil the criteria. When a corporate guarantee is applied, the corporate parent’s financial condition is employed. Almost all FA programmes permit self-assurance and corporate guarantees as methods of compliance (Miller, 2005). To the regulated community, self-guarantee is inexpensive, and, therefore, a desirable form of compliance since no coverage needs to be purchased, or no dedicated funds need to be kept back (Miller, 2005). Consequently, regulatory agencies and governments may be pressured to relax self-guarantee standards to permit more operators to conform in this nearly costless manner. Self-guarantee is desirable when utilised by the wealthiest, most ecologically responsible, and most financially stable companies since it avoids the cost of purchased EFA. Regrettably, it can be unexpectedly problematic to differentiate between such entities and their less stable and scrupulous counterparts.

The main issue surrounding self-assurance and guarantees is that there exists no FA instrument devoted to environmental obligations. In concession of self-assurance's dangers, regulations feature a set of defences designed to guarantee the company's capacity to absorb future costs. For instance, corporate entities must pass one of two assessments – a bond rating test or a set of financial ratio tests based on the sum of net income plus depreciation, depletion, and amortisation to total liabilities; current assets to current liabilities; and total liabilities to net worth (Boyd, 2001). Furthermore, there is a domestic assets test, a tangible net-worth test, a net working capital test, and a net working capital and tangible net worth to estimated closure and post-closure costs ratio test. Such a daunting set of accounting challenges suggests that many mining companies would not qualify for self-guarantees.

A regulator's task is similarly daunting. Interpretation, verification, and monitoring of such financial litmus tests over time entail either substantial in-house accounting expertise or reliance on third-party audits. Regulations regularly require independent accounting reports; however, this is not iron-clad protection since accounting fraud is relatively common, and representative among smaller mine operators and those experiencing financial distress which could lead to insolvency – precisely the kind of company and condition that can pose the most severe financial assurance complications (Boyd, 2001).

Accounting standards for environmental liabilities and other financial obligations are also not satisfactorily standardised (Boyd, 2001). There tends to be a significant inconsistency in the manner EFA obligations are recognised for accounting purposes. It can also be very challenging to fully evaluate the degree to which a company's assets are pledged to other creditors or liens. From a bookkeeping perspective, it is difficult to evaluate all the environmental obligations attached to a single company. Mining companies often operate multiple operations with multiple commitments in various host jurisdictions. Consequently, summing up all these requirements and accounting for them properly is fundamental to the goal of evaluating a corporate entity's capacity to internalise costs years in the future (Boyd, 2001). In brief, EFA accounting is problematic not only for regulators untrained in its intricacies but for accountants themselves.

Another concern is that a company's financial status can rapidly worsen and if this materialises the regulator may not even be informed of a financial crisis for many months. Self-guaranteeing also raises another issue since it involves no specific financial asset to which a regulatory authority can lay claim in the event obligations are not performed. Certain EFA instruments may not always be easily converted into compensation. Nonetheless, these instruments are more likely to yield liquid sources of payment (US EPA, 2001) – mainly true if the regulating agency is made the sole recipient of the FA instrument. The purchased coverage will also tend to be regarded by courts as explicitly committed to liability or reclamation requirements, and therefore more probable to be recoverable for regulatory agencies. The assets claimed by a self-guarantee company are much more fleeting. Assets that are not expressly dedicated to FA requirements in a legally binding capacity would be sought in competition with other creditors should they be in place and possess material value upon obligations becoming due.

Financial assurance rules are intended to discourage environmental damage and to provide compensation when environmental problems cause injury while assuring that corporate entities will be able to meet their future environmental R&C obligations. EFA is alluring in theory since it helps allocate costs to the parties best able to plan for and reduce them – the potential polluters themselves. FA is enticing in practice since it accomplishes its goals at comparatively low cost and without significant commercial disruption. It is significantly desirable when observed relative to the alternatives: charges imposed after-the-fact on offending companies' commercial partners or abandoned to society. Compared to such alternatives, financial assurance leads potential polluters to a transparent, in-advance understanding of their future environmental obligations. EFA's value as a deterrent is enhanced further when companies must purchase FA from third-parties since availability and coverage rates will be determined by the entity's environmental track record and expectations of future environmental performance. The extensiveness of operations and risks covered by current regulations is an illustration of FA's practicality. Markets for EFA coverage offer a wide variety of financial instruments that can be personalised to the requirements of individual corporate entities, facilities, and regulatory requirements.

If there is to be a critique of FA requirements, it could be that they do not go far enough. It is clear, for instance, that much of the held EFA by government and third-parties has not been sufficient to safeguard a sufficient level of mine reclamation. In other programmes, more exposure to cost recovery over more extended periods is required to determine whether the scope of FA requirements is acceptable. The security of specific assurance instruments is also deserving of continuing examination. Self-guaranteeing assurance, captive insurance arrangements, trust funds with lengthy pay-in periods, and claims-made insurance policies may hamper cost recovery – principally the recovery of costs that arise only after a period of possibly many decades.

3.7 Financial Assurance for Reclamation Regulations and Policies

Regulation is frequently predicated on international standards, benchmarks, and policies, and these regulatory influences are themselves often conditioned by contending political, social, economic, and philosophical concepts (Schiavi and Solomon, 2007). Formal regulation is a product of benchmarks, standards, and policies and has mostly been included in the legal jurisdictions of both developing and developed countries. Regulation, as it relates to environmental R&C efforts, is no different.

Regulation surrounding reclamation and closure efforts of mine sites includes oversight of the abandonment notification of approval, reclamation inspection and certification, and liability management. Such guidelines are currently partitioned, depending upon the kind of operation activity and whether the mine site is on private versus public lands (Lefsrud, 2017). Such a partitioning result in differences in the regulatory agency possessing authority, the relevant legislation and regulations, the approval/review process, and access to the regulatory-acceptable financial instrument(s) to terminate or transfer liability.

The objective of regulatory policies is to fundamentally take suitable measures to mitigate environmental risk and increase the efficiency of reclamation activities for mining operations in a host jurisdiction. However, many observers have expressed how regulations are narrowly focused, out of date and inefficient, which can slow the advancement of mining projects (Lefsrud, 2017). The consensus is that the regulatory efficiency for managing industrial developments needs to be amended (Lefsrud, 2017).

There are many limitations of the common law in promoting prevention, including the likelihood of spotting the harm, the latency period between cause and effect, the appointment of blame, and the probable judgment-proof nature of the corporate entities (Shavell, 1986). A review of the limitations of liability in handling risks is instructive for the advancement of an understanding of the practicality of financial assurance mechanisms. The first concern is the capacity to detect and assign blame for the environmental harms caused (Faure and Grimeaud, 2000). If there are complications with the storage facility, such as a surface leak in a remote area, then the impairment could be problematic to detect, making it improbable that any party would sue for damages.

Another challenge to liability is that companies responsible for injection and storage could lack the necessary funds to address any complications that arise (Faure and Grimeaud, 2000). In such instances, a company's assets are the upper bound on liability and the deterrent effect of debt will be inadequate. In this circumstance, the entity is said to be judgment-proof, and ex-post damage awards will not offer adequate deterrence against the risky activity. Shavell (1986) describes the confines of liability in internalising external costs. Ringleb and Wiggins (1990) contend that large companies form subsidiaries, such as SPVs, to protect the assets of the parent company from environmental and safety liabilities (Klee and Kornhauser, 2007). If a company becomes insolvent, there will be no funding available to continue mine site monitoring and maintenance or to address any complications that arise. In circumstances where they become insolvent due to the financial obligations arising from some unfortunate environmental or safety mishap, this can be a critical issue.

A third difficulty with liability is the time horizon between cause and effect (Shavell, 1986; Ringleb and Wiggins, 1990; Faure and Grimeaud, 2000). Given the time horizons for appropriation, there could be an extended latency period before any surface leaks or underground seepage ensue – this presents several complications. First, a responsible party may no longer be in the position to deal with the damages by the time that problems arise (Faure and Grimeaud, 2000). Additionally, since problems may only occur after some extended period, companies might lack the motivation to take necessary measures to guarantee the long-term integrity of the storage facility (Faure and Grimeaud, 2000).

3.7.1 Financial Assurance as a Complement to Liability and Regulation

The necessity for financial assurance requirements stems from the moral hazard debate – if there are high costs of monitoring performance, companies may respond by shirking on their environmental and safety responsibilities. The principal concern is that the public will be burdened with the obligation to remediate environmental damages and safety risks. Liability and assurance mechanisms each offer financial incentives for them to address such effects. Under liability, a damaged party initiates litigation to recuperate monetary damages for any harm caused, and the prospect of a damage award is the motivation to ensure due care. Nevertheless, the deterrent consequence of tort liability is inadequate if the company lacks enough assets to cover damages. In effect, its assets are the upper bound on liability.

Financial assurance possesses several distinct differences from reliance on a liability rule:

- it is posted up-front contrasted with being settled after-the-fact;
- if the corporate entity neglects to comply with its R&C obligations, the forfeited collateral is instantly available to remedy the performance failure;
- the FA instrument shifts the burden of proof from the regulator proving that harm was done to the company to demonstrate that compliance criteria were met; and
- the public sector is only protected up to the amount of the EFA posted, and not for the full amount of possible reparations. If the company remains solvent, regulators can pursue a remedy through the courts.

Public Ownership

One of the concerns regarding long-standing mining projects is that in the far distant future it seems doubtful that any legislative or regulatory structure will provide private mine operators long-term reclamation responsibilities in perpetuity (Bocking and Fitzgerald, 2012). It is more likely, however, that there will possibly be some period where these companies are accountable, and subsequently, such long-term obligations are turned over to the public sector. While EFA is regularly required to ensure proper reclamation and closure efforts are achieved, in many instances no long-term monitoring after-the-fact is compulsory, and the financial assurance funds are released upon completion of the work.

3.7.2 Regulatory Efficiency

Economists, regulators, and industry have different viewpoints in how regulatory efficiency is defined. These perspectives are not mutually exclusive.

Economic Perspective

Economists describe regulatory efficiency as attaining the anticipated objectives at the lowest possible cost (Arrow et al., 1996; Goodstein and Polasky, 2007). Preferably, the benefits of the regulation surpass the costs. The costs and benefits should be quantifiable to calculate this but if that is not possible best estimates of the costs and benefits should be utilised coupled with the accompanying uncertainties (Arrow et al., 1996; Goodstein and Polasky, 2007). Distributional inequity must also be considered since those who receive the benefits are not necessarily the same as those who bear the costs (Arrow et al., 1996; Goodstein and Polasky, 2007).

Regulatory Perspective

From the regulators' viewpoint, efficiency is described as safeguarding the protection of society as paramount while permitting development that benefits the country (McNamara, 2009; Dondo, 2014). To accomplish this, regulators must have a clear direction from the government to guide them to support sound regulatory decision making and adjudication. It also entails that the public understands the government's position on a resource and environmental policy issues and can offer input to the development of new policy.

Internal regulatory efficiency entails access to required data and information to government, industry, and the public. Preferably, the requirement for enforcement should be minimised since constant vigilance and enforcement is equally expensive and resource-consuming (McNamara, 2009). Enforcement has become increasingly more significant as host mining jurisdictions face the difficulties associated with EFA forfeitures and insolvencies be it mine operators or financial assurance providers themselves (McNamara, 2009; Dondo, 2014).

Industry Perspective

Industry leaders often classify and remark regulations as being a burden that makes their operations inefficient and uncompetitive. The truth of the matter is that well-written environmental protection policies can encourage businesses to be more innovative and efficient (Steen, 2017). Innovative products and processes in response to regulation efficiency can also lead to renewed industrial competitiveness and growth (Steen, 2017).

The industry describes regulatory efficiency as possessing a strong understanding of the duties it must meet while offering society confidence that industry is pursuing sound and responsible operating practices (Rajaram et al., 2005; Campbell, 2012). Such efficiency is achieved through transparent, predictable, and effective regulatory policies to allow companies to define their operational strategies adequately. It also entails an application review process with a specified period. Regulatory efficiency would ensure that industry participants can appeal a regulator’s decisions through a timely, formal, transparent, and procedurally fair appeal process.

Effective governmental regulation can also lead to innovation performance during low market uncertainty (Blind et al., 2017). They examined the impact of formal standards and regulation on a company’s innovation efficiency in contrasting levels of technological uncertainty. Their findings outlined that formal standards lead to lower innovation efficiency in markets with low uncertainty, while regulations display the contrary effect. In instances of high market uncertainty, Blind et al. (2017) observed that regulation leads to lower innovation efficiency while formal standards had the opposite effect.

Munro (2015) contends that the mining industry’s reputation is exposed to two states which may develop in a regulatory vacuum. First, on occasions where there is an alleged regulatory weakness, it attracts rogue mine operators who try to take advantage of lower environmental regulatory thresholds, primarily to save time and reduce costs. This method of mining has produced many environmental scars and health effects throughout Africa. Secondly, Munro (2015) asserts that some mine operators fail, through ignorance, to observe acceptable standards – where there is minimal in-country supervision. These factors place an added burden on mining companies operating in the African continent.

Many complications result from Africa’s stage of development and recent history since such factors can destabilise the mining sector’s recovering reputation across the African continent and pose new threats and risks to both the industry and companies. The entrance into the industry of mine operators from countries without a proven history is an additional cause for alarm and growing discontent in host societies (Munro, 2015).

Steen (2017) outlined the Porter hypothesis for the relationship between proactive environmental policy and industry competitiveness. Porter and van der Linde (1995) maintained that the environment-competitiveness debate had been framed inaccurately. They contended that appropriately designed environmental standards could prompt innovation that may partly or more than fully offset the costs of conforming to regulation and can even lead to absolute advantages over companies in foreign countries not subject to comparable rules. The hypothesis proposes that strict environmental regulation prompts the discovery and introduction of environmental improvements and cleaner technologies, the innovation effect, making production processes and products more efficient (Wagner, 2003). The cost savings that can be attained are appropriate to overcompensate for both the compliance costs directly attributed to the innovation costs and new regulations. Such savings in funding charges through financial assurance-backed securitisation is expected to be effective if they are higher than the cost of innovation in reclamation efforts, unless external pressure from specific stakeholders arises.

The PH is debatable since this opinion defies a long-held paradigm in economics that postulates that, as profit-maximising companies, such entities are already using their resources most efficiently to attain maximum profits, and that regulations confine its options, unavoidably leading to suboptimal returns (Ambec et al., 2013). Interest in the hypothesis has increased rather than contracted over the past two decades, due in part to the prevailing implications of this theory. If well-constructed regulations can be demonstrated to benefit companies, it could become much easier for industry and government to jointly establish environmental regulations that encourage productivity, improve competitiveness, and attain significant environmental targets that benefit a nation.

Literature has evaluated different aspects of the Porter hypothesis and has also investigated several environmentally regulated industries to discover what the existing evidence indicates regarding the theory in practice. Some literature proposes that it is difficult to find general theoretical arguments on which to build mechanisms that provide the results of the hypothesis. As a result, its validity could be regarded as an empirical question – this suggests that it is challenging to distinguish between the ‘*weak*’ form, the ‘*narrow*’ version, and the ‘*strong*’ form of the hypothesis (Jaffe and Palmer, 1997).

The ‘*weak*’ version of the PH theory suggests that environmental regulation will inspire certain types of environmental innovations. Environmental regulation encourages innovation; though, it does not extend to competitiveness and profitability. The ‘*narrow*’ version of the theory emphasises that governments with flexible environmental policies give companies greater motivation to innovate than rigid regulations, such as technology-based standards. Lastly, the ‘*strong*’ version of the hypothesis proposes that appropriately designed regulation may encourage cost-saving innovation that more than reimburses for the expenditures of compliance. The implication is that environmental regulation indorses innovation, which instigates competitiveness.

Using data collected in the recent AUD$200 billion expansion of the Australian oil & gas industry, Steen (2017) provided evidence that the Porter hypothesis relationship does indeed hold. However, it is highly reliant on the maturity of the sector and its stage of technological development. Specific cases of innovation in answer to regulation within the hydrocarbon and mining industries further highlight the central role of regulatory frameworks in the development of these industries. Steen (2017) expressed that:

- environmental regulation is essential for novel innovation but so is reputation and technical skill;
- regulation should be sensitive to the level of industry technical and development capability;
- surpassing compliance and pushing industry standards can be a good business strategy;
- service companies are much more likely to introduce innovations of any type; and
- industry, environmental, and innovation policies are all connected here.

Bare-knuckling between business competitiveness and environmental protection is negligent since good environmental policy benefits environmental protection, and business can make use of environmental performance for competitive advantage. Steen (2017) concluded by discussing the need to connect government policy silos since environmental protection should not just be considered an environmental agency problem. Engaging in discussions between industry and policymakers is equally crucial given well-designed industry policy encourages international competitiveness and productivity while strengthening environmental education and research policy boosts both research and development capabilities and develops workforce skills (Colla et al., 2012).

3.7.3 Issues and Policies in the Use of Financial Assurance

The mining industry has always considered itself a global industry. Since the 1990s, though, an extraordinary explosion of interest among countries on every continent in using their mineral resources as an engine of development has been witnessed (Connolly and Orsmond, 2011). To do so involves attracting considerable mining investment. Together, companies, governmental regulators, and international institutions have all become more conscience that mining activities should be carried out with due care to the protection of the environment and FA measures are essential instruments to pursue such objectives.

Two forms of policy are associated with financial assurance for mine R&C requirements (US Congress, 1994; Peck, 2005): i) there are framework policies which outline the general rules relating to the usage of assurance, and ii) decision rules are governing the selection of specific EFA arrangements to be applied to companies and mining projects.

Policy Summary of Mine Reclamation Regulations

The analysis describes the current FA regulation in the following mining jurisdictions:

- Afghanistan (Renaud, 2017);
- Australia (Western Australia) (Kabir et al., 2015; Australian Government: Department of Industry, Innovation and Science, 2016; Morrison-Saunders et al., 2016; Stantec Consulting, 2016);
- Canada (British Columbia) (Kabir et al., 2015; Stantec Consulting, 2016);
- Chile (Veiga et al., 2000; Bastida and Sanford, 2006; Olivari, 2014; Bastida, 2015; Sanzana et al., 2015; Calmon, 2016; OECD, 2016);
- China (Zhao et al., 2015a; Zhao et al., 2015b; Cheng and Skousen, 2017);
- Ghana (Twum, 2013a; Twum, 2013b; Morrison-Saunders et al., 2016);
- Kazakhstan (Faizduldayeva, 2016);

- Kyrgyzstan (Faizduldayeva, 2016);
- Mongolia (Hogan Lovells, 2012; Cane et al., 2015; Robinson, 2015);
- Mozambique (Morrison-Saunders et al., 2016);
- North Korea (Yoon, 2011; Vasey, 2017);
- Papua New Guinea (Commonwealth of Australia, 2006; Sassoon, 2008);
- Peru (Veiga et al., 2000; Bastida and Sanford, 2006; CCSI, 2016; Calmon, 2016);
- Russia (Faizduldayeva, 2016);
- South Africa (Sassoon, 2008; Morrison-Saunders et al., 2016);
- Tanzania (Morrison-Saunders et al., 2016);
- United States of America (Gorton, 2013); and
- Zambia (Morrison-Saunders et al., 2016).

Similar patterns in R&C objectives are observed in Western Australia, Canada, Chile, South Africa, and the United States. Physical and chemical stability is one of the repeated environmental targets, along with public health and safety. Financial assurance in Western Australia, British Columbia, Chile, South Africa, and the United States covers the full cost of mine closure. Different EFA mechanisms are employed to ensure that the cost of the mine closure will be adequately provided for.

When contrasted with international good practise standards of certain countries such as Australia, Canada, South Africa, and the United States, the analysis reveals that the mine closure regimes in some countries are still in their developmental stages and are well below advanced standards.

The present level of foreign investment in mining interests in resource-based jurisdictions around the world is influencing the way approved reclamation and closure requirements are approached. Notably, as companies apply more stringent closure policies from their native countries to mine sites in developing nations and as investors increasingly demand that sustainability issues be incorporated into all mining operations, despite a lack of local, suitable environmental regulation and policy (Garcia, 2008).

In the absence of well-defined closure regulations, mine operators may choose to use reclamation and closure guidance from international sources such as the World Bank, as well as prominent national and state or province-specific legislation. Although R&C regulations are not equal in all countries, the trend is for increased regulation of mine closure by governmental and lending agencies.

Details relating to the financial assurance securitised structure are described in Appendix G.

Chapter 4: EFA Securitisation Framework Model and Results

> *Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.*
>
> — Dr George E.P. Box
> Professor Emeritus, University of Wisconsin

A key objective of the dissertation is to examine if the financial assurance requirements that mining companies[41] are obligated to post, in escrow, before the authorised mine activity is carried out can be securitised in the same manner as other conventional and nonconventional assets[42]. The response to this question, if found *favourable*, could benefit the various stakeholders, including government regulators and mine operators, while attracting sophisticated investors (e.g., institutional clientele) and others (via exchange-traded funds (ETFs) and specialised funds) as a potentially cost-effective and readily-accessible source of '*social-centric*' financing for environmental reclamation purposes for mine operators but not necessarily exclusively.

The proposed securitised model[43] could alleviate the upfront financial burden that these mine operators face in needing to demonstrate they possess an adequate amount of financial assurance at the initial onset of a mining project when their cash burn rate is often high while access to debt funding is sometimes low. Such a structured finance mechanism could become an alternative, potentially cost-effective, FA supplier in a financial market's environment where the increasing lack of surety providers is present (Learn, 2016).

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[41] Although not limited to this sector alone, any industry that requires financial assurance – including oil & gas, infrastructure, nuclear, chemicals (including paint and coatings), and livestock farming.

[42] The research refers to it as an *EFA-backed structured finance technique* or simply *EFA-backed securitisation*.

[43] A viable form of ESG (environmental, social, and governance) financing.

Appendix F provides a review of structured finance and securitised mechanisms. It also describes and explains the essential methodologies used to develop the model, and the appendix discusses the observed benefits and drawbacks of asset-backed securitisation to key stakeholders of environmental risks.

Securitisation of financial assurance obligations may help to resolve another practical matter, the proper valuation of mine R&C costs. Rethinking the FA challenge might begin by trying to minimise or even eliminate in some circumstances both the high-cost government work and the budget-constrained mine operator from the liability equation. To do this would require that an operator works on an ongoing basis with an independent group of qualified industry parties that may help determine the future value of the R&C costs, oversee the completion of reclamation requirements, and, if required, mediate when required should adverse issues arise within the company (similarly, for reclamation left in default). This party, which would be certified by government and industry, would also undertake the R&C responsibilities of orphaned and abandoned mines from governments.

What group of professionals would possess sufficient resources and expertise for such a purpose? The local mining industry, and under the guidance of its respective regulators, of course. Should such a strategic alliance proposal be rejected out of hand just because of the competitive nature of the sector? It is worth mentioning that collaboration does already exist between the government and mine operators on many issues (KPMG LLP, 2017; Warner and Sullivan, 2017; Yakovleva, 2017). Not surprisingly, the opinion that seems to rule is that of common interest. Does this comradery exist regarding issues surrounding reclamation and closure activities left in default? Indeed, it does when the issue is one of growing environmental concern and public image.

Once these scrutinised R&C costs, which would then become public knowledge, are packaged into an asset product offering and brought on the capital market in the form of securitised securities, the underlying mine reclamation costs immediately receive a market valuation. These values may serve as a reference guide for many stakeholders and industry rivals who may not possess adequate experience or tools for evaluation of such reclamation and closure expenses due to poor regulation surrounding lack of clarity on what constitutes acceptable closure standards.

A tempting thought is to declare securitisation as the ideal method to finance R&C obligations for mining companies (or even oil & gas, and others). It should be regarded as merely another '*hard*' financial assurance tool in a regulator's toolbox to assist them in their regulatory and auditing duties. The incentive to make such a bold statement would be that securitising of assets is generally inexpensive compared to a bank loan or issuing corporate debt. It also permits a company to improve its balance sheet (by removing the debt assets from its financial statements). Moreover, it increases the leverage of capital structure (which is sometimes a positive signal to the market, especially if the corporate entity is publicly-traded). Nevertheless, the truth is that so far securitisation of EFA obligations is a promising, but untested (as far as the author is aware), solution for consideration.

4.1 Conceptual EFA Securitised Framework: Defining Possible Attributes

> *Neurosis is the inability to tolerate ambiguity.*
>
> — Dr Sigmund Freud

> *It is not everything that can be proved, otherwise the chain of proof would be endless; you must begin somewhere, and you must start with things admitted but indemonstrable?*
>
> — Aristotle

Canada, like other financial centres, including the US, has not regulated EFA-backed securitisation in any specific sui generis[44] system or integrated it into its capital markets, or regulation under corporate or FA regulations due to their current lack of existence.

The absence of regulation concerning EFA-backed securities sparks a fundamental problem for their application. Without specific regulation, their validation by interested parties – regulators, capital markets, mine operators, investors, and others – would be questioned. The uncertainty of the law may also raise doubts about determining whether such a securitised mechanism is worthwhile. Moreover, without specific regulation in place, there would be uncertainty as to whether FA-backed securitisation would be considered part of the securitisation of assets or should it be separated and treated differently from the asset securitisation. Regulatory vagueness surrounding financial assurance valuation would also delay and risk the abandonment of EFA-backed securitisation possibilities.

The critical aspects of FA-backed securitisation are the valuation and calculation of reclamation obligations due to the mentioned uncertainties, which is also related to conflicting and vague environmental mine closure regulation. Calculation and valuation are required to determine the feasibility of securitisation and to predict future cash flow (Rosenberg and Weiss, 2003). However, at the practical level, EFA valuation uncertainty is the main practical challenge to structuring an FA-backed securitised mechanism.

Another challenge arises since financial assurance-backed securitisation would involve multiple parties, complex interdisciplinary laws, and economic infrastructures. Such an environmental-focused securitisation mechanism would be a problematic area of study since it would require multidisciplinary research and requirements – including reclamation costs valuation, environmental regulations, taxes, credit ratings, securities regulations, capital markets, corporate finance, and other areas. Securitisation involves not only a

[44] As per the Black's Law Dictionary, a '*sui generis*' system means '*one that is of its own kind*.'

portion of a financial system, but the entire system, not one or several branches of law, but most branches of the law.

EFA-backed securitisation would require professionals and practitioners such as the SPV, servicers[45], credit rating agencies, credit enhancers[46], investment bankers[47], insurance companies, appraisers, capital market professionals, financial intermediaries, tax and accounting advisers, auditors, environmental regulators, and many others. It would not merely need the traditional intermediaries, but the finance subsidiaries of mining companies and government intermediaries.

The literature surrounding *EFA-backed securitisation* or even *EFA-backed structured finance techniques* seems to be non-existent. Published papers in this field could be constrained by several factors, including the lack of available data and by the secrecy surrounding posted EFA amounts and the valuation of reclamation liability cost estimates of mining operations.

A variety of issues limits the appropriateness and diffusion of EFA-backed securities, which could reduce both borrowers' and sellers' confidence in such a form of tools:

- they would be complex instruments of financial engineering, which would involve high structuring costs;
- assessing the value and risk profile of a financial assurance obligations portfolio would be a key challenge for the development of these solutions; and
- the absence of generally accepted methodologies for the valuation of R&C costs and the high degree of uncertainty regarding the accuracy of somewhat subjective FA values is expected to affect the confidence in such a financial mechanism adversely.

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[45] The servicer is the entity that collects principal and interest payments from obligors and administers the portfolio after transaction closing. Regularly the originator acts as servicer, although this is not always the case.

[46] Credit enhancement is used to improve the credit rating of the issued securities. Therefore, credit enhancement providers are third parties that agree to elevate the credit quality of another party or a pool of assets by making payments, usually up to a specified amount. This is done in the event that the other party defaults on its payment obligations or should the cash flow generated by the pool of assets be less than the amounts contractually required due to defaults of the underlying obligors.

[47] Investment banks mainly perform structuring, underwriting, and marketing of the securitisation transaction.

Such limitations could be due in part to conflicting and vague regulation (i.e., regulatory incompleteness and vagueness) in some mining jurisdictions and given that uncertainty defines every mining project since no two projects are identical.

While leaving this substantive investigation to future work, the research, in part, examines how, and under which conditions, an EFA-backed securitisation transaction can potentially create value for both the issuer and the investors. Like a typical asset-backed securitisation transaction, a successful FA-backed securitisation transaction would be defined as one in which the issuer monetised its diversified portfolio of EFA obligations assets in an efficient, cost-effective manner, with the investors receiving a well-structured, highly-rated investment that provides a favourable risk/return trade-off.

Since an FA-backed securitised mechanism would be customised financial solutions, and their numbers could be too small to support statistical evidence, a traditional empirical analysis cannot be implemented. Therefore, the dissertation provides a conceptual framework that was tested based on some specific and deemed-relevant parameters.

The structure consists of a set of variables which are assumed to be able to explain the potential outcomes that a marketable EFA-backed security might possess in the extractive industries sector. The identification of specific leading, independent linguistic determinants of failure and success, and their level of influence compared to the other variables observed, of such a mechanism was based on:

- the thorough analysis of existing literature;
- information derived from Appendix A, financial statement details of each participating publicly-traded mine operator (a subset of the owners list detailed in the appendix), and other data;
- discussions with industry experts on structured finance and mining operations; and
- personal, professional experience.

A Mamdani-type FIS-based methodology approach was adopted to build the framework of the analysis. It should be mentioned that securitisations are expensive due to management and system costs, legal fees, underwriting fees, rating fees, ongoing administration, and other factors. An allowance for unforeseen expenses is usually essential in securitisations, especially if it is an atypical one. Numerical data is scarce, and only ambiguous and imprecise information could be available for such complex systems (Ross, 2010).

In terms of the inference process, the other main type of FIS is the Sugeno system. The Mamdani system, however, is more widely employed mostly because of the reasonable results with the relatively simple structure it offers, and the intuitive interpretable nature of the rule base (Zaher et al., 2014; MATLAB, 2018). It is also well-suited to human input, unlike Sugeno, since it is more appropriate for mathematical analysis and is computationally efficient. Since the consequents of the rules in a Sugeno FIS are not fuzzy, this interpretability is lost.

Fuzzy logic permits approximate interpolation between input and output situations (Ross, 2010). The Mamdani scheme is a sort of fuzzy relational model where each rule is represented by an IF-THEN relationship. It is also referred to as a linguistic model since both the antecedent and the resulting are fuzzy propositions (Babuška, 1998). The model structure is manually developed, and the final model is neither optimised nor trained. The output from a Mamdani-type model is a fuzzy membership function based on the rules established. Since this method is not solely dependent on a data set, with enough expertise on the system involved, a generalised model for valid future predictions can be attained.

Appendix H discusses how a Mamdani FIS can be applied to determine the possible success of mine reclamation for a particular mine site based on two input variables, '*Financial Assurance*' and *Regulatory Transparency and Openness* ('*Regulatory Transparency*') adequacy. Figure H.3 demonstrates how these two input variables are taken through the fuzzy reasoning process with three IF-THEN rules. The results from these rules are then combined and transformed into a crisp numerical value to quantify the likelihood of '*Reclamation Failure*' for a particular mine site. A numerical example is also provided.

Results from the Mamdani FIS model highlight that factors related to the quality of the assets, as it relates in part to the credit and financial strength of the participating mine operators, underlying an FA-backed securitised mechanism can reasonably increase the probability of reclamation-completion success. Moreover, a higher quality of financial obligations is likely to decrease the risk of default of reclamation. Finally, the stability of the credit enhancement mechanisms, the adoption of a diversification strategy, and the flexibility of the deal architecture are other central factors in determining the possible success of the proposed financial assurance-backed securitised mechanism.

4.1.1 Method

An EFA-backed securitisation space is estimated. The securitisation space is a numerical index related to the potential of mine reclamation success measured with several variables. Along with the uniqueness of financial assurance obligations in comparison to other types of pooled assets used in standard securitisation, to estimate deal potential, a broader range of factors must be considered, they include:

- the variables related to FA obligations features;
- the financial assurance value;
- the financial condition of the observed mine operators (based in part on economic conditions);
- the economic size of the deal; and
- the key elements of the deal structure.

The fact that an FA obligation could be potentially securitisable, as a cash flow generating asset, is not a satisfactory condition to make such a securitisation structure perform successfully. Financial assurance obligations, to be used as the underlying for a financial deal, should possess distinct attributes suitable to guarantee a successful transaction.

A conceptual framework was developed and tested to understand what factors may influence the success of an FA-backed securitised mechanism. The unique nature of each EFA obligation within a portfolio implies a case by case assessment of their value and risk profile and, consequently, the design of such a securitised mechanism transaction would not involve a standard process as it happens with ABS deals. Since FA-backed securitised mechanisms would be highly specific and customised financial solutions, some asset-backed examples of securitisation were referred to which some relevant conclusions were drawn. Given some distinct features surrounding environmental financial assurance obligations, in comparison to other physical assets, designing a standard process would be challenging. The cash flow generation streams are the only main resemblance between FA obligations and other asset classes of ABS deals.

The initial step of the research was to select suitable candidates to be incorporated within the EFAs portfolio. For simplicity, a subset of the mine operators listed in Appendix A was chosen. The fundamental strategy that would be applied to decrease risk reduction in the financial assurance obligations portfolio is provided by modern portfolio theory as it relates to a combination of diverse assets (Markowitz, 1952). In practice, a low correlated (interrelated, in part, by factors such as the location of the asset, asset type, and the degree of relationship between the price movements of the different assets included in the pool) portfolio of FA assets would originate from the mining sector and other sectors of the economy (e.g., oil & gas, nuclear, chemicals, infrastructure, and livestock farming) since the global pool of suitable mining-related EFA obligations at any given time is limited.

EFABSs may eventually offer an attractive alternative to investors who seek to allocate to high levels of credit quality while maintaining a level of diversification difficult to achieve in the corporate credit market alone. Securitisation provides diversification within the asset class and when used in conjunction with some other assets such as FA obligations from different sectors. Under the securitisation process, idiosyncratic (unsystematic) risk contributions from individual financial assurance assets are diversified away. The second level of diversification provided stems from the wide range of economic activity EFABS support. Individual subsectors would retain sensitivities specific to the economic activity they finance and therefore are subject to factors affecting that particular market, encompassing all of those that would be familiar to corporate credit buyers and more.

EFABS may also offer a level of diversification when used in a portfolio of broader fixed-income assets. Securitised products such as ABSs and MBSs exhibit a relatively low strength directional relationship with other fixed-income assets, of both high and low credit quality, as measured by correlation. So, a strategic allocation to EFABS could help diversify portfolios containing a variety of fixed-income assets. The low correlation also means the relative value of EFABS to the asset classes fluctuates, providing an opportunity for tactical positioning by an active manager.

Long-term investors, such as sovereign wealth funds and pension funds, have also started to account in their investment decisions for systematic risks that may manifest themselves over several decades, and hence they possess a different perspective on risk than short-term investors (Bonnafous et al., 2017; Mercer, 2019). In particular, they have a growing interest in understanding how environmental and climate risks may impact the corporate entities comprising their investment portfolios (specifically, incorporating ESG factor integration and climate change considerations into the investment process). Global water risk, including scarcity, flooding, pollution, and anthropogenic climate change is of increasing concern to investors, companies, regulators, and governments worldwide. An approach towards portfolio risk assessment and portfolio diversification that accounts for the geographical distribution of assets in a portfolio and the associated exposure to climate extremes is one that would be expected to be undertaken when constructing the proposed securitisation mechanism's portfolio of reclamation obligations.

Although an in-depth analysis of just one single case study portfolio might not be necessarily representative of delineating the relevant factors that could influence an EFABS deal outcome, it will nevertheless provide some insights regarding which features could be relevant indicators. A portfolio of TSX (Toronto Stock Exchange) and TSX Venture Exchange publicly-traded companies[48] that possessed total reclamation liability cost estimates of greater than CAD$14.5 million[49] was selected. These EFA requirements are combined into one aggregate pool of EFA obligations. So, these individual FA requirements form the collateral for the FABS that will be created. Ideally, this portfolio would have consisted of total liabilities from constituents of other natural resources extractive industries and other sectors but similar data, as detailed in Appendix A, is not publicly available. The remaining data required for the analysis was obtained from each observed constituent's financial reports and Bloomberg.

The second step was to define several potential factors deemed to influence the outcome of an EFABS deal[50]. A well-formulated theory is missing, and the literature on EFA-backed securitised mechanisms is non-existent, and, consequently, such analysis is lacking. The conceptual framework of the dissertation, which employed the literature surrounding asset-backed securitisation for guidance, therefore needed to be defined.

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[48] Due to data limitations only, the following portfolio constituents are observed: Barrick Gold Corp., Goldcorp Inc., Taseko Mines Ltd., and Teck Resources Limited. Their combined total reclamation liability cost estimates amounted to CAD$1.50 billion, as outlined in the *2014 Mine Reclamation Securities in BC for Metal and Coal Mines* report (see Appendix A).

[49] As outlined in the *2014 Mine Reclamation Securities in BC for Metal and Coal Mines* report (see Appendix A).

[50] By existing literature, industry experts in the field of structured finance and mining, and from personal, professional experience.

Finally, the third step was to examine the information collected with the assistance of an FA-based methodology that can capture the high level of complexity and uncertainty characterising the undertaken research topic. For this reason, a FIS approach was adopted.

Case Selections: Single-Asset versus Multi-Asset EFA Obligations Portfolio

The first step was to select two examples of financial assurance obligations pools, one a single-asset and the other a multi-asset FA obligations portfolio, sufficiently alike to be compared but differentiated in their outcome and transaction architecture. These two portfolios are considered distinct securitisation deals.

The first portfolio consists of one asset, Taseko Mines Ltd., with a reclamation liability cost estimate valued at CAD$29.8 million. The multi-asset EFA obligations portfolio is comprised of four constituents – Barrick Gold Corp., Goldcorp Inc., Taseko Mines Ltd., and Teck Resources Limited. Their combined total liability cost estimates amounted to CAD$1.498 billion, as outlined in the *2014 Mine Reclamation Securities in BC for Metal and Coal Mines* report (see Appendix A).

Three sub-dimensions[51] that are included in the FIS framework are the Altman Z-Score, Interest Coverage Ratio (ICR), and CSR/ESG rating. These financial metrics will be applied to help predict the financial distress status of a mine operator. Studies have found these metrics to be effective financial distress models with an overall high degree of reliability (Beaver, 1966; Altman, 1968; Ohlson, 1980; Taffler, 1983; Zmijewski, 1984; Aziz et al., 1988; Asquith et al., 1991; Koh, 1992; Eidleman, 1995; Altman, 2000; Aoki and Hosonuma, 2004; Carter, 2005; Fich and Slezak, 2008; Attig et al., 2013; Sun and Cui, 2014; Altman et al., 2017; Devalle et al., 2017; Gupta and Krishnamurti, 2018).

[51] The Altman Z-Score is a statistical method used to measure the probability that a company will become insolvent. The ICR is a safety margin' ratio advising how many times the business can cover its interest on its interest-bearing debt. CSRHub's CSR/ESG (corporate social responsibility/environmental, social, and governance) ratings allow evaluation and comparison of company employee, environmental, community, and governance issues.

If many mine operators begin to default on their financial assurance payments, the financial institution would have a difficult time passing through required payments to FABS owners. Depending on how diversified the underlying pool of EFA obligations is across demographic and geographic regions, the risk of an operator defaulting may be mitigated. However, if a significant number of mining companies begin to default on their financial assurance loan requirements, the SPV may default on its EFABS, and investors will suffer, demonstrating the need for some form of a guarantee or insurance.

Table 4.1: Financial Metrics

Financial Metrics	Single-Asset	Multi-Asset (*weighted average*)
Altman Z-Score	0.53	1.99
Interest Coverage Ratio	3.16	7.54
CSR/ESG Rating	56.00	89.43

The third quarter of 2018 results for the constituents in both portfolios are presented in Table 4.1. Advantages of diversification include minimising the risk of loss, preserving capital, and generating higher returns for investors.

Conceptual Framework Defined

Information drawn from existing literature and industry specialists was considered to analyse the feasibility of the portfolio of financial assurance obligations transactions. The overview provided a broader perspective on the central issues related to the proposed EFA-backed securitised mechanism and represented a valuable source of information. Given the main issues observed from the literature, the framework of analysis was developed as the basis of the Mamdani FIS model.

The Analysis: A Fuzzy Logic System Approach

The evaluation of EFA-backed securitisation deals would be complicated and would rely to some extent on subjective judgment. Due to the uniqueness of financial assurance obligations as underlying pooled assets, of the transaction architecture, of the main stakeholders, each case is different from every other, and a high degree of uncertainty is involved. Moreover, many endogenous and exogenous factors are likely to influence the outcome. It is, therefore, difficult to assess the actual factors that determine the success of an EFA-backed securitised deal; specifically, tailored methodologies are required to handle such a complex phenomenon.

The analysis is not based on an overly advanced application of the observed FIS. It is intended to be a first attempt to understand the proposed complex phenomenon surrounding FA obligations in a structured and comprehensive way, without the limits imposed by traditional methodologies, until case studies are completed. Hence, a set of variables for each dimension of the analysis was identified. These variables are considered to be noteworthy determinants in explaining the feasibility of an FA-backed securitised mechanism. Each independent linguistic input variable was given a numeric value, based on expert judgments, closeness to the theoretical assumptions, and data evidence. The different input values have been aggregated to create a defuzzified output result that can be considered a measure of the probability of success or failure of the mechanism.

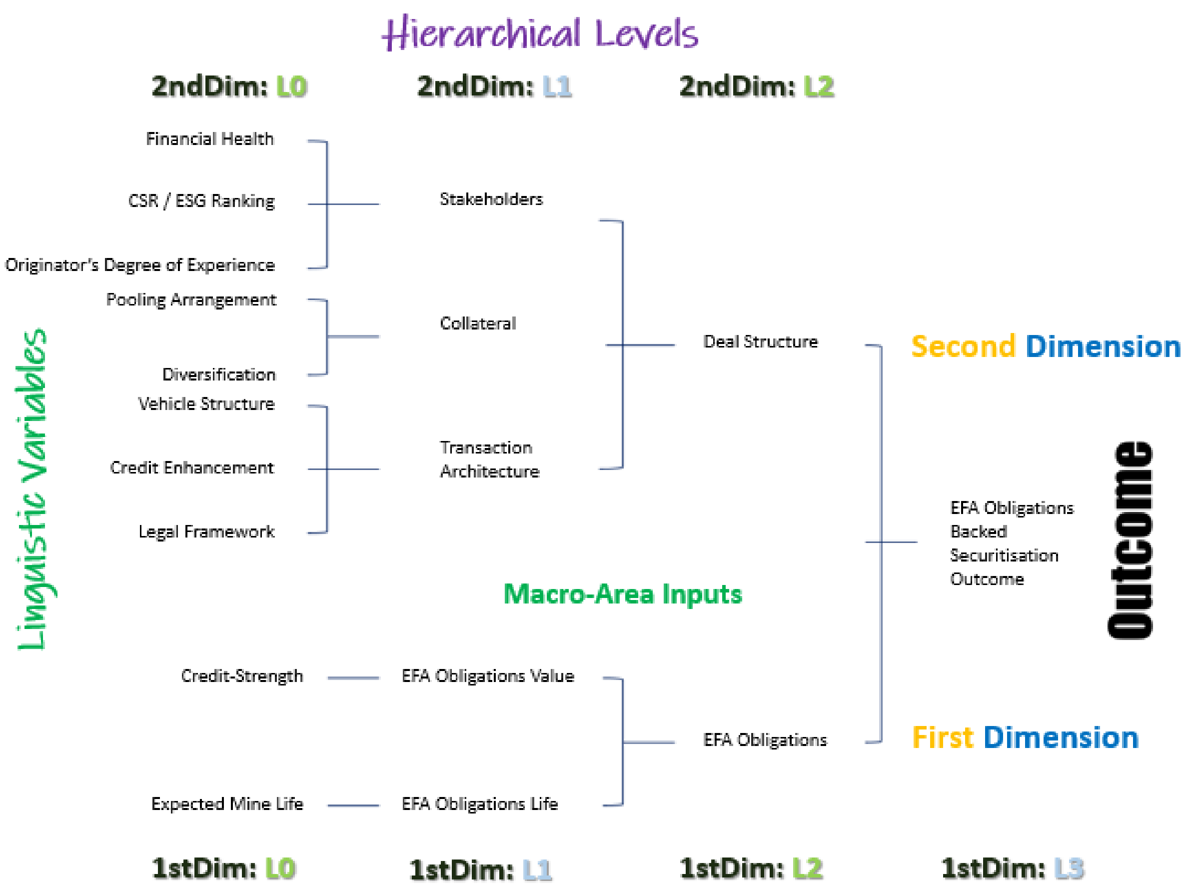
4.1.2 The Model

Conceptual EFA-Backed Framework

The analysis tried to point out which observed exogenous, independent factors may influence the likelihood of success of the proposed EFA-backed securitisation mechanism.

The main concerns[52] for which the proposed mechanism becomes an efficient solution for mine operators needing funding and a favourable investment for investors have been selected according to a detailed review of the available literature and discussions with industry experts in the fields of structured finance and mining.

Figure 4.1: Framework of the Analysis



A two-level dimension tree is defined (Figure 4.1), where information flows from left to right, in which each level relates to a macro category affecting an FA-backed securitised mechanism outcome. Each node of the tree is further divided into sub-dimensions, for which the relevant parameters were identified. The model result is a defuzzified output

[52] In the deal structure and the financial soundness of the constituents in each observed portfolio.

value, for the corresponding independent input linguistic and the defuzzified macro-output values, that implies the probability of success of an EFA-backed mechanism transaction.

The first dimension, *EFA Obligations*, of the hierarchical structure associates the portfolio of EFA obligations[53] characteristics, like their respective values in terms of their quality, which is crucial for securitisation to be attractive to both issuers and investors alike.

Due to data limitations surrounding the confidentiality of mine reclamation security calculations and the underfunding reclamation securities liabilities outstanding in other extractive industries, besides mining, macro-categories relating to asset correlations as a measure of portfolio diversification and the strength of compliance & enforcement in the observed jurisdictions are omitted from the model.

The second dimension, *Deal Structure*, is concerned with the overall soundness of the deal architecture: the vehicle structure, the legal framework, and the CE mechanisms. The credit merit of the involved participants is the critical variable affecting the strength and credit rating of a financial assurance obligation. The whole transaction is considered when dealing with the *Deal Structure* dimension.

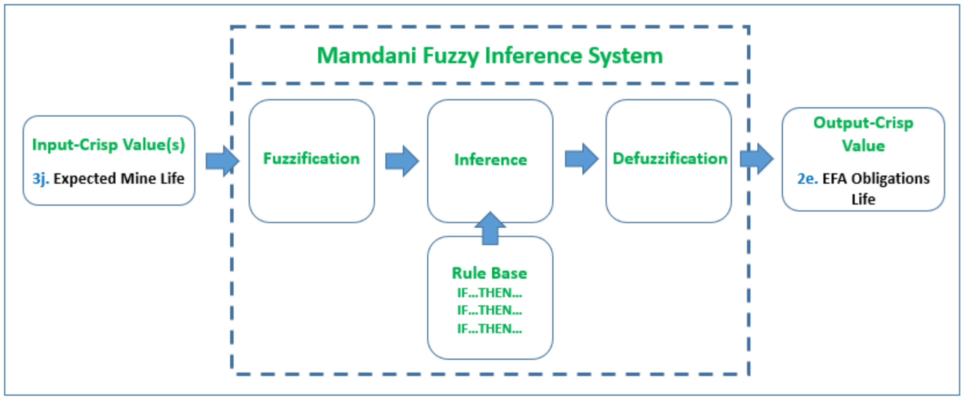
Figure 4.2 displays the proposed hierarchical FL model with ten crisp inputs that are converted to linguistic variables and one concluding crisp output, as exhibited in Figure 4.1, for determining the degree of potential success of the EFA-backed securitisation model.

The hierarchical structure used to design the Mamdani-type fuzzy inference process-based methodology model is detailed below.

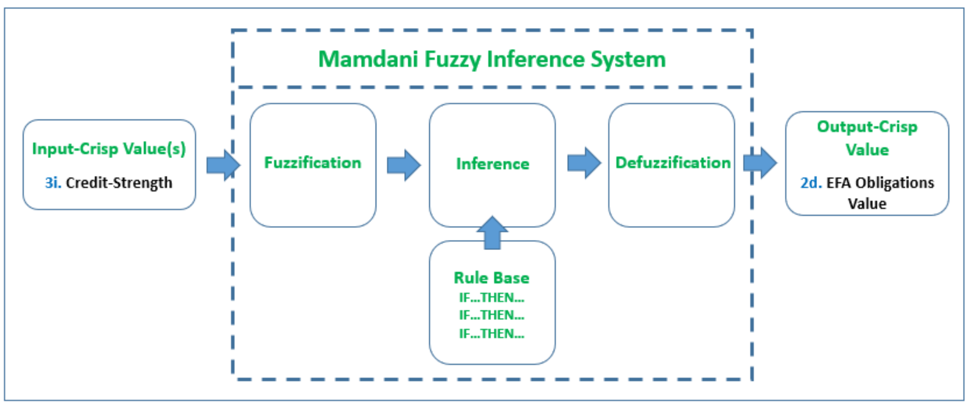
[53] It is denoted as the total reclamation liability cost estimates of each portfolio constituent in 2014 (see Appendix A).

Figure 4.2: Hierarchical Mamdani Fuzzy Logic System Model

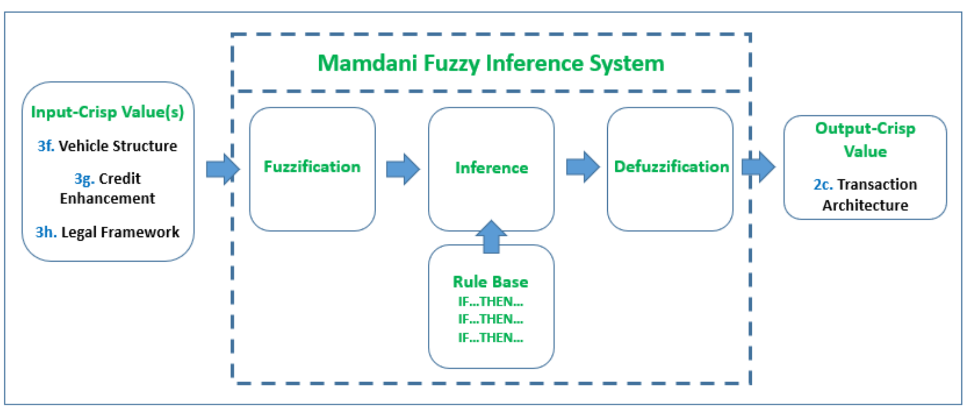
Output-Crisp Value: EFA Obligations Life



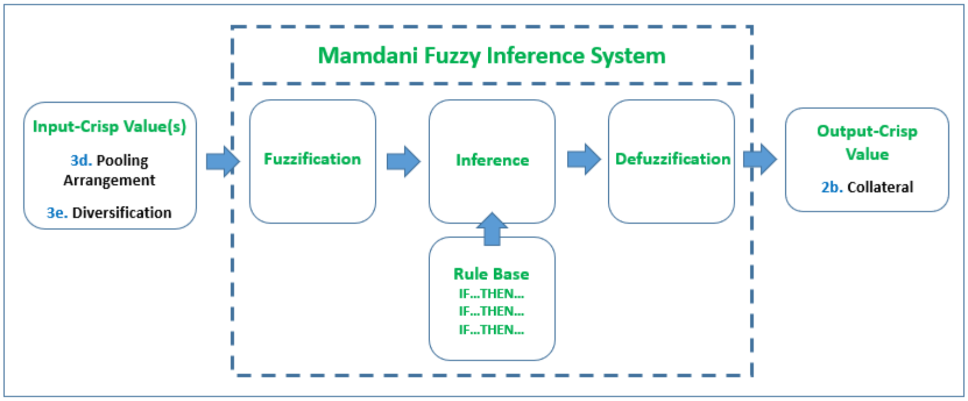
Output-Crisp Value: EFA Obligations Value



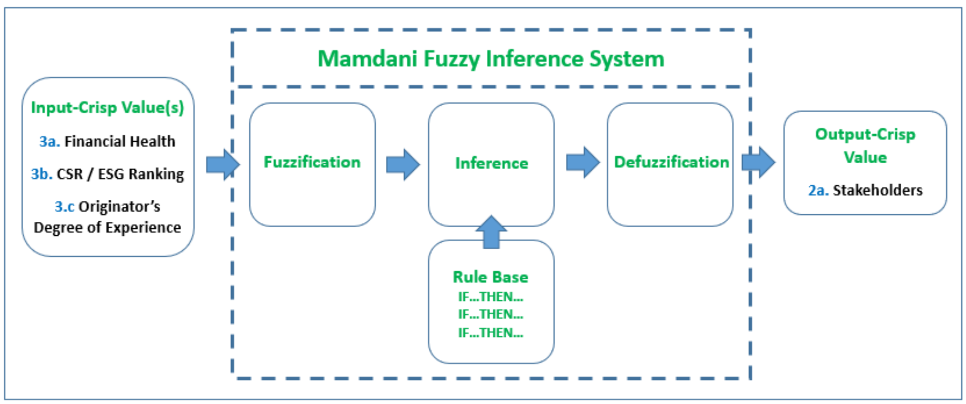
Output-Crisp Value: Transaction Architecture



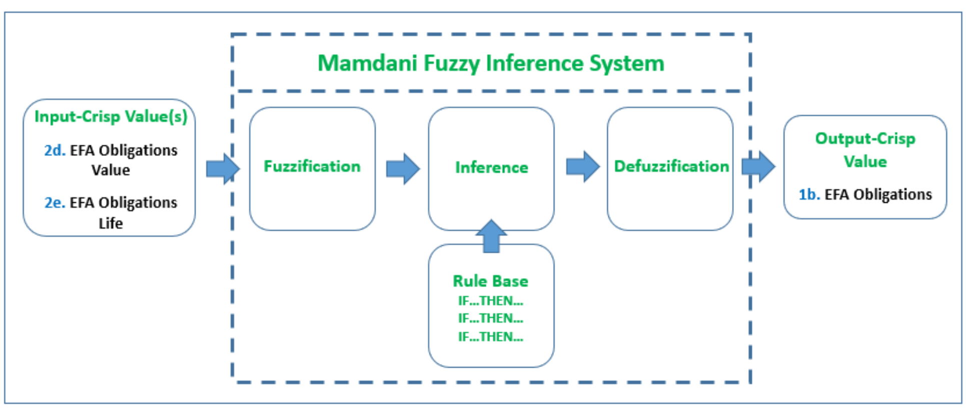
Output-Crisp Value: Collateral



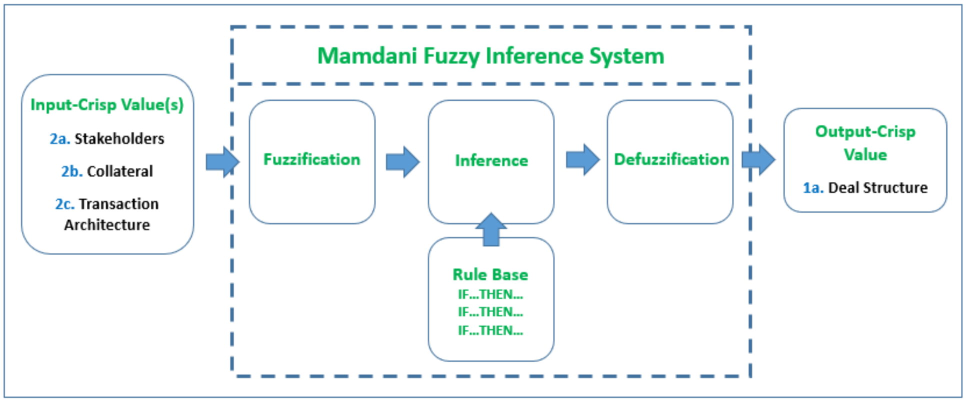
Output-Crisp Value: Stakeholders



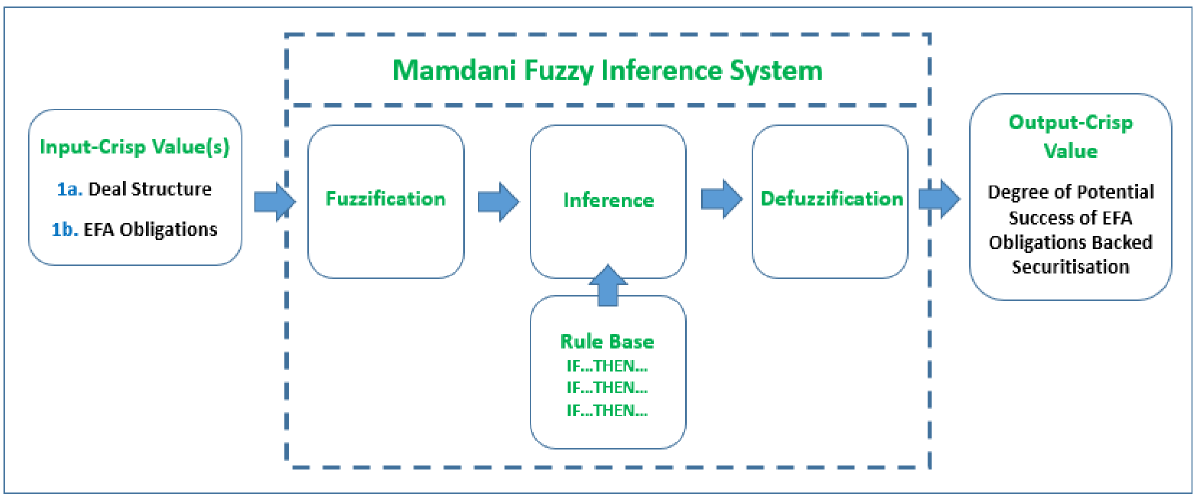
Output-Crisp Value: EFA Obligations



Output-Crisp Value: Deal Structure



Output-Crisp Value: Degree of Potential Success of EFA Obligations Backed Securitisation



D1: EFA OBLIGATIONS

The obsolescence and quality of the assets underlying a securitisation offering are critical risk factors, which need to be considered when defining the credit merit of a deal. In designing an EFA-backed securitised mechanism, it is important to assess the ability of a pool of FA obligations to generate sufficient cash flow to pay interest and the amortisation of the financing loans. Consequently, the quality of the mine operator behind each EFA obligation influences the degree of successfulness of an FA-backed securitised deal.

D1.1: EFA Obligations Value

Credit-Strength. Based on:

- the creditworthiness of the mining company;
- the size of the mine operator (partly based on the number of mining operations in its portfolio);
- the type of FA posted, the jurisdiction where the mining operation is situated in;
- the degree of conflicting and vague regulation, the uncertainty of R&C costs; and
- other related factors, financial assurance obligations vary in their economic value.

From both a literature and industry perspective, the better the creditworthiness of the mine operator, the higher the probability it can originate consistent cash flow payments to be securitised and the lower the level of financial distress which could result in its demise that could jeopardise mine reclamation and closure requirements.

Credit estimation and bankruptcy prediction methods have utilised the Altman Z-Score method since it was developed in 1967 (Altman, 1968; Zlatanovic et al., 2016; Altman et al., 2017; Syamni et al., 2018). Such a method is the output of a credit strength test that evaluates a publicly-traded company's likelihood of bankruptcy. Altman's five-ratio Z-Score model is a significant predictor of bankruptcy among mining and oil & gas companies (Altman, 1968).

Corporate bankruptcy is an important topic, particularly since the wake of the financial crisis of 2007-2009 that trembled financial institutions worldwide. The importance of examining such possible issues and the application of a suitable model for forecasting business distress or mining company failure forecast is a cornerstone of the development of the proposed securitised mechanism.

D1.2: EFA Obligations Life

Expected Mine Life. In the mining industry, the expected life of a mining operation is an important indicator. A long-life of a mining site can make it challenging to securitise it due to increasing uncertainties relating, in part, to reclamation liability cost estimates. Besides the market risks associated with commodity-prices fluctuations and the interest-rate risks related to debt financing, mine operators also face risks linked with default risk (or credit risk). Such default risk, which is associated with the company defaulting on any form of debt, increases its bankruptcy risk and inflation risk that is related, in part, to rising payments associated with rising R&C costs.

Country risk (e.g., expropriation/government interference) for the mine operator can also be an issue with time. The mining and energy industries, predominantly in emerging markets, are possibly two of the most susceptible industries to political risk due to their significance to host economies. In jurisdictions where the economic and political stability of the host country is unclear, and unexpected changes in the business environment could adversely affect the value of a company's assets or its profits.

Mining operations that possess a lifespan of at least ten years were analysed.

D2: DEAL STRUCTURE

An EFA-backed securitised architecture is another critical element to understanding and interpreting the outcome of a deal (Segoviano et al., 2015; BIS, 2016). Since such securitised mechanisms would be considered somewhat ad-hoc transactions, the underlying financial and legal structure would be customised, and each financial assurance obligations pool would be different from the others. Such pools require a proper legal framework, professional servicing, highly specialised financial, legal and tax advisers, and the choice of appropriate credit enhancements. The deal strength and rating assessment are also influenced by the degree of experience of the originator, by the financial situation of the mine operator(s) and investors, and by the strength of collateral guarantees.

The importance of a sound securitised architecture was observed during the financial crisis of 2007-09. A moderate shock originating in the housing and subprime mortgage markets was substantially magnified temporarily by the issues surrounding the architecture of securitisation (which reflected concerns about the quality of underwriting standards and rating methodologies for ABS and MBS, and similar problems, along with liquidity risks).

D2.1: Stakeholders

Financial Health. Since EFA-backed securitisation would be based on the actual availability of FA obligations, assessing the financial stability of the mine operators in the portfolio is a significant issue. The financial strength of mine operators is vital since interest and principal payments on securities depend on its performance. Financially stable mining companies are more likely to afford such an undisrupted stream of financial payments. A financial disruption can be an early indicator of possible insolvency issues at hand.

The degree of the financial strength of mine operators in the examined deal is measured with a rating indicator, a credit metric, built on the ICR of each mine operator in the year the mining operations are operating.

***CSR/ESG Ranking*.** Bloomberg's CSRHub rating tool provides corporate social responsibility and sustainability rankings of companies[54]. The tool aims to be an engine of transparency that encourages more consistent and actionable disclosure from the observed companies.

[54] Bloomberg's CSRHub takes information from its data sources and transforms it into a 0 to 100 scale. The higher the rating, the better (0 = lowest, 100 = highest). These ratings are currently clustered around 50. That is because, in general, companies have some ways to go to become sustainable and socially responsible.

CSRHub (2018) claims that providing these corporate social ratings will increase the transparency of CSR progress and performance, and more openly encourage critical discussions of how corporate entities treat their employees, impact the environment, adjust their carbon footprint, act in their community, provide innovative products and services for sustainable development, and govern themselves.

Wherever an operator oversees a mining project, existing or proposed regulations or their commitment to corporate social responsibility makes mine R&C responsibilities a must (Global Affairs Canada, 2014). The focus and robustness of CSR programmes vary from industry to industry, and as well as from company-to-company (Lozano et al., 2008).

Originator's Degree of Experience. The degree of experience of an originator in handling a securitisation process can help determine the possible success of an EFABS transaction. The accrued knowledge on how to structure the process might lessen the risk of failure. The more experience in the field, the higher is the likelihood to structure an EFA securitised deal properly. Moreover, each new deal requires setting up a level of trust among investors, which is costly. A long and consolidated knowledge in managing an FA-backed securitised mechanism could make a new transaction more efficient and cost-effective. An originator's next deal is characteristically much cheaper and easier to implement than the previous one, as documentation and covenants are adjusted to the new pool.

The originator's degree of experience is expressed by the number of similar transactions in which it was involved in throughout the years before the considered deal.

D2.2: Collateral

Pooling Arrangement. The primary benefit in aggregating interest rates payment streams coming from a pool of EFA obligations (rather than just one) is that diversification lowers the risk that underperformance of any one income stream will cause the deal to possibly default. The number of specific financial assurance obligations in the pool is considered to assess the diversification potential of the FA-backed securitised mechanism.

Over-collateralisation of the income streams would be employed to offset the potential default risk in EFABSs. In this case, the additional income streams would be included in the security, along with the locked-in investors' funds and the income payment streams from the mine operators included in the diversified portfolio, to cushion possible capital losses due to defaults on the financial assurance obligations that are packaged in the security.

Diversification. The risk of underperformance of EFA-backed securitised securities would be mitigated by the diversity of the overall pool of assets, of the types of held FA obligations from the various sectors of the economy (e.g., mining, oil & gas, nuclear, chemicals, infrastructure, and livestock farming) they represent. The process of diversification of EFA obligations is to invest in sectors that are not significantly correlated to one another. The idea here is to pick a pool of FAs with different lifetimes and cycles to minimise the impact of any adverse conditions on a portfolio.

D2.3: Transaction Architecture

Vehicle Structure. In a standard securitisation process, the originator sells the asset itself or cash flow rights to an SPV, a bankruptcy-remote entity, to separate future receivables from its corporate risks. If the SPV controls the assets transferred and retains the risk, then the company that sold the assets to it loses control over the activities altogether, making the consolidation of the OBS treatment desirable. The structuring of asset securitisation is, therefore, of high importance (PwC, 2011).

SPVs are not usually created for single transactions but, in most instances, are revolving and multi-purpose organisms. The unique nature of a pool of FA obligations implies a case by case assessment of their value and risk profile and, consequently, the design of an EFA-backed security transaction cannot be a standardised process. Flexibility and customisation of the vehicle can add solidity to the deal structure and increase the overall probability of success of the transaction.

Credit Enhancement. An essential structural element of each transaction is the amount of CE which permits the credit rating of the rated securities to surpass that of an originator by building a cushion into a deal to absorb potential losses on collateral from non-payment of contractual requirements of the borrower. It serves as a cushion that absorbs losses from defaults on the underlying securitised assets. Securitisations are structured with several CEs that tend to improve the attractiveness of ABSs.

Credit enhancement mechanisms can either be external (e.g., basket credit default swaps or third-party guarantees) or internal (e.g., subordination, overcollateralisation, excess spread mechanisms, reserve accounts, or internal guarantees). Due to the usage of CEs in securitisation structures, it is possible to achieve a larger separation between the asset risk and the company risk (Moody's, 2000). By these tools, a security's credit quality can be raised above the quality of the underlying asset pool or the entity originating the assets. Consequently, the use of tailor-made CE tools is assumed to increase the likelihood of success of a securitised deal.

Legal Framework. In investigating the feasibility of an EFA-based deal, consideration must also be given to a variety of legal issues, such as the impact of host country regulations upon the asset's underlying value and specific bankruptcy concerns. Decoupling the assets from the insolvency risk of the originator requires a suitable legal structure.

OUTCOME: EFA OBLIGATIONS BACKED SECURITISATION OUTCOME

Model Implementation

Following the FL system approach, each of the identified variables is defined by five elements $(X, T(X), U, G, M)$, where: X is the exogenous variable; $T(X)$ is the '*term set*,' namely the set of values (single values are called '*fuzzy variables*') that the variable can take; U is the universe of values upon which each set is defined; G is a grammatical rule to generate variables' names; and M is a semantic rule linking each linguistic variable to its meaning. A fuzzy set is defined by its elements and by their grade of membership: for example, in the fuzzy set $T1 = \{(x, \mu\,(x))\}$, x belongs to the universe and $\mu\,(x)$ is its grade of membership to $T1$. The function that represents the relationship between a value and its grade of membership in a specific set is referred to as the '*membership function*' (MF).

The model methodology is based on Mamdani's fuzzy inference method[55] (Mamdani and Assilian, 1999). There are many decisions to be made in designing such a model (e.g., which MF shape to use, how many MFs in each input and output domain, and how to construct the rule base). The reliability of a fuzzy system often depends on the context, the problem under investigation, and the researcher's subjectivity (McNeill and Thro, 1994; Melin et al., 2018). Appendix H introduces the basic concepts of fuzzy sets and fuzzy inference.

In the academic literature, two membership function shapes, Gaussian and trapezoidal (with triangular MFs as special cases), are the most popular by far due to their simplicity in terms of implementation and calculation (Zhao and Bose, 2002). Thus, only these two shapes are considered in the dissertation. Simple trapezoidal and Gaussian membership functions, according to the discrete or continuous nature of linguistic variables, are employed. The assortment of the explanatory variables, of the term set and the grade of membership relied both on data collection and subjective judgment stemming from

[55] Mamdani-type fuzzy inference is the most commonly utilised fuzzy methodology and was among the first control systems built using fuzzy set theory (Moahmmed and Sadkhan, 2013).

literature and industry specialists. Accordingly, the shapes of membership functions are important for a particular problem given their impact on a FIS.

An MF must vary between 0 and 1. The function itself can be an arbitrary curve (linear, nonlinear or discrete) whose shape can be defined as a function that is suitable from the point of view of simplicity, convenience, speed, and efficiency. That said, the type of MF does not play a crucial role in shaping how the model performs. The shape of MFs is important and depends on one's beliefs and intuition concerning a given linguistic variable.

While membership functions can take values between 0 and 1, it might be required to allow some of them to never reach the value of 1 in order to represent information that is never certain. Gaussian MFs are popular methods for specifying fuzzy sets because of their smoothness and concise notation. These curves have the advantage of being smooth and nonzero at all points. Similarly, if there is no information on the shape of an MF, triangular or trapezoidal shapes are simple to implement and fast for computation. Such membership functions are formed using straight lines. Ultimately, the shape of MFs should be chosen by the experts on the subject and its framework.

Each membership function is defined by some values according to its shape. For a Gaussian membership function, it is defined by mean and standard deviation values (μ, σ) while the trapezoidal membership functions are defined by lower and upper base values (i.e., by the values of basis orthogonal projection on the abscissa (a,b,c,d)). For instance, in Figure 4.1 it indicates that the linguistic input variable *Financial Health* possesses three trapezoidal-shaped membership functions defined by (-20,-20,-10, 1) for '*Low*,' (1,2.5,2.5,2.5) for '*Acceptable*,' and (2.5,10,20,20) for '*Solid*.' These values represent the membership functions' parameters for the fuzzy variable.

Within the term set of the variable *Financial Health*, the fuzzy variable '*Low*,' '*Acceptable*,' and '*Solid*,' respectively, relate the financial strength of the mine operators to a grade of membership in the fuzzy set. The Interest Coverage Ratio is used to assess how rapidly a company can pay its interest expenses on outstanding debt. The ICR (alias, the '*times interest earned'* ratio) is commonly used by lenders, creditors, and investors to determine the riskiness of lending capital to it. A higher ratio (from low ('*Low*'), medium ('*Acceptable*') to high ('*Solid*')) indicates better financial health as it means that the company is more capable of meeting its interest obligations from operating earnings.

The input's universe represents the upper and lower bound for each variable on the financial assurance-backed securitised mechanism. An [a,b] bound range is utilised when a variable is primarily based on qualitative judgments or is a synthetic indicator of different parameters. For instance, Figure 4.1 Illustrates that the input variable *Financial Health* possesses an upper and lower bound of [-10,10].

A number of the input linguistic variables (e.g., *Originator's Degree of Experience*, *Diversification*, *Vehicle Structure*, *Credit Enhancement*, and *Legal Framework*) in the *Deal Structure* dimension possess identical trapezoidal abscissa (a,b,c,d) value sets given their observed similarities relating to the deal structure of the securitisation transaction. Unique values are, however, employed for such linguistic variables relating to each of the two observed portfolios (single-asset *vs* multi-asset). For the variable *Originator's Degree of Experience*, its term set T(*Originator's Degree of Experience*) is T(*Originator's Degree of Experience*) = {low, medium, high} where each term is characterised by a fuzzy set in a universe of discourse U = [0,10]. Similar observations for the first and second dimension inputs (see Figure 4.1 and Table 4.2) of the model (first dimension inputs: *Transaction Architecture*, *Collateral*, *Stakeholders*, *EFA Obligations Life*, and *EFA Obligations Value*; second dimension inputs: *Deal Structure* and *EFA Obligations*) are observed since they have identical Gaussian abscissa (μ, σ) value sets.

To reduce arbitrariness in assigning grades to the different variables and dimensions, the identification of the observed input model values and rules are based on existing literature, industry experts in the field of structured finance and mining, and from personal, professional experience. Industry professionals were also consulted to help interpret the results and to validate the observed model. Setting exact, fuzzy rules and, MFs can be a challenging task and is somewhat subjective at times. Specifically, the applied membership function is a matter of definition rather than measurement for some of the observed linguistic variables in the securitisation model.

The model was implemented on each hierarchical level for the two macro dimensions (see Figure 4.1). Starting from the lower level variables, it produces a numerical value by accruing the generated numbers into superior hierarchical stages. The final number is employed to appraise the securitised deal under investigation.

Table 4.2 details the FIS that is employed to analyse the observed securitised deal. It shows the applied MF shapes (Gaussian and trapezoidal), the universe of values upon which each term set was defined, and the corresponding fuzzy numbers for each macro-area, sub-dimensions, and variables analysed. Appendix I lists the fuzzy range of magnitude and their implication for each observed variable in the model, as described in Table 4.2. The utilised membership functions are shown in Figure 4.3.

The FL system model works straightforwardly. It was developed and implemented using MATLAB (release: R2018b, Version 9.5). The first step is the fuzzification of the linguistic inputs, which entails determining the degree to which each input value belongs to each fuzzy set through the membership functions. Second, a collection of relatively stringent rules which define the output level according to input values were established. For instance, the macro defuzzified variable, *Stakeholders*, can be considered as the output deriving from the combination of three linguistic inputs: *Financial Health*, *CSR/ESG Ranking*, and *Originator's Degree of Experience*.

Table 4.2: Description of the Mamdani-Type Fuzzy Inference System Model[56]

LINGUISTIC VARIABLES		MEMBERSHIP FUNCTION SHAPE *	UNIVERSE **	FUZZY NUMBERS ***		
EFA OBLIGATIONS		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
EFA Obligations Value		**Gaussian (μ,σ)**	**[0,10]**	**Low (0,1.7)**	**Medium (1.7,5)**	**High (5,10)**
Credit-Strength	A quality index which applies the Altman Z-score analysis. It is a credit-strength test that gauges a publicly-traded company's likelihood of bankruptcy.	Trapezoidal (a,b,c,d)	[-5,5]	Distressed (-10,-10,-5,1.81)	Grey (1.81,2.99,2.99,2.99)	Safe (2.99,5,10,10)
EFA Obligations Life		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
Expected Mine Life	The expected life of a mine operation.	Gaussian (μ,σ)	[0,100]	Low (60,100)	Medium (40,60)	High (0,40)
DEAL STRUCTURE		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
Stakeholders		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
Financial Health	The financial strength of the mine operators. The Interest Coverage Ratio is used to assess how rapidly a firm can pay its interest expenses on outstanding debt.	Trapezoidal (a,b,c,d)	[-10,10]	Low (-20,-20,-10,1)	Acceptable (1,2.5,2.5,2.5)	Solid (2.5,10,20,20)
CSR/ESG Ranking	Bloomberg's CSRHub ratings tool provides corporate social responsibility and sustainability rankings of companies.	Trapezoidal (a,b,c,d)	[0,100]	Low (0,39,39,39)	Medium (39,59,59,59)	High (59,100,100,100)
Originator's Degree of Experience	Similar transactions in which the Originator was involved in the years prior to the considered securitised deal.	Trapezoidal (a,b,c,d)	[0,10]	Low (-6.47,-1.59,1.59,6.47)	Medium (3.59,8.47,11.59,16.47)	High (13.59,18.47,21.59,26.47)
Collateral		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
Pooling Arrangement	The number of different EFA obligations (i.e., mining, oil & gas, chemical, etc.) involved in the securitised portfolio.	Trapezoidal (a,b,c,d)	[0,20]	Narrow (-5.13,-0.49,2.49,7.13)	Medium (4.39,9.03,11.99,16.63)	Wide (13.89,18.53,21.49,26.13)
Diversification	The risk of underperformance of EFA obligations backed securities would be mitigated by the diversity of the overall pool of assets, of the types of held EFA obligations from the various extractive industries. Diversification lowers the risk that underperformance of any one income stream will cause the deal to default.	Trapezoidal (a, b, c, d)	[0,10]	Low (-6.47,-1.59,1.59,6.47)	Medium (3.59,8.47,11.59,16.47)	High (13.59,18.47,21.59,26.47)
Transaction Architecture		**Gaussian (μ,σ)**	**[0,10]**	**Unsuitable (0,1.7)**	**Acceptable (1.7,5)**	**Suitable (5,10)**
Vehicle Structure	Synthetic index of the flexibility of the SPV.	Trapezoidal (a,b,c,d)	[0,10]	Low (-6.47,-1.59,1.59,6.47)	Medium (3.59,8.47,11.59,16.47)	High (13.59,18.47,21.59,26.47)
Credit Enhancement	Synthetic index of the effectiveness of the internal and external credit enhancement mechanisms.	Trapezoidal (a,b,c,d)	[0,10]	Low (-6.47,-1.59,1.59,6.47)	Medium (3.59,8.47,11.59,16.47)	High (13.59,18.47,21.59,26.47)
Legal Framework	Synthetic index of the legal structure of the deal.	Trapezoidal (a,b,c,d)	[0,10]	Low (-6.47,-1.59,1.59,6.47)	Medium (3.59,8.47,11.59,16.47)	High (13.59,18.47,21.59,26.47)

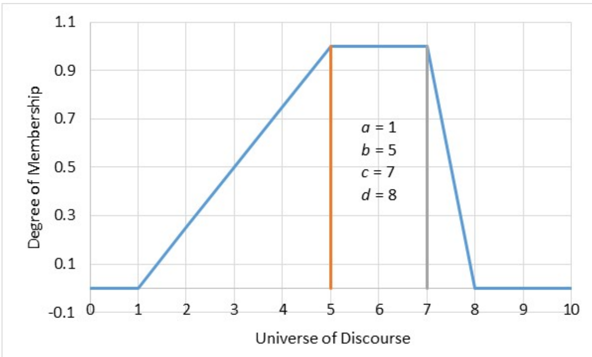
[56] * A Gaussian MF is specified by its mean (μ) and standard deviation (σ) values. A trapezoidal MF is defined by the values of basis orthogonal projection on the abscissa (a,b,c,d).

** Universe represents upper and lower bounds for each variable on the financial assurance-backed securitised mechanism. A [a,b] bound range has been used when a variable is mainly based on qualitative judgments or is a synthetic indicator of different parameters.

*** Fuzzy numbers represent the membership functions' parameters for each fuzzy variable.

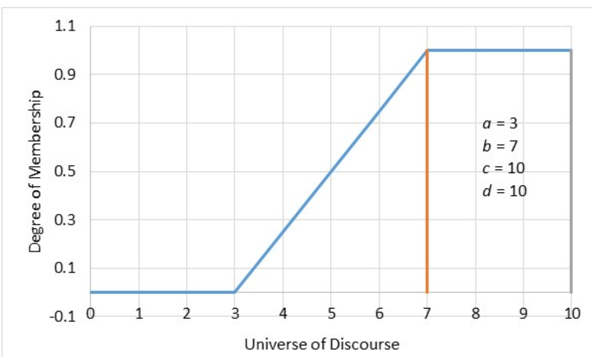
Figure 4.3: Membership Functions Applied

Trapezoidal Membership Function

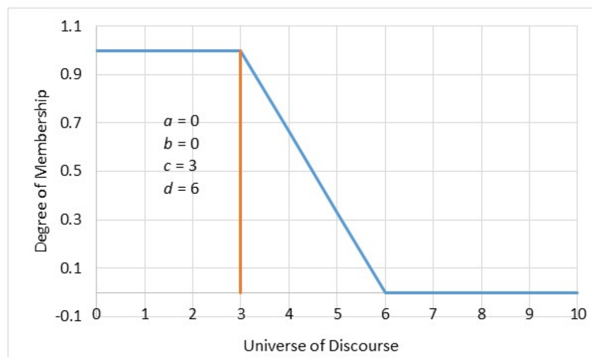


$$T\,(x;\,a,\,b,\,c,\,d) = \begin{cases} 0 & x < a \\ \frac{x-a}{b-a} & a \le x \le b \\ 1 & b \le x \le c \\ \frac{d-x}{d-c} & c \le x \le d \\ 0 & d \le x \end{cases} \qquad (4.1)$$

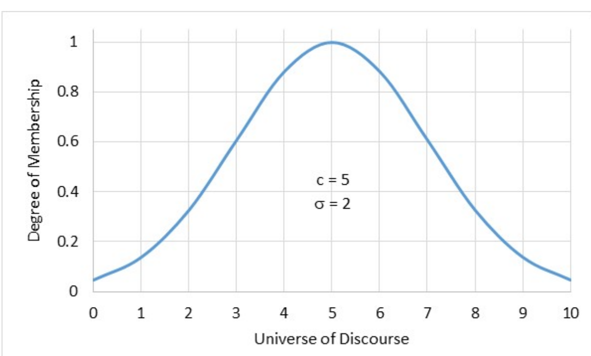
Leftmost Trapezoidal



Rightmost Trapezoidal



Gaussian Membership Function



$$\text{Gaussian}\,(x;\,c,\,\sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2} \qquad (4.2)$$

Table 4.3: Input Combinations and Rules for the Variable '*Stakeholders*'

	IF	PROPOSITION 1	OR	PROPOSITION 2	OR	PROPOSITION 3	THEN	OUTPUT
1	IF	(Financial Health) IS Low	OR	(CSR/ESG Ranking) IS Low	OR	(Originator's Degree of Experience) IS Low	THEN	(Stakeholders) IS Unsuitable
2	IF	(Financial Health) IS Low	OR	(CSR/ESG Ranking) IS Low	OR	(Originator's Degree of Experience) IS Medium	THEN	(Stakeholders) IS Unsuitable
3	IF	(Financial Health) IS Low	OR	(CSR/ESG Ranking) IS Low	OR	(Originator's Degree of Experience) IS High	THEN	(Stakeholders) IS Unsuitable
		*		*		*		*
		*		*		*		*
25	IF	(Financial Health) IS Solid	OR	(CSR/ESG Ranking) IS High	OR	(Originator's Degree of Experience) IS Low	THEN	(Stakeholders) IS Unsuitable
26	IF	(Financial Health) IS Solid	OR	(CSR/ESG Ranking) IS High	OR	(Originator's Degree of Experience) IS Medium	THEN	(Stakeholders) IS Acceptable
27	IF	(Financial Health) IS Solid	OR	(CSR/ESG Ranking) IS High	OR	(Originator's Degree of Experience) IS High	THEN	(Stakeholders) IS Suitable

These rules are symbolised in the form of IF-THEN constructs and are built on linguistic variables that can take the verbal values. As an illustration, and as observed in Table 4.3, "IF *Financial Health* is Low OR *CSR/ESG Ranking* is Low OR *Originator's Degree of Experience* is Low, THEN *Stakeholders* is Unsuitable." In general, all the scenarios deriving from the combination of the different inputs' levels that are considered are aggregated using the OR operator[57]. In the upper hierarchical level, a more conservative approach, by reporting a '*Low*' state for the final output each time that a linguistic variable recorded '*Low*,' was adopted. It was done to consider both *EFA Obligations* and *Deal Structure* dimensions as necessary conditions for a potentially successful transaction. Table 4.3 displays part of the input combinations and the rules that are set for the exemplification variable, *Stakeholders*. Appendix J lists the input combinations and the rules for each variable in the model.

Although the shape of a membership function does have some impact on the resulting FL controller behaviour, the most influential factors are the fuzzy rules and their inference methods that are applied in the controller.

The observed fuzzy inference model is configured based upon two default assumptions; the input variables possess equal weights for simplicity purposes since assigning weights is

[57] The OR operation can be replaced with the max function, so that the values A OR B becomes equivalent to max(A, B).

relatively subjective. It is common to set up a fuzzy inference system with several input variables for practical purposes, especially in industry, where each of the input variables provides a different degree of relevance in determining the output variable. Secondly, the IF-THEN rules are construed in conventional logic by the implication operators, such as fuzzy union, intersection and complement, and the output of each rule is aggregated into a fuzzy set. The weight of every observed fuzzy rule in the model is one, and, consequently, it has no impact on the implication process. Furthermore, setting each input value to one implies they are all of equal importance, and no one input variable possesses a greater influence on each output-crisp value than another.

The implication method has been implemented through the *min* (minimum) operator, which truncates the output fuzzy set, while the output aggregation process has been implemented through the *max* (maximum) operator. Finally, this cumulative output fuzzy set is defuzzified with a centroid method, and the resulting output is a single numerical value that represents the degree of potential success of FA-backed securitisation deals.

4.1.3 Discussion of Results

Table 4.4: Hierarchical Levels Scores

LINGUISTIC VARIABLES	Single-Asset EFA Obligations Portfolio	Multi-Asset EFA Obligations Portfolio
EFA Obligations	**2.82**	**7.28**
EFA Obligations Value	1.97	7.01
EFA Obligations Life	3.50	7.66
Deal Structure	**3.07**	**7.41**
Stakeholders	4.39	7.93
Collateral	1.49	7.62
Transaction Architecture	4.03	7.97
RESULT	**2.78**	**7.13**

Table 4.4 summarises the final scores at the different hierarchical levels.

Results for the *EFA Obligations* macro-area point to a more pronounced difference between the single- and multi-asset portfolios (respectively, 2.82 and 7.28). The aggregation of the three sub-dimensions for the *EFA Obligations* macro-area resulting into the macro-area *EFA Obligations Value* leads to a final grade of 1.97 (single-asset EFA obligations portfolio) and 7.01 (multi-asset EFA obligations portfolio). In contrast, the macro-area *EFA Obligations Life* reached 3.50 (single-asset EFA obligations portfolio) and 7.66 (multi-asset EFA obligations portfolio). The *Credit-Strength*, as it relates to the *EFA Obligations Value* macro-area, for the financial assurance obligations on which the single-asset portfolio was based, is lower than the average value of the multi-asset portfolio, indicating a possible overall lower quality, in terms of credit strength, of the mine operator constituent. This observation signifies that the single constituent portfolio is bound to potentially face higher financial risk as compared to the diversified portfolio.

Concerning the *Financial Health* and *CSR/ESG Ranking* dimensions, the constituents of the multi-asset portfolio are expected to possess the financial capability and willingness to provide positive value to society and meeting or to exceed the expectations of their stakeholders than its single-asset counterpart, on average.

For illustrative purposes, to analyse the overall effectiveness of the model, it is assumed both deals possessed several different input parameters, related to *Originator's Degree of Experience* and *Diversification*.

In the second macro-area, *Deal Structure*, visible differences between the two EFA-backed securitised mechanisms are observed, the final scores of this dimension are respectively, 3.07 (for the single-asset portfolio) and 7.41 (for the multi-asset portfolio). The financial situation of each mine operator constituent in the respective portfolios is expected to be a critical element to ensure the generation of consistent cash flows.

An important factor that is likely to determine the success of EFA-backed securitisation is the *Originator's Degree of Experience* in handling a securitisation process. In both deals, it is assumed the values are dissimilar. Concerning the originator who is overseeing the multi-EFA-backed securitisation transaction, it is also expected that its expertise in dealing with such forms of financial solutions increased with each passing deal, and scores of 4.6 and 8.1 were observed for the single-asset deal and the multi-asset deal, respectively. The aggregation into the macro-area *Stakeholders* resulted in a final score of 4.39 (single-asset EFA obligations portfolio) and 7.93 (multiple-asset EFA obligations portfolio).

The first transaction was backed by the EFA obligations of a single mine operator. The second deal was built on the EFA obligations of four different mining companies, and was highly diversified. In both *Pooling Arrangement* and *Diversification*, the diversified deal obtained superior scores (12.9 *vs* 1.5 and 8.6 *vs* 1.8, respectively): the resulting scores of the macro-area, *Collateral*, are, 1.49 for the single-asset deal and 7.62 for its diversified counterpart. These two macro-area values arise since *Collateral* stems from the *Pooling Arrangement* and *Diversification* linguistic inputs.

The EFABS would utilise the funds raised from investors to meet the EFA requirements demanded by government regulators, combined possibly with suitable default insurance and/or credit derivative instruments, as a locked-in form of collateral. A benefit in aggregating the funding streams coming from a pool of FA obligations (rather than just one) is that portfolio diversification lowers the risk that underperformance of any one income stream will cause the deal to possibly default. To assess the diversification potential of the studied EFABSs, as outlined in the *Pooling Arrangement* linguistic variable, the number of mine operators involved in the pooling arrangement was observed. The risk of underperformance of EFA-backed securities is mitigated by the diversity of the overall pool of mine operators and their respective underlying financial assurance obligations.

The more unpredictable exogenous factors are likely to influence the calculated value reclamation values, the posted financial assurance obligation commitments, and the solvency of participating mine operators, the more an originator needs to diversify its portfolio of assets to reduce the volatility of expected cash flows. Leveraging on a pool of diversified financial assurance obligations from multiple sectors (e.g., mining, oil & gas, nuclear, chemicals, infrastructure, and livestock farming) has a good diversification potential and helps to reduce the risk of underperformance.

The two securitised deals are also differentiated in their *Transaction Architecture*[58]. Considering the *Legal Framework* dimension, the characterisation of the special purpose vehicle in charge of the transaction was deemed to be different. Consequently, the scores 8.2 and 5.9 were assigned for the multi-asset deal and the single-asset deal, respectively.

Another differentiating element between the two deals lies in the structure of each SPV. The trust surrounding the single-asset portfolio was assumed to be an ad-hoc vehicle, with a fixed structure which was established with the sole purpose to fund the FA obligations of Taseko Mines. In contrast, the trust of the multi-asset portfolio[59] was structured to be a warehouse facility, not only structured to handle the pooled deal but also allowing for the inclusion of other EFA obligations constituents by the originator should it chooses to do so at a future date. With such a structure, it could continue acquiring new financial assurance obligations interests and issuing new securities to investors, even after the deal’s closing date. Being adjustable, expandable, scalable, and so more flexible than the single-asset trust, a score of 7.8 was

[58] In reference to the *Vehicle Structure*, *Credit Enhancement*, and *Legal Framework* variable inputs.

[59] Consisting of the pooled EFA obligations from Barrick Gold, Goldcorp, Taseko Mines, and Teck Resources.

assigned to the multi-asset deal and 1.6 to its counterpart for their respective *Vehicle Structure* input values.

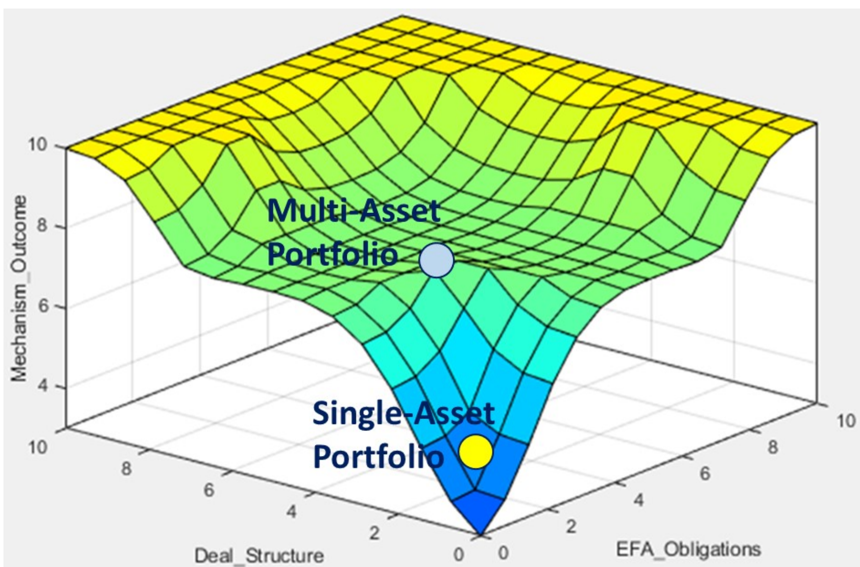
To obtain higher credit merit, it was assumed the single-asset deal relied on some internal CE mechanisms: overcollateralisation and subordination through the issuance of three tranches of senior notes, mezzanine notes, and equity. Quarterly distributions are expected to cover the collateral trustee service expenses first, then senior noteholders' interest and principal, and lastly mezzanine, junior, and equity holders. The agreement would also include a senior ICR test covenant that could bring to early amortisation and default unless requirements were met for three consecutive payment dates.

The multi-EFA-backed securitisation pool would be backed by a default insurance policy, which would protect against issuer default and downgrade risk. Finally, in case of underperformance of some of financial assurance streams, the originator could request an indemnity from the mine operators. Since the multi-asset deal is stronger in terms of CE mechanisms, a score of 8.5 was arbitrary assigned to it and a lower value equal to 5.2 to the single-constituent deal for their respective *Credit Enhancement* input values. The final score of *Transaction Architecture* is 4.03 for the single-asset deal and 7.97 for the alternative diversified deal.

As earlier described, the model produces a numerical value by combining the scores of lower-level variables into superior hierarchical stages. Notably, the output value represents the degree of potential success of EFA obligations backed securitisation based on the observed inputs and model parameters. The final number represents the strength and suitability of the two securitised deals under investigation. Outcomes point to a higher final score for the multi-asset FA obligations portfolio securitisation (7.13 *vs* 2.78 for the single-asset EFA-backed securitisation portfolio deal), suggesting that the diversified financial solution was more likely to create greater value for both the issuer and the investors.

The results from the FIS analysis in Table 4.4, and as seen in Figure 4.4, point to some compelling conclusions to explain the relative success of the diversified portfolio compared to its observed single-asset counterpart. Figure 4.4 displays a FIS map given the two macro-area inputs, *EFA Obligations* and *Deal Structure*, to the outcome variable, *Mechanism Outcome*. The comparative analysis indicates that securitisation potential is expected to be low for single-asset portfolios. Specifically, it shows a high *Mechanism Outcome* output level arising from a multi-asset portfolio possessing a high credit strength and rating *EFA Obligations* and *Deal Structure* dimension inputs. Conversely, a low *Mechanism Outcome* value is projected by the model for low credit strength and rating *EFA Obligations* and *Deal Structure* macro-area inputs values.

Figure 4.4: Surface Viewer: '*Mechanism Outcome*' as It Is Affected by the Two Macro-Area Inputs: '*EFA Obligations*' and '*Deal Structure*'



Key observations from the analysis indicate advantages in terms of credit strength (*Credit-Strength*) and financial strength (*Financial Health*) of the participating mine operators, along with the degree of diversification of the EFA obligations portfolio, is expected to increase the likelihood to generate stable and constant cash flows to cover the debt service and principal payments. Moreover, the fewer uncertainties surrounding the valuation and calculation of reclamation liability cost estimates due to the various mentioned uncertainties, which is also related to conflicting and vague environmental mine closure regulation, are likely to reduce the risk of corporate insolvency which would have an adverse financial impact on the success of an EFA-backed security.

Finally, the flexibility of the deal architecture, the strength of the CE mechanisms, and the adoption of a diversified FA obligations strategy (stemming from the mining industry and other sectors of the economy (e.g., oil & gas, chemicals, livestock farming, and infrastructure)) can potentially increase the overall probability of success for such a securitisation transaction.

From the overall analysis, and based on industry practices, it can be observed and concluded that the success of a typical securitisation transaction (including the proposed EFA-backed mechanism) is dependent on the presence of the following nine requirements:

1. a sound loan origination process;
2. full-fledged investment banking services (underwriting and the distribution of newly issued securities);
3. a complementary transaction architecture (i.e., the vehicle structure, credit enhancement, and legal framework inputs);
4. high integrity of cash-flow analysis (selecting well-diversified groups of homogenous assets that generate regular cash flows and the ability to predict the performance of the underlying pool of assets);
5. prudent credit risk evaluation (credit risk of the underlying pooled assets as well as the securities);
6. clearly defined regulatory, securities, and accounting rules;
7. a mature debt market;
8. an active secondary market; and
9. a broad, sophisticated investor base.

These requirements contribute to each other's growth and are usually complementary to one another. The development of one requirement adds to the growth of the others. All these requirements are developed simultaneously, which typically increases the overall success of the securitisation process. The bottom-line success of such asset securitisation connects corporate entities with investors.

4.1.4 Sensitivity Analysis of the Hierarchical FIS Model

A sensitivity analysis was performed on the observed FL-based expert system.

The purpose of a sensitivity analysis is twofold. Firstly, it can be employed to observe the validity of the rules developed and, secondly, it serves to determine which linguistic input variable(s) will generate the desired effect. The first purpose will be satisfied by asking the question "*Does it make sense that if we increase a certain input, we will get an increase/decrease in a particular conclusion?*" The second one will be satisfied if the following question is asked, "*What input has to be modified, and by how much, to change a conclusion from a given level to another level?*"

The MATLAB fuzzy logic toolbox was utilised. The analysis was performed in terms of rules, by creating eight different graphical interfaces, as observed in Figure 4.2, to describe the eight observed subsets (i.e., the eight output-crisp values).

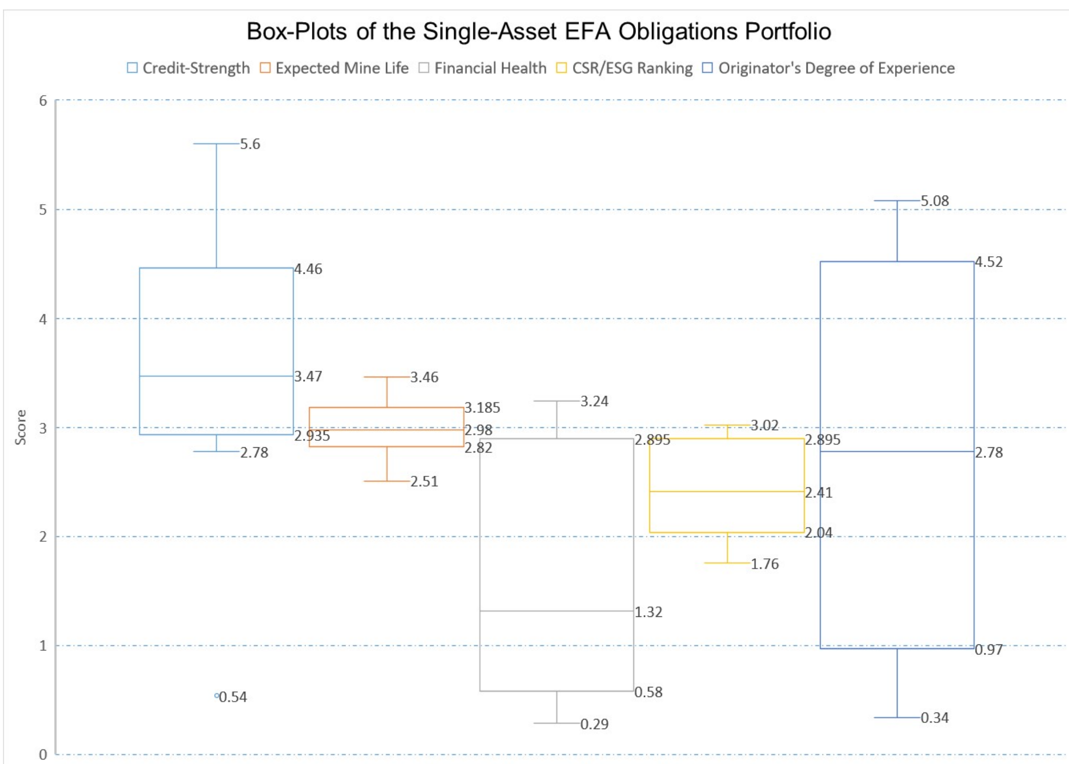
In general, for each of the eight inferences the numerical results were defined[60] and obtained in reference to *EFA Obligations Life*, *EFA Obligations Value*, *Transaction Architecture*, *Collateral*, *Stakeholders*, *EFA Obligations*, *Deal Structure*, and *EFA Obligations Backed Securitisation Outcome*, respectively (see Figure 4.1).

[60] The type of membership function, membership classes, fuzzy rules, and defuzzification method.

The sensitivity analysis was performed by repeating the whole fuzzy inference procedure, modifying only one linguistic variable at a time, while keeping the others constant. Thus, 90 different simulations were performed (based on each input variable's three ranges (and their respective minimum, medium, and maximum values) – as described in Table 4.2) for each of the two FA obligations portfolios (single-asset and multi-asset).

From each of the ninety simulations performed per portfolio, information regarding their respective output value was collected (i.e., their *EFA Obligations Backed Securitisation Outcome* value). Such analysis helps determine the factors that may influence the likelihood of success of the proposed FA-backed securitisation mechanism.

Figure 4.5: Box-Plots of the Single-Asset EFA Obligations Portfolio



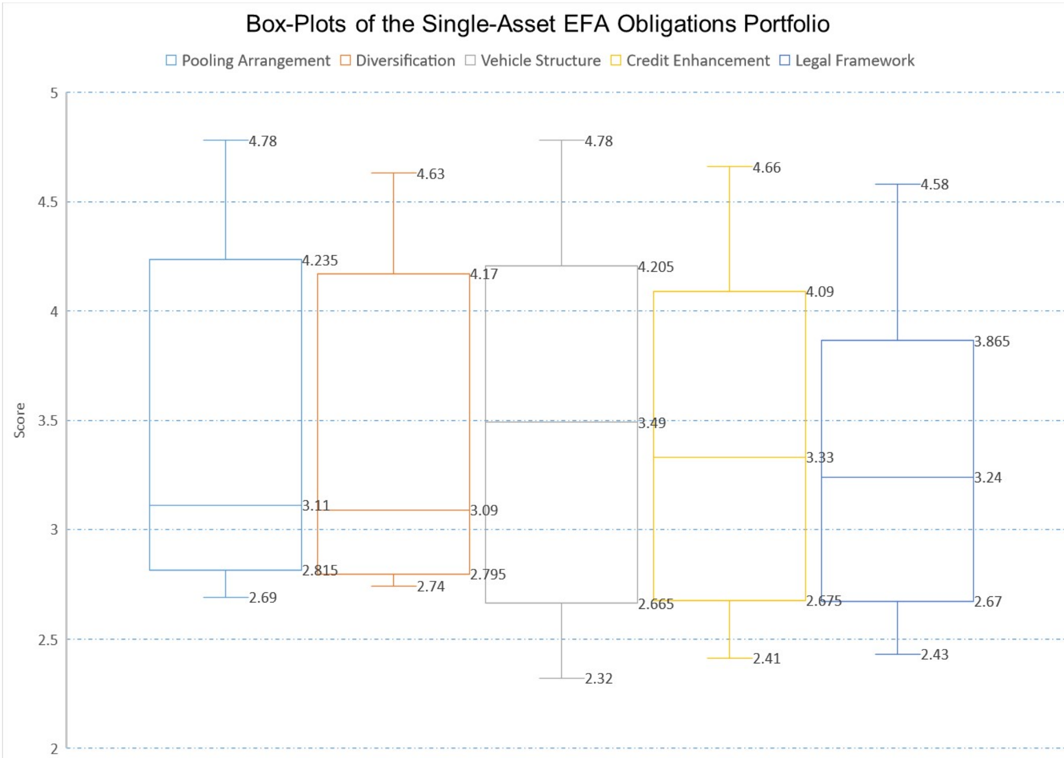
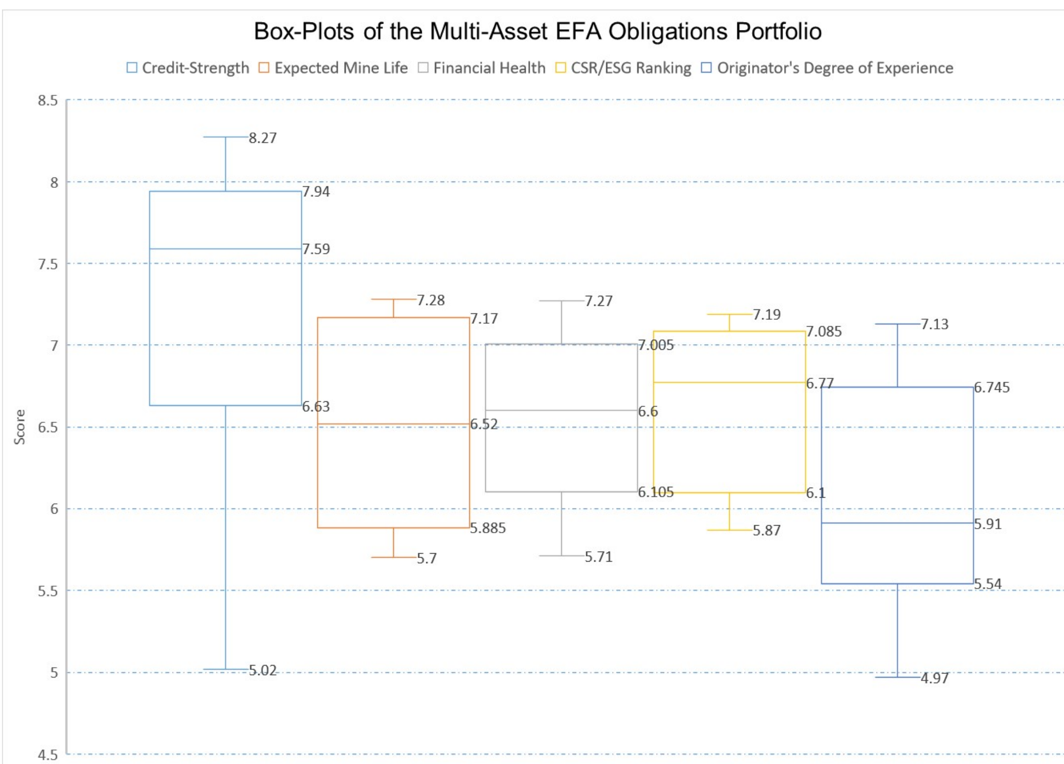
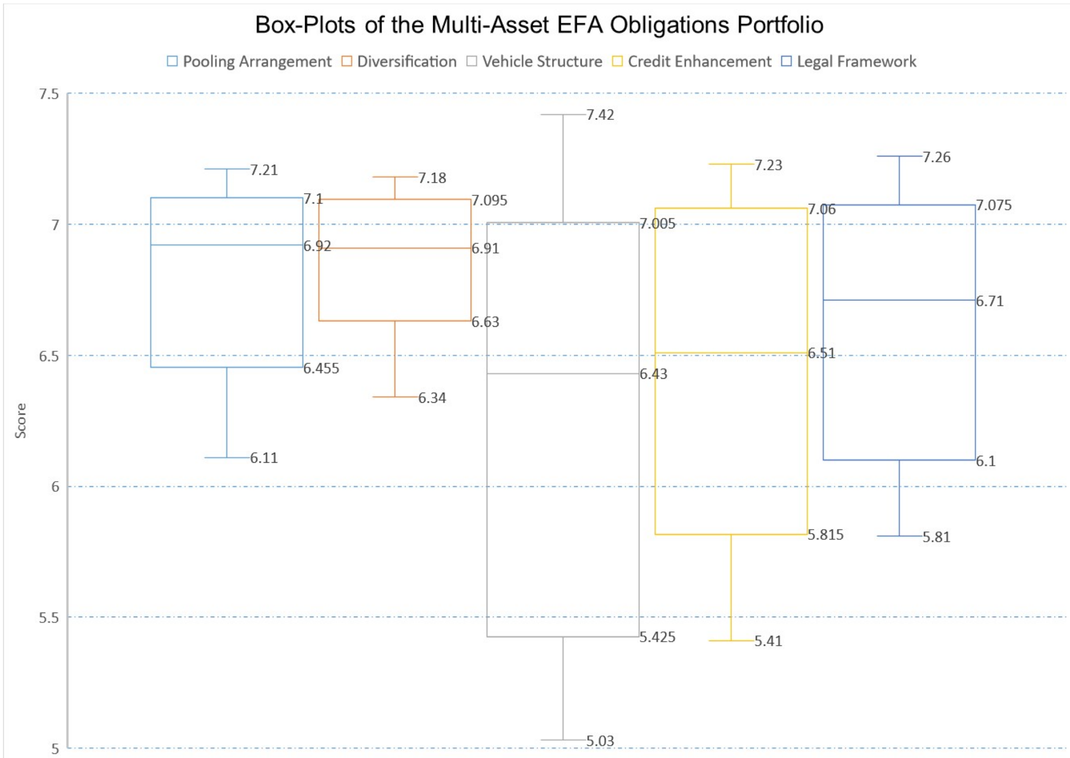


Figure 4.6: Box-Plots of the Multi-Asset EFA Obligations Portfolio





The box-plots in Figures 4.5 and 4.6, respectively, describe the output frequency distribution, and supply general information on data dispersion and asymmetry for the single- and multiple-asset portfolios. From these diagrams, conclusions can be made:

- The higher the *Credit-Strength* and *Financial Health* of the participating mine operators, and the *Originator's Degree of Experience* of the EFA obligations portfolio, the higher the likelihood of generating stable and consistent cash flows to cover the debt service and principal payments.
- The need for portfolio diversity (*Diversification*) might not influence the score as much as anticipated if the observed mine operator's financial health is acceptable, as illustrated in Figure 4.5 (assume it is a large mining company such as BHP Group or Rio Tinto, by market capitalisation, with multiple projects globally and diversified natural resources).
- The results in Figure 4.6 suggest that the number of different financial assurance obligations participating in the securitised portfolio (*Pooling Arrangement*), portfolio

diversity (*Diversification*), the flexibility of the SPV (*Vehicle Structure*), the strength of the *Credit Enhancement* mechanisms, and the *Legal Framework* of the deal can increase the overall probability of success for such a securitisation transaction.

The selection of the explanatory linguistic variables, and their level of influence compared to the others observed, relied in part on subjective judgment based on proven industry practices and scientific research. To reduce the arbitrariness in assigning degrees to the different dimensions and variables, a thorough analysis of existing literature; personal, professional experience; and industry professionals in the field of structured finance and mining were consulted. The accumulated opinions helped to interpret the evidence and to validate the suitability of the applied Mamdani-type FIS model.

The results obtained from the fuzzy logic simulations show that the observed linguistic input variables possibly impact the outcome of the EFA-backed securitisation at various degree levels (ordered from *most* to *least* sensitive):

- Vehicle Structure
- Credit-Strength
- Expected Mine Life
- Credit Enhancement
- Originator's Degree of Experience
- Legal Framework
- Financial Health
- CSR/ESG Ranking
- Pooling Arrangement
- Diversification

The sensitivity analysis of the effect of *Pooling Arrangement* and *Diversification* might not impact the ranking score as was anticipated. Their insignificance could be due to the greater importance of the health of each pooled mine operator, as observed by the *Credit-Strength* and *Expected Mine Life* variables, and the overall soundness of the *Vehicle Structure* in reference to their pooling selection capabilities, which is the case for ABSs and MBSs.

Figures 4.5 and 4.6 illustrate that the whiskers of these input variables are a bit longer than the rest of the linguistic variables, which implies those variables, holding all the other independent variables constant, might noticeably influence the likelihood of success or failure of the proposed EFA-backed securitisation mechanism. In future research, attention will be given to try to determine why there is such a variation in their performance. There are also low and high outliers, which provides an indication of which input variables possess a greater influence on the potential outcome.

4.2 Discussion and Analysis

> *Countries across the world pay for the costs of environmental crimes done long ago and for those perpetrated in the present day.*

The current ecosystem for financing EFA obligations depends on a finite, and dwindling, number of FA providers (Chambers, 2005; US EPA, 2010; Learn, 2016). The dissertation demonstrates that a financial assurance funding model that utilises a structured finance technique such as securitisation could be suitable to address such challenges. The general asset-backed security model was extended to account for FA-specific parameters.

The research analysed the potential attributes leading to the success of securitisation deals having FA obligations as their underlying pooled assets. More precisely, it aimed to explore how, and under which conditions, an EFA-backed securitisation transaction could create value for both the issuer and investors. A successful transaction would be defined as one in which the issuer monetised its financial assurance obligations assets in an efficient, cost-effective manner, with the investors receiving a well-structured, highly rated investment that provides a favourable risk/return trade-off.

If such an EFA-backed structured finance instrument is potentially commercially viable and given its discussed potential within various industries, why does it not already exist? No study exists to answer such a question but it could be due to multiple factors, including:

- the overall complexity of the proposed structured finance system;
- the exorbitant costs associated with establishing such securitisation mechanisms, especially a non-existent one from the ground up;
- issues surrounding calculating reclamation costs and corresponding financial assurance requirements accurately;
- regulatory vagueness in many jurisdictions globally;
- the needed securities, regulatory, reclamation and closure, and taxation regulations;
- lack of possible interest by some stakeholders (including regulators, financial markets, potential investors, and mining companies); and
- technology limitations.

There must be, nevertheless, a first for everything; hence, the dissertation research provides some insights into its potential feasibility. Case studies are, subsequently, planned to be carried out to assess and test the hypothesis of their commercial viability potential.

Since EFABSs are non-existent and would be customised financial solutions, and their numbers would be too small to support statistical evidence, a traditional empirical analysis could not be implemented. Moreover, due to the overall complexity and the exorbitant costs associated with such a structured finance system, the use of FL as a modelling tool is fitting. Securitisations are costly due to system and management costs, legal fees, rating fees, underwriting fees, and ongoing administration. A conceptual fuzzy logic-based framework was therefore developed and tested.

Despite the incentive to employ fuzzy logic as a modelling language, and given the commercial and academic success of it, there are some observed critical drawbacks in applying a FIS model.

A disadvantage of the rules utilised in the dissertation is that the research model gave the same importance to all factors that were combined. For example, it is possible that the *Financial Health* and *CSR/ESG Ranking* input linguistic variables might not provide the same level of importance to the potential success of securitisation deals having EFA obligations as its underlying pooled asset.

Starting from the question of whether structured finance can provide a reliable, regulatory approved, financial assurance funding source to the mining industry, among others, for R&C obligations in the advent of diminishing surety providers. An exploratory analysis of EFA-backed securitisation was carried out to try to quantify the main factors influencing its potential in this industry. From the outcome of the research work, a broader issue emerges – large mining companies usually possess high corporate credit ratings. They can, thus, leverage on a wide range of '*soft*' and '*hard*' FA funding possibilities at a relatively low cost. Therefore, it is clear that improving funding conditions, even though quite important, for such corporate entities is probably not the main driver for them wanting to securitise EFA obligations unless mandated or other appropriate reasons exist.

It seems that FA-backed securitisation should be more suitable for small and medium-sized mining companies that do not have easy access to capital markets or that have a higher financial risk and few possibilities to raise unsecured financing. Large diversified natural resources companies often possess a sizable portfolio of mine projects and have a higher likelihood to exploit it and to generate a steady cash flow to cover the cost of issuance and debt service required to deal with their financial assurance requirements.

The research also aimed to explore how, and under which conditions an EFA-backed securitisation transaction can create value for both the issuer and the investors. A successful transaction is defined as one in which the issuer monetised its FA obligations in an efficient, cost-effective manner, with the investors receiving a well-structured, highly-rated investment that provides a favourable risk/return trade-off.

Despite the analysis undertaken, the market potential for EFA-backed securitisation will remain uncertain until case studies are completed and conclusive results are obtained. Future case studies in multiple jurisdictions are expected to be conducted to examine the likelihood of such market potential. Other barriers to overcome are the assessment of the financial assurance portfolio value and its risk profile, and its disposal in case of default since no such securitisation deals have yet been established up to now; thus, a secondary market does not exist. Environmental finance trends could, however, support financial assurance-backed securitisation developments.

Another critical observation of the dissertation is the need to recognise the calculation of reclamation costs as a technical and complex issue, regardless of the applied financial assurance mechanism, which is subject to enduring changes and is influenced by many regulatory and economic considerations. These features have several implications for policymakers in the global context. First, the matter needs to be addressed with an in-depth technical and innovative approach; therefore, authorities must ensure there is a growing consensus not to play politics on the topic before putting it in the public agenda.

4.2.1 Research Limitations

The observed financial assurance securitised framework was tested by applying a FIS-based methodology approach; however, alternative approaches exist that employ more traditional probabilistic methods (e.g., decision tree-based models) and others that analyse randomly sampling from all available paths (e.g., Monte Carlo methods). Such a comparison of models is expected to be examined in future research studies.

Canada, like other financial centres, has not regulated EFA-backed securitisation in any specific sui generis system or integrated it into its capital markets, or under corporate or environmental regulations due to their current lack of existence. The credit rating agency's procedures, methodologies, assumptions and the key elements underlying the assessment of EFABSs would also need to be developed. They would need to be publicly available and on a non-selective basis to FABS stakeholders, which include investors and regulators. The absence of such provisions sparks a fundamental problem for the application of EFA-backed securitisation as outlined in the dissertation. Without specific regulation, the validation of such a securitised mechanism is in question. As well, the uncertainty of the law may also raise doubts about determining whether FA-backed securitisation would be worthwhile.

The literature on *EFA-backed securitisation* also seems to be non-existent. Published papers in this field could be constrained by several factors which could include:

- the absence of accessible data;
- regulatory vagueness and incompleteness;
- the lack of mining regulation enforcement;
- the extent of reclamation cost estimates being confidential; and
- the extent of the detailed evaluations used to set the financial assurance amount also being non-public (varies from jurisdiction to jurisdiction).

Another practical challenge also arises, due to the multi-layered complexities, and the actual effort and time required, to undertake such a costly, yet feasible and reasonable, FA-backed securitised mechanism initiative. The dissertation only focused on their conceptualisation aspects. Its implementation could be an innovative element that is expected to contribute to the further advancement of the state of knowledge in mining reclamation and closure.

Despite the analysis undertaken, the market potential for EFA-backed securitisation will remain uncertain until commercial-related studies have been completed in multiple jurisdictions.

Empirical research and case studies are needed to explore the potential effectiveness of the observed financial assurance-securitised mechanism within a specific jurisdiction and the extent to which efficiency is influenced by particular contexts, which includes regulatory, legal, political, deal structure, and transaction architecture.

Such research limitations warrant future examination of the viability of their implementation and their overall impact on mine reclamation and closure efforts around the world while simultaneously offering investors a competitive yield on their investments.

Chapter 5: Conclusions, Contributions, and Future Work

The polluter-pay principle doesn't work if the polluter goes bust.

— Chris Zimmer
Alaska Campaign Director, Rivers without Borders

A principal purpose for FA requirements for mining projects is to offer a high degree of certainty that sufficient funding will be available to undertake final environmental reclamation, upon mine closure, in the event of default by the mining company. Such an FA mechanism is the system by which governments manage risks associated with the reclamation liability cost, including determining the required amounts of FA, regulating the provision of environmental financial assurance, and encouraging progressive land reclamation and interim clean-up.

Any such financial mechanism must be based on a sound understanding of the likely economic costs surrounding environmental reclamation. The instrument must mandate periodic reviews of those costs, and the progressive reclamation works within the mines to maintain the foundation of robust liability cost assessments.

The success of any such mechanism stems, in part, from the soundness of conservation and reclamation regulation and the comprehensive evaluation of land reclamation. The critical aspects of EFA-backed securitisation are the valuation and calculation of reclamation costs due to the mentioned uncertainties, which is also related to subjective, political, conflicting, and vague environmental mine closure regulation (Green, 2018a; Green, 2018b; Bishop, 2019). Contradictory, incomplete, and ambiguous regulation can lead to unnecessary higher or additional reclamation costs and opposing interpretation of reclamation requirements.

5.1 Conclusions

Regulatory agencies mandate mine operators to establish that they possess sufficient financial resources for the reclamation requirements before initiating their operation activities and to adequately restore the environmental condition of the disturbed lands upon completing their mining activities. Safeguarding taxpayers against the mining industry's environmental noncompliance expenditures has become a growing global concern due in part to the uncertainty of reclamation costs, inconsistencies and unclear regulations, inadequate enforcement of regulations, insufficient financial assurance funding, diminishing surety providers, cessation of treatment of polluted mine drainage due to corporate dissolution or bankruptcy, and unplanned ongoing treatment obligations of mine discharge water.

The effectiveness and suitability of mainstream financial assurance instruments have been an ever-growing concern in terms of the R&C regulation of mining operations, globally. They will continue to provide an abundance of challenges going forward due in part by financial assurance inadequacy and regulatory vagueness and incompleteness. A goal of the research was to examine whether and how EFA-backed securitisation might be applied in the post mine closure period and over a time-varying horizon.

There are circumstances where conventional FA is expected to continue to be an effective mechanism for ensuring compliance. These are aspects related to low transaction costs (well-defined agreements and agreed-upon definitions of compliance and non-compliance, a limited number of contracting parties, a clear time horizon for regulatory compliance, and a high probability of detecting non-compliance); a low FA value relative to the regulated company's assets; and no irreversible environmental effects. These factors, to some extent, are in place for mining project closures, though there are evident complications with regulatory compliance, oversight, enforcement, and completion requirements.

It appears that prevailing regulatory policies in countries such as Canada and the United States should be able to accommodate foreseeable mine closure projects, in principle; however, there has been little in the way of rigorous empirical analysis of the effectiveness of financial assurance programmes that might be applied to long-term mining closure projects. Periodic review of assurance levels is essential to capture changes in the plan or to offset changes in factors such as interest rates and inflation. When calculating reclamation costs and the corresponding regulatory required financial assurance amount for long-term projects, consideration must be given to constant care and maintenance requirements, risk assessments, discount interest rates, and time frames.

The dissertation highlights that mine operators, regulators, investors, and other stakeholders need to work towards meeting such immediate and long-term environmental reclamation objectives. Interested parties should, therefore, work together to reach essential goals, as expressed by Rio Tinto CEO, Jean-Sébastien Jacques, when he commented that going forward resource companies need to build the "*United Nations of the mining industry*" to tackle rising resource nationalism and cost inflation, among other things (Lewis, 2018). Questioned at a conference presented by BAML in Miami (Bank of America Merrill Lynch, 35th Annual Global Mining Metals & Steel Conference. May 16, 2018), whether forming partnerships was the answer, Jacques stated "*absolutely*" (Lewis, 2018). "*Partnerships were seen as value leakage, not as risk mitigation*," he said. "*Going forward, we need to spread the risk. In some very challenging jurisdictions, we will have to build the United Nations of the mining industry*." The fight against orphaned/abandoned mines clean-up, refinement of reclamation issues, and preventing mine operators from abandoning their required reclamation obligations issues involves a diverse range of agents.

An important implication that EFA-backed securitisation could offer is the new opportunities for more in-depth education, technology transfer, and international cooperation of mine reclamation and closure practices between developed and emerging markets as touted by Rio Tinto's CEO. Structured finance, as indicated, can potentially be applied to build and strengthen potential relations between sovereign borrowers and international lenders which can have a far-reaching impact on the outlook of global '*public law*' financing programmes.

Approaches to mine site reclamation need to be dynamic, and evolving '*best practices*' should be an integral component of R&C planning. Best practices for both regulatory and voluntary/non-regulatory efforts include policies, programmes, reclamation research, technologies, and other measures that are environmentally and cost-effective appropriate. FA mechanisms should be flexible, responsible, and reasonable. The selection of key R&C measures should be based upon best practicable technology together with comprehensive and current technical information. The use of leading-edge scientific and technological measures is encouraged when coupled with feasibility assessments. Best practices encompass and build on standards embodied within local, national, and international initiatives.

These dual forces act as both a '*stick*' (i.e., increased regulatory and market risks in certain mining jurisdictions where uncertainty surrounding environmental regulations exists) and a '*carrot*' (i.e., decreased risk profiles or superior returns in mining companies with exposure to advanced environmental technologies and proper reclamation funding) for investors in the global economy. Proactive investors may realise that the risks of diversifying their portfolios into compliant corporate entities and jurisdictions can be overshadowed by the threats of not reacting to these signals and continuing to invest in mine operators and regions operating in a business-as-usual manner.

Relying on a '*stick*' alone to support new investments can be challenging due to continued regulatory volatility in addressing issues surrounding mining regulation (i.e., compliance, oversight, and enforcement) and funding. The examination is whether a '*carrot*' can be satisfactory to support investment and if the proposed '*green finance*'[61], of the sort, FA-backed

[61] Green financing permits the increase in the level of financial flows (from insurance, investment, and banking) from the private, public, and not-for-profit sectors to sustainable development priorities (OECD iLibrary, 2019). It typically refers to financial investments flowing into sustainable development initiatives, environmental initiatives and policies that promote the

securitised mechanism can unleash more capital to help the financial resources market to fund mandatory, mine site R&C requirements following the completion of mining operations.

Despite some inherent risks affiliated with FA-backed securities, there is genuine optimism. Such confidence is based on the discussed conceptual securitisation framework results and expectation that the move from deals backed by the physical property to transactions backed by financial assurance obligation requirements appears to be a natural, innovative, and progressive next step. Not only in the evolution of the ABS market beyond the more familiar mortgages, prime auto, credit card, life settlements (life insurance policies), cancer biotechnology, and student loan sub-sectors, but also the surety services industry and in reducing regulatory burden by increasing regulatory efficiency as well.

Lending partly or wholly against FA obligations assets remains to be seen even in developed countries. The dissertation illustrated that collateralising commercial financial assurance obligations loans, and bank financing by granting a security interest in inflation-hedged, aggregate interest revenue streams could become a growing practice[62].

It can be concluded that the securitisation of EFA obligations would involve great complexity. The costs to develop an EFABS scheme would also be enormous and would require multiple parties, and the volume of such securities would need to be substantial for it to become feasible for everyone. If the recent advent of diminishing FA providers is a foreshadowing indication, then it is only a matter of time before concerned stakeholders could develop interest and capacity to use financial assurance obligations income streams to financially secure R&C requirements. Mine operators' R&C financing needs, diminishing regulatory oversight and enforcement efforts by some regulators in various jurisdictions due to multiple reasons, and

better development of society. A crucial part of this is to manage environmental and social risks better, take up opportunities that bring both a modest rate of return and environmental benefit and deliver greater accountability.

[62] Particularly in the mine and energy, chemicals, livestock farming, nuclear, and infrastructure sectors.

growing investors’ risk appetite could discover the rewards that could arise from the untapped potential of securitisation of financial assurance obligations regulatory requirements.

The research also discussed how the proposed EFA-backed securitised mechanism could be applied practically to help overcome the deficiencies surrounding the availability of surety providers since the recent global financial crisis of 2007. Consequently, operators in the mining industry, and other sectors, including oil & gas, have found it progressively more problematic to satisfy FA obligations required by regulators with the typical FA mechanisms of choice. It is expected to be even more so, in Canada, now that energy companies may have to deal with their environmental obligations before paying back creditors in the case of insolvency or bankruptcy, as the Supreme Court of Canada has recently ruled (in *Orphan Well Association, Alberta Energy Regulator v. Grant Thornton Limited and ATB Financial*).

The SCC verdict could strengthen the arguments raised in the dissertation in favour of the utilisation of securitisation to meet the regulatory requirements surrounding FA. Securitised mechanisms, as previously mentioned, are typically made bankruptcy-remote.

It is also possible that other industries where environmental liabilities feature prominently, similar to the mining sector, will experience a decline in lending and investment. Investors and lenders may not lend money where the recovery of their funds is now so uncertain. Companies in these extractive industries may now need to seek alternative sources of financing, and creative deal structures for growth and funding, such as the discussed securitised mechanism.

Financial assurance obligations, although possibly problematic to properly securitise, may open new opportunities for domestic and cross-border investment while offering various sectors of the economy with better cost-effective methods to attain the required EFA financing more readily, and, consequently, potentially creating new niches in the social financing and securitisation markets. To reiterate, Morgan Stanley Investment Management estimates that the global securitised market is nearly $9.8 trillion in size.

The study also provides relevant principles which may function to balance the possible acceleration of EFA-backed securitisation as a new social-focused financing mechanism for the extractive industries and others. Such a financial product, however, is unlikely to reach the volume which other asset- and mortgage-like securitisation asset classes within the fixed-income sector have reached. Nevertheless, an attempt is expected to be undertaken in the immediate future using case studies as its basis.

Future research is expected to assess the viability of FA-backed securities as a lower-cost financing mechanism and to identify policies (e.g., regulatory, financial, and taxation) that could facilitate the implementation of securitisation. Limited access to low-cost financing impedes the funding of financial assurance requirements. Securitisation of EFA obligations provides a potential solution to this problem.

5.2 Contributions to Knowledge

The purpose of the research was not only to produce new knowledge and to deepen the understanding surrounding FA but also to investigate if key attributes could be identified that may influence the likelihood of success of an EFA-backed securitised mechanism.

The dissertation discusses an environmental FA-backed security structure that is free of some of the inherent discussed limitations of conventional financial assurance forms. It is expected that this proposed model would as well provide potentially significant financial savings to stakeholders; strengthen existing regulations' oversight, enforcement, compliance, and completion requirements and capabilities; and offer financial support to mine operators in need of fulfilling their EFA regulatory-mandated obligations.

The research also highlighted the potential impact that the proposed EFA securitised mechanism could create to its stakeholders, which includes the mining industry and society. As well, it may open new opportunities for domestic and cross-border investment while offering the mining sector and other related extractive industries with better cost-effective means to obtain the required FA financing, through securitisation, and thus subsequently creating new niches in the financing and structured finance markets.

A properly designed and fully-funded EFA financing programme would be expected to meet or exceed a company's guidelines for CSR, as should be outlined by its *Corporate Social Responsibility and Environmental and Sustainability* policies. A mine operator's standards should specify the requirements for responsible closure planning, cost estimating, and financial assurance. These requirements would be accomplished by providing a regulatory, oversight- and enforcement-focused, permitted financial mechanism that would ensure there are adequate funds available for a responsible party to manage the reclamation-related obligations of a mine site properly. It would also offer an effective response to community and non-governmental organisations concerns about environmental legacies from mining operations.

In investigating such themes, the dissertation was guided in part by existing academic literature and current industry practices. Until the research was initiated, information surrounding EFA-backed securitisation was non-existent. Publications in the field of FA obligations outstanding, as it relates to mining, have been constrained, in part, by the lack of available public data and by the high level of secrecy surrounding such required financial obligations by mine operators.

The analysis demonstrates that it is conceptually feasible to develop a more effective environmental oversight framework and, also, an EFA mechanism that appears practical and straightforward. The dissertation contributes to the existing literature, particularly concerning regulatory, financial innovation, mine reclamation and closure efforts, and FA requirements in the natural resources extractive and infrastructure industries.

In summary, the research demonstrates that the integration of a structured finance, financial assurance mechanism, along with progressive mining policies and regulations, could be an achievable reality which when effectively executed could virtually balance economic development and environmental destruction for a safer future. It illustrates that it is possibly feasible to establish a more effective and efficient EFA framework structure and assurance mechanism. Uncertainty will remain until case studies are completed.

5.3 Recommendations for Future Work

> *A bias for action.*
>
> — Peters and Waterman, 1982

> *Now, this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.*
>
> — Sir Winston Leonard Spencer-Churchill

The dissertation highlights several future research needs. Notably, case studies are needed to determine the practicality, acceptability, and feasibility of the discussed conceptual FA-backed securitised mechanism. The market potential for such an EFA-based financial instrument will remain uncertain until industry-wide studies are undertaken. Several journal papers are expected to spawn from the current research-based, in part, on FA, the observed securitised mechanism, and regulatory oversight and enforcement activities.

It is the author's interest to work with local and international stakeholders to analyse the viability of such a progressive FA initiative. The success of securitising unmarketable and intangible assets such as life settlements (life insurance policies), cancer treatments, and intellectual property is a strong incentive to pursue such a social finance-focused initiative despite the many obstacles to be overcome since EFABSs are timely and well overdue.

The proposed case study within a targeted jurisdiction would identify the range of essential regulatory, legal, accounting, and financial reforms such an observed market should implement to establish the financial infrastructure that authorises the structuring of EFA securitisation transactions. Issues surrounding financial assurance-backed securitisation that would have to be examined, for each considered jurisdiction to assess its commercial potential, include:

- the complexity of the proposed FA-based structured finance system;
- the potentially exorbitant costs associated with its pioneering development;
- identify policies (e.g., regulatory, financial, and taxation) that need to be written or updated; and
- the necessity for the many contributors (e.g., governments, regulators, mine operators, government tax agencies, potential investors, and financial markets) to be identified.

This research would aim at investigating and promoting the prospective EFA securitisation as a feasible alternative method of financing FA requirements, while helping to conceivably overcome possible regulatory oversight and enforcement shortcomings, in the targeted jurisdiction where the case study would be carried out. Each study is expected to evaluate:

- the assessment and the possible redesign of its financial assurance framework for mine resource projects to greater tailored environmental reclamation solutions for various types of operators within the resource sector[63];
- the laws regulating or relating to prudentially regulated corporate entities that typically utilise securitisation to refinance (if such national regulations exist);
- the corporate and trust laws to identify legal structures which can be employed as securitisation-focused SPVs;
- the laws of sale to determine whether it permits the true-sale of financial assets;

[63] It would be aimed at encouraging '*best practice*' environmental outcomes, dealing with residual risk issues, and to minimise its risk in the event of EFA obligations not being met.

- the various legal risks, including substantive-consolidation, veil-piercing, foreclosure, insolvency, and tax risks;
- the dispute resolution framework;
- the structured finance risk mitigation properties of the host jurisdiction's financial market regulatory framework; and
- the capital market gatekeeping framework consisting of structured finance lawyers, auditors, and credit rating agencies.

The internationalisation of capital markets can play an essential role in the engineering of structured financings. Therefore cross-border FA-backed securitisations where reclamation and closure regulatory requirements must comply to the laws of one country while they are securitised, and the debt securities are offered to investors in other jurisdictions will bring much more legal issues than those discussed in the dissertation.

It is recognised that such a case study proposal may spark some unique challenges at the doctrinal, normative, and practical levels for each observed case-study jurisdiction. At the doctrinal level, the potential concerns are, in part, related to risks associated with adverse selection, regulatory capture, moral hazard, and asymmetric information between regulator and firm(s). At the normative level, the challenges are expected to be caused by the absence of regulation concerning EFA-backed securitisation, or possibly securitisation connected with illiquid assets, in the observed jurisdiction influencing the validity and viability of FA-backed securitisation transactions. At the practical level, there is no guarantee regarding the potential success of such a mechanism due to matters relating to determining the required amount of financial assurance necessary to cover potential reclamation liabilities of a mine site, the needed interdisciplinary laws and regulations, and the compulsory developed capital markets.

The research would provide relevant principles which may function to balance the acceleration of EFA-backed securitisation as a new form of FA financing mechanism for jurisdiction-local mining companies, to overcome the doctrinal challenge. For addressing any normative and practical challenges, the research would promote the need for industry and government involvement in developing and promoting FA securitisation. Such an endorsement would be in the form of providing the necessary economic and legal frameworks – starting with the enactment of regulation and the establishment of infrastructures for FA-backed securitisation.

An issue that may arise is the fact that large and diverse mining corporations (i.e., Teck Resources) are often able to meet the funding requirements of financial assurance obligations for a specific mining project with the generated cash flows of another established one(s) from their mine development projects portfolio. As well, these corporate entities usually have high corporate credit ratings and can leverage a wide range of funding possibilities at relatively low cost. Therefore, improving funding conditions, even though quite important, is probably not the central driver for recourse to financial assurance-backed securitisation, at least for such established industry participants.

EFA-backed securitisation, thus, seems to be more suitable for small and medium mine operators that do not possess sufficient access to capital markets or that have a higher financial risk and fewer possibilities to raise unsecured financing. Furthermore, other barriers to overcome are the calculation of the financial assurance obligation value and its risk profile, and its disposal in case of default. Case studies are expected to test these hypotheses and others.

Preliminary discussions are currently underway with industry leaders to assess the commercial relevance and viability of the outlined financial assurance-backed securitised mechanism. A conversation with Rio Tinto CEO, Jean-Sébastien Jacques, is warranted to understand better his vision of building a "*United Nations of the mining industry*" since his insights and perspective appear to be in line with the viewpoints discussed in the dissertation.

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Appendices

Appendix A: Mine Reclamation Securities in British Columbia for 2014

Table A.1: 2014 Mine Reclamation Securities in BC for Metal and Coal Mines Summary

Mine	Owner (2014)	Total Bond Amount	Liability Estimate	Differential
COAL MINE PERMITS				
Elk Valley (Elkview, Fording, Greenhills, Coal Mtn, Greenhills)	Teck Coal Ltd.	$384,460,000.00	$925,358,035.00	$540,898,035.00
Sage Creek	Sage Creek Coal Ltd.	$1,000.00	$1,000.00	$0.00
Tent Mountain	Luscar	$58,500.00	$58,500.00	$0.00
Sukunka Coal	Tailsman Energy Inc.	$50,000.00	$67,500.00	$17,500.00
Mt Speiker	Canadian Natural Resources Ltd.	$10,000.00	$10,000.00	$0.00
Benson Mt.	Netherlands Pacific Mining Co. Ltd.	$5,000.00	$5,000.00	$0.00
Willow Creek	Walter Energy	$6,000,000.00	$11,987,574.00	$5,987,574.00
Quintette	Teck Coal Ltd.	$20,083,200.00	$30,070,900.00	$9,987,700.00
Bullmoose	Teck Coal Ltd.	$1,000,000.00	$1,000,000.00	$0.00
Benson Mt.	Wolf Mountain Coal Ltd.	$20,000.00	$20,000.00	$0.00
Mt Klappan	Fortune Coal Ltd.	$306,900.00	$123,050.00	$0.00
Quinsam Coal Mine	Hillsborough Resouces Ltd.	$7,281,000.00	$7,281,000.00	$0.00
Basin Coal	Coalmont Energy Corp.	$276,547.00	$559,500.00	$282,953.00
Brule	Walter Energy	$3,350,000.00	$14,683,875.00	$11,333,875.00
Wolverine	Walter Energy	$11,500,000.00	$12,498,812.00	$998,812.00
Trend	Peace River Coal Ltd.	$43,900,000.00	$111,300,000.00	$67,400,000.00
METAL MINE PERMITS				
Endako	Thompson Creek Mining Co.	$15,345,700.00	$44,560,000.00	$29,214,300.00
Pinchi	Teck Metals Ltd.	$2,000,000.00	$2,000,000.00	$0.00
Granisle	Glencore Canada Corp.	$161,522.00	$4,253,690.00	$4,092,168.00
Red Mountain	Ministry of Energy and Mines	$464,991.08	$464,991.08	$0.00
Island Copper	BHP Billiton	$4,208,076.10	$4,637,000.00	$428,923.90
Kitsault	Avanti Kitsault Mine Ltd.	$740,000.00	$270,000.00	$0.00
Highland Valley Copper	Teck Highland Valley Copper	$18,250,000.00	$204,395,357.00	$186,145,357.00
Brenda	Glencore Canada Corp.	$5,000,000.00	$27,333,333.00	$22,333,333.00
Cassiar	Cassiar-Jade Contracting Inc.	$600,000.00	$1,530,000.00	$930,000.00
Myra Falls Operation	Nyrstar	$78,254,733.00	$118,760,133.00	$40,505,400.00

Copper Mountain	Copper Mountain Mines Ltd.	$11,500,500.00	$12,765,873.00	$1,265,373.00
Gallowai Bul River	R.H. Stanfield	$491,511.19	$498,228.00	$6,716.81
Bell Mine	Glencore Canada Corp.	$1,000,000.00	$45,440,833.00	$44,440,833.00
Taseko Mines Ltd.	Gibraltar Mines Ltd.	$45,638,329.00	$29,800,000.00	$0.00
Alwin Mine	Dekalb	$6,000.00	$6,000.00	$0.00
Giant Nickel	Barrick Gold Inc.	$27,000.00	$600,000.00	$573,000.00
Silvan/Hickey	Slocan/Klondike Gold Corp	$75,000.00	$185,333.00	$110,333.00
Craigmont	Huldra Silver Corp.	$700,000.00	$706,000.00	$6,000.00
Dolly Varden Mine	Dolly Varden	$6,000.00	$6,000.00	$0.00
Beaverdell	Teck Resources Ltd.	$5,000.00	$10,000.00	$5,000.00
Mt Copeland	KRC Operators	$3,484.10	$3,484.10	$0.00
Sullivan	Teck Metals Ltd.	$22,500,000.00	$22,500,000.00	$0.00
HB Mine	Teck Resources Ltd.	$10,000.00	$10,000.00	$0.00
Dankoe	439813 BC Ltd.	$10,000.00	$10,000.00	$0.00
Boss Mountain	Glencore Canada Corp.	$30,000.00	$2,434,033.00	$2,404,033.00
Afton	KGHM Ajax Mining Inc.	$350,000.00	$350,000.00	$0.00
Equity	GoldCorp	$62,447,000.00	$62,447,000.00	$0.00
Cusac	Cusac Gold Mines Ltd.	$264,444.00	$627,762.00	$363,318.00
Mosquito Creek	Mosquito Creek	$5,000.00	$437,119.00	$432,119.00
Caroline	New Carolin Gold Corp.	$256,250.00	$199,564.00	$0.00
Scottie Gold	Red Eye Resources	$15,000.00	$15,000.00	$0.00
Baker	Dupont Canada Ltd.	$15,606.00	$165,681.00	$150,075.00
Goldstream	Bethlehem Resources	$200,000.00	$1,048,056.00	$848,056.00
Venus Mine	United Keno Mines	$7,000.00	$7,000.00	$0.00
Taurus	Cassiar Gold Corp/Inter Taurus	$10,000.00	$10,000.00	$0.00
Diamc	Silence Lake	$10,000.00	$10,000.00	$0.00
Baymag	Baymag Mines Co. Ltd.	$15,101.71	$836,048.00	$820,946.29
Ashlu Gold	Osprey Mining and Exploration	$10,000.00	$10,000.00	$0.00
Four-J/Lussier	Georgia Pacific Canada Ltd.	$20,000.00	$20,000.00	$0.00
Perlite	Perlite Canada Inc.	$0.00	$0.00	$0.00
Union Mine	Pearl Resources Ltd.	$5,000.00	$5,000.00	$0.00
Blackdome	J- Pacific Gold Inc	$100,000.00	$100,000.00	$0.00
Nickel Plate	Barrick Gold Inc.	$1,671,754.00	$96,500,000.00	$94,828,246.00
Cheni/Lawyers	Cheni Gold Mines Ltd	$15,000.00	$15,000.00	$0.00

Johnny Mountain	Skyline Gold Corp.	$562,310.33	$319,000.00	$0.00
Premier	Boliden	$3,000,000.00	$15,909,000.00	$12,909,000.00
Parson Barite	Highwood Res/Sherritt	$10,000.00	$53,680.00	$43,680.00
Moberly Silica	HCA Mountain Minerals			$0.00
Candorado	Candorado Mines	$0.00	$3,000,000.00	$3,000,000.00
Samatosum	FQM Akubra Inc.	$7,800,000.00	$7,276,145.00	$0.00
South Fork Silica	331670 BC Ltd.	$1,000.00	$1,000.00	$0.00
Barrier Feldspar	Kanspar	$20,000.00	$20,000.00	$0.00
Golden Bear	Goldcorp	$210,000.00	$73,200.00	$0.00
Horse Creek Silca	HiTest Sand Inc.	$125,000.00	$125,000.00	$0.00
Sable/Shasta	Int'l Shasta/Sable Resources Ltd.	$164,000.00	$1,110,000.00	$946,000.00
Snip	Barrick Gold Inc.	$1,000,000.00	$2,940,833.00	$1,940,833.00
CIL	Clayburn Industries	$1,000.00	$5,000.00	$4,000.00
Cirque Mine	Cirque Operating Corp.	$220,000.00	$220,000.00	$0.00
Gypo Pit	Pacific Silica and Rock Quarry	$2,500.00	$2,500.00	$0.00
Eskay Creek	Barrick Gold Corp.	$3,774,000.00	$118,514,270.00	$114,740,270.00
QR	Barkerville Gold Mines	$2,860,000.00	$10,250,000.00	$7,390,000.00
Elk / Siwash	Almaden/Fairfield Minerals	$150,000.00	$61,816.00	$0.00
Mount Polley	Mt Polley Mines Ltd.	$19,050,011.00	$29,500,000.00	$10,449,989.00
Huckleberry	Huckleberry Mines Ltd.	$26,000,000.00	$59,000,000.00	$33,000,000.00
Kemess South	AuRico	$18,520,000.00	$17,144,663.00	$0.00
Bralorne	Bralorne Gold Mines Ltd.	$115,000.00	$1,114,607.00	$999,607.00
Bow mines (Tailings)	Golden Dawn Minerals Inc.	$50,000.00	$70,000.00	$20,000.00
Crystal Graphite	Eagle Graphite Corporation	$0.00	$0.00	$0.00
Ainsworth Mill	Blue Bird Mining	$5,000.00	$250,000.00	$245,000.00
Brittania	BC Government			$0.00
Quinto Mine	Consolidated/Quinto Mining Corp.	$70,000.00	$5,000.00	$0.00
Blue Bell	Teck Resources Ltd.	$0.00	$0.00	$0.00
HB Tailings	Regional Distirct East Kootenay	$0.00	$0.00	$0.00
Churchill Copper	Teck Resources Ltd.	$0.00	$0.00	$0.00
Max Molybdenum	Forty Two Metals Inc.	$730,000.00	$1,313,403.00	$583,403.00
New Afton	New Gold Inc.	$9,500,000.00	$9,681,190.00	$181,190.00
Galore Creek	Teck Metals Ltd.	$1,167,000.00	$1,167,000.00	$0.00
Ruby Creek	Adanac Molybdenum Corp.	$100,000.00	$100,000.00	$0.00
Tulsequah	Chieftain Metals Inc.	$1,200,000.00	$1,200,000.00	$0.00
Zip Mill	Huakan International Mining Inc.	$235,000.00	$303,558.00	$68,558.00
Lexington-Grenoble	Huakan International Mining Inc.	$215,000.00	$168,232.00	$0.00
Yellowjacket	EaglePlains	$150,000.00	$150,000.00	$0.00
Mount Milligan	Terrain Metals Corp.	$30,000,000.00	$35,171,000.00	$5,171,000.00
Dome Mountain	Gavin Mines Ltd.	$579,000.00	$1,360,000.00	$781,000.00
Bonanza Ledge	Barkerville Gold Mines	$960,000.00	$4,446,000.00	$3,486,000.00
Treasure Mountain	Huldra Silver Inc.	$505,100.00	$505,100.00	$0.00
Red Chris	Red Chris Operating Corp.	$12,000,000.00	$9,774,073.00	$0.00
Yellow Giant (Tel)	Banks Island Gold Ltd.	$355,000.00	$283,700.00	$0.00
		$892,153,070.51	$2,133,597,234.18	$1,262,769,510.00

*bonds greater than liability have an undersecure of zero (not minus)

(MEM, 2016)

Appendix B: Funding Mechanisms for Mine Reclamation

Review of Financial Assurance Instruments

Mining presents two critical types of risks to the environment, the risk of mining disasters and the risk of non-reclamation & remediation. The costs of these can land on taxpayers when mining companies declare bankruptcy.

To ensure that the reclamation work outlined in the mine closure plans is successfully performed, even if the proponent of the mining activity faces financial or legal troubles, a FA (financial guarantee) equal to the estimated cost of the reclamation work must be held by the regulator (Peck and Sinding, 2009). The financial guarantee must be included with the submission of the closure plans before the mine operator can initiate its operations.

Financial assurance can be provided in one of the following forms: cash, letter of credit from a bank, surety bond, mining reclamation trust, compliance with a corporate financial test in the prescribed manner, and any other form of security or any other guarantee or protection (including a pledge of assets, a sinking fund or royalties per tonne) that is acceptable to the government regulator. Table E.1 in Appendix E assesses the relative benefits and shortcomings of each of the conventional forms of EFA instruments.

Surety bonds are a type of FA instruments to regulate the peripheral effects due to resource depletion and pollution (Costanza and Perrings, 1990). These bonds emerged from the material user fees suggested by Solow (1971) and Mills (1972), where a corporate entity is obligated to post a bond that will cover any possible environmental expenditures associated with damages (Perrings, 1989). The objective is for the company to internalise alleged social expenses into its corporate capital optimisation allocation decisions (Perrings, 1989; Costanza and Perrings, 1990). The monetary value of the surety bond would be a function of the environmental authority's best estimate of the worst-case scenario outcome of any given activity based on the current state of understanding (Costanza and Perrings, 1990).

Perrings (1989) stated that this worst-case outcome scenario is the '*focus loss*' of an activity – describing it as an unlikely, hypothetical financial expenditure. The surety bond value would fluctuate with time to reflect the real-world experience and the outcomes of theoretical and experimental research into pioneering activities. They would also guarantee that funding exists to protect taxpayers against possible environmental costs stemming from present operational activities, with this capital accumulating in proportion to the presumed risks.

Perrings (1989) proposed three benefits to environmental surety bonds:

- efficiency and the motivation to cheat (shirk);
- financial assessment registration, identifying the charge placed on the possible damages from the suggested project by the environmental specialist;
- shifting the burden of proof; and
- research encouragements.

Perrings (1989) also argued for the flexibility of the surety bonding approach since its value can change over time based on the most current reclamation status of the mine. Despite the perceived benefits of surety bonds, there exist limitations to them in the form of moral hazard, financial constraints, and legal restrictions on contracts (Carmichael, 1989).

Moral hazard exists when the regulator possesses some motivation to seize the surety bond despite the company's level of safeguard (Carmichael, 1989). If the government is enticed by financial greed, capturing the bond would add monies to the regulatory agency's coffers and enhance its power. The overseer will weigh the costs and benefits of moral hazard and could potentially enforce a legal structure that will allow for the easy seizure of the bond.

Company moral hazard can also exist (Carmichael, 1989). If the company recognises that its damages are expected to exceed, or surpasses, the value of the bond, it will possess greater motivation and leverage to disregard pollution controls since they are no longer useful as a deterrent. The use of private information to benefit from an incomplete contract arises in markets where information asymmetry exists (Arrow, 1963). Hölmstrom (1989) denotes that such an issue stemming from moral hazard may results when entities partake in risk-sharing under circumstances where their actions influence the probability distribution of the outcome.

Corporate finance theory devotes significant attention to the conflict of interest between managers and shareholders, and between creditors and shareholders. Merton's (1974) structural model for corporate debt argues that shareholders hold a call option on a company's assets. If the assets' value, when the debt is maturing, is greater than the value of the debt itself, shareholders will exercise the call option by paying off the debt and re-obtaining the ownership of the assets. If, conversely, the assets' value decreases below the debt value, they possess the right to default and walk away from the company leaving the assets to the lender. The shareholders, due to their options right, and the debtholders possess different incentives which create conflicts of interests.

One of the streams of the corporate finance literature on strategic default focuses on the usage of collateral (e.g., financial assurance) as an inducement that encourages the borrower to stay solvent (Fay et al., 2002). Giroud et al. (2012) focus on the level of snow that accumulates at a particular resort as an exogenous instrument to spot distress due to debt overhang (strategic defaulters) among a group of highly leveraged Austrian ski hotels (Myers, 1977).

Two approaches to controlling the moral hazard problem are reviewed in the literature (Shavell, 1979; Winter, 1991; Dionne and Harrington, 2013). The first one is control of the insured and a suitable adaptation of the premium, while the second method exposes the insured party partially to the risk(s). An appropriate solution is full control of the insured (Spence and Zeckhauser, 1971; Winter, 1991; Okura, 2012; Dionne and Harrington, 2013). In such an instance, the premium conditions would be adapted to the behaviour of the insured, and the premium would echo the care taken by the insured. In an optimal scenario, this would give the insured incentives to conduct themselves precisely as if no insurance existed and the premium would reflect the right level for calamity risk.

The next best solution would be to expose the insured partially to the risk, which is considered runner-up since insurance is expected to compensate the injurer for the risk(s) endured. Exposing the insured to risk implies that some degree of risk aversion remains. Such an implication suggests that the insured party will have some motivation for care-taking despite it being insured. Exposure to such risk can be either at a higher level or a lower level of damage. One could think of a structure with a deductible by which a lower threshold applies, or one could present an upper limit on coverage whereby the insured party would bear their loss in the event the damage surpasses the insured amount.

In practice, an individual will, of course, be offered a blend of both structures to minimise moral hazard behaviours. There is usually some degree of differentiation within the policy conditions, a deductible and an upper limit on coverage. Of course, the approaches applied would depend upon the information costs and on the value of the insurance policy (Marshall, 1976; Winter, 1991; Okura, 2012; Dionne and Harrington, 2013). An insurer will be more inclined to invest resources in making a personalised insurance policy for a large company that pays a substantial premium. If moral hazard is restrained optimally through the usage of the structures, the insured will once-more conduct themselves as if no insurance coverage was available with the benefit that the disutility of risk is expunged from themselves.

Insurance bias, moral hazard, and adverse selection do not appear to be significant issues in this environmental insurance market when the FA scheme is considered mandatory (Hudson et al., 2014). Adverse selection and insurance bias are complications related to voluntary insurance markets (Wolfe and Goddeeris, 1991; Hudson et al., 2014). Such issues arise when information problems alter the demand for insurance that is to be acquired voluntarily. There can be no adverse selection when insurance is compulsory (Hudson et al., 2014). Similarly, insurance bias is immaterial if it is mandatory (although any such bias will contribute to potentially responsible parties' (PRP) discontent and the regulated mining community's political opposition to stricter environmental reclamation regulations) (Boyd, 2000).

Moral hazard continues to be a theoretical problem. However, several aspects of the rules lessen the likely influence of moral hazard (Einav et al., 2013). Foremost, insurers charge premiums as a function of the technologies being insured and claim history of the insured (Boyd, 2000). Insurers can also cancel coverage if they provide enough prior notice. The option of cancellation can act as a deterrent to lack of precaution by the insured. Coverage cancellation would pressure the insured to go back to the insurance market and obtain coverage from another insurance provider who is, likely, cognisant of the reasons for the original coverage cancellation — failure to obtain coverage results in the mine closure or termination of operations. There are also legal and regulatory rules that discipline the actions of PRP (e.g., safety standards and the threat of criminal liability). Lastly, any noticeable lack of provision will void the liability limits in a standard insurance policy, and therefore, exposing the PRP to possible unlimited liability.

The adverse selection problem is also identified in the technical annexe (Dionne and Harrington, 2013). It arises if the responsible parties neglect to disclose their actual risk profile, which may compromise the narrowing of risk pools (Faure, 2007; Dionne and Harrington, 2013). The suitable antidote for both moral hazard and adverse selection is risk diversification via risk pools (Faure, 2007; Dionne and Harrington, 2013). It implies that the insurers would have to obtain some relevant data about the insured, and, subsequently, it should punish bad risks with higher premiums and reward reasonable risks with lower ones. The answer to adverse selection is, once again, risk pool diversification (Faure, 2007).

Another limitation is the liquidity constraints facing the regulated company. A surety bond can tie up a substantial percentage of its financial assets. Even with a minimal chance of occurrence, if the possible price tag of ineffective protection is hefty, the bond's value will be substantial. If it does possess adequate capital to post it, credit providers and insurance markets will most likely not offer any financial support (Perrings, 1989). Liquidity constraints due to the bond can push a company out of production or can limit its access into new markets.

Such liquidity constraints also limit the interest in surety bonds (Perrings, 1989). When confronting likely environmental damages, the financial liabilities may well be in the hundreds of millions of dollars.

Self-bonding, conversely, permits a corporate entity with sufficient finances to make legally-binding pledges that it will cover all the clean-up and reclamation expenditures. It benefits since the company avoids tying up its monies on obtaining surety bonds. If a self-bonded company goes insolvent without enough financial assets to back their clean-up, closure, and reclamation liabilities, taxpayers might find themselves having to be on the hook ultimately for all the future financial obligations of the corporate entity (Shogren et al., 1993).

Self-bonding is not the only financial assurance instrument in the assurance marketplace that perhaps proves insufficient to cover clean-up and reclamation liabilities adequately. Some US states, like Virginia, use a pooled surety bonding approach (Morgan, 2015). The pooled instrument is also wholly unprepared to handle an industrywide breakdown. Pooled bonding requirements allow individual mine operators to pay a portion of their overall projected R&C costs into a common fund (an option for smaller companies). Privacy and ethical concerns exist with such an approach. If any individual mine operator becomes insolvent, the pooled funds are tapped to cover the clean-up and reclamation and closure costs.

In Nevada, a mine operator[64] who cannot obtain a surety bond privately can join the state's surety bond pool, but the costs of being part of the pool are higher than purchasing a surety

[64] Only applicable to small mining companies.

bond for itself (Gerard, 2000). Such a state surety bond pool is one alternative in how to handle liquidity constraints; however, pooling risks amongst operators that are unable to acquire individual sureties is expected to introduce a conflicting candidate selection issue where only high-risk companies will choose the surety bond pooling alternative. Moreover, the pool is only big enough to accommodate the reclamation and closure obligations of one mine at any given time until the bond pool is replenished. Miller (1998) deliberates the issues of the development of surety insurance markets for clean-up and reclamation policies.

In 2011, Virginia regulators commissioned an independent study of the state's surface mining reclamation fund (Conrad, 2014). The assessment determined that the programme possessed enough monetary funds to handle the forfeiture of around two smaller permits but that the more severe risk would arise from the bankruptcy of companies with multiple permits. The pooled bonding is not able to handle a scenario where several mine operators whom each possess multiple licenses conclude they cannot or will not commit to their clean-up and reclamation obligations.

It should be noted that general trust funds are prone to misuse by jurisdictions. The US Office of Surface Mining Reclamation and Enforcement (OSMRE), for example, has failed to properly oversee state spending, according to a recent watchdog report (Geiling, 2017; Wardle, 2017). Big money often attracts big interests. The US federal government-overseen Abandoned Mine Land fund (AML), which collects and pays out billions of dollars to reclaim abandoned coal mines, is without exception (Wardle, 2017). US Congress, unions, and other special interests have repeatedly attempted to tap into the fund's vast reserves for their benefit.

The OSMRE, in some cases, failed to ensure that US states use the AML programme for reclamation projects altogether. Thus, communities living near abandoned mines are left to contend with environmental pollution while money earmarked for clean-up is spent on projects like highways and public universities. Wardle (2017) comments that turning the fund into a slush account jeopardises progressive reclamation efforts for short-term political favours. If the government permits political gamesmanship antics like risking a fund to default, it threatens the prospect of the fund's objects being carried out (Fleischer, 2010; Ford, 2013; Wardle, 2017).

Where longer-term, clean-up reclamation obligations are necessary, it is likely to pressure mine operators to forfeit any existing pooled surety bonds and walk away from their responsibilities without some other form of financial assurance in place (Conrad, 2014). The bond fund is insufficient to cover such longer-term expenditures. Trust funds are better suited for such types of longer-term financial commitments given their ability to earn income throughout time (Kempton et al., 2010).

Conventional individual and pooled surety bonds, or similar instruments, focus on the shorter term and well-defined financial commitments that have a high probability of ultimately being released upon the completion of clean-up and reclamation requirements. A financial assurance underwriter will usually avoid offering surety bonds if it concludes that a mining operation site will have long-term pollution discharges since the bond will most likely never be released – it is a circumstance that surety bond providers try to avoid. This is because surety bonds, unlike typical insurance, are designed to perform mainly as credit transactions in which the bond expects to incur no loss.

A trust fund is a financial account (portfolio) managed by a trustee, a third-party, where the monetary funds are provided by the mine operator and payable to the province, state or government regulator (the beneficiary) if the operator fails to perform its R&C obligations. The portfolio offers for the appreciation of the invested capital and therefore, can compensate for increased clean-up and reclamation expenditures. Such a fund provides an opportunity to handle longer-term reclamation obligations better; however, the upfront costs of launching one for long-term, post-closure reclamation monitoring and maintenance are high in comparison with other forms of financial assurance instruments.

Like long-term obligations, trust funds also possess uncertainties and risks (BLM, 2005; BLM, 2006a; BLM, 2006b; Kempton et al., 2010). For instance:

- technical factors can impact the confidence of reclamation cost estimates;
- presumptions should be made concerning utilised investment strategies and expected levels of inflation;
- the robustness of contractual structures on which the obligations are formed influence the term of the trust fund; and
- the capacity of the regulatory institutions to adjust to unexpected changes can impact how well the fund can meet its objectives.

Kempton et al. (2010) also point out that the primary motivation for a company to create a trust fund for long-term mine clean-up and reclamation obligations could be due to the possibility of surrendering all these obligations of their project mine site to the government following closure (BLM, 2005; BLM, 2006a; BLM, 2006b).

The Alaska State Legislature, in 2003, approved a statutory amendment that recognises certain forms of financial assurance, including trust funds, to meet the requirements of Alaska's mine clean-up and reclamation policy (Moselle, 2015). Even though the state permits a mining company to meets its assurance obligation through the creation of a trust fund, the absence of economic incentives has resulted in this EFA alternative to be underutilised (Moselle, 2015).

Conrad (2014) commented that in discussion workshops, which the Interstate Mining Compact Commission[65] hosted for US state regulatory authorities, a variety of matters that the states are working through in the bonding arena were covered. They focused on:

- surety bond forfeitures, particularly those related with insolvencies and the possibility for alternative enforcement;

[65] The IMCC is a multi-state governmental agency that came into existence in 1970, which speaks for the natural resource and related environmental protection interests of its member states.

- tracking letters of credit due to bank mergers and mine closures;
- issues related to amending and raising surety bond financial amounts;
- the expenditure pertaining to full cost bonding;
- inadequate funds resulting from bond forfeitures; and
- the mounting complexity of administering a bonding programme, specifically with regards to default risk analysis.

Appendix C: Issues Surrounding Financial Assurance

Standards of Reclamation

Mineral-rich nations are passing new regulations, and companies are implementing new standards of practice to boost the positive impacts of mining and to reduce and mitigate the adverse effects (Steenhof, 2015). Given that mine reclamation and closure are essential obligations for any mining operation, one of the questions faced by the extractive sector is what happens after the closure with possible perpetual treatment of water and reclamation costs? The environmental closure standards which mine operators must meet affect the cost of the work and the subsequent amount of the financial assurance required (Steenhof, 2015).

In earlier years some host regulators specified that the disturbed lands should be returned to their pre-disturbance condition or a condition allowing resumption of its earlier use (e.g., farming). Such type of standard does have appeal; however, most advanced exploration and mining operations unavoidably leave some permanent and evident alterations. Nonetheless, such earlier thinking still exists (Pilkey and Pilkey-Jarvis, 2009).

Reclamation Cost Uncertainty

Reclamation liability cost estimates can vary significantly for the same mine site. Regulators and owners often have opposing assumptions and perspectives regarding what should be included in the R&C cost estimate (Otto, 2009; Brodie, 2013). It may be practical for a mine operator to carry one value on its financial statements as to their projected cost of reclamation and post some form of financial assurance for a higher value assuming the host government must carry out the environmental reclamation work. The use of the owner's equipment versus contractor equipment, salvage value, the linkage between the mine plan and reclamation plan, and other related factors will greatly influence the estimated cost. The choosing of a fitting contingency value is an item of subjective experience that may be the largest line item in an expenditure estimate (Roscoe, 2002; Brodie, 2013). The value reflects several facets, which add ambiguity to the reclamation liability cost estimate. The relationship between the stage of mine life and uncertainty is presented to understand the differences between reclamation cost estimates.

There are some general definitions of good practice concerning the amount of FA and timing:

- The company shall secure and deliver adequate financial assurance as early as possible, preferably at the exploration stage but before commencing construction or disbursing significant investments (Miller, 2005).
- The posted amount of FA is to be evaluated by costing mine closure.
- The cost estimate needs to be systematically reviewed to improve its accuracy when addressing evolving circumstances. Such changes may include economic variations; new technologies affecting the estimated costs; possible partial releases of EFA because of progressive mine closures carried out during unanticipated environmental incidents; and day-to-day operations that may impact the scope of closure works. Nevertheless, the act of assessing mine closure costs is riddled with tensions and questions that need to be addressed by regulatory authorities.

The first decision that must be made is to determine who should carry out the reclamation cost assessments? The exactness of any R&C cost estimate is closely tied to the quality of the mine closure plans, which is in turn related to the stage of the mine life. A pre-mining plan and associated cost estimate cannot be as detailed as the same documents which are prepared towards the end of the mine life. The performance of critical components of the mine plan will be known (e.g., control of ARD (acid rock drainage) and metal leaching, dams, and the effectiveness of progressive reclamation) and the actual extent of surface disturbance will be better quantified.

Predicting mine site R&C costs several years into the future is an imprecise science since there are many sources of uncertainty. Mine site conditions may prove to be different from those evaluated at the beginning of the project. ARD may unexpectedly arise, increasing the possibility that additional funding may be required for long-term care. The actual costs of labour and equipment may be dissimilar from those estimated. As knowledge of the mine site grows with mining operation and as technology advances, mine plans, and subsequently, reclamation plans are regularly revised.

Some mine operators have argued that the date of mine closure is uncertain and that financial security is not required until that time it can be better predicted or identified. An operator may be financially incapable of ramping up the total EFA security if this is not dealt with during the mine's operating life when its cash flows tend to be positive. Nevertheless, since operators often undervalue reclamation requirements to minimise costs (Roscoe, 2002; Otto, 2009; Brodie, 2013), and many regulators delegate the assessing to an independent third-party or request an auditor to review the mine operator's calculations before granting the approval (Brodie, 2013), such a tactic tends to increase the company's financial liabilities. Another issue, often overseen, is the need to formulate the cost estimate under the assumption that the mine reclamation and closure duties will be performed by a third-party, which generally results in higher costs for hiring contractors.

In the case of reclamation cost estimations, a further issue arises. It is essential to understand for whom the estimate is being prepared. Such liability cost estimates could be developed from one of four perspectives: owner's assessment – internal use; owner's view – bonding purpose; regulator's evaluation; and worst-case evaluation (Brodie, 2013).

In most instances, the financial amounts required to be set aside in EFA instruments are based on the projected costs of reclamation. Given the uncertainty in these assessed expenditures, the amount of a specific financial assurance estimated at any time may surpass, or fall short, of the required financial burden of the reclamation work. If the company is still in business at the time of closure, it will perform the work and absorb such costs, regardless if they are different from the estimated value. The host government suffers no loss. A different circumstance arises if the mine operator is no longer in business or nowhere to be found, and the government subsequently inherits the responsibility for mine site reclamation, financing the work obligations from the financial assurance. If the financial assurance is insufficient, the regulator is typically forced to pay the difference.

Most governments are risk-averse and will try to side-step losses. Overall, there will be a propensity by host regulators to build a safety factor into the sum of EFA demanded. Such an action ties up additional funds and levies sometimes unnecessary costs on both large, stable, long-lived mine operators and on those who might be contenders for failure.

It is recommended that governments have a general policy of needing financial assurance or insurance, which is reasonable given the risk levels identified. In negotiating specific arrangements, aspects such as the mine operator’s financial condition, its track record, and management systems will impact just how much FA the host regulator will demand.

Both industry and governments see value in EFA instruments as a method of guaranteeing or financing environmental protection ensuing the closure of a mine. While most host jurisdictions expect that reclamation is carried out upon mine closure, occasionally the mine operator may be unable to implement their obligations. In such instances, regulators expect to be assured that they will not be left with unfunded environmental and financial liabilities. Likewise, accountable corporate entities understand that financial assurance provides governments and communities with future certainty that the necessary funding will be available for mandatory mine reclamation and closure duties, irrespective of their current or projected financial stability. Therefore, an effective EFA policy has the likelihood to lessen the scope for public disapproval of industry practices.

It must, nevertheless, be respected that the amount of capital tied up in financial assurance may be considerable. Some host jurisdictions expect continual financial security for the full reclamation liability during operation. Such a financial commitment may be reduced by well-thought-out prior mine site planning and progressive reclamation.

Large mine operators may each carry environmental liabilities on their financial statements amounting to hundreds of millions of dollars. For most of these companies, such financial obligations will be covered by a mix of '*hard*' and '*soft*' financial assurance. The '*harder*' forms involve out-of-pocket costs (Miller, 2005; Otto, 2009). The '*softer*' types may not include direct costs, but they still represent a substantial financial burden in that they diminish the borrowing ability and credit rating of the company.

Financial assurance instruments may be chosen from several mechanism options. Each specific type may be suitable in a set of circumstances or given situation, depending, in part, on the financial strength of the corporate entity, the amount of the possible environmental liability, and the period over which the liability is to be eliminated (Miller, 2005; Scodari et al., 2016).

Any obligation for FA is expected to settle early in the life cycle of a mine, and before any significant investment is incurred. Some jurisdictions request that FA is posted at the time a mineral rights certificate is granted (Miller, 2005; Scodari et al., 2016). Such an amount may vary over the life of the project, rising through the stages of exploration, advanced exploration and mine development, but declining as reclamation obligations are met (Miller, 2005).

Different host countries often require some form of financial assurance at the time of advanced exploration or on occasions when substantial land disturbance may occur. Still, other jurisdictions take financial security upfront to guarantee exploration work commitments.

Company Size Matters

Mine operators have an interest in guaranteeing that any financial assurance policies are appropriately structured so that practical environmental objectives are achieved at a satisfactory cost (Brodie, 2013). Furthermore, it should be mentioned that not all companies are affected in the same manner by EFA requirements. In several countries, it may be suitable for a large, profitable and diversified company to have fewer demanding requirements than smaller, less financially robust, ones (OAGBC, 2016). It mostly applies in circumstances where an established entity operates several mines within one jurisdiction and possesses an excellent performance track record. In such instances, it may be fitting for the regulator only to request a corporate guarantee which might include access to the parent company's assets in the event of failure instead of multiple individual surety bonds for each mine site. An incentive of this sort encourages mine operators to establish reliable records of good practice.

This distinction between large and small companies is often justified since the latter may have shorter planning horizons than the former (Sassoon, 2008; Otto, 2009; Allan, 2016). Smaller mine operators may be more inclined to abandon a problematic mine site or may be forced to do so, through a deficiency of financial capital resources. To the degree they do so, this harms the environment, the local economy, and the global reputation of the entire mining industry. Such a difference often works against smaller companies in that it raises their investment costs and hurdles.

Administration of Assurance

Regarding the administration of financial assurance, two questions stand out (Otto, 2009):

- Should the posted approved financial assurance instrument(s) be held and managed by the regulator or a third-party?

- Should the posted EFA be held in a separate account for each specific mining operation or in a pooled account for mining closures across the jurisdiction?

Regulators may plead for managing the instruments, while other stakeholders (e.g., companies, non-governmental organisations, and communities) may back the idea of entrusting this to a third-party, for reasons of technical capacity, but mainly to guarantee transparency and to circumvent misapplication (Miller, 2005).

Mine operators generally prefer user-pay reclamation funding but creating a public account, or fund, may be financially prudent and provide further financial assurance for the regulator and the local society (Miller, 2005).

Supervision and Oversight Expectations

A prerequisite for a regulatory approved financial security typically involves the calculation of the environmental liability followed by negotiations, between the regulator and the mine operator, on the proper liability amount and the acceptable financial assurance form(s) to be subsequently posted (Miller, 2005; Otto, 2009). In some instances, the regulator may have the capacity to review and approve the mine reclamation plan. At the same time, in other circumstances, it may lack such knowledge-capability, depending instead on the guidance of an independent expert or even of the mine operator (Miller, 2005).

Review of Taxation Arrangements

An EFA requirement may be onerous, depending on the taxation arrangements between the government and the mine operator (Stano, 2012; PwC, 2016). At best, the company will expect to withhold from profits all the costs related with the FA. Some jurisdictions may be prepared to offer a net fiscal incentive to gain some reprieve from environmental liability.

Most governments offer tax relief for companies' direct costs of providing financial assurance but few if any offer incentives to do so (Stano, 2012) – this is a possibility worth investigating. There are some suggestions that cash accumulation through an insurance mechanism may be done on a pre-tax basis (Stano, 2012).

Extinguishment of Reclamation Liabilities

Most people would agree that when the mine operator has completed their reclamation requirements and returned the mine site to the desired condition, it should be absolved of any further liability and financial responsibility connected with the site. Such an arrangement would prove an attractive feature of a host nation's investment climate. It may be essential for the operator to continue to hold the mine site and monitor its physical and chemical stability for some years before knowing with certainty that the reclamation efforts were practical. However, once such overseeing is finalised and if no complications are apparent, mine operators should be able to expect their exit ticket shortly afterwards (Errington, 2002; Finucane and Bastow, 2016) – this would include the release of any held financial assurance held by government.

For mine sites requiring long-term care, the situation is more complicated. In the absence of FA, the mine operator could be held accountable for its site's management for several years or even decades (Milhollin, 1979; Sassoon, 2009). In this circumstance, regulatory legislation should stipulate that operators can attain their exit ticket by submitting adequate monetary funds to finance the mine site management activities for an indefinite period (Sassoon, 2009). The regulator can then hire a contractor with the collected cash to take over the mine operator's site management obligations and dismiss the company of additional liability.

Financial Assurance Issues

The global mining industry commonly agrees that the primary function of financial assurance is to shield the host government and its people if a company cannot meet its reclamation financial obligations (Miller, 2005). They understand that dropping commodity prices and unanticipated technical difficulties can render the most promising mining project uneconomic. Higher levels of credit risk are characteristically associated with higher levels of market risk (e.g., stemming from dropping commodity prices), which can increase a mining company's likelihood of default on its outstanding debt and subsequently increases its chance of bankruptcy (Bouteillé and Coogan-Pushner, 2012).

For a single project mine operator with limited financial capital, the result can be disastrous. As for large companies, however, they typically possess sufficient economic resources and have procedures in place to ensure ongoing environmental compliance and can generally fulfil their R&C obligations without the additional discipline of a financial assurance mechanism. The mining industry also admits that an EFA instrument does offer greater certainty for the protection of the environment even if they do not necessarily endorse its use (Miller, 2005).

The conditions and terms of permits and licenses are essential in protecting the environment (Miller, 2005). If these are set at a fittingly high standard, mine operators will respond accordingly. Some respondents of the ICMM 2005 survey felt that financial assurance instruments for decommissioning should not be compulsory for responsible operators. The determining factor should be its past performance or track record (Miller, 2005). EFA instruments undeniably have application for marginal, smaller, one-property mine operators. In this instance, respondents agree that such financial instruments are effective at enforcing environmental responsibility at mine closure (Miller, 2005).

While some companies consider the requirement for financial assurance as an administrative process of the government (a real cost), the industry accepts that regulators need to prove to stakeholders that it has obtained adequate financial protection from the holder of mineral rights to guarantee effective reclamation will take place when all the ore has been extracted from a given area. In no occasion did any surveyed mining company advocate that financial assurance instruments should be abolished for all operators (Miller, 2005).

The financial sector favours effective financial assurance policies (Miller, 2005). Respondents in the insurance and surety sectors had few comments on this matter – one found existing policies usually effective. Representatives of the government, however, had mixed views on the effectiveness of current policies. Government officials in Canada, South Africa, and the United States found the current policies generally adequate, though economic fluctuations can cause complications (Miller, 2005).

Financial assurance regulation for mine closure entails several and complex issues. It is about evaluating, through financial technicalities, a delicate balance between healthy levels of environmental protection and not preventing mineral resources development. The recent global financial crisis of 2007-09 complicated this balance even further. On the one hand, mine operators claim that FA became too costly, often hindering a project's feasibility. Conversely, after witnessing the failure of some top-rated, global financial institutions, governments may feel physical cash is the only safe assurance measure. Forecasting costs, a keystone of financial assurance schemes, has always been an inexact science; nevertheless, the recent economic and financial turmoil have made this statement more real than ever.

Appendix D: Regulators, Policy, and Enforcement

The Nobel Laureate economist, George Stein (1971), reported empirical data from several markets and determined that "*as a rule, regulation is acquired by the industry and is designed and operated primarily for its benefit*." Regulation may be sought by industry, or it may be forced upon it.

Regulation and legislation are only as good as the information on which it is based on and only as effective as a government's readiness to advance them and enforce them to meet the wants and needs of its people (Magat and Viscusi, 1990). Equally important is that the public is permitted to properly understand how mining in their jurisdiction is managed and how their government is protecting the public's interest. It can be stated that overall public interest is the appropriate approach for the management of public natural resources and the impacts on the environment and society (Magat and Viscusi, 1990).

In today's global mining environment, the defining question of obligation and accountability continues to persist due to both *moral hazard* and *morale hazard*. Insurance analysts, at times, differentiate between moral hazard and from a related theory they call morale hazard (Fanga and Moscarini, 2005). When both expressions are used, morale hazard implies the view that the insured person will be less than duly diligent in avoiding the risk at hand against which the policy is written. It is an attitude that increases the likelihood of loss from a peril. The opinion of, "*It's insured, so why worry…?*" is an example of a morale hazard.

By contrast, moral hazard arises from character flaws, or moral flaws, such as habitual criminality, corruption, and environmentally negligent. It occurs when one party takes more risks than it should since someone else will bear the cost of those gambles. The mining industry possesses many precedents of projects that are moral hazards. They privatise the financial rewards and socialise the downside risks; get in, get what the company can, get out and leave the taxpayer to contend with R&C responsibilities.

Society cannot expect the mining sector, or even other extractive industries, to voluntarily and willingly abide by the environmental regulatory framework established when it comes to environmental and socio-economic matters or also their financial assurance requirements without some effective incentives, in the form of enforcement, in place.

Much of the observed literature consumes itself with the choice of effective regulatory EFA instrument(s) to utilise, but minimal attention has been made regarding regulatory enforcement despite it being increasingly expensive and complex to impose (Cohen, 1998; OAGBC, 2016). Companies possess the bottom-line motivation to curb costs at the expense of environmental quality when regulations enforcement is negligible.

Consequently, the possible potential gains from selecting the appropriate regulatory policy instrument may well be affected either by the increasing financial costs of regulatory enforcement or by a company's contempt for the existing environmental regulations.

The issue of enforcing agreements and regulatory provisions is described as an *agency dilemma* (McElfish et al., 1996). In the perspective of the mining sector, it can be expressed as a two-level agency problem where the government can choose to regulate more stringently in which case a greater portion of the accounting profits will flow from the mining companies to cover environmental regulatory-related expenditures. Alternatively, it can be laxer and collect more revenue in the form of taxes and leaving the environmental costs for future generations to cover – a mineral tax revenue or environmental protection dilemma.

Along with the double dilemmas, there is also the issue of *regulatory capture* – a form of government failure and political corruption (Stigler, 1971). The corruption that arises when a regulatory agency, created to act on behalf of public interest, instead advances the needs and particular concerns of interest parties that influence the industry or sector it is responsible with regulating. A failure in this context leads to an opening for companies to act in manners detrimental to the public (e.g., producing negative externalities). Government agencies which have yielded to such pressures are termed *captured agencies*. Policies formulated and administered by captured agencies regularly generate negative externalities.

Standing (2007) makes the case that Angola, DR Congo, Ghana, Nigeria, and other continental African nations may be a warning to other countries where corruption and the exploitation of local communities run rampant while local regulatory agencies turn a blind eye for their financial gains. The author goes on to mention that there has been substantial growth in the size and number of mining companies based in Asia and Russia, with Chinese companies set to become the most significant in the future. Despite the increasing global competition, the international mining sector continues to be dominated by corporate entities based in Australia, Canada, South Africa, the United Kingdom, and the United States.

Such a dilemma is also nothing new to Latin America. The governments and regulators of major Latin American countries are often embroiled in scandals (Vogl, 2015). Vogl writes that some of the most significant corruption involves secret financial payments by multinational oil and mining companies to local authorities and guerrilla groups.

In the 2016 BC Auditor General's report, it mentions that the Ministry of Energy and Mines did not focus on developing a compliance and enforcement programme, but rather its efforts were primarily devoted to advocating the development of mining via processing permits for existing and new mines (OAGBC, 2016). While this emphasis reflects the ministry's mandate to endorse the development of mining in BC the report notes that this focus on mining promotion coupled with a weak compliance and enforcement programme creates regulatory capture risk for the provincial government ministry (OAGBC, 2016). It conflicts with its role as a regulatory agency, thus reducing its regulatory effectiveness.

The report outlines various signs of regulatory capture (OAGBC, 2016):

- the regulator is situated within the agency responsible for sponsoring the economic interests of the industry;
- in agency publications, environmental protection is only one goal alongside others such as economic development;
- the regulator possesses a low level of prosecution activity;
- the regulation applying to the regulator gives government broad discretion to act;
- the regulator’s resources and budget are not like those in the industry;
- the government shows a marked partiality for providing informal advocacy and advice, which is not recorded correctly;
- there is an elevated shift of enforcement officers from the regulatory agency to the industry; and
- administrative work often takes place in remote regional communities, and there is regularly a social collaboration between industry and the regulator.

It is the progression by which regulators in time come to be controlled by the very industries they were assigned to regulate (Shapiro, 2012). It implies that once one understands the meaning behind regulatory capture, the rational policy retort is to legislate enforceable regulation that cannot be gamed by even the largest companies and their captive bureaucrats.

In many less developed countries, there exists a growing movement by stakeholders and NGOs, alike, for governments to introduce necessary measures to prevent *regulatory failure* as a country transitions from possessing a state-owned system to establishing one that is focused more on a government-private or private design (Haselipa and Hilson, 2005). There are also other more central issues, which are inherent in any regulatory system; namely, possibilities for misconduct, corruption, and less than optimal sector outcomes, the likelihood of regulatory capture, and information asymmetries (Erdogdu, 2007). The state of unbalanced or asymmetric information between regulator and companies benefits the regulated company at the expense of not only the regulator but also actual and potential competitors and customers – commonly referred to as an *asymmetric information problem* (Erdogdu, 2007).

The sale of state-owned assets, including mining operations, to foreign corporations in these countries regrettably results in diminished power for governments and regulators and calls into question the effectiveness of local governments to oversee new private operators. Haselipa and Hilson (2005) highlight how privatisation creates asymmetries of market power, knowledge, and skills between large multinationals and the local governments.

Institutional capacity in such nations is often weaker than in developed countries, and the financial capital, necessary resources, and skilled supervisory staff required to regulate large multinational organisations successfully are frequently lacking. In many developing nations, this absence of capacity has led to either objectionable political interventions in the mining sector and electricity markets, or equally harmful regulatory capture by the corporations (Haselipa and Hilson, 2005). In Africa, many critics have argued that reformed markets have seldom been accompanied by independent and effective regulation, emphasising how regulatory board members have been directly appointed by the president or government ministers in Kenya, Malawi, Namibia, Uganda, and Zambia (AFREPREN/FWD, 2001).

Understanding prevailing circumstances under which regulatory capture occurs can assist policymakers and watchdog groups alike in recognising such occurrences. Grant (2011) questions if regulatory capture was partly to blame for the BP Deepwater Horizon oil spill in the Gulf of Mexico on April 2010. He responded in the affirmative demonstrating that the regulatory agency charged with overseeing the United States oil & gas industry, the Minerals Management Service, failed to enforce the safety concerns that the regulatory agency itself raised with the oil & gas industry. It left drilling site operators to determine the procedures they would pursue to ensure safety primarily on their own – this brought about some of the situations leading to the oil spill (Grant, 2011).

O’Faircheallaigh (2015) comments that in Alberta, the Provincial Energy Resources Conservation Board is obligated under its legislation to consider the interest and well-being of the public when deciding if to grant energy project license applications. Conversely, Fluker (2011) mentions that the Board grants almost all applications, most of them merely based on the information provided by the applicant company and is reluctant to permit public involvement in its decision-making process.

Findings suggest that regulatory agencies often do not possess the capacity to implement, monitor, and enforce environmental regulations effectively (Salamon and Lund, 1989; OAGBC, 2016). There are not enough resources, including inspectors, to execute the tasks of regularly monitoring industry and identifying violations. Third-party verification seems fitting for an era of ever-growing regulatory demands, on the heels of a financial crisis and commodities super slump, and reduction of governmental resources. Third-party verification can be viewed as being an external private consultant or auditor who is compensated by the regulatory entity.

Regulatory failure is a mounting concern as governmental agencies possess insufficient resources to sufficiently monitor and identify noncompliance actions or inactions (OAGBC, 2016). Third-party verification would partially privatise the regulatory function by demanding regulated companies to appoint independent third-parties to validate compliance data and make compliance-related decisions. Such a verification tool, as a form of privatisation, is anticipated to present both opportunities and potential challenges (Salamon and Lund, 1989).

Third-party verification has already been incorporated into environmental frameworks, and it perhaps possesses a wide application across many fields of social regulation (Salamon and Lund, 1989). Such a regulatory method has been applied in emissions trading schemes, climate change regulation, and taxation schemes, which are all greatly reliant on reliable compliance-related data. It is not just these areas of regulation that could benefit from more reliable data and greater compliance (Flatt and Collins, 2009). It could also be utilised more broadly in efforts to avert regulatory failure and to improve regulatory compliance.

Nonetheless, for publicly-traded companies needing audited annual reports, required by law, securities regulation has significantly relied on an approach much like third-party verification (Flatt and Collins, 2009). Employed by the corporate entities they audit, auditors have occasionally been short of independence and been a knowing culprit to financial disasters such as the savings and loan crisis, which ensued in the late 1970s and peaked in the 1980s, finally winding-up in the early 1990s, and the rise and fall of Enron in 2000 (Flatt and Collins, 2009). In June 2002, Arthur Andersen was convicted of obstruction of justice for destroying documents connected to its audit of Enron, which resulted in the Enron scandal.

Third-party verification represents limited privatisation of the public function of enforcing regulatory law (Flatt and Collins, 2009) and possible means of monitoring, compliance, and enforcement to counter regulatory capture instead of solely relying on environmental government agencies and the insurance industry to continually police reclamation efforts (Zinn, 2002). If a mining operation is of importance to a host jurisdiction, the interest of the government and the industry occasionally becomes fused. The Yukon's giant Faro mine is such an example, where the territorial government mismanaged one of the biggest projects it had ever tackled. A neutral party is equipped to adequately address such situations before it can potentially get out control. Some researchers have challenged the capability and liability of the third-party endorsers in voluntary certification schemes (Flatt and Collins, 2009).

In BC's 2016 Auditor General report, it concluded that the province's compliance and enforcement actions in the mining sector are not satisfactory to protect the environment (OAGBC, 2016). The report's key recommendation was the creation of an independent and integrated compliance and enforcement unit outside the ministry of mines – a third-party.

In the United States, the environmental regulatory standards specified in mine operating permits are regularly a product of consultations between the regulatory agency/agencies (the principal) and the regulated mining company (the agent) where environmental regulations provide a starting point for negotiations (McElfish et al., 1996). If a principal possesses high expenditures of monitoring performance, the agent may decrease costs by avoiding responsibility, the classic example of moral hazard. When there exists an arrangement between the principal and the agent that can be substantiated by an independent third-party, assigning liability to the agent solves the moral hazard issue (Fanga and Moscarini, 2005).

Liability rules will not encourage compliance if the regulated company is considered an insolvency risk. Environmental liabilities are imminent financial debts, and thus can be discharged in bankruptcy proceedings. The likelihood of insolvency, therefore, impacts a company's motivations and how it conducts itself even for a solvent corporate entity, and the judgment-proof problem is thought to be a fundamental flaw of sole dependence on liability rules (Shavell, 1986).

A remedy to the judgment-proof issue is to require financial collateral, such as financial assurance, thus offering the company with a direct economic incentive to observe the environmental regulations at hand. If it fails to accomplish its clean-up and reclamation obligations, the surrendered collateral is utilised to deal with performance failure.

Shavell (1986) describes the restrictions of liability in internalising external costs. Ringleb and Wiggins (1990) comment that large companies form subsidiaries (usually offshore holding entities) as a method to safeguard the assets of the parent company from clean-up and reclamation financial obligations liabilities.

If the company remains ongoing, regulators can pursue a solution through the judicial system.

As monitoring tools and techniques continue to develop the capacity of environmental regulatory agencies to recognise and evaluate all the requirements for long-term care and maintenance activities to protect all the stakeholders following mine reclamation and closure, standard forms of EFA may become impractical (Kempton et al., 2010).

Although the literature expresses mine reclamation and financial assurance an environmental regulatory prerequisites and the best supervision practices for handling possible destructive externalities of mining operations activities (Kramer, 2008), the recognition of some long-lasting treatments, such as water treatment or maintenance of tailings dams, and other long-term obligations affiliated with mining have only more recently been discussed in the literature (Peck and Sinding, 2009; Kempton et al., 2010).

This recent scholarly research has great relevance to the core of the dissertation. There seems to be a void in the literature concerning the economic considerations affecting a mining company's selection of a specific EFA instrument for long-term mining operations that are expected to possess perpetual, ongoing clean-up and reclamation obligations.

Since reclamation activities for most mines with a modest mine life (10-15 years) take just a few years to conclude, environmental financial assurance instruments like surety bonds typically assure regular mine R&C activities. Such financial obligations are short-term; hence, an FA of a one-time payment to the regulatory agency via a letter of credit or a bond from an assurance institution is appropriate to offset the financial and credit risks to the public concerns of the mining company unable or unwilling to achieve its reclamation obligations and, thus, ultimately forcing taxpayers to cover the cost.

Long-term proposed mining operations, coupled with perpetual clean-up and reclamation activities, require the expenditure of funds far into the future, possibly over a century in some instances. For example, the cost of the Faro mine (situated north of the Town of Faro, Yukon Territory) clean-up is estimated to be hundreds of millions of dollars and to take at least four centuries (Yukon Research Centre, 2013; Giovannetti, 2017). Faro Mine is considered the second-worst contaminated site in Canada (Jacques, 2017). Trust funds are suited for these kinds of enduring reclamation-related commitments due to their ability to recognise revenue over time (Kempton et al., 2010). Trust funds, however, like the long-term obligations they are expected to address, possess many inherent uncertainties and risks (e.g., credit, market, financial, regulatory, legal, and operational), as well (Kempton et al., 2010).

Even if it is assumed the uncertainties can be efficiently managed if the decision to choose from the list of suitable forms of EFA instruments is economically motivated by the mining company, what enticements are there for it to choose a trust fund over other more conventional forms?

A concluding point relates to regulatory enforcement, or the lack of it, which has become increasingly more relevant as regulators and stakeholders, alike, face the possible obstacles connected with bond forfeitures and insolvencies, be it mining companies or FA insurers themselves due to the current mining sector slowdown. Since its economic industry downturn in early 2011, it caused many mining companies to shut down some (or even all) of their mining operations, to sell properties, merge with other companies or to file for bankruptcy protection.

Appendix E: Commonly Used Financial Assurance Instruments

Table E.1: Evaluation of Commonly Used Financial Assurance Instruments

	Evaluation Criteria	Cash Deposit	Letter of Credit , Bank Guarantee	Surety Bond	Trust Fund	Corporate Self Guarantees
Advantages	Cheap to set up					
	Funds - readily available					
	No tied-up capital					
	Few administrative requirements					
	Advantageous for mining company					
	Public availability of annual reports					
	Governments can reserve the right to approve a bank - minimize credit risk					
	Low set-up costs					
	High public appearance (visibility)					
	Investment grade					
	Funds may appreciate in value					
	Modest cash outflow from mine operator					
Disadvantages	Funds may depreciate					
	Surety provider may fail					
	Reduction in the borrowing power of the mining company					
	Bond issuer may fail in the long term					
	Ratings of the company determines the cost					
	Risk of bad management of funds					
	Accumulative funds may be insufficient if mining project ceases prematurely					
	Management & administrative matters might be excessive					
	Significant capital tied up for a long duration at times					
	Government might use deposited funds for non-reclamation matters					
	Vulnerable to being lost to fraud or theft					
	Accounting scandals - financial statements and annual reports manipulation					
	Problematic public acceptance					
	Insufficient funds actually available when required					
	Financial reclamation assurance requirements incorrectly computed					
	Enforcement issues may arise if security provider is based abroad					

(Halland et al., 2015)

Appendix F: Framework for Securitisation

Securitisation is the process in which types of financial assets are pooled so that they can be repackaged into interest-bearing securities. It is a financial arrangement that entails issuing securities that are backed by a pool of assets, in most instances, of debt. The principal and interest payments from the assets are passed through to the purchasers of the securities. The underlying pool of assets is converted into securities, hence the expression *securitisation*. The holder of the instrument receives revenue from the products of the pooled assets, and this has given rise to the term *asset-backed security*.

Modern securitisation took off in the 2000s, thanks to the innovative structures implemented across the asset classes, such as UK Mortgage Master Trusts, insurance-backed transaction or even more esoteric asset classes (e.g., securitisation of lottery receivables) (Wainwright, 2010).

F.1 Modus Operandi: The Securitisation Process

Securitisation is the pooling of a set of assets, combined with the tranching of the resulting portfolio into slices of increasing risk. The conventional structure consists of multiple-tranche structures (typically three main tranches), all with varying degrees of risk and returns:

- the first tranche is referred to as the *senior tranche*;
- followed by the *junior/mezzanine tranche*; and
- the last tranche is the *equity tranche*.

Debt tranches are regularly assigned a credit bond rating that is assigned by a credit rating agency such as Fitch Ratings, Moody's Investors Service, or Standard & Poor's.

The focus in the dissertation is on cash flow securitisation (i.e., true-sale securitisation), as opposed to synthetic securitisation, which does not entail a transfer of assets. Cash flow securities are commonly referred to as ABSs, subclasses of which include MBSs and collateralised debt obligations (CDOs). An ABS is, at times, defined more narrowly as non-mortgage or CDO securities (Hu, 2011).

The key players involved in a conventional securitisation transaction include the originator, a bankruptcy-remote SPV or issuer, servicer, and occasionally an arranger, trustee, and guarantor.

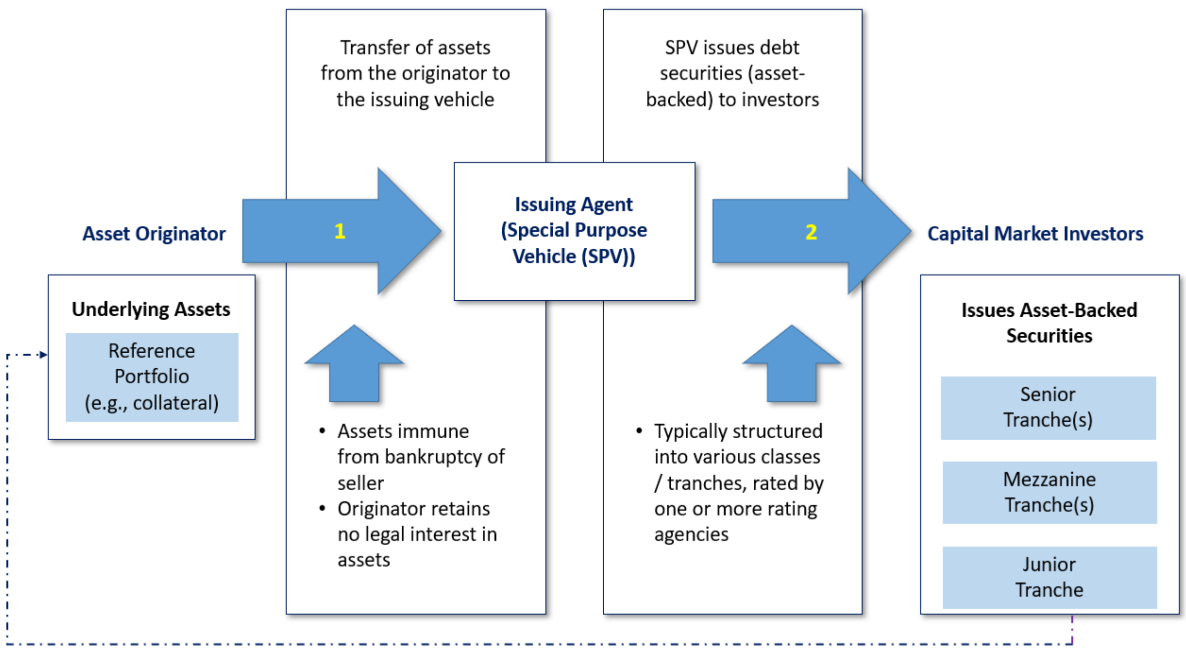
The impetus for securitisation is a decrease in the cost of capital and greater access to long-term capital through lower-risk investors who may not otherwise be able to take part in such a transaction (Lemmon et al., 2014). In addition to risks specific to certain forms of securitisation structures, other types of risks and misaligned incentives are a commonplace with such structures, which is often due to moral hazard (Hartman-Glaser et al., 2012).

A popular explanation for the substantial mortgage defaults during the financial crisis of 2007 is that securitisation led to lender moral hazard (Selody and Woodman, 2009). It is believed by many that lending banks that could resell loans to securitisers with ease had minimal motivation to diligently screen potential borrowers. Despite all the benefits that it offers the financial system and the economy, the financial crisis drew a spotlight to the fact that beneficial financial innovations such as securitisation can turn into a source of financial uncertainty if regulations and industry practices do not keep pace with financial innovation (Selody and Woodman, 2009).

In the aftermath of the latest global financial crisis, it became necessary for regulators and market participants to recognise the costs and benefits of securitisation under moral hazard so they can enhance the incentives and scope of securitisation to diminish the effects of this information problem. Berndt and Gupta (2009) remark that the highly deregulated nature of the secondary loan market is one of the core explanations for the manifestation of adverse selection and moral hazard issues.

A broad securitisation transaction is illustrated in Figure F.1, along with the various parties involved and the flow of the process. It shows the underlying mechanism for transferring assets and creating securitised securities.

Figure F.1: Securitisation Process



The process usually involves two steps, as illustrated. In the initial stage, a company with loans or other income-producing assets, the originator (seller), identifies the assets it wishes to remove from its financial statements and pools them into a reference portfolio. The company then sells this asset pool to an issuer, such as an SPV.

Figure F.2: Actors of Securitisation

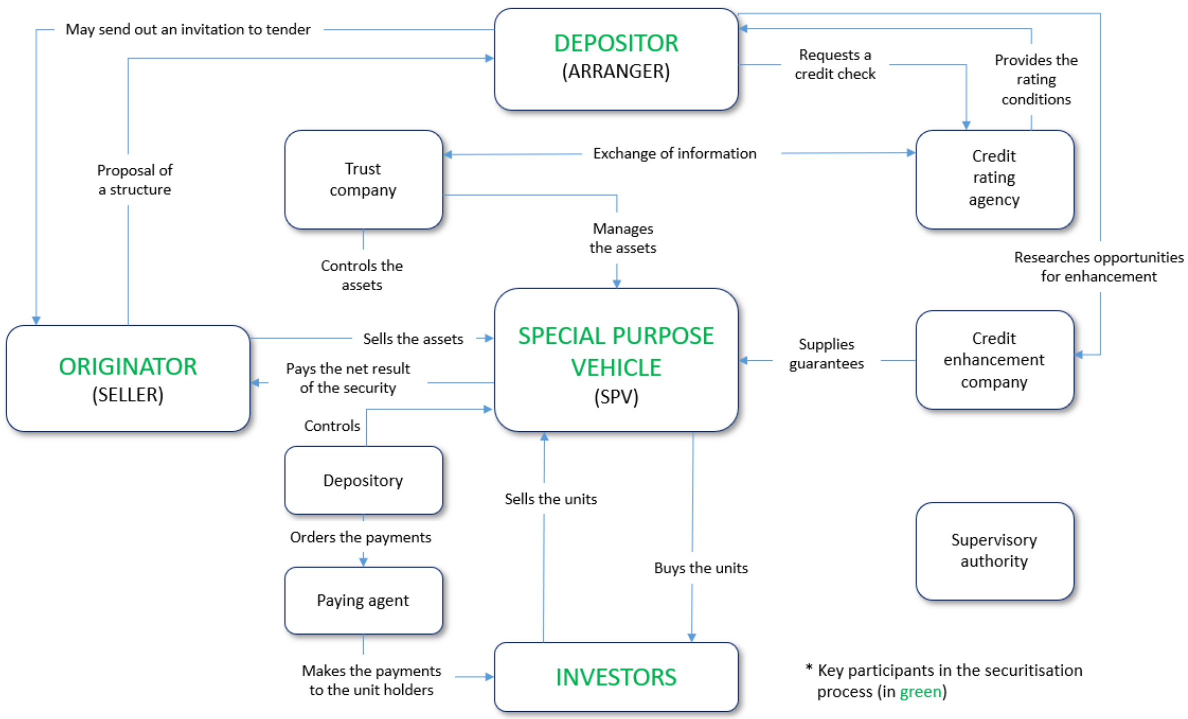


Figure F.2 shows the different actors involved in a securitisation transaction along with their respective roles.

The originator can instead establish an SPV for this purpose and utilise the services of an arranger (or depositor – usually a financial institution) to structure the transaction. Consequently, the institution's responsibility would be to arrange the structure of the risk profile of the pooled assets to create different tranches of securities, CE, credit arbitrage, profit extraction methods, liquidity support, ensure the transaction proceeds through each step to close, for counterparties to take on risks, and to initially purchase the securities as planned (Slaughter and May, 2010). In the second step, the issuer finances the purchase of the pooled assets by issuing interest-bearing securities that are sold to investors.

The investors accept fixed or floating rate payments from a trustee account funded by the cash flows generated by the reference portfolio. In most instances, the originator services the loans in the portfolio, collects payments from the original borrowers, and passes them on (less a servicing fee) to the trustee or SPV. Securitisation represents an alternative and diversified source of finance based on the transfer of credit risk (and maybe also currency and interest rate risk) from issuers to investors (Slaughter and May, 2010).

F.2 Securitisation: Benefits and Drawbacks

The key benefits and drawbacks of securitisation for both financial institutions and sovereign issuers are presented in this section. The benefits and costs of securitisation relating to the government, as the originator, are also discussed. Subsequently, the potential benefits and costs that securitisation of publicly issued ABSs are likely to possess are examined.

F.2.1 Originator and Investors: Benefits

Securitisation not only enables policymakers to channel credit to the preferred groups but may also increase macroeconomic activity and at times bring about market instability (Bertay and Gong, 2014; Meeks et al., 2017). It permits financial intermediaries to charge fees for matching borrowers with lenders while avoiding long-term credit risk as well as engaging in regulatory arbitrage. It may, however, impose excessive short-term risk and disastrous reputational damage in the event of a crisis (Bertay and Gong, 2014; Meeks et al., 2017). To savers, it offers an attractive investment option (often riskier than presented) and it also generally provides borrowers with cheaper levels of credit. Securitisation offers benefits to and imposes costs on all actors involved, and their participation in these markets demonstrates the perceived positive net benefit of ABSs.

F.2.2 Originator and Investors: Drawbacks

The success of a securitisation transaction is partly measured by its cost-efficiency where the benefits of the securitisation must surpass the expenses attached to it. The drawbacks associated with securitisation are presented in this section.

The downsides connected with securitisation include adverse selection, moral hazard, and other shortcomings. The reduction of these drawbacks is related to the importance of the tranching of the ABS transaction and the structural enhancement features. A composite of these two mechanisms will diminish the credit risk for the senior tranches, which could be sold to investors at full cost due to the adverse selection premium, leaving the originator with the equity portion of the securities issued (Kothari, 2006; Baig and Choudhry, 2013). Therefore, the cost-efficiency of securitisation is much reliant on the structure of the cost-mitigating mechanism.

With the recent subprime mortgage crisis of 2007-09 and the ensuing crisis of confidence, the securitisation market lost significant steam and specific segments, particularly those concerning with most complex products, came to a complete halt (Baig and Choudhry, 2013). Although the securitised structure proposed in the dissertation could conceivably be abused, as was in part the circumstance that led to the last financial crisis, it does not warrant abandoning such a structured finance technique. Instead, with suitable transparency, monitoring, and oversight, preceding faults and risks (such as moral hazard and intentional misuse) can be safeguarded against to hopefully an acceptable level.

F.2.3 Government: Benefits and Drawbacks

There are shortcomings mainly related to public securitisation, and some drawbacks surrounding securitisation, in general, that are applicable in this section. The costs affiliated with public securitisation consist of fiscal transparency and subordination of existing and future creditors.

F.3 Requirements for a Successful Securitisation: Structuring and Execution

The necessities for effective securitisation require an established financial structure and strong investor demand. An efficient financial market facilitates securitisation transactions stabilising administrative costs and legal requirements of the originator while concurrently offering security for investors. A strong investor demand eases a lower financing cost for the originator, which is dependent on the credit rating assigned by the CRAs.

F.3.1 Financial Infrastructure Stability

A nation's financial infrastructure includes its legal, accounting, and taxation environment. The characteristics of a stable infrastructure are presented below for each element of it.

Legal Environment

The legal meaning of an SPV is similar in concept to a trust; however, for a trust, the ownership title of assets is transferred to trustees who manage the assets on behalf of the investors. The easiness of the transfer of ownership of the underlying pooled assets should be observed to determine if the legal environment within a country is sponsoring securitisation deals (Alles, 2001). Even if a nation's legal environment allows for the transfer of the legal title (e.g., the ownership) of the assets, some countries require borrowers to be notified of such a transfer which infers higher costs to the originator (Alles, 2001). In instances when the transfer of ownership is restricted, it may be conceivable to modify contracts so that the assets can be bought and sold. Legal systems may differ in how to determine when a true sale of assets has indeed occurred. Some countries make a distinction between the financing and sale of assets. Legal systems may also differ in identifying the bankruptcy remoteness of the SPV or may not offer investors adequate protection in instances where the debtors or the servicer defaults (Alles, 2001).

Accounting Environment

Asset securitisation suggests a transfer of assets from the asset originator to an SPV or trust. Such transfers are at times made without recourse and on other occasions with recourse, and with the retention of some lingering interest in the assets.

Generally Accepted Accounting Principles (GAAP) or US GAAP requires that when the ownership of an asset is transferred to another entity, it is expected to be considered as sold for accounting purposes and, thus, removed from the seller's balance sheet (Federal Reserve System, 1990). Potential gains or losses from the transfer would consequently be recognised in its accounting statements. The advantage of securitisation is the improvement of the balance sheet; however, this requires the transaction to be treated as an off-balance business dealing.

Taxation Environment

The effect of taxation in a securitisation process could be a crucial factor that decides whether the securitisation is profitable and hence may determine its feasibility. Taxation may impact the process at several points. If securitisation is carried out within a country's borders, it is the domestic tax laws that govern its process. However, in cross-border securitisation, the influence of the taxation systems of the observed countries would need to be examined. Furthermore, taxation issues become more complicated since the tax regimes of more than one jurisdiction must be considered.

Taxation issues are mostly immaterial when securitisation is undertaken by a government seeing that tax paid remains within the public sector; however, taxation may add costs to the securitisation process if the government conducts its activities offshore. Offshore securitisations are often used by private corporate entities to get around barriers posed by the domestic regulatory and accounting environments and practices (Federal Reserve System, 1990; Alles, 2001).

F.3.2 Strong Investor Demand

Contributing factors of investor demand include the expected risk-return of a security, the degree of protection offered by the SPV structure, and the rating assigned to the securities. Since investors in ABSs have no recourse to the originator, it is critical to make sure that:

- receivables are adequate to meet the payments pledged by the SPV, financial protection exists to provide for shortfalls from receivables; and
- investors possess explicit legal claims on the income from receivables and have adequate protection in the event of default.

Two developments have arisen to facilitate the reduction and assessment of credit risk better; the utilisation of credit enhancements and a more significant role for the credit rating agencies (Rösch and Scheule, 2010; Mandel et al., 2012).

Credit Enhancement

Credit enhancement offers a degree of protection to investors against losses stemming from the underlying portfolio of assets. Many different forms of CE exist. They include third-party guarantees, cash collateral accounts/spread account, overcollateralisation, and subordinated debt.

Credit Rating Agencies

Credit rating agencies play a crucial role by offering investors assurances details regarding the creditworthiness of securities. Before each security issuance, one or more agencies examine the receivables, proposed securities, additional collateral, and the structure of the SPV, and accordingly assign a credit rating to the securities as an indication of their creditworthiness.

A common form of internal CE is the subordination of some tranche notes in order to attain a higher credit (investment) rating for other, more senior, tranche notes. The subordinated tranche notes are supposed to absorb deficits from the collateral pool before more senior note classes. Based on an examination of the pool, a credit rating agency will specify how many AAA notes, AA notes, BBB notes, and the like can be issued.

Consequences of Tranching

Like other sorts of credit risk transfer (e.g., CDS) structured finance instruments can be employed to transfer credit risk across sectors and financial institutions. However, a difference between structured finance and other risk transfer products is the tranching of claims. It implies that structured instruments can transform risk by creating different degrees of exposures to various segments of the underlying asset pool's loss distribution.

Because such a division and the contractual structures required to accomplish it, the risk-return features for each tranche could be problematic to evaluate. It should be mentioned that tranching can only re-allocate risk and not eliminate the inherent risk(s) of the asset (Antoniades and Tarashev, 2014).

Another implication of tranching is that tranched products can have risk properties that contrast significantly from those of similarly rated bond portfolio exposures due to the joint effects of tranching and pooling, and the reliance on the loss distribution (Antoniades and Tarashev, 2014). Consequently, ratings of structured finance products can be anticipated to offer an incomplete description of their riskiness relative to conventional instruments. Particularly, unexpected losses tend to be more likely for securitised instruments than for like-rated traditional securities, which could lead to accidental exposure to unforeseen losses for structured finance investors who rely on the ratings of the structured products.

Appendix G: Financial Assurance Securitised Structure

The EFA-backed security would be designed to achieve the following objectives, to:

- fund and transfer the budgeted closure liability;
- finance and transfer possible perpetual closure obligations;
- financially protect from unexpected or accidental events such as sudden/accidental pollution events, and closure cost overruns;
- provide FA of closure to the mining regulator;
- get rid of the closure provision from the mine owner's corporate balance sheet; and
- the expense of the programme cost for tax purposes.

The main elements of the generalised securitisation process described in Appendix F can be characterised by the following five stages:

- The originator establishes the SPV, aggregates the collateral pool of EFA-funded obligations, and transfers the assets to the SPV via an assignment.
- The bonds backed by the asset pool of EFA obligations are tranched into classes, rated, and then sold to investors.
- The SPV funds the purchase of the pool(s) of collateralised assets with the proceeds of the sale(s).
- Repayments from the collateralised assets are used to make the coupon payments to investors.
- The cash flows stemming from the assets are used to redeem the tranches by making the principal payments during the final amortisation period (see Figure G.1).

Figure G.1: Basic EFA-Backed Securitisation Process

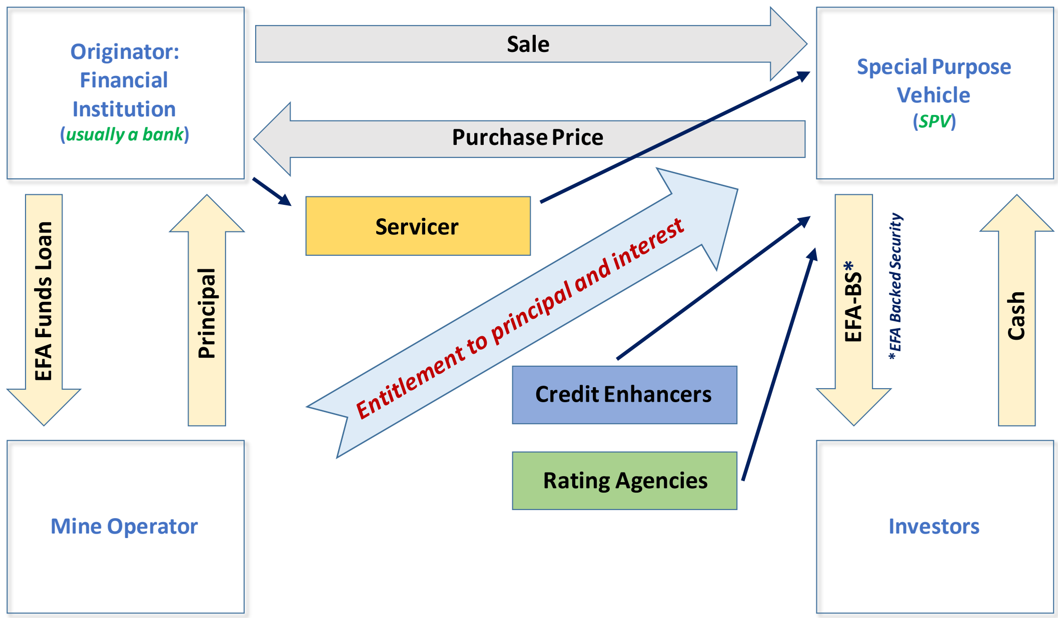
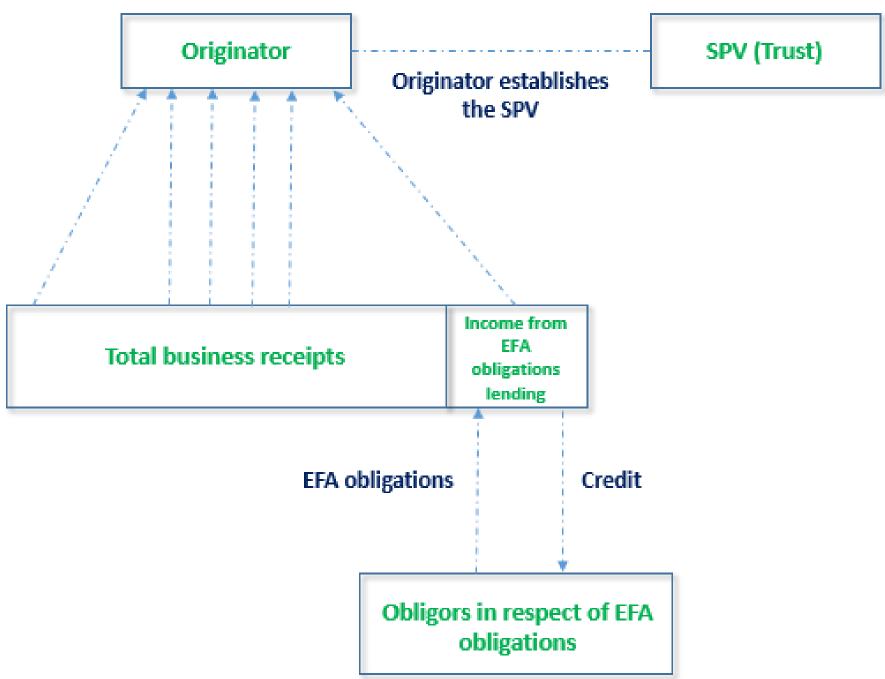


Figure G.2: The Originator



The next set of figures depict the following steps:

- The mine operator (borrower) obtains the required financial assurance funds from the financial institution (lender), on behalf of the investor(s) of the securitised security who initially funded the pool of EFA requirements, with the assistance of an intermediary, the investment bank or another entity (financial and/or legal), prior to the operator receiving their license to operate from the regulator.
- The lender subsequently sells the pool of accumulated EFA obligations (assets) to the issuer (SPV) and provides ongoing service (servicer), for a fee, between the pool of EFA-backed borrowers and the SPV. Specifically, the financial institution would isolate any of the EFA obligations streams it generates and uses these for a securitisation transaction. It would segregate the principal and interest payments it receives from its EFA lending (see Figure G.2).
- As Figure G.3 illustrates, the SPV would pay the transfer price for the pool of EFA obligations immediately on the transfer.
- The issuer sells the securities as bonds from a tranche of investment interest (each with a specific credit rating) to the institutional clientele and the other investors who initially funded the pool of FA obligations, as observed in Figure G.4. The underwriter assists with the sales transaction while the credit rating agency (or agencies) rates the securities. The credit enhancer may apply various CE techniques to improve the credit ratings of the securities, so they appeal to the investors (see Figure G.5). For example, the originator would transfer EFA obligations commitments of greater value than the consideration paid by the SPV, creating a reserve fund protecting against non-payment of part of the EFA pool.
- Given the precise nature of the EFA obligation assets, the transaction would be subject to interest rate and currency risk, which implies the SPV paying more interest on the securities than it receives from the EFA obligations repayments and it pays amounts due on the securities in a comparatively more expensive currency than that in which it receives the proceeds from the EFA obligations repayments. One or more derivative contracts, such as an interest rate and/or currency swap

agreement, with a swap counterparty, would need to be entered into by the SPV to mitigate such market risks, as observed in Figure G.6. The SPV would enter agreements to grant security and manage applicable risks with the security-holder, liquidity support provider and swap counterparty.

- The servicer accumulates the monthly payments from the various mine operator borrowers within the EFA pool and remits them to the SPV.

Figure G.3: Transferring the Pool of EFA Obligations

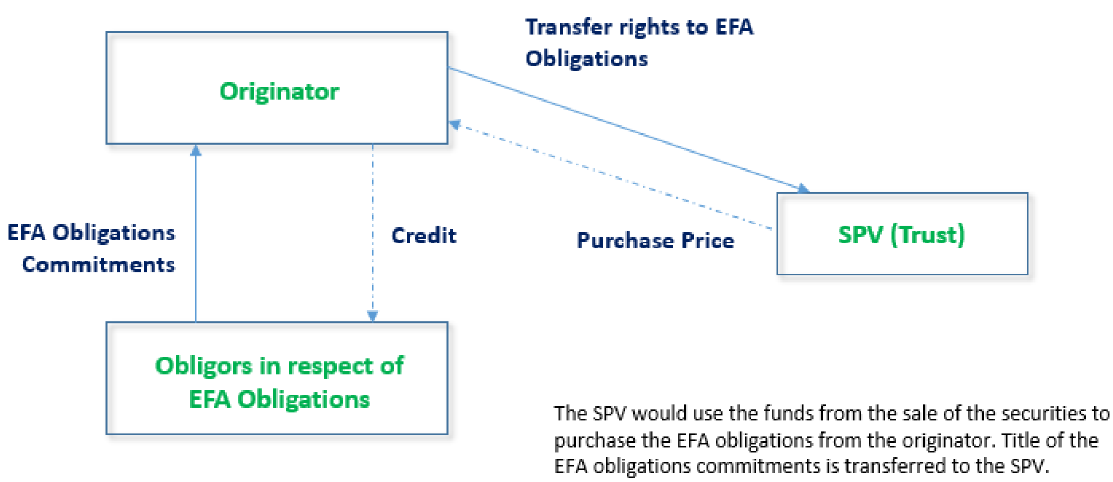


Figure G.4: Securities Issuance

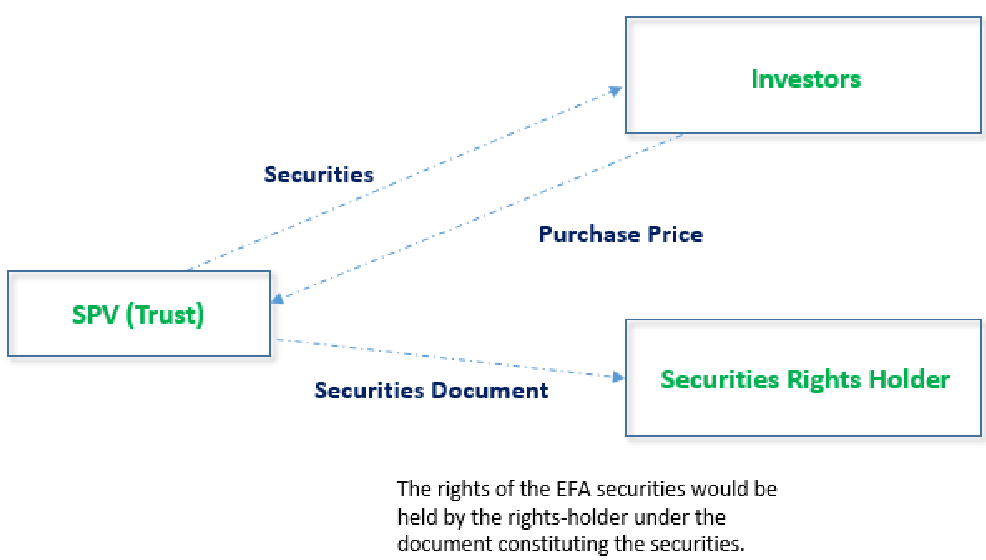


Figure G.5: Credit Enhancement(s)

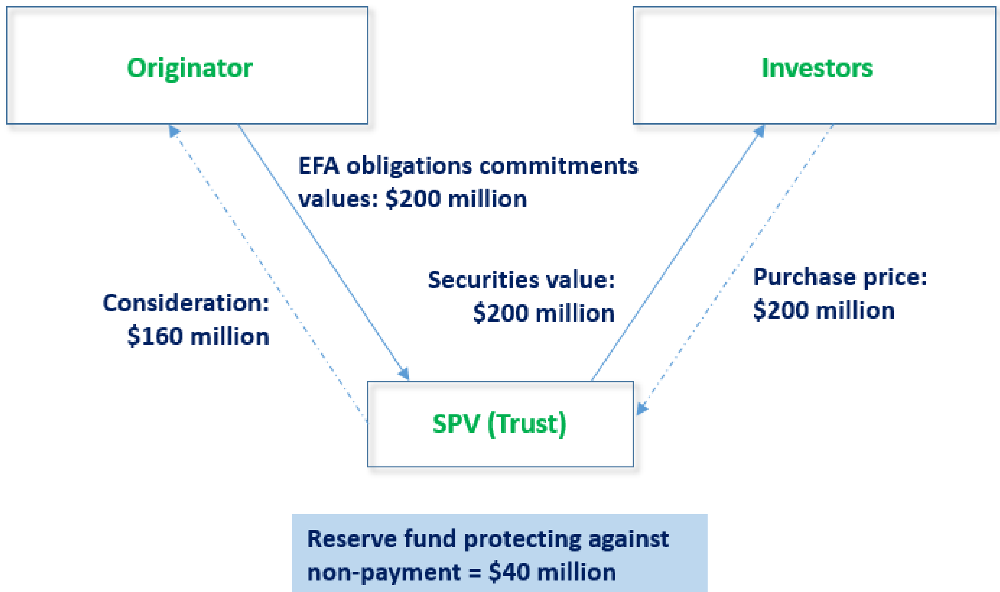


Figure G.6: Creating Security and Managing Risk(s)

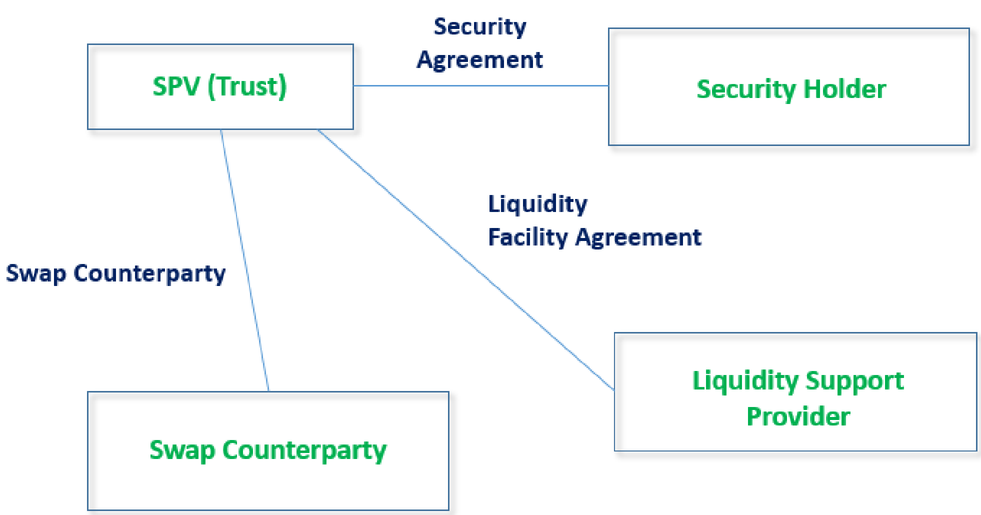
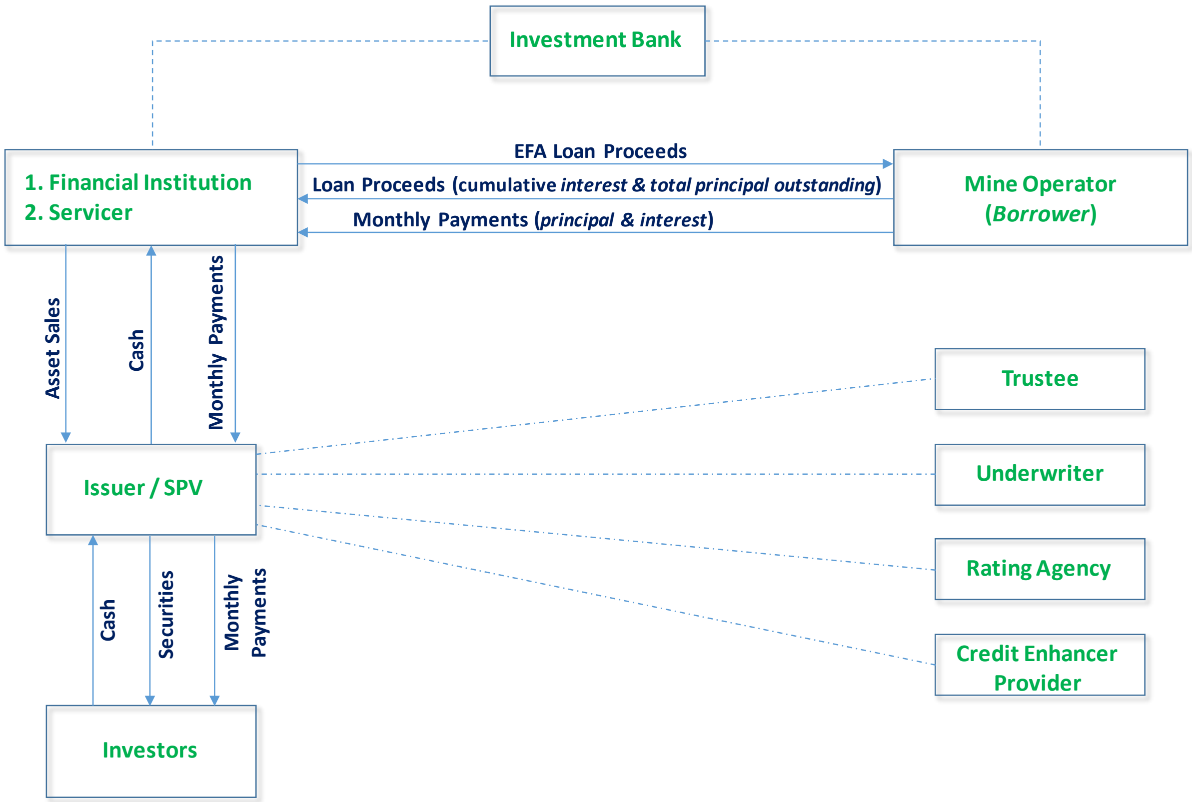


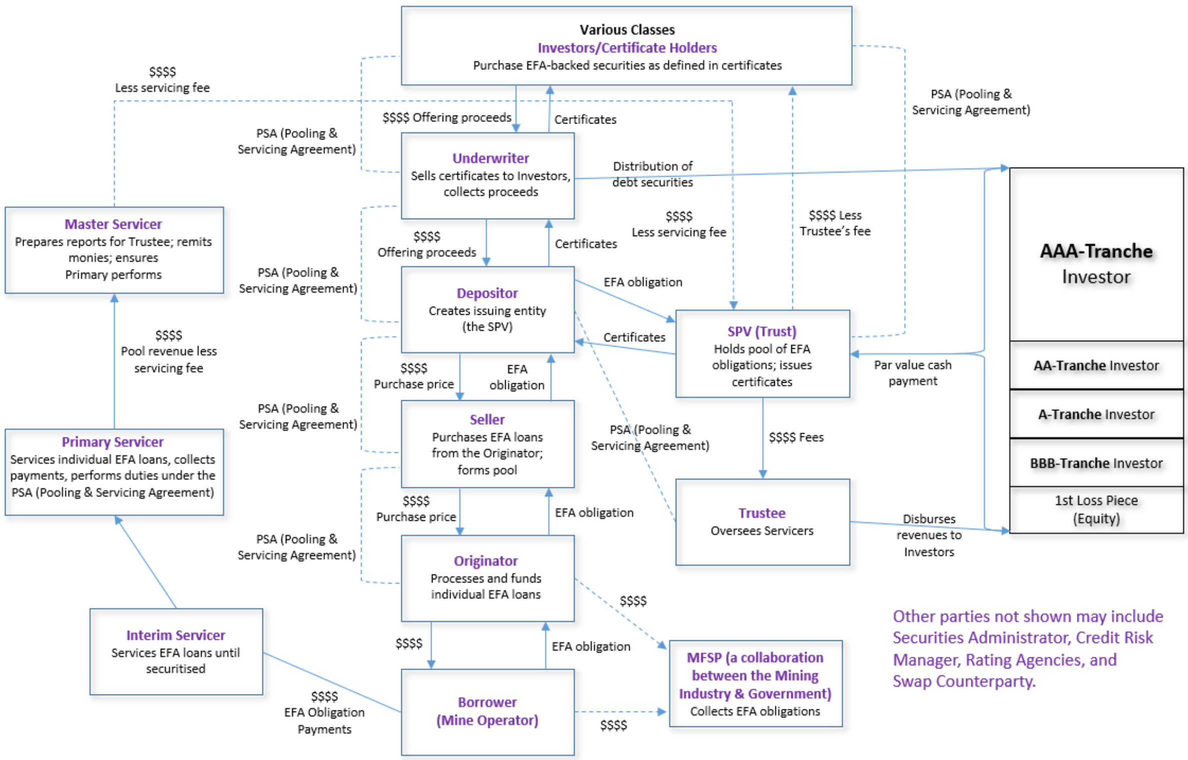
Figure G.7 outlines the roles and responsibilities of the various components involved in the conceptual securitisation structure that is illustrated in Figure G.1.

Figure G.7: EFA-Backed Securitisation Process Flow



Blockchain technologies, such as tokenisation, are likely to play a central role in both the handling and oversight of reclamation obligations, the securitisation of EFA requirements, and the associated risks (including credit, market, and inflation risks). This technology has also been touted as a potential transparency mechanism that incentivises emission reductions in carbon markets and can provide a decentralised infrastructure enabling new applications in carbon transparency and markets, clean energy generation, and climate finance. Specifically, it possesses the capability to accelerate global action towards the Paris Agreement agenda and the Sustainable Development Goals of the 2030 Agenda for Sustainable Development (UNFCCC, 2019).

Figure G.8: Multiple-Tranche EFA Securitised Structure



A securitisation structure that the proposed EFA-backed securities transaction could follow is presented. The structure is a multiple-tranche mechanism, and the goal of it and its tranching process is to generate at least one class of securities whose credit rating is greater than the average rating of the underlying pool of collateral assets or to develop credit-rated securities from an unrated pool of assets with different risk-return profiles. Through the tranching of claims, structured instruments transform risk by generating exposures to different slices of the collateralised asset pool's loss distribution. Because of this slicing and the contractual structures needed to achieve it, tranche risk-return characteristics may be difficult to assess. Consequently, subordinated structured finance tranches are riskier than the senior tranches in the structure; that is contingent on the credit rating agency's assessment of the possibility that the security will be paid by its terms. All else being equal, the higher a security's credit rating, the lower a return it must offer. For instance, a typical issuance could possess the following tranches and interest rate payouts: senior tranche (A%), mezzanine tranche (A% + B%), and equity tranche (A% + B% + C%) (listed from least to most risky). Equity tranche holders may have a motivation to increase risk and return, while senior tranche holders have a reason to minimise defaults in the asset portfolio. Figure G.8 illustrates the detailed EFA obligations-based structure of the proposed multiple-tranche.

This securitisation method would be like those commonly employed in the MBS market but with the central difference is that the underlying collateral would consist of FA obligations that derive their respective principal and interest cash flow from repayments made by the partaking mine operators. Financial institutions would analyse the amount and timing of these cash flows generated by the collateral, which is determined by the scheduled interest and principal payments as well as expected prepayment rates, delinquencies, defaults, and any potential recoveries.

Figure G.9: EFA Tranches

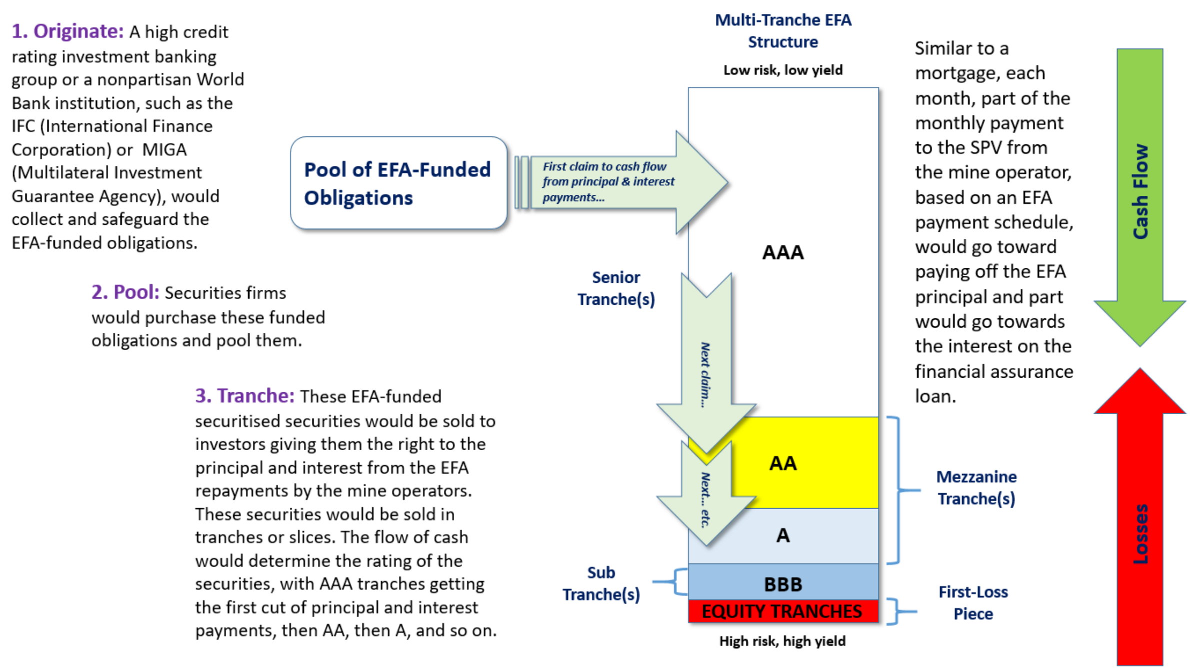
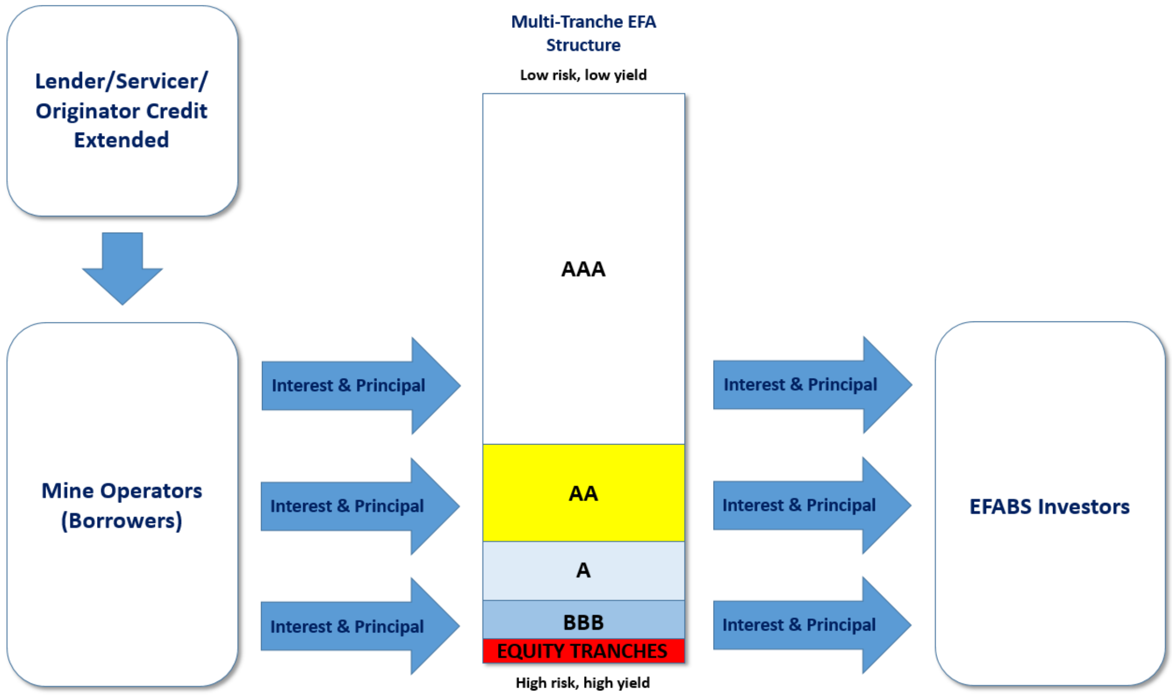


Figure G.10: EFABS Cash Flow Modelling



The tranches in this multi-tranche EFA '*sequential pay*' structure would be structured in terms of principal payments on the EFA obligations in the pool, to optimise the risk profile of the issued securities and therefore maximise the range of investors to whom they can be sold. That is, the structure would be used to allocate prepayment risk[66]. As illustrated in Figure G.9, in this structure the tranches would be retired (static collateral[67]) in sequential order where investors (e.g., institutional investors such as pension funds) in the first – senior – tranche (characteristics: highest rating, lowest interest rate, and priority of repayment) would receive principal payments from the underlying EFA obligation assets first, those in the subsequent tranche, middle tranches (mezzanine tranches – characteristics: rating, interest, and ranking between subordinated and senior tranches) next, and so forth. Investors (e.g., hedge funds) in the last – most junior (subordinated

[66] The uncertainty that a security will pay off prior to its maturity date, thereby requiring investors to reinvest their funds at a (potentially) lower rate.

[67] A revolving collateral pool mechanism can also be applied should the originator decide to use the proceeds of the repayments to invest in new assets (e.g., a new pool of EFA-funded obligations) rather than pay back the held securities. This implies that only interest payments would be made to investors while the principal amount would be held to purchase new pools of assets for each tranche. Such a structure can extend the maturity of each tranche.

tranche) – tranche (characteristics: low or no rating, highest rating, ranks last for repayment, and first to absorb any losses) would receive principal payments from the EFA obligations in the pool only when the tranches ahead of them in credit rating ranking have been fully paid, as depicted in Figure G.10. So, this is the process of the proposed FA-backed securitised mechanism.

In structuring the multi-tranche EFA structure, specifically, the issuer would distribute the cash flow from the underlying collateral over the series of classes (the tranches) which constitute the bond issue. The structure would comprise of two or more tranches, each having average lives and cash flow patterns designed to meet specific investment objectives. For example, the average life expectancies of the different tranches in the structure could be five, seven, twenty, fifty or more years. This structuring is done to create tranches that will meet the needs of investors, who may be looking for a specific maturity or other feature for their investment.

Credit enhancements would be used to cover the risk of an event where the mine operator fails to pay the R&C expenditures requirements due to bankruptcy or other financial difficulties. This may include insurance and swaps (including CDSs). When the debt market does not offer an investor the desired maturity, currency, and credit exposures, swaps and CDSs can be used to create the desired exposure. The issuer would subsequently obtain rating(s) for the '*insured*' notes through a rating agency.

One of the ways that these rated EFA securities of the SPV would obtain their credit rating is through the usage of a third-party swap. Swap agreements would be used to modify or supplement the cash flow of the SPV assets to meet investor demands. Commonly, swaps are used to transfer currency and interest rate risk to a third-party swap provider, which would be applicable for EFABSs their pooled collateralised assets would be situated in different jurisdictions, and the EFA obligations loans could be variable- or fixed-rate. As well, the SPV may hold fixed-rate EFA obligations loans, denominated in a non-dollar currency while investors may need dollar payments with a floating rate coupon. The swap permits the SPV to achieve investor goals by allocating asset credit risk to the investors while swapping interest rate and currency risk to the third-party swap provider. The provider, in this case, would offer floating-rate dollar payments to the SPV in exchange for fixed, non-dollar payments being created by the SPV's assets.

A fundamental problem with securitisation contracts is not the securitisation of '*good*' assets, but the securitisation of '*bad*' ones, '*lemons*,' due to default, bankruptcy, insolvency, and so forth, in the case of a mine operator's EFA obligations loan. To '*insure*' against such expected defaults, the lenders and the investors would enter into CDS contracts which are typically cheaper than the conventional loan insurance. A CDS is, basically, a quasi-form[68] of '*insurance*' against non-payment. Through a CDS, the purchaser of the swap makes a series of payments to the seller of the swap, in exchange for an assurance that if a specific credit instrument, such as a loan or bond, goes into default, the buyer will be paid a certain sum by the seller. Essentially, the seller of the swap is providing a guarantee that if the bond (that is the subject of the CDS) defaults, the seller will pay the buyer a specified sum of money. In other words, through a CDS, the buyer can avoid the repercussions of a borrower's default by transferring some or all that risk onto other CDS seller or an insurance company in exchange for a fee.

If the securitised EFA product failed, there would be complications that would not occur if it were an operating company. If it collapsed, despite all the protective measures undertaken, the investors' funds within the pool and those collected from the mine operators would be expected to be protected due to the arm's length securitisation trust. Additional funding would also be collected from the security's insurance policy and the purchased CDS. These combined funds would be utilised for R&C regulatory requirements and to protect the investors' invested capital if any funds remained after all the expenses and taxes are paid.

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[68] A CDS is not insurance because the protection seller's payment is triggered upon the happening of a negative credit event and such payment is not dependent upon the buyer having suffered a loss.

Long-term investors, such as those who would purchase EFABSs, face a common issue—how to achieve a level of real returns (inflation-adjusted returns) and maintain the purchasing power of their assets over time consistent with their investment objectives. Inflation-linked bonds and derivatives would also be utilised to hedge the effects of inflation given the disruptions it causes would be harmful to the value of the stream of payments that EFABSs would make, which affects their investment return.

Figure G.11: Cash Flow Schematic for an EFABS

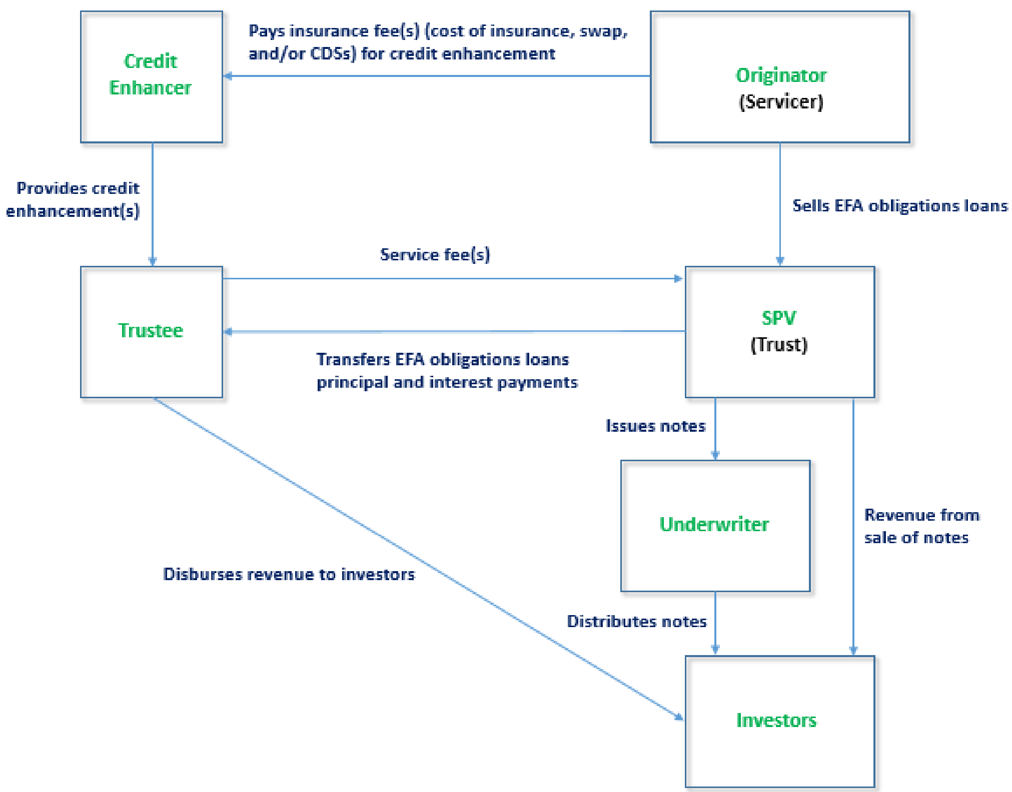


Figure G.11, an extension of Figure G.5, depicts the cash flow structure of an EFABS. As the figure illustrates, the SPV issues certificates/notes to investors, usually through an investment bank that underwrites the issue. The revenues collected by the SPV from principal and interest payments are transferred to a trustee. These revenues are added to cash contributions made by a credit enhancer, and then disbursements are made to investors by the trustee.

Variations in securitisation structures can impact direct transaction costs, flexibility, and investor's risk-adjusted rate of return. Each structure is also associated with certain indirect costs and benefits. For instance, transaction costs are not limited to direct expenses, such as fees for investment bankers, lawyers, and credit enhancement or liquidity facilities. They would also arise from the true sale requirement of the FA-backed security. A true sale can be described as a complex financial transaction in which loans or other assets (e.g., receivables) that generate a defined or identifiable cash flow are sold by their originator or subsequent owner to (and pooled by) an SPV.

The principal and interest payments on the EFA securities would be funded by (and limited to the extent of) the cash flows (both capital and revenue) collected from the pooled mine operators. The SPV's obligations under the EFA securitised security would be secured by the FA obligations and their collected cash flows (similar in concept that arises for an MBS). The tax treatment of an FA-backed security would be greatly influenced by the necessity of a true sale of the assets to the SPV.

Tax consideration may also affect the choice of profit extraction method; for example, servicing fees are subject to value-added tax, so that profit extraction through a servicing fee is not commonly used. A regularly utilised method of profit extraction in transactions is the deferred purchase price mechanism to pay out excess spread (whether that is monthly or trapped in a cash reserve account and paid out based on deal-specific timings). Another is ownership of a subordinate security instrument.

Appendix H: Mamdani Fuzzy Inference System

Fuzzy logic is an optimisation technique that considers different inputs and relates them with output with some rules. Rules specify the relationship between inputs and outputs. The output is optimised based on the relationship between variables. Due to the complexity of the proposed structured finance system, the use of fuzzy logic as a modelling tool is fitting. For such complex systems, numerical data might be scarce and only ambiguous and imprecise information could be available (Ross, 2010).

Fuzzy set theory is a convenient tool to represent and analyse qualitative information and to model systems which are hard to define precisely (Zadeh, 1976; Wang and Hwang, 2007; Minola and Giorgino, 2008). Specifically, a *fuzzy set* is a set with imprecise boundaries in which the transition from membership to non-membership is gradual rather than abrupt. In this way, a fuzzy set F in a universe of discourse U is characterised by an MF μ_F, which associates each element u $\in$ U with a grade of membership μ_F(u) $\in$ [0, 1] in the fuzzy set F. This theory offers a significant paradigm in modelling and reasoning with uncertainty.

The basic concept underlying fuzzy logic is a *linguistic variable*, which is a variable whose values are words rather than numbers. A linguistic variable is characterised by a quintuple (x, T(x), U, G, M) in which x is the name of the linguistic variable; T(x) is the *term set* of x, that is, the set of names of linguistic values of x defined on U; G is a syntactic rule for generating the names of values of x; and M is a semantic rule for associating with each value its meaning.

While the Boolean logic is based on the true-false paradigm, the fuzzy logic approach leverages on all probable values between these two extremes (the continuum of logical values between 0 (totally false) and 1 (absolutely true)). Resembling human reasoning in its use of approximate information, it converts linguistic variables to fuzzy numbers under ambiguous assessments. Such a technique is suitable to quantify assessments made by experts, who tend to make evaluations based on their experience, knowledge, and subjectivity (Chan et al., 2000).

FL provides operations that act on fuzzy sets. Those operations are counterparts to those, which act on crisp sets. For example, the union (A ∪ B) of two fuzzy sets is defined as:

$$\mu_{A\cup B}(x) = max\big(\mu_A(x), \mu_B(x)\big)\forall x \in U \tag{H.1}$$

Since the original contribution by Zadeh (1965), fuzzy logic has been studied considerably. While first used to signify uncertainty in human cognitive processes, over the last twenty-five years it has mainly been applied in engineering, management, and business studies (Kaufmann and Gupta, 1988; Chan et al., 2000; Chen, 2001; Wang and Hwang, 2007; Minola and Giorgino, 2008). In the field of artificial intelligence (AI) systems applied to financial markets, FL methods are commonly used to solve complex problems and to process undefined qualitative datasets.

The number of scientific contributions in finance and accounting that employ fuzzy logic has sharply increased in recent past. They include:

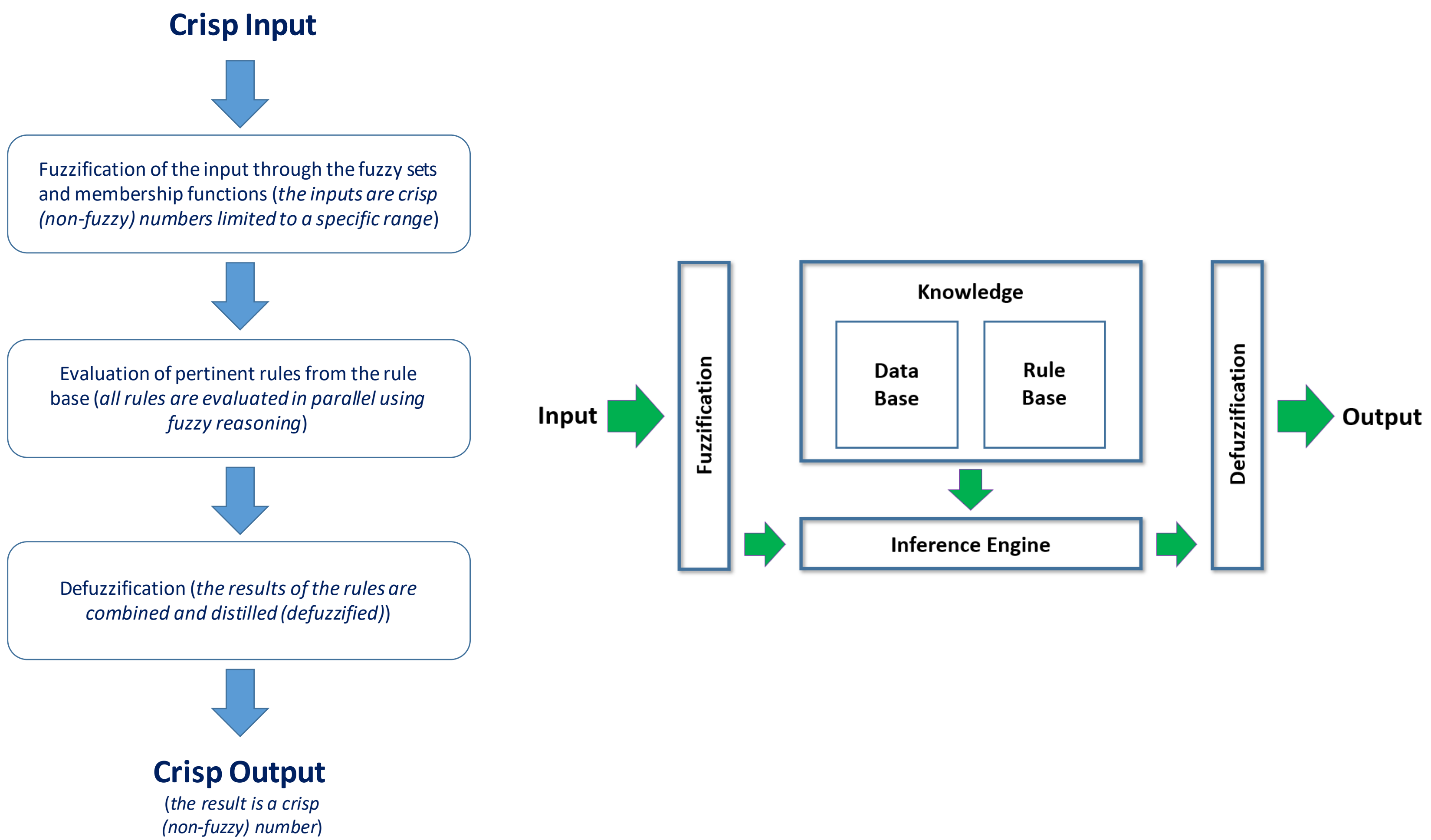
- De Wit (1982) applied fuzzy logic to insurance.
- Zebda (1989) and Zebda (1991) dealt with accounting and vagueness.
- Abdel-Kader et al. (1998) outlined a model for the evaluation of investments.
- Following suggestions in Magni (1998) on real-option evaluation, and Magni et al. (2002) provided an expert system to evaluate a real option.
- Further applications have been observed in economic fields such as industrial districts (Facchinetti et al., 2000), credit scoring (Facchinetti et al., 2001), and insurance (Facchinetti and Mastroleo, 2001).
- Montagna et al. (2003) studied the pricing of financial derivatives using computational algorithms.

- A real-life case has also been investigated and replicated regarding a company's acquisition (Magni et al., 2004).
- Streit and Borenstein (2009) analysed the regulation of the financial sector through a model based on agents.
- De Faria et al. (2009) utilised neural networks to predict the Bovespa's behaviour, the Brazilian stock market, through neural networks methods.
- Escobar et al. (2013) proposed a technical analysis indicator based on fuzzy logic.
- Sirignano et al. (2018) developed a deep learning model of multi-period mortgage risk. They applied it to analyse a dataset of origination and monthly performance records for over 120 million mortgages originated across the US, which has significant implications for MBS investors.

The significance of fuzzy logic stems from the fact that there are many real-world applications which fit these conditions, particularly in the realm of knowledge-based systems for decision-making and control. One of the main objectives of FL is to offer a computational framework for knowledge representation and inference in an environment of imprecision and uncertainty. In such situations, fuzzy logic is useful when the results need not be exact and/or it is acceptable for a conclusion to possess a dispositional instead of a categorical validity. Almost any control system can be substituted with a fuzzy logic-based control system (Zadeh, 1976). The most noticeable applications of fuzzy logic control have appeared in commercial appliances. It can also be used in areas other than control. It can be applied in any decision-making process, such as signal processing or data analysis.

In the dissertation, the observed output level, concerning the macro-area inputs, was estimated by applying a Mamdani-type FIS model using the Fuzzy Logic Toolbox Graphical User Interface Tools of MATLAB (intelligent system). Fuzzy inference (reasoning) is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then offers a basis from which decisions can be made, or patterns discerned.

Figure H.1: Basic Structure of a Fuzzy Logic System



The steps involved in modelling a fuzzy logic system, as illustrated in Figure H.1 (MATLAB, 2018), are (McNeill and Thro, 1994):

- define the input variables and their corresponding ranges of values;
- specify the output variables and their corresponding ranges of values;
- develop fuzzy membership functions for each input and output;
- develop a rule base based upon the possible outcomes of the system; and
- determine how each action will be carried out by establishing the rule strengths and defuzzification.

Like a typical fuzzy logic system, the MATLAB Fuzzy Logic Toolbox breaks down the fuzzy inference process into the following parts:

- the fuzzification of the input variables;
- the usage of the fuzzy operator (AND or OR) in the antecedent;
- the implication from the antecedent to the consequent;
- the aggregation of the consequents across the rules; and
- defuzzification.

A basic '*Mine Reclamation Success*' problem example to illustrate the process of a Mamdani fuzzy inference system follows. The basic structure of this FIS, as shown in Figure H.2, consists of the following conceptual components:

- a rule base, which comprises of a selection of fuzzy rules;
- a database, which describes the MFs employed in the fuzzy rules; and
- a reasoning mechanism, which executes the inference procedure upon the rules and given facts to derive a conclusion or output.

H.1 Example – Mine Reclamation Success

Figure H.2: Structure of the '*Mine Reclamation Success'* Mamdani Fuzzy Inference System

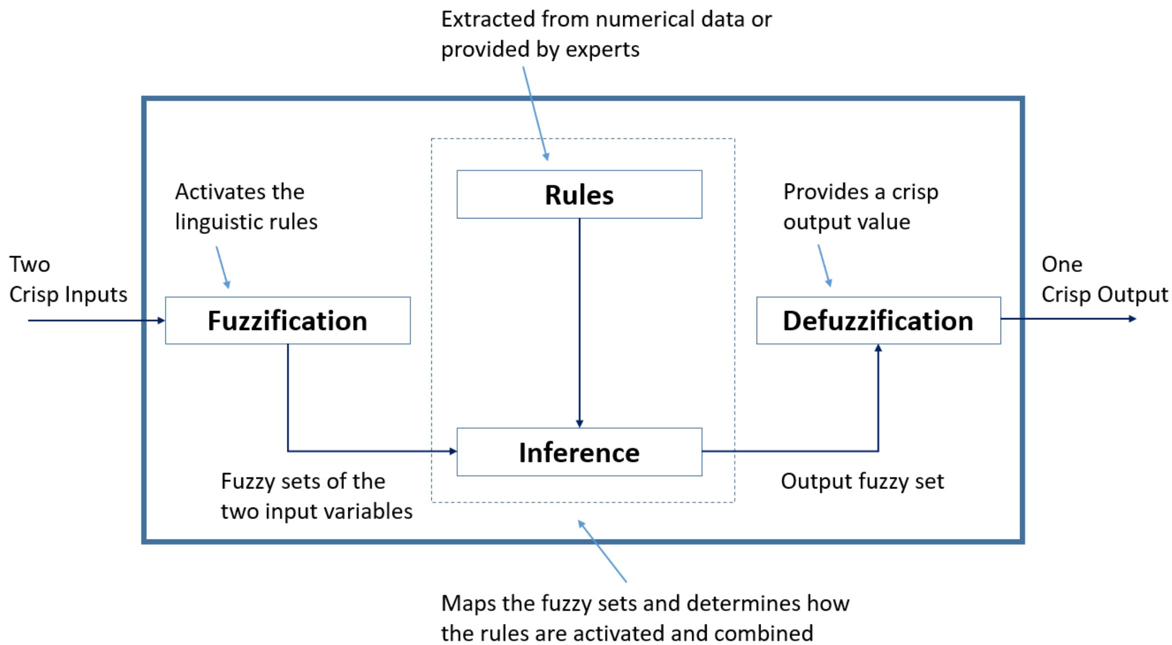


Figure H.3: Basic Structure of the '*Mine Reclamation Success*' Problem

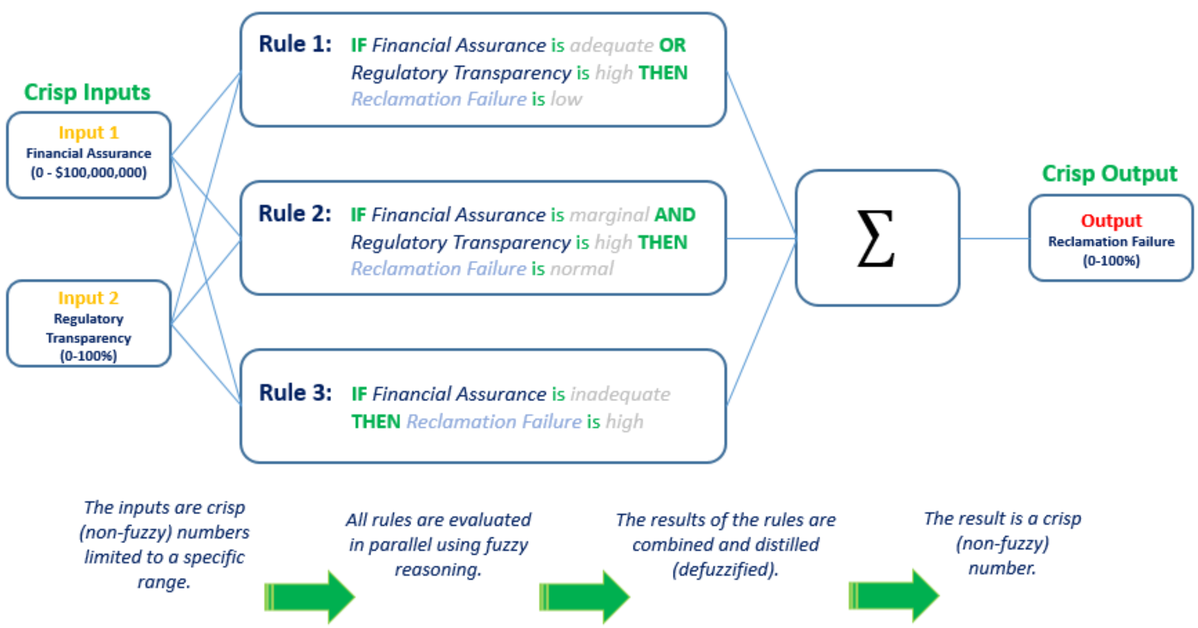


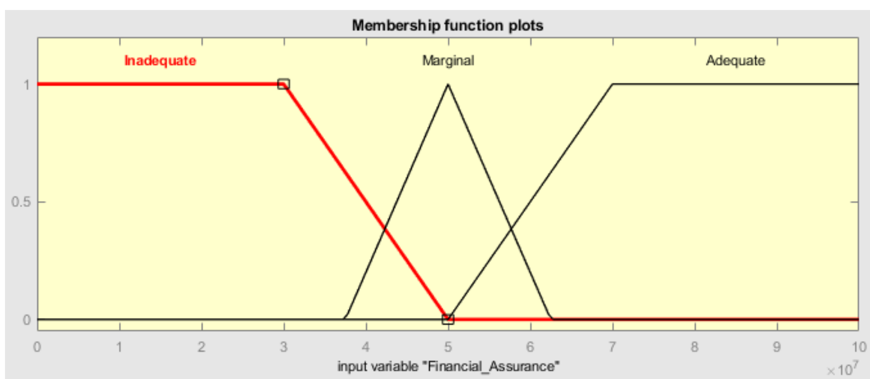
Figure H.3 illustrates how the two input variables, '*Financial Assurance*' and '*Regulatory Transparency*,' are taken through the fuzzy reasoning process with three IF-THEN rules. The results from these rules are then combined and transformed into a crisp numerical value to quantify the likelihood of '*Reclamation Failure*' for a particular mine site.

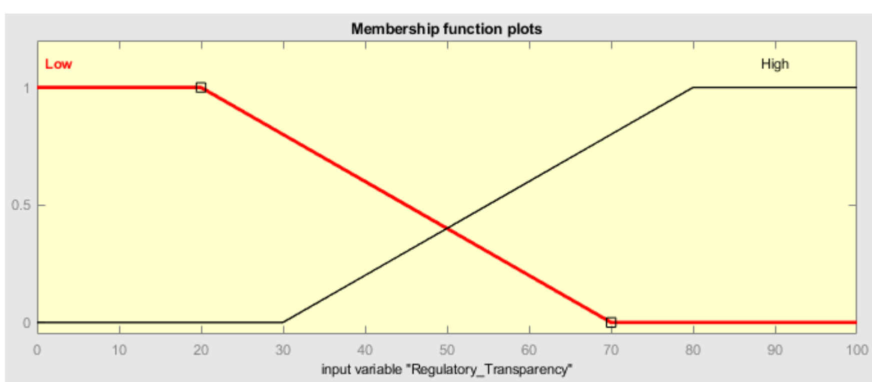
The Mamdani-type fuzzy inference process consists of the following steps:

1. Fuzzify Inputs
2. Apply the Fuzzy Operator
3. Apply the Implication Method
4. Aggregate All Outputs
5. Defuzzify

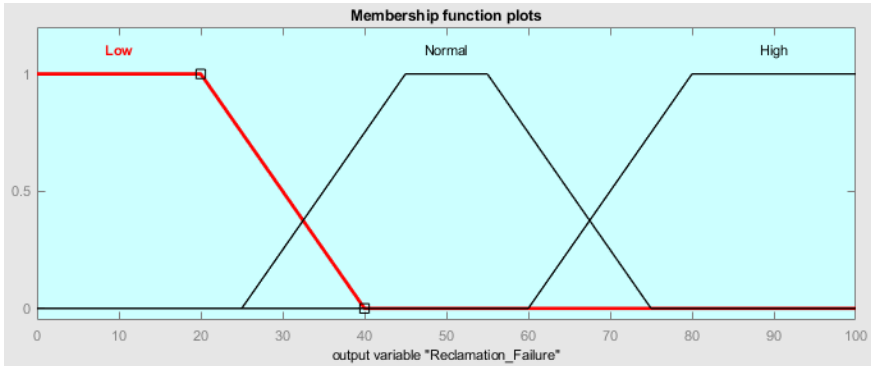
Figure H.4: '*Mine Reclamation Success*' Memberships

Antecedents (Inputs)





Consequents (Outputs)



Step 1: Fuzzify Inputs

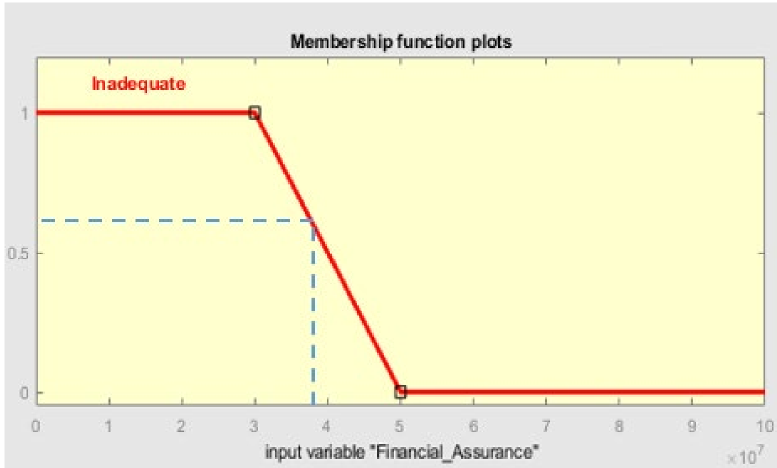
Figure H.4 illustrates what the two inputs and one output memberships look like.

The first step is to transform the crisp numerical values of the input variables into the equivalent membership values of the appropriate fuzzy sets via MFs. No matter what the input variables describe, through the fuzzification process, the output is usually the degree of membership in the related fuzzy linguistic sets within the interval between 0 and 1.

Fuzzification is the process of converting the crisp input data to a fuzzy set. A *fuzzy implication* is viewed as describing a fuzzy relation between the fuzzy sets forming the implication. A *fuzzy rule*, such as "if X is A then Y is B" is a fuzzy implication which has a membership function $\mu_{A\rightarrow B}(x, y) \in [0,1]$. The expression $\mu_{A\rightarrow B}(x, y)$ measures the *degree of truth* of the implication relation between x and y. The IF part of an implication is called the *antecedent* (*premise*), whereas the THEN part is called the *consequent*. When using the *Mamdani's* (*minimum*) *implication*, the MF of the fuzzy implication is defined as:

$$\mu_{A\rightarrow B}(x, y) = min[\mu_A(x), \mu_B(y)] \quad \text{(H.2)}$$

Figure H.5: Fuzzifying the Input Variable '*Financial Assurance*'



In the observed example, three IF-THEN rules present five different fuzzy linguistic sets: '*Financial Assurance* is *inadequate*,' '*Financial Assurance* is *marginal*,' '*Financial Assurance* is *adequate*,' '*Regulatory Transparency* is *low*,' and '*Regulatory Transparency* is *high*.' The two input variables, '*Financial Assurance*' and '*Regulatory Transparency*,' must be fuzzified according to the membership functions of these linguistic sets. For instance, Figure H.5 shows that the point representing $38 million is projected onto the MF shape which describes the linguistic set '*Financial Assurance* is *inadequate*,' and a membership value of μ = 0.60 for the fuzzy set '*Financial Assurance* is *inadequate*' is observed.

The input variables (in this case the interval is between 0 and $100 million for the amount of '*Financial Assurance*' posted and 0 to 100 percent to describe the degree of '*Regulatory Transparency*') and the output is a fuzzy degree of membership in the qualifying linguistic set (always the interval between 0 and 1).

Step 2: Apply the Fuzzy Operator

When the FIS contains more than one input variable, the antecedent of an IF-THEN rule might be defined by more than one fuzzy linguistic set since in most cases each input variable has one corresponding fuzzy set based on which to determine the degree of membership. In the example, the antecedent of Rule 1 consists of two fuzzy linguistic sets, '*Financial Assurance* is *adequate*' and '*Regulatory Transparency* is *high*.' Here the fuzzy operator is required to combine the two membership values from the set, '*Financial Assurance* is *adequate*' and set '*Regulatory Transparency* is *high*,' respectively, and then obtain one numerical value that denotes the result of the antecedent for this rule.

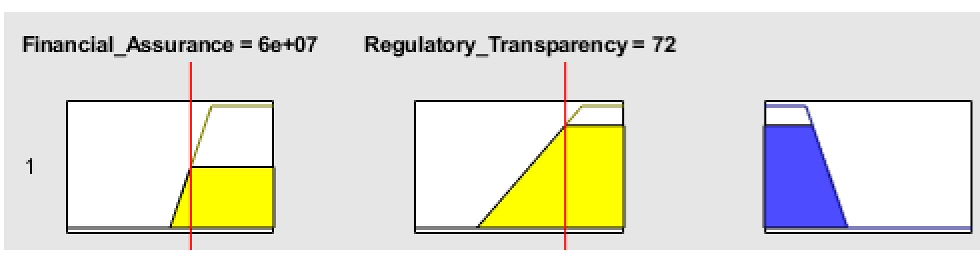
The most common fuzzy operators are the AND and OR operations. The functions *min* and *max* are applied to formulate these logical operations. Fuzzy expert systems make use of the conventional fuzzy operation union to represent the OR fuzzy operation:

$$\mu_{A \cup B}(x) = \max\,[\mu_A(x), \mu_B(x)] \tag{H.3}$$

Similarly, to evaluate the conjunction of the rule antecedents, the AND fuzzy operation intersection is applied:

$$\mu_{A \cap B}(x) = \min\,[\mu_A(x), \mu_B(x)] \tag{H.4}$$

Figure H.6: Applying the Fuzzy Operator



Although other functions, such as product and probabilistic OR, are also applicable in expressing these fuzzy operators, the functions *min* and *max* are simple, effective and widely used. Figure H.6 shows the OR operation via the *max* function. The two fuzzy sets of the antecedent in Rule 1 yield the fuzzy membership values 0.50 and 0.84, respectively, and the *max* (maximum) of these two values, 0.84, is selected as the result of the antecedent for

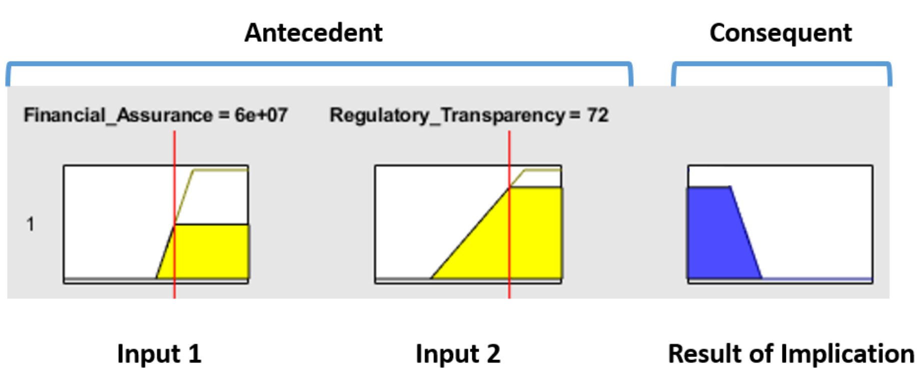
Rule 1. Specifically, this *max* value is a single number that represents the result of the antecedent evaluation.

Step 3: Apply the Implication Method

The result of the antecedent evaluation is now applied to the membership function of the consequent. Every rule has a weight (a value between 0 and 1), which is applied to the value given by the antecedent. Usually, this weight is 1 (as it is for this '*Mine Reclamation Success*' example) and therefore it has no impact on the implication process.

The *clipping* (alpha-cut) method is used to cut the consequent membership function at the level of the antecedent truth. The clipped fuzzy set loses some information since the top of the MF is sliced. Such a method is typically preferred since it involves less complicated and quicker mathematics, and it generates an aggregated output surface that is simpler to defuzzify. The cost of such simplicity in applying such a method is that it does not preserve the original shape of the fuzzy set.

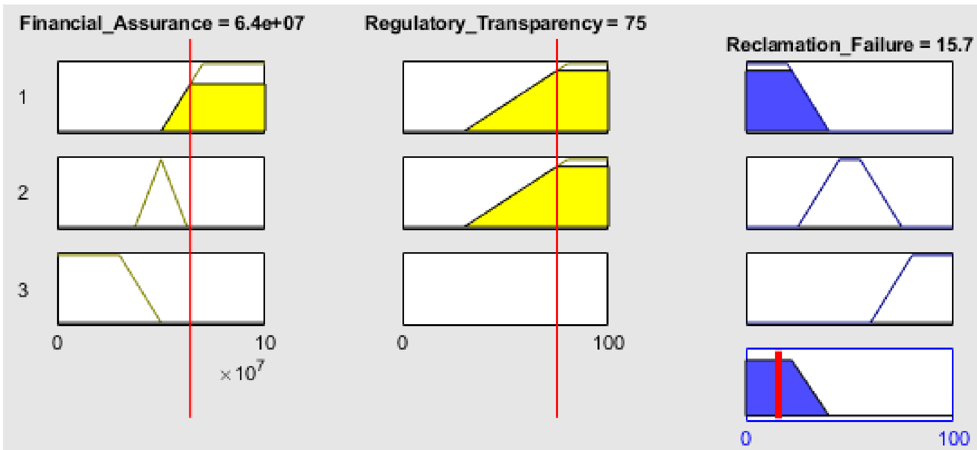
Figure H.7: Applying the Implication Method



In Rule 1, the AND operation is utilised, which truncates the fuzzy set of the consequent. The extent of deformation of the output fuzzy set in each rule depends on the specific single number coming from the matching antecedent of the rule, as observed in Figure H.7.

Step 4: Aggregate All Outputs

Figure H.8: Applying the Aggregation Method



Aggregation is the method of unification of the outputs of all the observed rules, as illustrated in Figure H.8. The MFs of all three observed rule consequents previously clipped are combined into a single fuzzy set. Specifically, the final combined fuzzy set is the output of the aggregation process, and every output variable of the FIS will possess a single matching combined fuzzy set for reference. The functions *max*, *min*, *sum*, and *probabilistic* OR and are all applicable for aggregation operation.

In this '*Mine Reclamation Success*' problem example, three truncated fuzzy sets coming from three rules, respectively, are operated through the *aggregation* method by the functions *max* and *min*, and a combined new fuzzy set signifying the outcome for the output variable '*Reclamation Failure'* is ready for the final step of the defuzzification process.

Step 5: Defuzzify

The result of the fuzzy inference system is a fuzzy set. The last step of the fuzzy inference process is *defuzzification*, through which the combined fuzzy set from the aggregation process will output a single scalar quantity. Specifically, this step produces a representative crisp value as the final output of the system. As the name implies, defuzzification is the opposite operation of *fuzzification*. Fuzziness helps to assess the rules, but the final output of a fuzzy system must be a crisp number. The input for the defuzzify process is the aggregate output fuzzy set, and the output is a single number.

Since in the first procedure the crisp values of input variables are fuzzified into the degree of membership concerning the fuzzy sets, the last step extracts a precise quantity out of the range of fuzzy set to the output variable. Among the many defuzzification methods available, the *Centroid Method* (also called the *centre of area* (COA) or *centre of gravity*) is the most appealing and is the method used in the dissertation. Mathematically the *Centroid Method* can be expressed as:

$$z_{COA} = \frac{\int_z u_a(z) * z dz}{\int_z u_a(z)} \qquad \text{(H.5)}$$

where z is the output variable, and $\mu_a(z)$ is the membership function of the aggregated fuzzy set a with respect to z.

Figure H.9: Applying the Centroid Method for Defuzzification

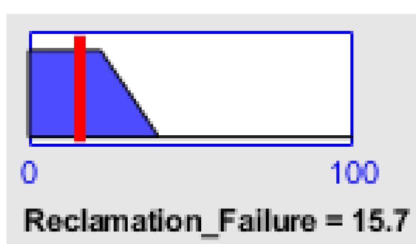


Figure H.9 shows the result for the example calculated using the *Centroid Method*. It indicates that when the '*Financial Assurance*' amount equals $64 million and the '*Regulatory Transparency*' reaches 75 percent, the FIS rates '*Reclamation Failure*' to be 15.7 percent. The output result suggests that the assessed '*Reclamation Failure*' risk is relatively low for the particular mine site in question.

The defuzzified '*Reclamation Failure*' risk value is between 0 and 100 percent. These limits relate to the centroids of the '*low*' and '*high*' risk membership functions, respectively.

Figure H.10: Relationship Between the Variables

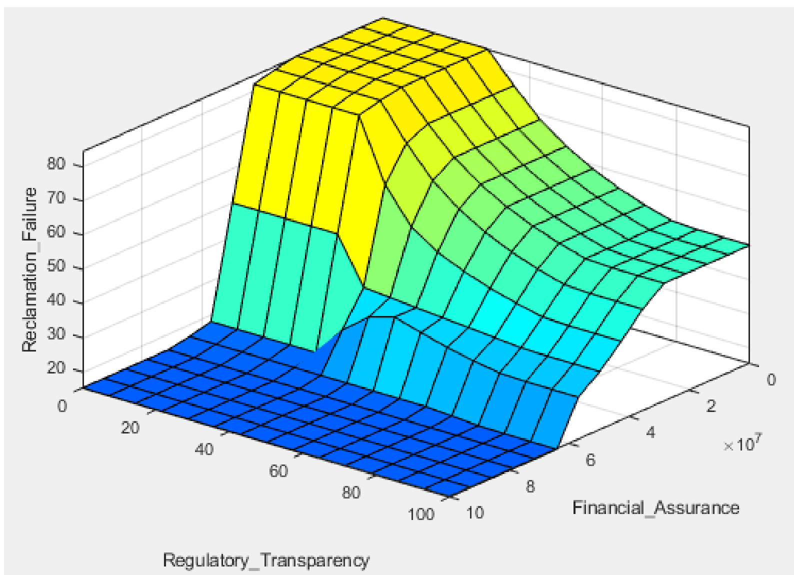


Figure H.10 displays the relationship between the input and output variables. The point with coordinates [10x10^7; 100], which represents the condition where the input variable, '*Financial Assurance*,' is very high (adequate) and the input variable, '*Regulatory Transparency*,' is very high, signifies that the output variable, '*Reclamation Failure*,' is evaluated as being a minimal risk level. The point with coordinates [0; 0] represents the reverse circumstance.

This problem can be summarised as:

Antecedents (Inputs)

- **Input 1: Financial Assurance**
    - Universe (i.e., crisp value range): What is the required FA amount requested by the regulators for a particular project, on a scale of 0 to $100 million?
    - Fuzzy set (i.e., fuzzy value range): inadequate, marginal, adequate

- **Input 2: Regulatory Transparency**
    - Universe (i.e., crisp value range): How transparent are mine regulations and how strong is regulatory enforcement, on a scale of 0 to 100 percent?
    - Fuzzy set (i.e., fuzzy value range): low, high

Consequents (Outputs)

- **Output 1: Reclamation Failure**
    - Universe (i.e., crisp value range): Evaluating the success of mine reclamation, on a scale of 0 to 100 percent.
    - Fuzzy set (i.e., fuzzy value range): low, normal, high

Rules

- **Rule 1:** IF *Financial Assurance* is *adequate* OR *Regulatory Transparency* is *high* THEN *Reclamation Failure* is *low*.
- **Rule 2:** IF *Financial Assurance* is *marginal* OR *Regulatory Transparency* is *high* THEN *Reclamation Failure* is *normal*.
- **Rule 3:** IF *Financial Assurance* is *inadequate* THEN *Reclamation Failure* is *high*.

Usage

- If the controller is inputted the following linguistic inputs values:
    - the *Financial Assurance* as $64 million.
    - *Regulatory Transparency* as 75 percent.

- it would output that:
    - the *Reclamation Failure* to be 15.7 percent, which is relatively low.

Appendix I: Fuzzy Membership Function Ranges of Magnitude

The identification and utilisation of the observed variables, as observed in Figure 4.1, was based on i) existing literature; ii) industry experts in the field of structured finance and mining; and iii) personal, professional experience.

A two-level dimension tree is defined (see Figure 4.1), in which each level relates to a macro category affecting an EFA-backed securitised mechanism outcome. Each node of the tree is further divided into sub-dimensions, for which the relevant parameters were identified. The model result is a defuzzified output, for the corresponding input values, summarising the suitability of each financial reclamation obligation in the portfolio, in comparison to an optimal case. It is a measure of the probability of success of an EFA-backed mechanism transaction. The fuzzy ranges of magnitude parameters of each variable (as summarised in Table 4.2) are presented.

First Dimension (1stDim: L0): EFA Obligations

Credit-Strength

The *Credit-Strength* variable applies the Altman Z-Score analysis. It is a credit strength test that gauges a publicly-traded company's likelihood of bankruptcy (Altman, 1968). The Altman Z-Score was designed for manufacturers, or sectors with high capital intensity, such as mining and oil & gas. The overall Z-Score is compared to the following grading scale:

- 0 – 1.81 indicates the company will declare bankruptcy in the future;
- 1.81 – 2.99 indicates the company is likely to declare bankruptcy; and
- 2.99+ indicates that the company is not likely to declare bankruptcy.

The Z-Score scale translates into the following fuzzy Trapezoidal MF ranges of magnitude, as illustrated in Table I.1.

Table I.1: Fuzzy MF Ranges of Magnitude for the '*Credit-Strength*' Linguistic Variable

State	a	b	c	d
Distressed	-10	-10	-5	1.81
Grey	1.81	2.99	2.99	2.99
Safe	2.99	5	10	10

Expected Mine Life

The expected life of a mine operation. A long-life of a mining site can make it challenging to securitise it due to increasing uncertainties relating, in part, to reclamation liability cost estimates. Besides the market risks associated with commodity-prices fluctuations and the interest-rate risks related to debt financing, mine operators also face risks linked with default risk (or credit risk). Subsequently, with more time until operations are scheduled to wrap up, the higher the likelihood a mine operator could eventually go into bankruptcy due to multiple reasons.

When applying the Gaussian membership function, the scale translates to the following fuzzy MF ranges of magnitude (in years) for the linguistic variable, *Expected Mine Life* (as displayed in Table I.2). A left-half part of the Gaussian function represents the (0,40) for the '*High*' zone range. It implies a lesser chance a mine operator will fail to meet its R&C obligations during the shorter life expectancy of the mine.

Table I.2: Fuzzy MF Ranges of Magnitude for the '*Expected Mine Life*' Linguistic Variable

State	c	σ
Low	60	100
Medium	40	60
High	0	40

Second Dimension (2ndDim: L0): Deal Structure

Financial Health

The financial strength of the mine operators. The Interest Coverage Ratio is used to assess how rapidly a company can pay its interest expenses on outstanding debt. An ICR below 1 indicates the business is having difficulties generating the cash necessary to pay its interest obligations (i.e., interest payments exceed its earnings (EBIT)). A higher ratio denotes better financial health since it suggests that the corporate entity is more capable of meeting its interest obligations from operating earnings. On the other hand, an ICR of 2.5 may imply a company is '*too safe*' and is neglecting opportunities to magnify earnings through leverage.

As outlined in Table I.3, these ICR ranges translate to the following fuzzy Trapezoidal membership function ranges of magnitude.

Table I.3: Fuzzy MF Ranges of Magnitude for the '*Financial Health*' Linguistic Variable

State	a	b	c	d
Low	-20	-20	-10	1
Acceptable	1	2.5	2.5	2.5
Solid	2.5	10	20	20

CSR/ESG Ranking

Bloomberg's CSRHub ratings tool provides corporate social responsibility and sustainability rankings of companies. Bloomberg's CSRHub takes information from its data sources and transforms it into a 0 to 100 scale. The higher the rating, the better (0 = lowest, 100 = highest). When applying the trapezoidal fuzzy membership, the scale translates to the following fuzzy MF ranges of magnitude (CSRHub rating limits), as observed in Table I.4.

Table I.4: Fuzzy MF Ranges of Magnitude for the '*CSR/ESG Ranking*' Linguistic Variable

State	a	b	c	d
Low	0	39	39	39
Medium	39	59	59	59
High	59	100	100	100

To reduce arbitrariness in assigning grades to the various observed variables and dimensions, the identification of the multiple ranges for the following observed linguistic input model values (*Originator's Degree of Experience*, *Pooling Arrangement*, *Diversification*, *Vehicle Structure*, *Credit Enhancement*, and *Legal Framework*) relied on industry experts in the field of structured finance and from personal, professional experience to determine them.

Setting exact ranges is a challenging task. It is a matter of definition and based on subjective interpretation acquired from industry experience accumulation or specific knowledge surrounding securitisation rather than measurement for these observed linguistic variables in the EFA-backed securitisation model. These second dimension (2ndDim: L0) variables rely on subjective interpretation based on industry expertise.

Originator's Degree of Experience

The originator's experience linguistic variable denotes similar transactions in which the originator was involved in the years before the considered securitised deal. Their experience level in managing a securitisation process can potentially determine the success of a transaction. The accumulated knowledge on how to structure the process might reduce the risk of failure. The more experience in the field, the higher is the chance to structure an EFA deal properly. As outlined in Table I.5, these ranges translate to the following fuzzy Trapezoidal membership function ranges of magnitude.

Table I.5: Fuzzy MF Ranges of Magnitude for the '*Originator's Degree of Experience*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

Pooling Arrangement

The number of different FA obligations (i.e., mining, oil & gas, and chemical) involved in the securitised portfolio. The primary benefit in aggregating interest rates payment streams coming from a pool of financial assurance obligations (rather than just one) is that diversification lowers the risk that underperformance of any one income stream will cause the deal to default possibly. The number of specific financial assurance obligations in the pool is considered to assess the diversification potential of the EFA-backed securitised mechanism. When using the trapezoidal fuzzy membership, the scale translates to the following fuzzy MF ranges of magnitude (as displayed in Table I.6).

Table I.6: Fuzzy MF Ranges of Magnitude for the '*Pooling Arrangement*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

Diversification

The linguistic variable represents the synthetic index of EFAs diversification. The risk of underperformance of EFA obligations backed securities would be mitigated by the diversity of the overall pool of assets, of the types of held financial assurance obligations from the various extractive industries. Diversification lowers the risk that underperformance of any one income stream will cause the deal to default. As observed in Table I.7, these ranges translate to the following fuzzy Trapezoidal membership function ranges of magnitude.

Table I.7: Fuzzy MF Ranges of Magnitude for the '*Diversification*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

Vehicle Structure

Synthetic index of the flexibility of the SPV. In a standard securitisation process, the originator sells the asset itself or cash flow rights to an SPV, a bankruptcy-remote entity, to separate future receivables from its corporate risks. The vehicle structure was assessed by analysing the degree of flexibility of the SPV and the possibility of further modifying the asset pool after the first issuance. When using the trapezoidal fuzzy membership, the scale translates to the following fuzzy MF ranges of magnitude (as shown in Table I.8).

Table I.8: Fuzzy MF Ranges of Magnitude for the '*Vehicle Structure*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

Credit Enhancement

Synthetic index of the effectiveness of the internal and external credit enhancement mechanisms. Securitisations are structured with several credit enhancements that should further improve the attractiveness of EFABSs. Due to the use of CEs in securitisation structures, it is possible to achieve a larger separation between the asset risk and the company risk. By virtue of these tools, a security's credit quality can be raised above the quality of the underlying asset pool or from the entity originating the assets. As a consequence, the use of tailor-made CE tools is assumed to significantly increase the likelihood that a deal will be successful. The presence of internal and external credit enhancement mechanisms and their efficacy to secure each deal were assessed. As presented in Table I.9, these ranges translate to the following fuzzy Trapezoidal membership function ranges of magnitude.

Table I.9: Fuzzy MF Ranges of Magnitude for the '*Credit Enhancement*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

Legal Framework

Synthetic index of the legal structure of the deal. In examining the feasibility of a deal, attention must be paid to a variety of legal issues, such as the impact that country regulations have on the asset's underlying value, specific bankruptcy concerns. Decoupling the assets from the bankruptcy risk of the originator requires an appropriate legal structure. The legal structure of the two deals was compared. When using the trapezoidal fuzzy membership, the scale translates to the following Trapezoidal fuzzy membership function ranges of magnitude (as displayed in Table I.10).

Table I.10: Fuzzy MF Ranges of Magnitude for the '*Legal Framework*' Linguistic Variable

State	a	b	c	d
Low	-6.47	-1.59	1.59	6.47
Medium	3.59	8.47	11.59	16.47
High	13.59	18.47	21.59	26.47

1stDim: L1

EFA Obligations Value

From a theoretical standpoint, the better the creditworthiness of the mine operator, the higher the probability the company can originate consistent cash flow payments to be securitised and the lower the level of financial distress which could result in its demise that could jeopardise mine reclamation and closure requirements. As shown in Table I.11, these Gaussian ranges translate to the following fuzzy MF ranges of magnitude.

Table I.11: Fuzzy MF Ranges of Magnitude for the '*EFA Obligations Value*' Macro Variable

State	c	σ
Low	0	1.7
Medium	1.7	5
High	5	10

EFA Obligations Life

In the mining industry, a critical time point is the expected life of a mining operation. A long-life of a mining site can make it challenging to securitise it due to increasing uncertainties relating, in part, to reclamation liability cost estimates. When applying the Gaussian fuzzy membership, the scale translates to the following fuzzy membership function ranges of magnitude, as exhibited in Table I.12.

Table I.12: Fuzzy MF Ranges of Magnitude for the '*EFA Obligations Life*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

2ndDim: L1

Stakeholders

The quality of some stakeholders (including regulators, financial markets, originators, and mining companies) is expected to influence a FA obligations-backed securitisation outcome. As presented in Table I.13, these ranges translate to the following fuzzy Gaussian membership function ranges of magnitude.

Table I.13: Fuzzy MF Ranges of Magnitude for the '*Stakeholders*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

Collateral

Since EFABSs would be ad-hoc transactions, the underlying financial and legal structure would be customised, and each deal would be different from the others. Such deals would require a proper legal framework, professional servicing, highly specialised financial, legal and tax advisers, and the choice of appropriate credit enhancements. The deal strength and rating assessment would also be influenced by the originator's degree of experience, by the financial situation of the mine operator(s), and by the strength of collateral guarantees. When using the Gaussian fuzzy membership, the scale translates to the following fuzzy MF ranges of magnitude (as observed in Table I.14).

Table I.14: Fuzzy MF Ranges of Magnitude for the '*Collateral*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

Transaction Architecture

For the EFABS offering to gain acceptance among investors, they must be provided with a measure of the level of risk involved in the securities. In this sense, a satisfactory credit rating by a credit rating agency will be the basis for investors to assess the soundness of the *Transaction Architecture*, the securities' creditworthiness, and the overall probability of default. As shown in Table I.15, these ranges translate to the following fuzzy Gaussian membership function ranges of magnitude.

Table I.15: Fuzzy MF Ranges of Magnitude for the '*Transaction Architecture*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

1stDim: L2

EFA Obligations

The first dimension, *EFA Obligations*, refers to the characteristics of the asset(s) underlying an EFA securitisation for which it is important to consider all the relevant features of the market addressed by the FA obligations, as well as its economic and regulatory attributes. When applying the Gaussian fuzzy membership, the scale translates to the following fuzzy membership function ranges of magnitude (as exhibited in Table I.16).

Table I.16: Fuzzy MF Ranges of Magnitude for the '*EFA Obligations*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

2ndDim: L2

Deal Structure

The second dimension, *Deal Structure*, concerns the deal architecture: the financial structure, the legal framework, the credit enhancement mechanisms, and the credit merit of the involved actors are key variables affecting the strength and rating of a securitisation deal. As presented in Table I.17, these ranges translate to the following fuzzy Gaussian membership function ranges of magnitude.

Table I.17: Fuzzy MF Ranges of Magnitude for the '*Deal Structure*' Macro Variable

State	c	σ
Unsuitable	0	1.7
Acceptable	1.7	5
Suitable	5	10

1stDim: L3

EFA Obligations-Backed Securitisation Outcome

The framework is defined by a two-level dimension tree, in which each level corresponds to a macro category potentially influencing an EFABS outcome. When applying the Gaussian fuzzy membership, the scale translates to the following fuzzy membership function ranges of magnitude (as observed in Table I.18).

Table I.18: Fuzzy MF Ranges of Magnitude for the '*EFA Obligations-Backed Securitisation Outcome*' Macro Variable

State	c	σ
Low	0	1.7
Medium	1.7	5
High	5	10

Appendix J: Input Combinations and Rules

Input combinations and rules for each observed output-crisp value are presented.

Stakeholders

The output-crisp value, *Stakeholders*, focuses on the degree of the financial strength of mine operators in the examined deal. It is measured, in part, with a credit metric and rating indicator, respectively, built on the *Financial Health* and the *CSR/ESG Ranking* linguistic values of each mining company in the year their operations are operating. The degree of experience of an originator in handling a securitisation process and choosing the appropriate portfolio assets/constituents can help determine the probable success of an EFABS transaction.

Table J.1: Input Combinations and Rules for the Output-Crisp Value, '*Stakeholders*'

	IF	PROPOSITION 1		OR	PROPOSITION 2		OR	PROPOSITION 3		THEN	OUTPUT	
1	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
2	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Unsuitable
3	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Unsuitable
4	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
5	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Unsuitable
6	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Unsuitable
7	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
8	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Unsuitable
9	IF	(Financial Health) IS	Low	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Unsuitable
10	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
11	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Unsuitable
12	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Unsuitable
13	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
14	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Acceptable
15	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	Medium	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Acceptable
16	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
17	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Acceptable
18	IF	(Financial Health) IS	Acceptable	OR	(CSR/ESG Ranking) IS	High	OR	(Originator's Degree of Experience) IS	High	THEN	(Stakeholders) IS	Acceptable
19	IF	(Financial Health) IS	Solid	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Low	THEN	(Stakeholders) IS	Unsuitable
20	IF	(Financial Health) IS	Solid	OR	(CSR/ESG Ranking) IS	Low	OR	(Originator's Degree of Experience) IS	Medium	THEN	(Stakeholders) IS	Unsuitable

	IF	PROPOSITION 1		OR	PROPOSITION 2		OR	PROPOSITION 3		THEN	OUTPUT	
21	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	Low	**OR**	(Originator's Degree of Experience) **IS**	High	**THEN**	(Stakeholders) **IS**	Unsuitable
22	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	Medium	**OR**	(Originator's Degree of Experience) **IS**	Low	**THEN**	(Stakeholders) **IS**	Unsuitable
23	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	Medium	**OR**	(Originator's Degree of Experience) **IS**	Medium	**THEN**	(Stakeholders) **IS**	Acceptable
24	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	Medium	**OR**	(Originator's Degree of Experience) **IS**	High	**THEN**	(Stakeholders) **IS**	Suitable
25	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	High	**OR**	(Originator's Degree of Experience) **IS**	Low	**THEN**	(Stakeholders) **IS**	Unsuitable
26	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	High	**OR**	(Originator's Degree of Experience) **IS**	Medium	**THEN**	(Stakeholders) **IS**	Acceptable
27	**IF**	(Financial Health) IS	Solid	**OR**	(CSR/ESG Ranking) **IS**	High	**OR**	(Originator's Degree of Experience) **IS**	High	**THEN**	(Stakeholders) **IS**	Suitable

Collateral

Collateral is an asset or a possible stream of income, pledged to guarantee that a loan will be repaid. The impact on securitisation depends on the underlying type of collateral (backing an ABS, e.g., financial assurance obligations) and its quality. Regulators and policymakers recognise the importance of fostering '*high quality*' securitisation, that is, securitisations that are transparent and include collateral.

Table J.2: Input Combinations and Rules for the Output-Crisp Value, '*Collateral*'

	IF	PROPOSITION 1		OR	PROPOSITION 2		THEN	OUTPUT	
1	**IF**	(Pooling Arrangement) **IS**	Narrow	**OR**	(Diversification) **IS**	Low	**THEN**	(Collateral) **IS**	Unsuitable
2	**IF**	(Pooling Arrangement) **IS**	Narrow	**OR**	(Diversification) **IS**	Medium	**THEN**	(Collateral) **IS**	Unsuitable
3	**IF**	(Pooling Arrangement) **IS**	Narrow	**OR**	(Diversification) **IS**	High	**THEN**	(Collateral) **IS**	Unsuitable
4	**IF**	(Pooling Arrangement) **IS**	Medium	**OR**	(Diversification) **IS**	Low	**THEN**	(Collateral) **IS**	Unsuitable
5	**IF**	(Pooling Arrangement) **IS**	Medium	**OR**	(Diversification) **IS**	Medium	**THEN**	(Collateral) **IS**	Unsuitable
6	**IF**	(Pooling Arrangement) **IS**	Medium	**OR**	(Diversification) **IS**	High	**THEN**	(Collateral) **IS**	Acceptable
7	**IF**	(Pooling Arrangement) **IS**	Wide	**OR**	(Diversification) **IS**	Low	**THEN**	(Collateral) **IS**	Unsuitable
8	**IF**	(Pooling Arrangement) **IS**	Wide	**OR**	(Diversification) **IS**	Medium	**THEN**	(Collateral) **IS**	Acceptable
9	**IF**	(Pooling Arrangement) **IS**	Wide	**OR**	(Diversification) **IS**	High	**THEN**	(Collateral) **IS**	Suitable

Transaction Architecture

The *Transaction Architecture* variable relates to the *Vehicle Structure*, *Credit Enhancement*, and *Legal Framework* linguistic variable inputs of the structure of the mechanism. The greater the solidity of the *Transaction Architecture*, the higher the overall probability of potential success of the transaction.

Table J.3: Input Combinations and Rules for the Output-Crisp Value, '*Transaction Architecture*'

	IF	PROPOSITION 1			OR	PROPOSITION 2			OR	PROPOSITION 3			THEN	OUTPUT		
1	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
2	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
3	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
4	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
5	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
6	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
7	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
8	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
9	IF	(Vehicle Structure)	IS	Low	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
10	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
11	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
12	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
13	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
14	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
15	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
16	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
17	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
18	IF	(Vehicle Structure)	IS	Medium	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Acceptable
19	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
20	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
21	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Low	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Unsuitable
22	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
23	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Unsuitable
24	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	Medium	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Acceptable
25	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Low	THEN	(Transaction Architecture)	IS	Unsuitable
26	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	Medium	THEN	(Transaction Architecture)	IS	Acceptable
27	IF	(Vehicle Structure)	IS	High	OR	(Credit Enhancement)	IS	High	OR	(Legal Framework)	IS	High	THEN	(Transaction Architecture)	IS	Suitable

EFA Obligations Value

Primarily based on the creditworthiness of a mining company. Generally, the better the creditworthiness of the mine operator, the higher the probability it can originate consistent cash flow payments to be securitised and the lower the level of financial distress which could result in its demise that could jeopardise mine reclamation and closure obligations.

Table J.4: Input Combinations and Rules for the Output-Crisp Value, '*EFA Obligations Value*'

	IF	PROPOSITION 1			THEN	OUTPUT		
1	**IF**	(Credit-Strength)	IS	Distressed	**THEN**	(EFA Obligations Value)	**IS**	Low
2	**IF**	(Credit-Strength)	IS	Grey	**THEN**	(EFA Obligations Value)	**IS**	Medium
3	**IF**	(Credit-Strength)	IS	Safe	**THEN**	(EFA Obligations Value)	**IS**	High

EFA Obligations Life

A long-life mining site can make it challenging to securitise it due to increasing uncertainties relating, in part, to reclamation liability cost estimates. Besides the market risks associated with commodity-prices fluctuations and the interest-rate risks related to debt financing, mine operators also face risks linked with default risk. Such credit risk, which is associated with the company defaulting on any form of debt, increases its bankruptcy risk and inflation risk that is related.

Table J.5: Input Combinations and Rules for the Output-Crisp Value, '*EFA Obligations Life*'

	IF	PROPOSITION 1			THEN	OUTPUT		
1	**IF**	(Expected Mine Life)	IS	Low	**THEN**	(EFA Obligations Life)	**IS**	Unsuitable
2	**IF**	(Expected Mine Life)	IS	Medium	**THEN**	(EFA Obligations Life)	**IS**	Acceptable
3	**IF**	(Expected Mine Life)	IS	Suitable	**THEN**	(EFA Obligations Life)	**IS**	Suitable

Deal Structure

Table J.6: Input Combinations and Rules for the Output-Crisp Value, '*Deal Structure*'

	IF	PROPOSITION 1		OR	PROPOSITION 2		OR	PROPOSITION 3		THEN	OUTPUT	
1	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
2	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Unsuitable
3	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Unsuitable
4	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
5	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Unsuitable
6	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Unsuitable
7	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
8	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Unsuitable
9	**IF**	(Stakeholders) **IS**	Unsuitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Unsuitable
10	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
11	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Unsuitable
12	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Unsuitable
13	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
14	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Acceptable
15	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Suitable
16	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
17	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Acceptable
18	**IF**	(Stakeholders) **IS**	Acceptable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Acceptable
19	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
20	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Unsuitable
21	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Unsuitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Unsuitable
22	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
23	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Acceptable
24	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Acceptable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Acceptable
25	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Unsuitable	**THEN**	(Deal Structure) **IS**	Unsuitable
26	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Acceptable	**THEN**	(Deal Structure) **IS**	Acceptable
27	**IF**	(Stakeholders) **IS**	Suitable	**OR**	(Collateral) **IS**	Suitable	**OR**	(Transaction Architecture) **IS**	Suitable	**THEN**	(Deal Structure) **IS**	Suitable

A financial assurance-backed securitised architecture is a critical element to understanding and interpreting the outcome of a deal. Since such securitised mechanisms would be considered somewhat ad-hoc transactions, the underlying financial and legal structure would be customised, and each FA obligations pool would be different from the others. Such pools require a proper legal framework, professional servicing, highly specialised financial, legal and tax advisers, and the choice of appropriate credit enhancements. The deal strength and rating assessment are also influenced by the degree of experience of the originator, by the financial situation of the mine operator(s) and investors, and by the strength of collateral guarantees.

EFA Obligations

The quality and type of specific financial assurance obligations in the pool is considered to assess the diversification potential of the EFA-backed securitised mechanism. The quality and obsolescence of the assets underlying a securitisation offering are critical risk factors, which need to be considered when defining the credit merit of a deal. In designing an FA-backed securitised mechanism, it is important to assess the ability of a portfolio of environmental financial assurance obligations to generate enough cash flow to pay interest and the amortisation of the financing loans. Consequently, the quality of the mine operator behind each FA obligation influences the sustainability of an EFA-backed securitised deal.

Table J.7: Input Combinations and Rules for the Output-Crisp Value, '*EFA Obligations*'

	IF	PROPOSITION 1			OR	PROPOSITION 2			THEN	OUTPUT		
1	IF	(EFA Obligations Value)	IS	Low	OR	(EFA Obligations Life)	IS	Unsuitable	THEN	(EFA Obligations)	IS	Unsuitable
2	IF	(EFA Obligations Value)	IS	Low	OR	(EFA Obligations Life)	IS	Acceptable	THEN	(EFA Obligations)	IS	Unsuitable
3	IF	(EFA Obligations Value)	IS	Low	OR	(EFA Obligations Life)	IS	Suitable	THEN	(EFA Obligations)	IS	Unsuitable
4	IF	(EFA Obligations Value)	IS	Medium	OR	(EFA Obligations Life)	IS	Unsuitable	THEN	(EFA Obligations)	IS	Unsuitable
5	IF	(EFA Obligations Value)	IS	Medium	OR	(EFA Obligations Life)	IS	Acceptable	THEN	(EFA Obligations)	IS	Unsuitable
6	IF	(EFA Obligations Value)	IS	Medium	OR	(EFA Obligations Life)	IS	Suitable	THEN	(EFA Obligations)	IS	Acceptable
7	IF	(EFA Obligations Value)	IS	High	OR	(EFA Obligations Life)	IS	Unsuitable	THEN	(EFA Obligations)	IS	Unsuitable
8	IF	(EFA Obligations Value)	IS	High	OR	(EFA Obligations Life)	IS	Acceptable	THEN	(EFA Obligations)	IS	Acceptable
9	IF	(EFA Obligations Value)	IS	High	OR	(EFA Obligations Life)	IS	Suitable	THEN	(EFA Obligations)	IS	Suitable

EFA Obligations Backed Securitisation Outcome

Table J.8: Input Combinations and Rules for the Output-Crisp Value, '*EFA Obligations Backed Securitisation Outcome*'

	IF	PROPOSITION 1			OR	PROPOSITION 2			THEN	OUTPUT		
1	IF	(EFA Obligations)	IS	Unsuitable	OR	(Deal Structure)	IS	Unsuitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Low
2	IF	(EFA Obligations)	IS	Unsuitable	OR	(Deal Structure)	IS	Acceptable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Low
3	IF	(EFA Obligations)	IS	Unsuitable	OR	(Deal Structure)	IS	Suitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Low
4	IF	(EFA Obligations)	IS	Acceptable	OR	(Deal Structure)	IS	Unsuitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Low
5	IF	(EFA Obligations)	IS	Acceptable	OR	(Deal Structure)	IS	Acceptable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Medium
6	IF	(EFA Obligations)	IS	Acceptable	OR	(Deal Structure)	IS	Suitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Medium
7	IF	(EFA Obligations)	IS	Suitable	OR	(Deal Structure)	IS	Unsuitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Low
8	IF	(EFA Obligations)	IS	Suitable	OR	(Deal Structure)	IS	Acceptable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	Medium
9	IF	(EFA Obligations)	IS	Suitable	OR	(Deal Structure)	IS	Suitable	THEN	(EFA Obligations Backed Securitisation Outcome)	IS	High

A two-level dimension tree, in which each level corresponds to a macro category affecting an *EFA Obligations Backed Securitisation Outcome* is presented. In doing so, the research tried to determine factors that could potentially influence the likelihood of success of a financial assurance-backed securitised security, by defining a theoretical framework that was tested on two FA portfolio deals. The FL-based process utilises some investigated inputs values to output a single numerical output that signifies a potential outcome.