REAL OPTION ASSESSMENT OF THE Au-Ag FRUTA DEL NORTE PROJECT,
SOUTH-EAST ECUADOR

by

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A dissertation submitted in partial fulfilment of the requirements for the diploma of Imperial College London in Metals and Energy Finance

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Disclaimer

The present work is entirely motivated by academic purposes. While it uses the Fruta Del Norte project, formerly a part of Kinross Gold, as a framework with variables drawn from information in the public domain, the base case assumptions are not to be considered as accurate and representative of the actual Fruta Del Norte project. The objective of the study is to test the application of quantitative financial models applied to the base case of Fruta Del Norte in order to meet part of the academic requirements of the MSc Metals and Energy Finance at Imperial College London. The results generated should not, therefore, be considered as an indication of the real value or actual potential of the project, and much less, a recommendation to investors and the public.
Abstract

Gold grades at major mining operations have declined steadily during the last decade. Meanwhile, new deposits are becoming more elusive to explorers. Dubbed the gold discovery of the decade, Fruta Del Norte remains at the evaluation stage with politics and mine economics struggling to extract value from the probable exploitation. An orebody hosting 6.8M oz of gold in southeast Ecuador, Fruta Del Norte’s financial assessment is undertaken in the present study. An overall valuation of the project was obtained through discounted cash flow methodologies, probabilistic simulations, and quantitative finance pricing techniques. A benchmark for the study is given by the pre-feasibility study of Fruta Del Norte published by Kinross Gold. Major improvements were implemented in comparison to Kinross’ study; namely, an updated cost structure based on industry evidence, an updated fiscal regime from an agreement in principle between the Government of Ecuador and Kinross Gold, and an updated tax treatment provided by the latest reform to the Mining Law of Ecuador. A Net Present Value of US$ -240M, along with an Internal Rate of Return of 5.18% were estimated under a weighted average cost of capital of 8.17%. This compares with a US$ 479M NPV and 11.3% IRR under a discount rate of 5% obtained in the Kinross Gold pre-feasibility study. Monte-Carlo simulation was undertaken proving that Fruta Del Norte holds an almost equal chance of having a positive or negative NPV. Furthermore, cash exposure is substantial and there’s a 76% chance the project will pay back to investors within the project life. Deemed a break-even project, real option assessment was compelling for Fruta Del Norte. The optionality of the project was evaluated through a deferral option with an estimated value of US$399M for the project, and an improvement over simple NPV of up to US$555M. Such finding is remarkable and proves Fruta Del Norte needs to be delayed for 5 years in order for investors to extract the most value out of it.
Acknowledgements

Gratitude shall be paid to The Divine Providence, for without Its Grace underground minerals would not manifest, and my endeavours would prove fruitless.
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1. Introduction

Heralded as the gold discovery of the decade, the extraordinary Fruta Del Norte Au-Ag deposit is regarded as a milestone in the metal mining industry of Ecuador. Traditionally a producer of petroleum and refined products (Wacaster, 2013), Ecuador is at the threshold of a historic inflection point: once Fruta Del Norte starts production, the era of world-class mining will officially begin. Output growth, income expansion for unskilled labour, and a diversified economic basis are just a few of the benefits of Fruta Del Norte. Even more so, the merits for a country-wide prosperous large-scale mining industry are overwhelming.

In terms of metals, the geology of the Cordillera orogenic belt, where Ecuador sits, has proved to be one of the most generous globally. The band of relatively recent and unsettled rocks is situated from Alaska to British Columbia, the western United States, down into Mexico, Central America and the Andes in South America. The complex rock structures are host to some of the largest base metal and richest gold deposits ever found. In base metals, a few examples include the largest copper mine in the world—Escondida in Chile—, the largest copper mine in North America—Morenci in Arizona—, the largest lithium deposit in the world—Salar de Uyuni in Bolivia—, and the largest Cu-porphyry ever discovered—Pebble deposit in Alaska. Turning to precious metals, the second largest silver mine in the world—Fresnillo in Mexico—, the largest gold mine in the world—Yanacocha in Peru—, and the largest gold and silver project under development—Pascua Lama in the border between Chile and Argentina. Geologically, half a billion years after much of the tectonic activity in the crust had ceased, activity was restarted in the Cordillera region entailing a propitious environment for mineral concentration and deposition. Fruta Del Norte is portrayed as the latest chapter in the history of the ever-plentiful Cordillera. Figure 1 is explanatory of the tectonic dynamics underlying the Cordillera.

Figure 1. Tectonic setting of the Cordillera orogenic belt with Ecuador located in the South America region (Dickinson, 2004).
Within South America, a long history of mining is offered by world-class producing countries like Peru, Chile, Bolivia, and Colombia. A natural missing player is provided by Ecuador. The country has had a long history of artisanal and small-scale mining—with cities like Zaruma in the southwest entirely built around gold mining by Spanish conquistadors. However, the potential for modern large-scale mining was only recognized in the new millennium with the discovery of medium-sized Cu-Mo porphyry deposits at the Corriente Copper Belt in the Cordillera del Cóndor, southeast Ecuador (Makepeace, 2001). By 2006, the imagination of prospectors and geologists worldwide was captured when the Fruta Del Norte (FDN) discovery was announced by junior exploration company Aurelian Resources. Eventually, the orebody was acquired by global gold producer Kinross Gold, offering a remarkable return-on-investment to Aurelian shareholders. With current Reserves of 6.8Moz of gold grading 8g/t, and 9.1Moz of silver grading 11g/t, FDN is ranked as one of the largest undeveloped deposits globally (Natural Resource Holdings, 2012).

The financial evaluation of FDN is relevant in a jurisdiction with well-known political uncertainty but extraordinary geological potential. Furthermore, in a world of scarce natural resources, falling metal grades (see Figure 2), and insatiable economic growth, the importance of frontier destinations like Ecuador is highlighted more than ever before. In the present study, modern financial modelling techniques are drawn for the project evaluation of FDN. A pre-feasibility study published by the previous owner, Kinross Gold, is used as a contrasting basis with the current study. Moreover, an updated cost scenario, an agreement in principle with the Government of Ecuador, and an updated fiscal regime are included to enhance the understanding of the financial viability of FDN. Most importantly, real option valuation models are applied to FDN in order to elicit the value offered by the optionality characteristics of the project. Finally, and given the recent exit by Kinross Gold, an evaluation of the fiscal regime is offered with a proposal for an improved framework that could benefit the Ecuadorian people as well as mining investors.

![Figure 2](image_url). Gold mines head grade and gold price evolution during the last decade (Barrick Gold Corp, 2013).
1.1. Mining and Geology of Ecuador

Ecuador is characterized by three geological domains. In the lowlands of the oriental Amazon region, Tertiary and Recent continental sediments overlay the Brazilian craton. To the west, the Andean Cordillera, which extends for approximately 150 km, is positioned as the result of convergent tectonic boundaries, where the South American Plate collides with the Nazca Plate (subducting plate). The northern and central sections of the Cordillera are host to a variety of stratovolcanoes of basaltic andesite composition (Potter, 2004). Finally, further to the west, the coastal area is underlain by Tertiary sediments infilling the fore-arc basin. Figure 3 displays the general geology.

Most of artisanal mining in Ecuador has taken place in the Zaruma and Portovelo region on the southwest, and on the Nambija region on the southeast (see Figure 3). Gold and silver have been extracted from the Zaruma and Portovelo hills for centuries. Zaruma was founded by Spanish conquistador Mercadillo on 1549 upon realizing the Incas were extracting gold from the area (Waldick, 2003). In 1897, after Ecuador gained independence, the South American Development Company (Sadco), an American concern, was given the main gold deposits of the area. During 53 years, Sadco mined approximately 3.5Moz of gold, and 17Moz of silver (ibid). Nowadays, the region is dominated by small mining operations through the high-grade veins crisscrossing the mountains.

The Nambija gold deposit was exploited by the Inca, and subsequently by the Spanish. After being abandoned in the 1700s, the Nambija deposit was rediscovered in the 1980’s and small scale miners invaded the area. Two types of deposits are found in the area: oxidized calcic...
gold skarns, and epithermal low sulphidation deposits (Besserer, 2008). Other minor alluvial gold mining activities are located all around Ecuador.

Modern mining in Ecuador is dominated by the deposits found in the Cordillera del Cóndor. Middle-sized copper porphyrys have been discovered during the last decade by junior explorer Corriente Resources: Mirador, Mirador Norte, Panantza and San Carlos. The Zamora batholith is host to all these deposits as well as Fruta Del Norte. Figure 4 illustrates the location of the Cordillera del Cóndor.

2. The Development of Fruta Del Norte

Spanish conquistadors are credited to have explored the Cordillera del Cóndor as early as 1562 (Henderson, 2010:p.6-1). Indigenous peoples, nevertheless, are thought to have lived in the area and mined hard rock and alluvial gold since hundreds of years before. By 1935, the area was mined for alluvial gold by artisanal miners once again. Subsequently, and after a series of country-wide political transformations, the concessions of the project were granted to an Ecuadorian enterprise by 1986, who explored the area until 1992 (ibid). During this period alluvial terraces were built, rock chip sampling was performed, and a geological map was drawn.

By mid-1993, a Soviet investor was sold control of the concessions and transferred them to his investment vehicle Amlatminas. Under this concessionaire, a topographic base map, stream sediment sampling, rock chip sampling, and geological mapping were completed in the Ubewdy prospect. Option agreements were considered by a variety of parties.

Figure 4. Map of Ecuador displaying the Zamora Batholith and the Cordillera del Cóndor Cu-Au porphyry district (Drobe, 2013).
Finally, La Zarza concession, where Fruta Del Norte sits, as well as the Ubewdy and Bonza-Las Peñas prospects, was subject of modern exploration methods in 1996 when Australian miner Climax Mining Ltd (nowadays OceanaGold) decided to acquire an option for the area from Amlatminas. First, reconnaissance sampling was undertaken, and by 1997, a full-fledged exploration programme was outlined (ibid:p.6-2). Diamond drilling was executed and reached 22 drill holes for 3,562 metres of core. The first geophysical survey, induced polarization, was undertaken for a 74km gradient array. Different prospects were targeted where precious and base metal anomalies were found, and where “quartz veins with pyrite and local silification and brecciation or clay-silica-pyrite alteration” was observed (ibid). Climax was not attracted by the prospects and the concession returned to Amlatminas.

Canadian geologists Patrick Anderson and Keith Barron were interested in the potential for gold deposits in the southern Andes of Ecuador. By 2001, the prospectors were convinced the Cordillera del Cóndor would make a good exploration play and applied for concessions. In a strike of good fortune, rules for concessionaires were changed by the Ecuadorian government, and within a month 80% of the concessions were forfeited. Anderson and Barron were granted a substantial and continuous land package under the new regime (Silvester, 2009). The La Zarza concession was bought from Amlatminas in 2002 (Henderson, 2010:p. 4-1). The entire land package was consolidated at around 95,500 ha (Aurelian Resources Inc, 2004e). The explorers were ready to bring this asset to the Toronto Stock Exchange-Venture and fund an exploration programme.

2.1. The TSX Venture and Exploration by Aurelian Resources

With more than 1,300 mining development companies listed (TSX Inc, 2013b), the TSX Venture Exchange of Canada is highly demanded by entrepreneurs and investors alike. The Capital Pool Company programme (CPC) is recognized as one of the most robust mining-focused venture capital vehicles worldwide (TSX Inc, 2013a), offering comprehensive regulatory standards and an experienced investor community. In a two-step process, an entrepreneur’s project is financed by private investors, and subsequently by the public. Private investors are offered a seed-financing deal by entrepreneurs. If a transaction is reached, the company with no assets other than the transferred cash can list in the TSX Venture Exchange through an initial public offering (IPO) or a reverse takeover (RTO), and form a CPC. A “qualifying transaction” is offered to the public, upon which the listed CPC acquires the project in development, and the entrepreneurs are paid in shares of the CPC and cash. Private investors, entrepreneurs, and public investors are aligned in risking capital in search for attractive returns. A graphic summary of the programme is offered in Figure 5.
After an initial CAD 330,000 seed-financing round was done, and a subsequent CAD 300,000 IPO (Bio 1 Inc, 2002b) (Bio 1 Inc, 2002a), a publicly traded concern, Bio 1 Inc., was ready to perform a qualifying transaction under the CPC. On June 2003, Bio 1 and Aurelian Resources Corporation Ltd were merged in a transaction valued at CAD 3M, or CAD 0.5 per share (Aurelian Resources Inc, 2003a). By late July, exploration was restarted in the Condor Project with a focus on sampling at historic pits, trenches and tunnels (Aurelian Resources Inc, 2003c).

Drilling was recommenced on November 2003 with a 1,500 m programme testing the Aguas Mesas prospects, and doing infill drilling at the Bonza-Las Peñas (BLP) prospect, which was targeted by Climax Mining in the 90s. Encouraging intersections—up to 51 g/t Au over 9.2 m (Aurelian Resources Inc, 2003c)—were well received by investors and a private placement was announced by December (Aurelian Resources Inc, 2003b), and it eventually reached CAD 12M (Aurelian Resources Inc, 2003d). The share price of Aurelian was rising by the day and had reached CAD 2.75 from just pennies months ago. The private placement was closed on December 19, 2003 (ibid). A milestone for the company had been reached.

Pitting and trenching were scheduled for 2004 at the Aguas Mesas prospects with the objective to find close gridding, geological mapping and structural profiles. With those in hand, Aurelian was positioned to find a three-dimensional mineralization model which would predict the direction of the mineralization. During the year, the BLP prospect was scheduled for drilling as well (Aurelian Resources Inc, 2004f). By April, Aurelian had intersected 2.31 g/t Au for 101 m at the BLP zone. In less than a year of work, the explorer was enthusiastic so far as to hypothesize a possible bulk-mineable open pit along the low-sulphidation epithermal system of BLP (Aurelian Resources Inc, 2004b). Infill drilling was performed in the mineralization and successful intersections were reported by June, when 2.23 g/t Au were found over 110 m, and 1.24 g/t Au were intersected for 133.15 m (Aurelian Resources Inc, 2004c). By late August, the prospect was progressively elicted by the deployment of a second drill rig (Aurelian Resources Inc, 2004a). By December, Aurelian was ready to make the first declaration of a resource: based on 45 drill holes, 9,760 m of core, and 580 m of trenching, the orebody at BLP was inferred to

Figure 5. Example of the corporate structure of a CPC (TSX Inc, 2010).
hold half a million ounces of Au. Table 1 is offered as a summary of the report (Aurelian Resources Inc, 2004d).

Table 1. Inferred resource for BLP assuming Au price of US$ 400/oz, Ag at US$ 7/oz, and Au:Ag 75:1, Au recovery of 90%, Ag recovery of 70% (ibid)

<table>
<thead>
<tr>
<th>Au Eq Cut-off g/t</th>
<th>Confidence</th>
<th>Tonnes</th>
<th>Au g/t</th>
<th>Ag g/t</th>
<th>Contained Au oz</th>
<th>Contained Ag oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75</td>
<td>Inferred</td>
<td>15,030,000</td>
<td>1.07</td>
<td>11.6</td>
<td>517,100</td>
<td>5,605,500</td>
</tr>
</tbody>
</table>

The gold-in-soil mineralizations were deemed economically unimportant and the Aurelian team had to sketch a new plan to capture investor attention. The share price was halved from 2003 levels (Aurelian Resources Inc, 2005c), and a grassroots programme was not attractive to fund managers. A geophysical survey was undertaken and new drilling targets were planned where gold geochemistry and resistivity-chargeability anomalies coincided (Aurelian Resources Inc, 2005a). However, grab sampling and trenching were the main activities during the year, along with minor and disappointing drilling at the BLP deposit. After completion of 168 km of surveying, 61 line km of magnetometer geophysical surveying, 39 like km of IP geophysics surveying, 16,845 m of diamond drilling, and 9,347 m of trenching, Aurelian was positioned at a cross-roads (Aurelian Resources Inc, 2005b). The following year was going to be crucial in the survival of the concern.

By late January 2006, the Aurelian team, under the guidance of newly-hired and epithermal system-experienced geologist Stephen Leary, MAusIMM, was positioned to restart drilling at some targets, first as copper porphyry scouting, and afterwards as deep drilling at the Fruta Del Norte target (Aurelian Resources Inc, 2006a). The rationale that led to the Fruta Del Norte (FDN) programme was delineated by Karl Roa, member of the Kinross Brazil Exploration team (Roa, 2010). Contrary to other exploration targets, FDN was characterized by absent gold-in-soil anomaly. However, similarly to BLP, the arsenic and antimony traces were displayed uniquely in the area. Figure 6 shows the stream sediment sampling of FDN.

Figure 6. FDN vs. BLP stream sediment signature (ibid).
Leary was instrumental in realizing the potential of FDN. Quoting CEO Patrick Anderson: “He reinterpreted a pull-apart basin identified by Climax, and decided that the basin infill conglomerate was mostly post-mineralization and, therefore, epithermal deposits could lie buried below the basin sediments” (Silvester, 2009). FDN, located 1km north of BLP, was drilled for 1,000m core programme after a failed porphyry Cu-Au scout programme (Aurelian Resources Inc, 2006c). Discovery hole was reported immediately by April 5\textsuperscript{th}, 2006, when Aurelian sent a press release to markets announcing the intersection of 237m of 4.14g/t Au, and additional 60m at 3.42g/t Au at a second hole which could not proceed further because of borehole collapse. Holes were separated by 90m approximately (Aurelian Resources Inc, 2006b). High mineralization was reported to start at around 190m of depth on hole CP-06-51, and at 280m on hole CP-06-52—lost borehole. Figure 7 shows visible gold at 199.45m.

![Figure 7. Visible Gold in Quartz-Carbonate Epithermal Vein in hole CP-06-51 (Hennessey, 2007b).](image)

Trading in the shares of Aurelian Resources was suspended by regulators at the TSX Venture Exchange until further oversight was undertaken. Two days later, Aurelian was prompted to raise another CAD 10M on a private placement that gave a much needed cash infusion to the exploration endeavour. By late April, the financing round was successfully completed at CAD 20M (Aurelian Resources Inc, 2006d). The share price had reached CAD 2.75 once again. The momentous situation surrounding FDN and Aurelian was unexpected in the mining exploration world. It had been a long time since anything like this had been seen. The steady flow of long, high-grade intersections was getting started. Table 2 summarizes the highlights of the 2006 FDN drilling programme.
Table 2. Remarkable interceptions by the 2006 FDN exploration programme (press releases by Aurelian Resources).

<table>
<thead>
<tr>
<th>Date</th>
<th>Drill hole</th>
<th>Interval m</th>
<th>Au g/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 5</td>
<td>CP-06-51</td>
<td>237.25</td>
<td>4.14</td>
</tr>
<tr>
<td>April 5</td>
<td>CP-06-52</td>
<td>60.25</td>
<td>3.42</td>
</tr>
<tr>
<td>June 2</td>
<td>CP-06-56</td>
<td>204.80</td>
<td>8.40</td>
</tr>
<tr>
<td>June 6</td>
<td>CP-06-57</td>
<td>189.20</td>
<td>24.00</td>
</tr>
<tr>
<td>June 21</td>
<td>CP-06-58</td>
<td>255.00</td>
<td>12.55</td>
</tr>
<tr>
<td>July 6</td>
<td>CP-06-59</td>
<td>195.69</td>
<td>5.97</td>
</tr>
<tr>
<td>July 6</td>
<td>CP-06-60</td>
<td>81.40</td>
<td>5.54</td>
</tr>
<tr>
<td>August 21</td>
<td>CP-06-62</td>
<td>191.60</td>
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<td>August 21</td>
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<td>215.90</td>
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<td>September 14</td>
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<td>107.50</td>
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<td>September 14</td>
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<td>173.00</td>
<td>4.73</td>
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<td>October 18</td>
<td>CP-06-67</td>
<td>161.00</td>
<td>6.51</td>
</tr>
<tr>
<td>November 1</td>
<td>CP-06-72</td>
<td>135.34</td>
<td>9.78</td>
</tr>
<tr>
<td>November 1</td>
<td>CP-06-74</td>
<td>171.80</td>
<td>3.84</td>
</tr>
<tr>
<td>December 15</td>
<td>CP-06-83</td>
<td>260.45</td>
<td>6.59</td>
</tr>
<tr>
<td>December 15</td>
<td>CP-06-85</td>
<td>248.60</td>
<td>3.09</td>
</tr>
</tbody>
</table>

The intersection reported on June 6\textsuperscript{th} is placed as one of the highest grade-interval quantities ever reported in gold exploration (Roa, 2010). Investors were flabbergasted by the rolling news releases and the share price went up 90% on a single day on June 2\textsuperscript{nd} (Maurino, 2006). Shares of Aurelian were mobbed by investors on June 6\textsuperscript{th} when the price reached CAD 18.27, rising 30% in the trading session (Canadian Press, 2006). In a memorable month, by June 21\textsuperscript{st} shares of Aurelian were located at CAD 21.85 (eSource Canada Business News Network, 2006). Canaccord Adams senior banker Graeme Currie was keen to ascertain: “This represents one of the best drill holes we have seen in a very long time frame (past decade). The FDN discovery is very quickly taking on world-class potential, with significant higher-grade areas” (Robertson, 2006a). Blackmont Capital’s Don Pirier was motivated to comment: “This is one of the best drill hole results we have ever seen. We are excited about this new discovery, believing that it represents one of the best in the past decade” (Robertson, 2006b).

By November, a new bough deal equity financing round was announced, where Aurelian would receive CAD 75M for shares priced at CAD 37.50 (Aurelian Resources Inc, 2006f). An appreciation of more than 1,200% was witnessed since discovery hole was announced in April. The financing was closed by late November (Aurelian Resources Inc, 2006e). Takeover speculation was running wild in Canada exploration circles where mining analyst Kerry Smith, of Haywood Securities, commented: “we believe Aurelian’s high-grade Fruta Del Norte gold deposit on its Condor Project is the best junior-controlled gold discovery we have seen in the past decade. Quality ounces, 100% ownership and a district-scale land position place Aurelian in the middle of the takeover sweet spot”(Wong, 2007).

For 2007, Aurelian was positioned to define the resource of FDN on a National Instrument 43-101-compliant and inferred-confidence level. With five drill rigs on site, and capabilities to reach depths of 1,000m, the company was ready to define the length and depth of
the orebody, as well as to find new targets (Aurelian Resources Inc, 2007c). After a steady flow of news, the company was graduated to the Toronto Stock Exchange market, which increased the investor base and improved the liquidity of the shares. A technical report was filed in late February, where geologists reaffirmed the quality control protocols used by Aurelian at FDN (Hennessey, 2007b). Dr Richard Sillitoe, a world-know expert in epithermal systems was retained. An epic moment of the FDN story was reported in late March, when the company released information of hole CP-07-100: 250 m grading 35.18g/t Au of infill drilling—quite possibly, the highest grade-length combination ever reported (Aurelian Resources Inc, 2007a). By October, the company was ready to announce the first estimate of the FDN resource. Table 3 summarizes.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Tonnage (t)</th>
<th>Au grade (g/t)</th>
<th>Ag grade (g/t)</th>
<th>Au Eq grade (g/t)</th>
<th>Au oz (t)</th>
<th>Ag oz (t)</th>
<th>Au Eq oz (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>58,900,000</td>
<td>7.23</td>
<td>11.8</td>
<td>7.42</td>
<td>13,689,500</td>
<td>22,366,700</td>
<td>14,051,600</td>
</tr>
</tbody>
</table>

At the outset of 2008, infill drilling was prioritized at FDN, where 50m spaced sections were targeted within the high-grade orebody in order to attain a resource of Indicated and Measured status (Aurelian Resources Inc, 2008a). The discovery of FDN was reaching two years of age by 2008 and little takeover talk had surrounded Aurelian. The Globe and Mail of Canada was motivated to state that geography and politics were diminishing the attractiveness of FDN (Hoffman, 2007). The political stability of the mining regime of Ecuador was continuously challenged by president elect Rafael Correa. A new mining policy was expected and uncertainty pervaded the sector. Confidentiality agreements were signed by more than a dozen suitors, according to CEO Patrick Anderson (ibid). The stock price was mired at CAD 32 for months without value-creation drivers.

By April 2008, uncertainty was maximized when the constitutional assembly of Ecuador enacted a moratorium on all mining activity for up to six months, until a new mining law and environmental regulations were in place (Spicer, 2008). Shares of Aurelian were hit and fell to CAD 20 a share.

2.2. Acquisition by Kinross Gold

On the 24th of July, a takeover proposal was made official by Kinross Gold Corp. The offered amount was settled at CAD 1,200M in an all-share deal that valued Aurelian shares at CAD 32.80 on a pre-split basis (Hoffman, 2008a) (Aurelian Resources Inc, 2008b). On a 20-day volume-weighted average price, the Kinross offer was placed at a 63% premium for Aurelian shares. A friendly combination was confirmed and unanimously approved by Aurelian’s board.

Aurelian’s Anderson commented: “We think it’s the right deal. This mitigates our shareholder’s risks while we still get an opportunity to participate in the upside of the FDN project, other potential discoveries on the concession, and Kinross’s whole portfolio” (Hoffman, 2008b). The proposed transaction was not well received by the investor community and Kinross shares lost 10% on the day of the announcement. Political risk was of paramount
importance for Aurelian as Ecuador was drafting a new mining law, and a referendum for a new
collection was to take place by October (Vaccaro, 2008). Shareholders of Aurelian were
blindsided at the offer and complained FDN was being sold at half the peak value. By
September 2008, success was declared by Kinross when it announced 75% of Aurelian’s stock
had been tendered, well above the two-thirds required by the proposal (Hoffman, 2008c).

The story of Aurelian Resources, the Condor project, and the FDN discovery is written in
the history books of successful mining exploration finance. Two Canadian geologists used the
Capital Pool Company Programme of the TSX Venture Exchange and funded a relentless
exploration programme that created value for venture capital investors. Table 4 summarizes the
funding rounds of Aurelian Resources. Figure 8 shows the stock price evolution of Aurelian
and milestones at the TSX Venture Exchange.

Table 4. Financing events on the TSX-Venture for Aurelian Resources (press releases by Aurelian Resources).

<table>
<thead>
<tr>
<th>Date</th>
<th>Shares #</th>
<th>Price CAD</th>
<th>Warrants #</th>
<th>Proceeds CAD</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 6, 2003</td>
<td>6,000,000</td>
<td>0.50</td>
<td>6,000,000</td>
<td>3,000,000</td>
<td>Grassroots Bonza-Las Peñas</td>
</tr>
<tr>
<td>December 8, 2003</td>
<td>5,333,350</td>
<td>2.25</td>
<td>2,666,675</td>
<td>12,000,000</td>
<td>Define BLP and find prospects</td>
</tr>
<tr>
<td>April 27, 2006</td>
<td>7,272,278</td>
<td>2.75</td>
<td>363,636</td>
<td>20,000,000</td>
<td>Confirm FDN discovery</td>
</tr>
<tr>
<td>November 22, 2006</td>
<td>2,000,000</td>
<td>37.50</td>
<td>50,000</td>
<td>75,000,000</td>
<td>Expand and Define FDN</td>
</tr>
</tbody>
</table>

Figure 8. Share price, market capitalization and milestones of Aurelian Resources (TSX Group Inc, 2008).

With total invested funds of CAD 110M and a sale price of CAD 1,200M, profits of
roughly 1,100% were booked by investors. By the end of 2008, Patrick Anderson, Keith Barron
and Stephen Leary were offered the prestigious Mining Person of the Year award by Canada’s
premier mining publication, The Northern Miner (Cumming, 2008).

2.3. Updated Geological Model & Resource Definition

The geological findings have been the driver of value creation for Fruta Del Norte. It is
consequently of significant importance for the reader to capture the fundamentals of the
gology of the orebody. Fruta Del Norte is identified as an intermediate sulphidation epithermal
mineralization orebody (Hennessey, 2007a). A brief overview of hydrothermal processes and epithermal orebody categorization is appropriate.

2.3.1. Hydrothermal processes
The evidence that strong brines occur in nature was widely found in the study of fluid inclusions. When crystals grow, the fluid on which they sit is usually trapped in cavities, giving important information to researchers on the formation of many rocks, and particularly on the orebody genesis (Evans, 1993:p. 42). Such brines are more concentrated underground than any found on surface (ibid:p.43). Moreover,

[…] there is strong experimental and thermodynamic evidence which shows that chloride in hydrothermal solutions is a potent solver for metals through the formation of metal-chloride complex ions, and indeed inclusions that carry more than 1 wt % of precipitated sulphides are known. (ibid)

In other words, it is expected that hydrothermal solutions would be an important medium of mineral accumulation and deposition.

2.3.2. Alteration
Alongside veins or irregular orebodies resulting from hydrothermal processes, it is acknowledged that alteration typically occurs. “The spatial and temporal relationships [between alteration and adjacent orebodies] suggest that wall rock alterations is due to reactions caused by the mineralizing fluid permeating parts of the wall rocks” (ibid:p.44). Changes in colour, textural, and mineralogical characteristics are recognized as evidence of alteration. Minor colour changes are accepted as minor alteration; complete recrystallization is situated as substantial alteration. Alteration is correlated with temperature, but not with the spread of alteration. In fact, the areal extent of alteration is situated from very few centimetres around a vein to a thick halo around an orebody (ibid). In modern mining exploration, alteration is recognized as one of the clearest messages that a mineral deposit of interest may be nearby (White, 2007:p.13).

Controls of alterations are classified in two groups: the ones based on the nature of the host rocks, and the ones based on the ore-forming solutions. Factors regarding the host rocks include grain size, physical state and permeability. Factors regarding the solutions include the chemistry, pH, Eh, pressure and temperature (Evans, 1993:p. 44). Some metals and minerals are correlated with alteration, and the understanding of the chronology of alteration processes is critical in mining exploration. The ore-forming solutions are mostly deduced from identified alteration (ibid:p.50).

2.3.3. Epithermal Gold Deposits
Swedish-American geologist Waldemar Lindgren is credited as the first to recognize the epithermal environment as being an area of shallow depth that can host deposits of gold, silver, and base metals—in addition to mercury, antimony, sulphur, kaolinite, alunite, and silica (Hedenquist, 2000:p.245). F.L. Ransome, however, is acknowledged to have distinguished between two precious-metal deposits that form from environments akin to geothermal springs and volcanic fumaroles (ibid). Figure 9 illustrates the environments.
Figure 9. Volcanic fumarole at Kamchatka volcanoes (top) (Kozintsev, 2011) and geothermal spring at Yellowstone National Park (bottom) (Helmenstine, 2013).

Figure 10 displays the location of the end-members within the orogenic environment.

Figure 10. Schematic illustration of various volcanic and hydrothermal processes and their respective environments (Hedenquist, 2000).
Nowadays, low and high-sulphidation are the names generally used to identify the two end-types of metallic deposits. These names are used as a reference of the sulphidation state of the sulphide assemblage. Table 5 summarizes the differences between the two end-types.

Table 5. Feature comparison between high sulphidation and low sulphidation precious metals deposits (Halsall, 2012).

<table>
<thead>
<tr>
<th>Feature</th>
<th>High Sulphidation</th>
<th>Low Sulphidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Association</td>
<td>Au Cu (Ag Bi Te)</td>
<td>Au Ag (As Sb Se Hg)</td>
</tr>
<tr>
<td>Alteration</td>
<td>Argillie (clay) alteration; alunite, kaolinite</td>
<td>Adularia, sericite, calcite</td>
</tr>
<tr>
<td>Texture</td>
<td>Vuggy quartz, leaching of host rock, stockworks and breccias</td>
<td>Silica sinter, crustiform veins, colloform banding</td>
</tr>
<tr>
<td>Source of Fluid</td>
<td>Acidic pH, dominantly magmatic</td>
<td>Near-neutral pH, dominantly meteoric</td>
</tr>
<tr>
<td>Source of Metal</td>
<td>Magmatic and leached</td>
<td>Leached</td>
</tr>
<tr>
<td>Source of Sulphur</td>
<td>Magmatic</td>
<td>Predominantly leached</td>
</tr>
</tbody>
</table>

FDN is an intermediate sulphidation end-type, as described by Hedenquist et al (ibid). The distinction is well received as it is not simply a sulphide assemblage distinction, but a recognition that intermediate sulphidation bodies in fact form in a different tectonic setting (ibid:p.250). Table 6 summarizes the differences of sulphide assemblages in a three end-type categorization.

Table 6. Sulphide assemblages of end-types of epithermal Au deposits (ibid).

<table>
<thead>
<tr>
<th>Low Sulphidation</th>
<th>Intermediate Sulphidation</th>
<th>High Sulphidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrite-pyrrhotite-arsenopyrite and Fe-rich sphalerite</td>
<td>Tennantite-tetrahedrite-chalcopyrite and Fe-poor sphalerite</td>
<td>Enargite-luzonite-covellite and pyrite</td>
</tr>
</tbody>
</table>

2.4. Fruta Del Norte Geological Model

Palaeozoic and Mesozoic sedimentary and Mesozoic arc-related lithologies are found at the Cordillera del Cóndor region. The sub-Andean rocks are intruded by an I-type batholith, the Zamora Batholith, which dates to the Jurassic. The extension of the batholith is estimated at 200 km, the orientation is recognized as parallel to the Andes, and the presence is believed to be part of subduction plutonic dynamics. Contemporaneous with the Zamora Batolith, the Misahualli Formation is profiled as volcaniclastics/epiclastics and intrusives that crop out on a north-south direction (Henderson, 2010:p.7-1).

The batholith is also intruded by mafic dikes and porphyries in certain localities. Breccia zones are associated with the batholith and are essential in the Corriente Porphyry Copper Belt, located just north of the Condor Project. In the Early Cretaceous, the arc sedimentary and volcanic belts were invaded by alluvial to shallow-water conglomerate and sandstone that make the Hollin Formation (ibid).
Sediment-filled graben and half-grabens within the batholith are evidence of Jurassic rifting while the arc was forming. A subsequent event of uplifting and denudation is evidence by the exposition of the Zamora Batholith. A back-arc fold and thrust belt is also evidenced as part of the Andean orogeny. Fault zones are predominant on the Cretaceous cover. Las Penas Fault Zone (LPFZ) is highlighted as the prominent regional structure. A length of 80 km is reached by the LPFZ, and the strike-slip fault is oriented north-south. A locus of mineralization is offered by LPFZ, and it is crucial in the FDN orebody and other epithermal bodies and mesothermal mineral occurrences (ibid: p.7-3). Figure 11 is offered as an illustration of the regional geology of the Condor Project.

![Figure 11. Local geology of the Condor Project and FDN (ibid: figure 7-1).](image)

The Misahualli Formation andesites and feldspar porphyry intrusions are host to the FDN deposit. Most importantly, the LPFZ is stepped-over in the region, offering a pull-apart basin, where, at the nor-easter corner, FDN sits. Conglomerate-dominated epiclastic and volcaniclastic rocks are part of the Suarez pull apart basin, which overlies FDN. Figure 12 demonstrates.
FDN is bounded by sub-parallel strands (East and West) of the fault forming the pull-apart basin. At the north, the orebody is closed as the East and West Faults converge. A hard boundary is offered by the West Fault, as mineralization occurs only to the east of the West Fault. Figure 13 illustrates.

The mineralization of FDN is characterized by “intense multiphase quartz-sulfide ± carbonate stockwork veining and brecciation over broad widths typically 100 – 150 m wide in the coherent central and northern parts of the system where the grades are highest” (ibid, p.7-12). Multi-phase, colloform and banded quartz-carbonate-(adularia) ± rhodochrosite (base
metal) veins are host to enhanced grade and visible gold. Variability of vein intensity is marked, with percentages ranging from 5% at the southern end, to 100% over broad intervals in the northern end (ibid, p.7-13). Variability of sulphide content is also systematic, with the upper central part exceeding 20% sulphide, and decreasing to less than 1% in quartz veins at the north end. Figure 14 is offered to put forward examples of vein and breccia textures, along with visible gold in selected holes.

2.5. Fruta Del Norte Resource

The resource of FDN is estimated from a drilling campaign between February 2006 and August 2010. The total metreage of drilling core recovered is estimated at 106,808.31m, collected from 221 core drill holes. For Mineral Resources estimation, only 205 core drill holes are used. The Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition...
Standards of 2005, along with the CIM Best Practice Guidelines of 2003 are used for the Resource and Reserve determination (Henderson, 2010:p.17-1). Figure 15 is offered as a preliminary view of the topography and extent of the FDN orebody.

Figure 15. Corebox rendition of FDN with cut-off grade of 3.05 g/t Au. (Corebox Online Services Inc., 2007).

2.5.1. Block Model, Geological Interpretation and Kriging Exercise

Blocks of dimensions 4 m x 10 m x 10 m on the X, Y, and Z axis were used as units for estimation. For the geological interpretation, lithological, alteration, and structural wireframes that encapsulate the mineralised gold-bearing silicic core were used. Subdomains were created through correlation matrices that defined alteration and lithologic relationships with gold mineralization (ibid:p.17-1 – 17-2). Associations were defined as following:

- Lithologic – Strong correlation between breccia and Au mineralization
- Alteration – Weak correlation between Au mineralization and clay alteration
- Alteration – Strong correlation between Au mineralization and silica alteration (ibid).

Once the silicic core was isolated from the clay alteration, correlation matrices were again used to segregate the silicic core into four domains. Figure 16 illustrates the four sub-domains.
Grade capping on the four domains was applied based on basic statistical analysis. Ordinary kriging was performed to estimate Au, Ag, S and Ca grades within the blocks. An example is offered in Figure 17.

**FDN 1W - Au - OMNIVARIOGRAM**

Figure 17. Variogram and parameter estimates used for resource estimation (Hennessey, 2007a).

### 2.5.2. Resources and Reserves

Measured Mineral Resources were not estimated as the orebody does not crop out to the surface (Henderson, 2010: p.17-5). Three cut-off grades were studied for the mining plan: a break-even cut-off grade, an incremental cut-off grade, and a mill cut-off grade. They are defined as including total costs, including mining (less development costs), processing and overhead operating costs, and only processing costs, respectively. Total operating cost: mining cost + ore processing cost + g&a cost + miscellaneous costs. Assumptions for the cut-off grade estimates for Reserves and Resources are presented on Table 7 for the two types of mineralogy within the orebody—one processed by Carbon In Leach (CIL), and another processed by Pressure Oxidation (POX).
Table 7. FDN resource estimation assumptions (*ibid* table 17-2).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CIL Reserve Value</th>
<th>POX Reserve Value</th>
<th>Resource Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au Price</td>
<td>US$ 900/oz</td>
<td>US$ 900/oz</td>
<td>US$ 1,000/oz</td>
</tr>
<tr>
<td>Ag Price</td>
<td>US$ 14.00/oz</td>
<td>US$ 14.00/oz</td>
<td>US$ 15.00/oz</td>
</tr>
<tr>
<td>Process Recovery</td>
<td>82.5%</td>
<td>94.4%</td>
<td>94.4%</td>
</tr>
<tr>
<td>Break-even Cut-off Grade</td>
<td>5.0 g/t Au</td>
<td>3.2 g/t Au</td>
<td>2.9 g/t Au</td>
</tr>
<tr>
<td>Incremental Cut-off Grade</td>
<td>4.9 g/t Au</td>
<td>3.0 g/t Au</td>
<td>N/A</td>
</tr>
<tr>
<td>Mill Cut-off Grade</td>
<td>2.4 g/t Au</td>
<td>2.0 g/t Au</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Indicated and Inferred Mineral Resources are presented on Table 8.

Table 8. FDN Indicated and Inferred Mineral Resources (*ibid* table 17-3).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Tonnage t</th>
<th>Au grade g/t</th>
<th>Au oz</th>
<th>Ag grade g/t</th>
<th>Ag oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicated</td>
<td>3,583,000</td>
<td>5.50</td>
<td>634,000</td>
<td>10.7</td>
<td>1,235,000</td>
</tr>
<tr>
<td>Inferred</td>
<td>19,553,000</td>
<td>5.50</td>
<td>3,460,000</td>
<td>10.7</td>
<td>6,707,000</td>
</tr>
</tbody>
</table>

Assumptions are: cut-off grade of Mineral Resources is 3g/t Au, Au price of US$ 1,000/oz, Ag price of US$ 15/oz, life-of-mine Au recovery of 94.8%, and an operating cost of US$ 85.51/t.

Mining dilution and mining recovery are included for Mineral Reserves, and a mining plan of transverse open blast-hole stoping with backfill. Cut-off grade for Reserves is 3.3 g/t Au, price assumptions as presented in Table 7, and operating cost of US$ 85.51/t. Table 9 is presented for Reserve estimates.

Table 9. FDN Mineral Reserves (*ibid* table 17-4).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Tonnage t</th>
<th>Au grade g/t</th>
<th>Au oz</th>
<th>Ag grade g/t</th>
<th>Ag oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proven</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Probable</td>
<td>26,117,000</td>
<td>8.07</td>
<td>6,775,000</td>
<td>10.9</td>
<td>9,141,000</td>
</tr>
<tr>
<td>Total</td>
<td>26,117,000</td>
<td>8.07</td>
<td>6,775,000</td>
<td>10.9</td>
<td>9,141,000</td>
</tr>
</tbody>
</table>

3. Project Evaluation Theoretical Framework

The evaluation of a project like Fruta Del Norte is typically undertaken on a variety of fronts: from the resource definition presented above, to the optimal engineering design, the optimal metallurgical route, the optimal capital structure. For the purposes of this study, the engineering and metallurgical factors are assumed as optimized, and thus, the defined resource is also economically optimal. Deciding the optimal capital structure is fundamental for this study. The underlying framework to approach this decision is offered by the theory of investment and the weighted-average cost of capital. Subsequently, methodologies derived from the theory of investment are applied. Developments of the net present value and the internal rate of return are presented in this chapter.
3.1. Theory of Investment

The development of the theory presented in this section follows the development by Barro and Sala-i-Martin (1995). Traditional theory of investment is developed in the Economic sciences assuming a firm production function of the type

\[ Y = F(K, L) \]

where \( Y \) is output, \( K \) is amount of capital, and \( L \) is the effective amount of labour input.

Additionally, the theory assumes each firm has access to the same technology. A firm owns the stock of capital \( K \), and the households get a claim on the firm’s net cash flows. A firm’s capital stock change function is given by

\[ \dot{K} = I - \delta K \]

where \( I \) is gross investment, and capital stocks depreciate at a constant rate of \( \delta \). Another assumption is convenient: the cost in units of output for each unit of investment is 1 plus an adjustment cost, which relates \( I \) to \( K \) increasingly; in other words,

\[
\text{Cost of Investment} = I \cdot [1 + \phi(I/K)]
\]

where \( \phi(0) = 0 \), \( \phi' > 0 \), and \( \phi'' \geq 0 \). Expressly, the adjustment costs depend on gross investment \( I \), instead of net investment \( I - \delta K \).

Firms pay a wage rate \( w \) for each unit of labour \( L \), and any adjustment cost for labour is ignored for the sake of simplicity. The firm’s net cash flow is given, subsequently, by

\[
\text{Net Cash Flow} = F(K, L) - wL - I \cdot [1 + \phi(I/K)].
\]

A fixed number of equity shares outstanding from the firm are traded in the stock market and at time 0 the value is \( V(0) \) (i.e. the price per share at time 0). Net cash flow in the equation above is paid out in dividends to shareholders. Accordingly, the present value of the net cash flows of the firm between times 0 and infinity is represented by \( V(0) \). The discount rate is the market rate of return \( r(t) \)—implying shareholders will get a rate of return of \( r(t) \) in each period. It is in the interest of the firm to maximize the value of \( V(0) \).

The market rate of return \( r(t) \) varies from period to period, and an expression for the average is found as

\[
\bar{r}(t) \equiv (1/t) \cdot \int_0^t r(v)dv
\]

Finally, the objective of a firm is to maximize the value of the expression,

\[
V(0) = \int_0^\infty e^{-\bar{r}(t) t} \cdot \{F(K, L) - wL - I \cdot [1 + \phi(I/K)]\} \cdot dt
\]
In order to make the theory more applicable to reality, the assumption that $r(t)$ is a visible and unique market rate needs to be relaxed. In fact, $r(t)$, which can be interpreted as the cost of capital, depends on a variety of factors including: the idiosyncratic risk of the particular business sector, the idiosyncratic risk of a particular project, the use of third-party capital (i.e. debt) and the term structure of the riskless cost of capital. A proper treatment of $r(t)$ is offered by the weighted average cost of capital.

3.1.1. Weighted Average Cost of Capital

Simply put, two types of capital are employed by a firm (or a project): equity and debt. By the contractual nature of these two types of capital, their market rate of return differs substantially. According to market historian Prof Jeremy Siegel, stocks returned 6.8% after inflation between 1871 and 2001. Meanwhile, bonds returned 2.8% after inflation during the same period (Siegel, 2002:Table 1.1 and 1.2). Therefore, when estimating the hybrid $r(t)$, the so-called weighted average cost of capital (WACC) will be assessed. Symbolically, WACC takes the following form:

$$\text{WACC} = \frac{D}{C} \cdot r_{\text{debt}} (1 - t) + \frac{E}{C} \cdot r_{\text{equity}}$$

where $C$ is the total capital employed by the firm, $D$ is the amount of debt used, $E$ is the amount of equity deployed by shareholders. The return on debt, $r_{\text{debt}}$, is customarily estimated as the risk-free rate plus a premium which accounts for the leverage (i.e. $D/C$), and the idiosyncratic risk of the project. It should be noted $r_{\text{debt}}$ is tax-deductible and thereby the net cost of debt is multiplied by $(1 - t)$, where $t$ is the corporate tax rate. The return of equity, $r_{\text{equity}}$, is not calculated in a straightforward manner but rather necessitates of a theoretical framework underlying it. In the current study, the capital asset pricing model is assumed to be a satisfactory framework.

3.1.2. Capital Asset Pricing Model

The capital asset pricing model was developed by William Sharpe (1964), John Lintner (1965), and Jack Treynor (unpublished), as an attempt to elicit the expected risk premium of holding a security when beta, the sensitivity of the security to market fluctuations, is not 0 or 1. The basic precept is based on the fact that, under competitive markets, the expected risk premium for holding a security varies in proportion to $\beta$. Symbolically,

$$r_{\text{security}} - r_f = \beta (r_{\text{market}} - r_f)$$

where $r_f$ is the risk-free rate, and $r_{\text{market}}$ is the expected market return. Thereby, the return on the security $r_{\text{security}}$ can be estimated from the previous expression as

$$r_{\text{security}} = r_f + \beta (r_{\text{market}} - r_f)$$

The return on a security can be a useful proxy for the minimum return investors ask when assessing a project. In other words, $r_{\text{security}}$ can be used instead of $r_{\text{equity}}$ in the WAAC estimation. Intuitively, if $r_{\text{security}}$ represents the return obtained from exposing shareholders to
a similar risk profile to the risk profile of the investment under consideration, \( r_{\text{security}} \) is the best instrument to discount future cash flows from an equity point of view.

As WACC has been satisfactorily defined, the theory of investment still needs refurbishing in order to be applicable. The introduction of two methodologies, the net present value assessment and internal rate of return evaluation, is deemed timely.

### 3.1.3. Net Present Value and Internal Rate of Return

The net present value methodology (NPV) was pioneered by economist Irving Fisher (Fisher, 1930) and is used to account for the value of an investment at a specific point in time. In the case of an investment decision, the value of the investment is accounted for at the present time. Therefore, all future cash flows are brought to present value through a discount factor \( r \), which accounts for the opportunity cost of foregone return on the resources invested by not deploying them elsewhere. In short, NPV takes the following form,

\[
\text{NPV} = C_0 + \sum_{t=1}^{n} e^{-r \cdot t} \cdot C_t
\]

where \( C_0 \) is the initial investment and \( C_t \) is the net cash flow at time \( t \). Additionally, continuous compounding and a project maturity at time \( n \) are assumed. The similarities of this expression with the equation for \( V(0) \) under theory of investment are noticeable. The maximization of NPV is prioritized by the operation of the firm. If everything else is given, in evaluating a project, a positive NPV is reason to approve a project as it crosses the minimum barrier, or discount rate \( r \). Additionally, the discount should be estimated under the WACC if the project employs debt as well as equity. It is important to note risk is ignored when undertaking NPV; in other words, the cash flows are assumed certain.

The internal rate of return (IRR), also called discounted-cash-flow rate of return, is defined as the discount rate which makes NPV = 0. Symbolically,

\[
\text{NPV} = C_0 + \sum_{t=1}^{n} e^{-IRR \cdot t} \cdot C_t = 0
\]

A project is accepted if the IRR is higher than the opportunity cost of capital, or WACC. NPV and IRR estimation procedures are called discounted cash flow analysis. In order to understand what the main drivers are behind the behaviour of NPV and IRR, a sensitivity analysis is typically produced. Under such analysis, alternative scenarios are considered with one variable changing at a time and measuring the NPV reaction. However, a more probabilistic approach is offered by Monte-Carlo simulation, which is introduced in the next section.

### 3.2. Monte-Carlo Simulation

A game of roulette is proposed to understand this methodology. Assume every time the wheel spins, a number is recorded. By repeating the process thousands of times, a probability distribution of outcomes is elicited from the outcome-recording process. The obtained distribution may be used to simulate the behaviour of the roulette. As such, the distribution may be programmed in a computer and the game of roulette successfully replicated. The entire process just mentioned is the underlying process behind Monte-Carlo simulation (MCS).
Under MCS, variables within the discounted cash flow analysis are assigned probability distributions from historical data or reasonable assumptions. One trial involves taking random values of the simulated variables and recording the value of the forecast variable (i.e. NPV). Finally, thousands of trials are run and a probability distribution is obtained for the forecast variable. The shape and statistics of the distribution are insightful for investment appraisers and can tell what the worst and best scenarios might be, whether the project has substantial upside and extreme scenarios, and whether a theoretical distribution can be fit in order to further understand the project under more sophisticated methodologies such as the real option assessment. In fact, real option analysis has gained popularity during the last two decades as it accounts of the optionality feature of a project.

3.3. Real Option Valuation

Real option valuation is a methodology drawn from financial derivative pricing theory applied to non-traded assets or capital investments. Specifically, when evaluating an investment, ‘optionality’ or ‘uncertainty’ may be understood as value enhancer since it allows for different entry points and reactive flexibility without fixed commitment on the investment. Figure 18 illustrates.

A call option is the analogous financial derivative to a real option. Specifically, a call option is a financial derivative that gives the holder the right, but not the obligation, to buy a security at specific price and time in the future. When maturity has come, a call option is exercised and the payoff is represented symbolically as:

$$\max(S_T - K, 0)$$
where $S_T$ is the price of the security at the time of maturity $T$. $K$ is the strike price of the call option contract. In order to price the call option, the Black-Scholes-Merton model is predominantly applied. The price of the option takes the form:

$$V = N(d_1) \cdot A - N(d_2) \cdot X \cdot e^{-rT}$$

where

$$d_1 = \frac{\ln\left(\frac{A}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot T}{\sigma \cdot T^{0.5}}$$

$$d_2 = d_1 - \sigma \cdot T^{0.5}$$

Where $A$ is the spot price of the traded security, $X$ is the strike price, $T$ is the time to maturity of the option, $r$ is the risk-free rate of return, and $\sigma$ is the volatility of the returns of the security (assumed to follow a log-normal distribution). Finally, $N(d)$ is the cumulative normal distribution at point $d$.

Once all the project evaluation theoretical tools have been unfolded, the next step of the current study is to examine carefully the only previous financial evaluation of FDN; namely, the pre-feasibility study published by Kinross Gold.

4. Pre-feasibility Study by Kinross Gold

After the acquisition of Aurelian Resources by Kinross Gold (see section 2.2), two reports were published by the new owner, one dated December 2009 (Henderson, 2009), and another dated December 2010 (Henderson, 2010). Since Aurelian Resources had only obtained an Inferred Resource of FDN (see Table 3), an Indicated Resource was obtained on the first report (2009), and a pre-feasibility study along with Reserves and Resources was declared on the second report (2010). The pre-feasibility study is used as the basis of comparison with the financial analysis of FDN undertaken in the current study. In this chapter the pre-feasibility study is summarized.

4.1. Mining Engineering

Given the FDN orebody is next to the Machinaza River, open pit and caving mining methods are not feasible (*ibid* p.19-3). Backfill is indispensable given the poor to fair quality rock mass; moreover, in order to preserve the crown pillar and minimize stope collapse risk, cemented rock fill is necessary. Kinross declared transverse open blasthole stoping with cemented rock fill and, subsequently, paste fill, as the mining method of choice. Figure 19 illustrates.
The main drivers of the decision are summarized below:

- A thickness ranging 50m to 130m is suitable for this mining method.
- Flexibility in the mining schedule is attractive.
- High mechanization and high tonnage is favourable.
- The orebody sits between two faults and targeted stoping is necessary to preserve integrity.
- Share cross-cuts between stopes decreases costs.

The mine and schedule calls for load-haul-dump vehicles (LHD), jumbo drillers, bolters, boom bolters, long-hole drills, emulsion carriers, and support equipment like backhoes, rock breakers, shotcrete sprayers, etc (ibid. p.19-10).

4.2. Mineralogy and Metallurgical Recovery

Four metallurgical domains were identified from the studies (ibid. p.16-1):

- FDN-1: lower and southern Mn carbonate stockwork
- FDN-2: upper silica-high sulphide
- FDN-3: upper silica-low sulphide carapace
- FDN-4: northern quartz vein zone

Mineralogy studies concluded that the great majority of the gold is microscopic and associated with quartz, carbonates and sulphides, along with some visible gold. There is a refractory portion of 40% of the gold primarily tied up to pyrite and marcasite (ibid. p.16-2,9-1).
Electrum and native gold Bench-scale circuits were used for refractory gold including: floatation concentrate biological oxidation, pressure oxidation and roasting, and whole ore pressure oxidation; the last one, WOPOX, is chosen given the recoveries. For the non-refractory section, whole ore carbon-in-leach (WOCIL) was the most efficient method. The estimated recoveries are presented in Table 10.

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Au</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOCIL</td>
<td>82.4%</td>
<td>69.8%</td>
</tr>
<tr>
<td>WOPOX</td>
<td>94.4%</td>
<td>73.8%</td>
</tr>
</tbody>
</table>

A Phase 1 mining plan is offered to process only non-refractory ore. Phase 2, which starts processing ore within 18 months of the beginning of production, is built for refractory and non-refractory ore. The mining plan and the ore-types are presented in Figure 20.

Figure 20. Mining plan delineating refractory and non-refractory ore (*ibid* figure 19-3).

### 4.3. Fiscal Regime Assumptions

Given that under the Ecuadorian Mining Law a concessionaire needs to sign a “Contract of Mining Exploitation” with the State (a more detailed treatment is offered in section 5.2), the pre-feasibility study by Kinross is based on assumptions as no contract was signed by the date of publication. Table 11 is given as a summary of the taxation assumptions applied to FDN (*ibid* pp.19-18 – 19-20).
Table 11. Summary of fiscal regime and taxation assumptions for FDN.

<table>
<thead>
<tr>
<th>Concept of taxation</th>
<th>Certainty</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royalty</td>
<td>Assumption</td>
<td>6% (5% by law + 1% third party) of net revenue (sales - refining charges - transportation charges)</td>
</tr>
<tr>
<td>Windfall taxes</td>
<td>Assumption</td>
<td>Excluded as Au price is low</td>
</tr>
<tr>
<td>Profit-sharing taxes</td>
<td>Certain</td>
<td>15% of earnings before tax and deducts of taxable base</td>
</tr>
<tr>
<td>Income tax</td>
<td>Assumption</td>
<td>Corporate income tax of 25%</td>
</tr>
<tr>
<td>-Taxable earnings</td>
<td>Certain</td>
<td>EBITDA – depreciation – windfall taxes – profit-sharing tax + non-deductible expenses</td>
</tr>
<tr>
<td>-Losses</td>
<td>Certain</td>
<td>Carried forward for up to 5 consecutive years, and no more than 25% of taxable base</td>
</tr>
<tr>
<td>Tax depreciation</td>
<td>Certain</td>
<td>50% straight-line for 10 years, and 50% units-of-production</td>
</tr>
<tr>
<td>Value-added tax</td>
<td>Certain</td>
<td>12% of all goods and consumables. Depreciates if part of CAPEX. Non-recoverable</td>
</tr>
<tr>
<td>Withholding taxes</td>
<td>Certain</td>
<td>0% because of tax treaty with Canada</td>
</tr>
<tr>
<td>Capital outflow taxes</td>
<td>Assumption</td>
<td>2% of all imported goods and services</td>
</tr>
<tr>
<td>Import duties</td>
<td>Assumption</td>
<td>0% on CAPEX imports</td>
</tr>
</tbody>
</table>

On the contract negotiated with the State, the basis of windfall taxes, the royalty, the income tax, import duties, and capital outflow taxes are specified. For the financial analysis of next chapter, the aforementioned fiscal regime assumptions were updated and complemented accordingly.

4.4. Pre-feasibility of FDN: Net Present Value and Internal Rate of Return

An underground mine along with a processing plant are estimated to cost US$ 1,120M in a two-phased development—from WOCIL to WOPOX. A life-of-mine is estimated at 16 years, for a net production of 6.3Moz of Au, and 6.8Moz of Ag. The average cash cost of the project is situated at US$ 366/oz (ibid:p.1-1).

Only Mineral Reserves are considered for the financial analysis. Additionally, no leverage is assumed. The results of the financial analysis performed by Kinross is presented in Table 12, Table 13 and Table 14.

Table 12. Discounted cash flow (US$ M) at 5% discount rate (ibid:modified from table 19-4).

<table>
<thead>
<tr>
<th>Au</th>
<th>$800/oz</th>
<th>$900/oz</th>
<th>$1,000/oz</th>
<th>$1,100/oz</th>
<th>$1,200/oz</th>
<th>$1,300/oz</th>
<th>$1,400/oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag</td>
<td>$12.5/oz</td>
<td>$14/oz</td>
<td>$15.5/oz</td>
<td>$17/oz</td>
<td>$18.5/oz</td>
<td>$20/oz</td>
<td>$21.5/oz</td>
</tr>
<tr>
<td>Base Case</td>
<td>251</td>
<td>479</td>
<td>693</td>
<td>905</td>
<td>1,118</td>
<td>1,331</td>
<td>1,543</td>
</tr>
<tr>
<td>Capex +25%</td>
<td>15</td>
<td>245</td>
<td>458</td>
<td>671</td>
<td>884</td>
<td>1,097</td>
<td>1,310</td>
</tr>
<tr>
<td>Opex +25%</td>
<td>57</td>
<td>287</td>
<td>513</td>
<td>727</td>
<td>939</td>
<td>1,152</td>
<td>1,364</td>
</tr>
</tbody>
</table>
Table 13. Undiscounted cash flow (US$ M) (ibid: modified from table 19-5).

<table>
<thead>
<tr>
<th></th>
<th>Au $800/oz</th>
<th>Au $900/oz</th>
<th>Au $1,000/oz</th>
<th>Au $1,100/oz</th>
<th>Au $1,200/oz</th>
<th>Au $1,300/oz</th>
<th>Au $1,400/oz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$12.5/oz</td>
<td>$14/oz</td>
<td>$15.5/oz</td>
<td>$17/oz</td>
<td>$18.5/oz</td>
<td>$20/oz</td>
<td>$21.5/oz</td>
</tr>
<tr>
<td>Base Case</td>
<td>978</td>
<td>1,378</td>
<td>1,755</td>
<td>2,132</td>
<td>2,510</td>
<td>2,887</td>
<td>3,264</td>
</tr>
<tr>
<td>Capex +25%</td>
<td>664</td>
<td>1,065</td>
<td>1,442</td>
<td>1,819</td>
<td>2,197</td>
<td>2,574</td>
<td>2,951</td>
</tr>
<tr>
<td>Opex +25%</td>
<td>643</td>
<td>1,046</td>
<td>1,443</td>
<td>1,819</td>
<td>2,196</td>
<td>2,573</td>
<td>2,950</td>
</tr>
</tbody>
</table>

Table 14. Internal Rate of Return (ibid: modified from table 19-6).

<table>
<thead>
<tr>
<th></th>
<th>Au $800/oz</th>
<th>Au $900/oz</th>
<th>Au $1,000/oz</th>
<th>Au $1,100/oz</th>
<th>Au $1,200/oz</th>
<th>Au $1,300/oz</th>
<th>Au $1,400/oz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$12.5/oz</td>
<td>$14/oz</td>
<td>$15.5/oz</td>
<td>$17/oz</td>
<td>$18.5/oz</td>
<td>$20/oz</td>
<td>$21.5/oz</td>
</tr>
<tr>
<td>Base Case</td>
<td>8.5%</td>
<td>11.3%</td>
<td>13.8%</td>
<td>16.1%</td>
<td>18.2%</td>
<td>20.2%</td>
<td>22.22%</td>
</tr>
<tr>
<td>Capex +25%</td>
<td>5.2%</td>
<td>7.8%</td>
<td>10.0%</td>
<td>12.1%</td>
<td>14.0%</td>
<td>15.9%</td>
<td>17.6%</td>
</tr>
<tr>
<td>Opex +25%</td>
<td>5.8%</td>
<td>8.9%</td>
<td>11.7%</td>
<td>14.1%</td>
<td>16.3%</td>
<td>18.4%</td>
<td>20.4%</td>
</tr>
</tbody>
</table>

With a current Au price of around US$ 1,400/oz, an IRR of 22.22% on the base case scenario is very attractive. A substantial rise in costs is evidenced across the mining industry (O’Connell, 2011, Larkin, 2013); particularly in the gold sector, miners were producing at an average cash cost of US$ 180/oz a decade ago, and approached US$ 800/oz during 2012, for a compounded annual growth rate of roughly 16%, well above inflation (Mills, 2012). Thereby, the CAPEX +25% and OPEX +25% scenarios are sensible. IRR of 15-20% is expected under those scenarios, along with NPV of around US$ 1,300M, very attractive.

A payback period of 6.8 years with Au price of US$ 900/oz and Ag price of US$ 14/oz was reported as well (Henderson, 2010:p.19-22). Finally, a sensitivity test was run on NPV and IRR, with variables: Au price, operating costs, and capital costs. FDN return is most sensitive to Au price, with operating cost capital cost coming secondary (ibid:p.19-5).

5. **Project Evaluation of Fruta Del Norte**

In this section, a base case financial model, net-present value, and internal rate of return are obtained for FDN. Subsequently, a probabilistic approach is taken to the estimates through Monte-Carlo simulation. Finally, a real option valuation is undertaken and a concluding valuation is offered. Upon these results, a critical opinion is generated regarding the current fiscal regime of Ecuador.

5.1. **General Assumptions**

For the financial modelling of FDN, a number of assumptions have been taken; namely, the pre-feasibility study of FDN published by Kinross Gold is used as the cornerstone of the technical and financial assumptions (ibid). However, other sources have been used and will be mentioned accordingly.
5.1.1. Production Profile

A detailed production schedule of Au and Ag from FDN is provided by Kinross (ibid: Table 19-2). However, such schedule is estimated assuming variable grade and recovery, which is not offered in the publication. Thereby, the current study uses the schedule as an ‘acid test’ for an independently estimated schedule which assumes the same mining rates as the official schedule, but constant grades and recoveries. The differential of both schedules is an overestimation of 0.24% of production during the LOM. Both schedules are included in the electronic Microsoft Excel file, under the worksheet “prod sch.”

Figure 21 and Figure 22 display the production profiles of FDN under both schedules.

It should be noted that Ag production has been converted and added to Au production in order to obtain Au Equivalent production. The conversion factor is constant in all cases and is based on monetary value; specifically, the Reserve estimates of FDN assume Au price of US$ 900/oz, and Ag price of US$ 14/oz, thereby the conversion factor is 900/14, or roughly 0.01555, meaning that 1 oz of Ag produced translates into 0.015 oz of Au produced.
Under the official schedule, maximum production is reached in year 13 when the project turns out 510koz of Au Eq. However, similar level of output is reached in year 6 when production sits at 508koz of Au Eq.

Under the estimated schedule, production is more stable than in the official case, and plateaus at 454koz of Au Eq a year on the eighth year of production, until the fourteenth year of production. Production subsequently falls.

The estimated production profile varies slightly from the official profile and financial issues are expected. In particular, production under the official profile accelerates rapidly until year 6, and decreases slowly from year 13 until closedown on year 18. The increased revenue on years 5, 6, and 7 is never reached under the estimated profile. However, the increased production of years 12 and 13 would even out the overall effect of earlier higher production, thereby having a minor net effect on the financial model.

5.1.2. Capital Expenditures

The capital cost (CAPEX) offered by Kinross attaches to the Association for the Advancement of Cost Engineering (AACE) Class 4 standards (ibid: p.19-20); in other words, the estimate has a range of variability of -15% to +30%. CAPEX is structured for two-phase program detailed as:

- Phase 1: 2,500t/d WOCIL processing plant for non-refractory ore for a total cost of US$ 707M.
- Phase 2: completion after 18 months of the start of production, for a WOPOX processing plant of 5,000t/d capacity for the refractory ore. Total cost: US$ 413M.

The total CAPEX of both phases is US$ 1,120M. However, nowadays gold mining companies are faced with systematic CAPEX underestimation, and substantial cost increases (Mills, 2012). In the case of FDN, CAPEX was re-estimated by Kinross when the company offered guidance regarding the agreement in principle (Kinross Gold Corp, 2011). In particular,

As previously disclosed, the Company is experiencing industry-wide escalation on FDN project costs, and both capital and operating costs for the project are expected to be approximately 25-30% higher than estimates included in the project pre-feasibility study (ibid).

Accordingly, the CAPEX for the financial model analysis is 30% higher than the pre-feasibility estimate; namely, US$ 1,456M. Operating costs are adjusted as well with a 30% increase.

For the schedule of CAPEX deployment, several assumptions are in place. First, Phase 1 deployment is made in two years, with half committed each year. Phase 2 deployment is made with 1/3 in the first year of operation of the mine, and 2/3 on the second year of operation. Furthermore, sustaining CAPEX is assumed to be approx. 15% of total CAPEX, and runs evenly every year from the beginning of Phase 2 production. Graphically, the schedule can be seen on Figure 23.
5.1.3. Operating Expenses

The cash cost figure is defined by the Gold Institute and includes mining, processing, and general and administrative costs, along with royalties, transportation and refining charges, and includes by-product credits (Yamana Gold Inc, 2013). Cash cost for FDN is estimated at US$ 366/oz Au (Henderson, 2010).

A more detailed analysis of the cost structure is required for the present study. Thereby, the operating cost guidance offered by Kinross (ibid:p.19-21) was used. Operating costs (OPEX) include mining and processing costs, other operating costs (mine site service labour costs), and general and administrative costs, but exclude royalties, precious metal and refining charges, and Ag credit. The average total operating cost for Phase 1 is US$ 99.15 per ton of ore processed, and for Phase 2 is US$ 74.91 per ton of ore processed. The itemization of operating costs is offered in Table 15.

Table 15. OPEX by concept (ibid).

<table>
<thead>
<tr>
<th>Concept</th>
<th>Phase 1 US$/t of ore</th>
<th>Phase 2 US$/t of ore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining Cost</td>
<td>51.69</td>
<td>29.79</td>
</tr>
<tr>
<td>Processing Cost</td>
<td>30.50</td>
<td>37.15</td>
</tr>
<tr>
<td>Other operating costs</td>
<td>2.61</td>
<td>1.00</td>
</tr>
<tr>
<td>G&amp;A costs</td>
<td>14.35</td>
<td>6.97</td>
</tr>
<tr>
<td>Total operating costs</td>
<td>99.15</td>
<td>74.91</td>
</tr>
<tr>
<td>Expected (30% increase)</td>
<td>128.90</td>
<td>97.38</td>
</tr>
</tbody>
</table>

Accordingly, as presented in last row of the Table 15, the total operating costs used in the financial modelling are increased by 30%. Estimated cash costs become US$ 655/oz for Phase 1, and US$ 450/oz for Phase 2.

5.1.4. Weighted Average Cost of Capital and Capital Structure

As mentioned in the Project Evaluation Theoretical Framework chapter (see section 3.1.3), a minimum rate \( r \) is used to discount future cash flows and bring them to present value.
The choice of \( r \) is estimated from the actual capital structure of the project; in particular, the capital expenditures of a project are based on equity and debt. Thereby, for the analysis of FDN, the Weighted Average Cost of Capital (WACC) is used:

\[
WACC = \frac{D}{E} \cdot r_{debt} (1 - t) + \frac{E}{E} \cdot r_{equity}
\]

Since FDN was relinquished by Kinross Gold (Kinross Gold Corp, 2013), the Return on Equity of the industry is used instead of the company. Data from Prof Aswath Damodaran is applied on an industry-average basis (2013). The CAPM (see section 3.1.2) was applied to estimate the Return on Equity of the project. An average unlevered \( \beta \) of 1.032 is estimated for 83 firms in the precious metals realm. A risk-free rate of 2.79% is used from the 10-year US Treasury Yield. The risk premium for holding equity, or \( r_{market} - r_f \), is estimated at 5.80%. Thus, the Return on Equity under CAPM is appraised at 8.78%.

For the Return on Debt, the methodology of Prof Damodaran has been used (ibid). Specifically, the interest rate premium (over the risk-free rate) a firm services is linearly dependant with the standard deviation of its publicly traded stock. The standard deviation of the industry is 77.77%, which translates in a 2% premium. Thereby, the Return on Debt is appraised at 4.79%. The income tax rate for FDN is forecast at 22%.

Regarding the capital structure, the average share of debt in the capital employed by the industry is 12.01%, which translates an equity share of 87.99%. Figure 24 illustrates the capital structure.

![Figure 24. Capital structure of choice for FDN.](image-url)

Overall WACC is appraised at 8.17%. The estimation of WACC is included in the electronic Microsoft Excel file, under the worksheet “wacc.” With the CAPEX, Operating Expenses, and WACC assumptions in place, a proper treatment of the fiscal regime of Ecuador regarding mining is deemed timely.
5.2. Fiscal Regime of Ecuador

5.2.1. Mining Law of Ecuador

The current Mining Law of Ecuador was enacted on the 29th of January, 2009 (Registro Oficial, 2009). Under the new regime, a new Ministry is created to oversee the non-renewable resources sector of the Ecuadorian economy: mining, oil and gas. In the case of mining, a new regulatory agency, a research institution, and national mining company were erected. The overarching principle of the Ecuadorian Law is conceived at a constitutional level: the state is the inalienable owner of the non-renewable natural resources of Ecuador (Art. 408 of Constitution), and it will outsource to the private sector under exceptional circumstances. In the current environment, the experience and financial resources needed for the development of mining operations are lacking in the Ecuadorian State. Private enterprise has been historically the main actor of mining activities in the country. A compromise between the nationalist legal environment and the private sector initiative is currently debated; it is a work in progress. Even though the State owns the resources, the concessionaire is given the right to market freely the minerals or metals extracted from their concessions (ibid: art.49).

Under the current regime, the phases in the development of a mining project are divided in initial exploration, advanced exploration, economic evaluation, and exploitation—prospecting is a free right that requires no permits (ibid: art.28). Initial exploration is comprised of a four-year period after the concession has been accepted. Before the end of this stage, an option to extend the exploration stage for an additional four-year period can be exercised—called “advanced exploration”. In order to apply for such extension, the concessionaire is required to relinquish some area of the initial concession.

During both exploration stages, a yearly report is to be submitted by the concessionaire to the Ministry. A summary of activities and an investment plan are included in the yearly report, and a regulatory agency-approved auditor is required to certify it. If the investment plan is not fully executed, the concession may be terminated (ibid: art.38).

Once finished the exploration stages, the concessionaire may apply for an economic evaluation stage. After this two-year period, the concessionaire is offered the option to apply for a two-year extension; however, the cost of the conservation patent for the additional time is raised by fifty per cent. Table 16 summarizes the stages recognized under the Ecuadorian Mining Law.

Table 16
The maximum period of a standing concession is stipulated at 25 years, with the option for renewal for an additional period of the same length (ibid art.36).

The exploitation stage may be granted to the concessionaire if it is applied for before the economic evaluation stage ends. Exploitation, under the Mining Law of Ecuador, is comprised of a so-called “Contract of Mining Exploitation” (ibid art.39) signed between the concessionaire and the government. Given the lack of large scale mining experience in Ecuador, the contract of exploitation has become a contentious area where mining companies and government voice their aspirations.

Specifically, the contract is to be negotiated, evaluated, and possibly signed between the concessionaire and the Ministry within the first six months of granting the exploitation stage concession. The terms, conditions, and periods of construction, assembly, extraction, transportation, and marketing are stipulated within the contract. Additionally, terms on environmental management, presentation of guarantees, performance bonds, community relations, royalty payments, closure of the mine, and settlement of possible environmental liabilities are decided within the agreement. Parameters for taxation are also explicitly specified. Disputes between the parties regarding the interpretation of the contract are to be arbitrated by an impartial South American party (ibid art.41).

Another type of contract is also specified—the so-called “Contract of Services” (ibid art.40). Such contract is replicated from the services contract currently gaining popularity by national oil companies worldwide, and was recently implemented in the oil and gas sector of Ecuador. Typically, the resource is explored and appraised by the estate companies, and a private company is hired to maximize the production of that resource. The contract is written to define compensation per unit of production, incentives, bonuses, environmental obligations, guarantee requirements, community relationship management, and closedown issues. The precedent of this type of contract is still lacking, and none of the current contracts under negotiation is framed under this model.
5.2.2. Permits

Any mining activity in Ecuador requires a variety of permits. The permits, the grantors, and the concepts are outlined in Table 17.

Table 17. Summary of permits required under Mining Law *(ibid :art.26).*

<table>
<thead>
<tr>
<th>Permit</th>
<th>Granting Institution</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Licence</td>
<td>Ministry of Environment</td>
<td>Evaluate impact on environment and local community. Environmental Impact Assessment (EIS)</td>
</tr>
<tr>
<td>Operation Permit</td>
<td>Municipal Council</td>
<td>Permission to operate under local jurisdiction</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>Ministry of Transportation and Public Works</td>
<td>Permission to use buildings, highways, railways, etc.</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>National Telecommunications Secretariat</td>
<td>Permissions to use radio communications, antennae, etc.</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>Ministry of Defence</td>
<td>Permission to use areas adjacent to military grounds and international borders</td>
</tr>
<tr>
<td>Water Permit</td>
<td>Water Authority</td>
<td>Permission to use water according to the Law of the matter and the Constitution</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>National Hydrocarbons Bureau</td>
<td>Permission to use areas around oil, gas, and multipurpose pipelines</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>Civil Aviation Bureau</td>
<td>Permission to use airports, airfield, and adjacent lands</td>
</tr>
<tr>
<td>Use Permit (if needed)</td>
<td>Ministry of Electricity and Renewable Energy</td>
<td>Permission to use areas around power stations, electricity towers, etc.</td>
</tr>
<tr>
<td>Use Permit</td>
<td>National Institute of Cultural Heritage</td>
<td>Permission to prospect areas where archaeological remains are likely</td>
</tr>
</tbody>
</table>

The period of evaluation of these permits is capped at 60 days from the time of application. If rejected, the applicant can appeal. Of all permits, the Environmental Impact Assessment is typified as critical and time-consuming.

As early as initial exploration, Environmental Impact Studies (EIS) are required under law, and by advanced exploration a final EIS along with an environmental management plan shall be filed in the Ministry of Environment. An Environmental Licence is granted upon meeting certain standards specified in the regulations of the Law. At all stages of mining development, performance bonds are required. Concessionaires are required to file an annual environmental audit that allows the Ministry to monitor the fulfilment of the regulations *(ibid :art.68).*

Under the Ecuadorian Law, the participation of the community is built as a cornerstone of the EIS evaluation *(ibid.ch.3).* At all stages of development, the concessionaire is required to inform the local government, the local authorities, and the local communities about the possible positive and negative impacts. The local community might be required to poll in order to decide the development of a mining project; if the vote outcome is negative, the Ministry can still overrule the communal decision.

5.2.3. Taxation

On fiscal matters, the predominant principle of the Law is observed in art.93: “the State shall participate in the benefits arising out of the use of these resources in a sum equivalent to
not less than the amount received by the concessionaire who exploits them” *(ibid)*. An interpretation of this requirement is offered by the agreement in principle between the Government of Ecuador and Kinross Gold (see next section).

As part of the package of benefits obtained by the government, royalties, income tax, profit-sharing tax, windfall tax, and value-added tax (VAT) are put in place.

The royalty is conceptualized as a rent that recognizes the ownership of the resource by the State. Royalty parameters are not defined in the Law, and are open for negotiation under the Contract of Exploitation. A lower limit is specified at 5% of sales of primary and secondary minerals. Income tax is specified at 25% but subject to government policy; profit-sharing tax is specified at 12% of operating profit; wind-fall tax is specified at 70% of extraordinary income which is not numerically defined and open for negotiation under the Contract; and VAT in Ecuador is specified at 12%.

### 5.2.4. Agreement in Principle with Kinross Gold

On December 2011, an agreement in principle was announced by Kinross Gold (Kinross Gold Corp, 2011). A milestone in the emerging mining industry was reached with this pre-agreement, and a strong precedent on the fiscal regime was set. A summary of the agreement is given on Table 18.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government’s economic benefit</strong></td>
<td>52% of FDN economic benefits. Government’s share is defined as: royalty + income tax + state portion of profit sharing tax + windfall profit tax + VAT of expenditures. Kinross share: after tax free cash flow</td>
</tr>
<tr>
<td>Royalty</td>
<td>Sliding-scale net smelter return royalty: 5% for price ≤ US$ 1,200/oz, 6% for US$ 1,200/oz &lt; price ≤ US$ 1,600/oz, 7% for US$ 1,600/oz &lt; price ≤ US$ 2,000/oz, and 8% for above US$ 2,000/oz</td>
</tr>
<tr>
<td>Advanced royalty payment</td>
<td>US$ 65M against future royalty, paid in two instalments upon project development stages</td>
</tr>
<tr>
<td>Corporate income tax rate</td>
<td>22%</td>
</tr>
<tr>
<td>Profit sharing tax</td>
<td>15% of which 12% is for the State, and 3% for employees and deductible from income tax basis</td>
</tr>
<tr>
<td>Windfall profits tax</td>
<td>70% of the excess of the realized Au price greater than US$ 1,650/oz. The base price is indexed to USA inflation</td>
</tr>
<tr>
<td>Customs duties</td>
<td>0% on all capital goods imported during construction</td>
</tr>
<tr>
<td>Electricity</td>
<td>Industrial customer rate from national power service</td>
</tr>
<tr>
<td>Disputes</td>
<td>Arbitration by UNCITRAL Rules in Chile</td>
</tr>
<tr>
<td>Adverse new laws</td>
<td>Kinross holds right to seek amendments to preserve economic equilibrium, or seek remedies</td>
</tr>
<tr>
<td>Community investment</td>
<td>Kinross commits to invest in social infrastructure to benefit local communities including: roads, training centre, airport improvements, and other programmes</td>
</tr>
</tbody>
</table>
5.2.5. Recent Reform to Mining Law

On June 13th, 2013, the first major reform to the 2009 Mining Law was approved by the Ecuadorian National Assembly (Registro Oficial, 2013). Thirty two articles of Mining Law were changed with major modifications including: the creation of medium-scale mining operations, a fixed 4% royalty for such operations, a reduction in the time the Ministry of Environment takes to evaluate an EIS—from a de facto two years, to nine months. For large-scale mining, which covers FDN, the windfall tax article was modified to allow the mining company to recover its investment before the windfall tax starts running. Overall for the industry, only two permits are required—Environmental Licence and Water Licence—from ten in the original law.

For the tax treatment for current financial modelling of FDN, all assumptions are drawn from the agreement in principle with the Government of Ecuador published by Kinross Gold (2011) (see Table 18). Regarding depreciation, which varies across type of assets, facilities, machinery and equipment are assumed to encompass all the capital expenditures at FDN. A variety of other assumptions have been made, including:

- The recently enacted criteria that triggers windfall tax application (i.e. investment has been recovered by FDN owner), is assumed to be pre-tax cash flow and ex-royalty. This assumption is sensible as windfall tax is deducted from the royalty basis, and the profit-sharing and income tax basis.
- Pre-operating expenses are depreciated for the first 5 years of production at equal rate (Henderson, 2010:p.19-19). From annual reports of Kinross Gold, a total capital expenditure of US$ 1,241M has been accounted for at FDN.
- Working capital is assumed to be 50% of operating expenses.
- A prepaid royalty of US$ 65M is assumed to be evenly split between the first two years of commissioning.
- Environmental and Closure costs of US$ 2M at the end of the project.

5.3. Summary of Base Case Assumptions

A brief summary of the base case assumptions is presented in Table 19.
Table 19. Base case assumptions

<table>
<thead>
<tr>
<th>Item</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au price</td>
<td>US$ 900/oz</td>
</tr>
<tr>
<td>Ag price</td>
<td>US$ 14/oz</td>
</tr>
<tr>
<td>Mine life</td>
<td>16 years</td>
</tr>
<tr>
<td>Avg annual Au production</td>
<td>402,000/oz</td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>US$ 1,456M</td>
</tr>
<tr>
<td>OPEX Phase 1</td>
<td>US$ 128.90/t of ore</td>
</tr>
<tr>
<td>OPEX Phase 2</td>
<td>US$ 14.40/t of ore</td>
</tr>
<tr>
<td>Cash cost Phase 1</td>
<td>US$ 655/oz</td>
</tr>
<tr>
<td>Cash cost Phase 2</td>
<td>US$ 450/oz</td>
</tr>
<tr>
<td>Recovery Phase 1</td>
<td>82.40%</td>
</tr>
<tr>
<td>Recovery Phase 2</td>
<td>94.40%</td>
</tr>
<tr>
<td>Sustaining cost</td>
<td>US$ 16M/year from 4th year</td>
</tr>
<tr>
<td>WACC</td>
<td>8.17%</td>
</tr>
<tr>
<td>Debt/Equity</td>
<td>12:88</td>
</tr>
<tr>
<td>Royalty</td>
<td>Sliding scale with US$ 65M prepaid</td>
</tr>
<tr>
<td>Windfall tax</td>
<td>70% of excess revenue after investment recovered</td>
</tr>
</tbody>
</table>

5.4. Discounted Cash Flow Analysis

The estimation of NPV and IRR is presented in this section. The computation of both is included in the electronic Microsoft Excel file, under the worksheet “dcf.” The discounted cash flow analysis produces an NPV of US$ -238.86M, and an IRR of 5.18% over the life of the project. The maximum cash exposure is appraised at US$ -1,389M, and the payback period assessed at 12.44 years. The profile of discounted cash flows for the project life is presented in Figure 25.

![Discounted Cash Flow](image)

Figure 25. Base case profile of discounted cash flows during the life of the project.

Evidently, the positive cash flows are not strong enough to counter-balance the substantial budgeted capital expenditures. The first two years of CAPEX are extremely large and account largely for the decline construction, the mine development, infrastructure, and
utilities investments. Years 3 and 4 are largely invested in the WOPOX plant, which is estimated at US$ 220M (ibid:p.19-21). The cumulative cash flow profile of mine is displayed on Figure 26.

The payback period of 12.44 years is evidenced by the turning of negative to positive cumulative cash flow between years 12 and 13. The maximum cash exposure is evidence on year 4 when it reaches around US$ -1,400M.

The economic attractiveness of FDN is limited, from a Discounted Cash Flow analysis point of view and under the assumptions above mentioned. Crucially, an IRR of just 5.18% is not large enough to justify an investment in a high-risk jurisdiction with no large-scale mining, new regulatory environment, and historically-high political uncertainty.

To complement the base case scenario, the Au and Ag price assumptions along with CAPEX and OPEX are varied to produce new scenarios and obtain a broader view of the discounted cash flow analysis. Additionally, the assumption of constant Au/Ag ratio applied for Au-Equivalent conversion was relaxed. The resulting NPV and IRR are presented on Table 20 and Table 21.

Table 20. Base case Net Present Value (US$ M) with WACC discount rate.

<table>
<thead>
<tr>
<th>Au</th>
<th>$800/oz</th>
<th>$900/oz</th>
<th>$1,000/oz</th>
<th>$1,100/oz</th>
<th>$1,200/oz</th>
<th>$1,300/oz</th>
<th>$1,400/oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag</td>
<td>$12.5/oz</td>
<td>$14/oz</td>
<td>$15.5/oz</td>
<td>$17/oz</td>
<td>$18.5/oz</td>
<td>$20/oz</td>
<td>$21.5/oz</td>
</tr>
<tr>
<td>Base Case</td>
<td>-455</td>
<td>-239</td>
<td>-23</td>
<td>194</td>
<td>410</td>
<td>597</td>
<td>805</td>
</tr>
<tr>
<td>Capex +25%</td>
<td>-747</td>
<td>-525</td>
<td>-309</td>
<td>-93</td>
<td>123</td>
<td>311</td>
<td>524</td>
</tr>
<tr>
<td>Opex +25%</td>
<td>-728</td>
<td>-494</td>
<td>-278</td>
<td>-62</td>
<td>154</td>
<td>341</td>
<td>555</td>
</tr>
</tbody>
</table>

Figure 26. Base case profile of cumulative cash flow during the life of the project.
Table 21. Base case Internal Rate of Return.

<table>
<thead>
<tr>
<th></th>
<th>$800/oz</th>
<th>$900/oz</th>
<th>$1,000/oz</th>
<th>$1,100/oz</th>
<th>$1,200/oz</th>
<th>$1,300/oz</th>
<th>$1,400/oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td>$12.5/oz</td>
<td>$14/oz</td>
<td>$15.5/oz</td>
<td>$17/oz</td>
<td>$18.5/oz</td>
<td>$20/oz</td>
<td>$21.5/oz</td>
</tr>
<tr>
<td>Base Case</td>
<td>2.23%</td>
<td>5.18%</td>
<td>7.90%</td>
<td>10.45%</td>
<td>12.88%</td>
<td>14.92%</td>
<td>17.09%</td>
</tr>
<tr>
<td>Capex +25%</td>
<td>0%</td>
<td>2.58%</td>
<td>4.99%</td>
<td>7.24%</td>
<td>9.37%</td>
<td>11.15%</td>
<td>13.10%</td>
</tr>
<tr>
<td>Opex +25%</td>
<td>0%</td>
<td>1.84%</td>
<td>4.74%</td>
<td>7.43%</td>
<td>9.96%</td>
<td>12.06%</td>
<td>14.36%</td>
</tr>
</tbody>
</table>

Positive NPVs are guaranteed in all cases at Au price of US$ 1,200/oz and Ag price of US$ 18.5/oz. Above such price scenario, the project is very attractive. The minimum prices to achieve a positive NPV are US$ 1,100/oz for Au, and US$ 17/oz for Ag, assuming no CAPEX or OPEX increases (i.e. Base Case). In the case of IRR, 10.45% is achieved at US$ 1,100/oz, and IRRs of above 10% are achieved in all case from Au price of US$ 1,300 and above. With a current Au price of US$ 1,400, FDN is deemed an attractive investment if the current price is expected to persevere in the coming years. However, under the Base Case, FDN is unalluring.

5.5. Sensitivity Analysis

In order to further understand the main factors behind the investment attractiveness of FDN, a sensitivity analysis is required. Variables including income tax rate, Au price, recovery, grade, CAPEX, and OPEX were varied on a ceteris paribus basis. Sensitivity analysis is best assessed graphically, and the results are presented on Figure 27.

![Figure 27. Sensitivity of NPV for changes in different parameters.](image)

It is evidenced that FDN is most sensitive to Au price, recovery, and grade. Recovery is not expected to vary significantly through the LOM as thorough metallurgical studies have been completed to reduce such risk. Grade is also controlled on a daily basis and geostatistical analysis has been extensive. Au price is deemed the most important factor followed by CAPEX,
which has proved unpredictable for many major projects in the industry. Finally, the importance of OPEX is apparent and should be carefully estimated during a bankable feasibility study.

5.6. Monte-Carlo Simulation

For the probabilistic analysis of the investment attractiveness of FDN, a few variables were given theoretical probability distributions along with specific parameters. The variables to be simulated include: Au price, Au grade, Ag grade, processing recoveries for Phase 1 and Phase 2, capital expenditures, and operating expenses. The distributions and parameters are summarized as follows (Detailed data is presented in the electronic Microsoft Excel file, under the worksheet “m-c assumptions”):

- Au price: lognormal distribution with mean of 900, standard deviation of 325.17, and minimum and maximum values obtained from the last 5 years of monthly data from the London Bullion Market.
- Au, Ag grade: normal distribution with mean given by pre-feasibility study, minimum values at cut-off grade, and arbitrary values for maximum and standard deviation.
- Processing recoveries: lognormal distribution with mean given by pre-feasibility study, and standard deviation, minimum and maximum values taken arbitrarily.
- CAPEX: triangular distribution with mean of expected CAPEX, along with maximum of base case+30%, and minimum of base case-15%, which are Class 4 Standards by AACE. Standard deviation is arbitrary.
- Operating expenses: normal distribution with AACE Class 4 Standards for minimum and maximum values, along with arbitrary standard deviation.

NPV, maximum cash exposure and payback period are the output variables to be forecast. After 10,000 trials, the resulting distribution for NPV is presented on Figure 28.

![Figure 28. Simulated probability distribution for NPV with certainty limit for values above 0.](image)

The certainty of a positive (or zero) outcome for NPV is forecast at 53.96%. In other words, the chances for FDN to be attractive are almost equal to the chances to be unattractive. Most importantly, the positive skewness of the distribution, evidenced by the right-tail, is
attractive for equity investors of FDN. In particular, the NPV distribution displays substantial upside potential (however with low probability), but limited downside potential. Debt investors are less appealed by FDN. The distribution is leptokurtic, with high concentration of values around the mean of US$ 266M, but also thick tails, especially on the upside. Finally, a certainty of 90% is assigned to the NPV range US$ -1.4B to 2.4B. In Figure 29 and Figure 30 the distributions of maximum cash exposure and payback period are displayed.

![Figure 29](image1.png)

Figure 29. Simulated probability distribution for maximum cash exposure with 90% certainty limits.

![Figure 30](image2.png)

Figure 30. Simulated probability distribution for payback period with certainty limit within project life.

The maximum cash exposure is substantial, with a mean of 1.36B, and a 90% certainty of falling between US$ 1.85B and 0.93B. These values are vast when compared with NPVs of
equal probability of failure or success. The distribution is skewed to the left, with the maximum cash exposure reaching US$ 3.1B. Finally, the distribution is leptokurtic with substantial probability crowded around the mean, however with long tails particularly to the left (higher cash exposure).

Regarding the payback period, a note is convenient. Given that FDN has a substantial likelihood of never paying back, a column on year 18 is expected to bias the overall probabilistic study. A certainty limit is placed at years less than 18 (i.e. 17.9 years). A certainty of 76.40% is estimated as the probability the project will payback within the project life. The mean year of payback is assessed at 11.27 years, with a minimum of 4.12 years, and a maximum of ‘never paying back.’

### 5.7. Real Option Assessment

The value of a real option under the Black-Scholes-Merton model is given by the expression:

\[
V = N(d_1) \cdot A - N(d_2) \cdot X \cdot e^{-rT}
\]

where

\[
d_1 = \frac{\ln(A/X) + (r + \frac{\sigma^2}{2}) \cdot T}{\sigma \cdot T^{0.5}}
\]

\[
d_2 = d_1 - \sigma \cdot T^{0.5}
\]

A Monte-Carlo simulation was run to obtain the volatility of the present value of free cash flow, or \( \sigma \). The present value of the free cash flow (ex-capital expenditures) is used as \( A \). The present value of capital expenditures is \( X \). The US government debt yields are used as the risk-free rate, or \( r \), with different tenors depending on the time to expiration of the option, or \( T \). An assumption has been made regarding this parameter: a linear yield curve from year 2 to 5. The parameter values are summarized on Table 22.

<table>
<thead>
<tr>
<th>( T ) (years)</th>
<th>( A(T) ) (US$ M)</th>
<th>( X(T) ) (US$ M)</th>
<th>( \sigma ) (%)</th>
<th>( r(T) ) (%)</th>
<th>NPV (US$ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,076</td>
<td>1,315</td>
<td>70</td>
<td>0.00</td>
<td>-238</td>
</tr>
<tr>
<td>1</td>
<td>995</td>
<td>1,215</td>
<td>70</td>
<td>0.12</td>
<td>-220</td>
</tr>
<tr>
<td>2</td>
<td>920</td>
<td>1,123</td>
<td>70</td>
<td>0.39</td>
<td>-204</td>
</tr>
<tr>
<td>3</td>
<td>850</td>
<td>1,039</td>
<td>70</td>
<td>0.78</td>
<td>-188</td>
</tr>
<tr>
<td>4</td>
<td>786</td>
<td>960</td>
<td>70</td>
<td>1.17</td>
<td>-174</td>
</tr>
<tr>
<td>5</td>
<td>727</td>
<td>888</td>
<td>70</td>
<td>1.56</td>
<td>-161</td>
</tr>
<tr>
<td>10</td>
<td>491</td>
<td>599</td>
<td>70</td>
<td>2.76</td>
<td>-109</td>
</tr>
</tbody>
</table>
Finally, $N(d_1)$ and $N(d_2)$ are obtained from the cumulative probability from values $d_1$ and $d_2$ under a normal distribution with mean 0 and standard deviation 1. The estimated real option values are presented in Table 23.

<table>
<thead>
<tr>
<th>$T$ (years)</th>
<th>NPV (US$ M)</th>
<th>ROV (US$ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-238</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>-220</td>
<td>995</td>
</tr>
<tr>
<td>2</td>
<td>-204</td>
<td>920</td>
</tr>
<tr>
<td>3</td>
<td>-188</td>
<td>850</td>
</tr>
<tr>
<td>4</td>
<td>-174</td>
<td>786</td>
</tr>
<tr>
<td>5</td>
<td>-161</td>
<td>727</td>
</tr>
<tr>
<td>10</td>
<td>-109</td>
<td>491</td>
</tr>
</tbody>
</table>

Figure 31 is offered to visualize the evolution of the real option value through several delay periods. The increased value offered by the uncertainty of the real option is compelling. The traditional “delayed NPV” does not account for the uncertainty taking place during the deferral periods. Solely looking at the value of the real option, as maximum is reached in year 6.

However, finding the greatest possible value created by the ‘optionality’ of FDN is crucial for financial-return maximization purposes. The “real option excess value” has been estimated as the spread between the real option value and the delayed NPV. Figure 32 illustrates.
The excess value created by the ‘optionality’ is maximized for a deferral period of 5 years. From the computation, an excess value of US$ 555M is found for such delayed period. Given this estimation maximized the benefit of the real option in contrast to the second best option (i.e. opportunity cost), or delayed NPV, FDN is financially maximized when the project is delayed 5 years.

**Figure 32. Excess value of the real option through different delay periods.**
6. Conclusions

Fruta Del Norte, a successful story incubated by the TSX-Venture, private investors, and experienced geologists, is undeveloped after seven years of its discovery. Initially a grassroots exploration project, FDN nowadays is profiled as one of the world's largest future sources of gold. For the Ecuadorian economy, FDN is framed as a much-needed source of diversification and income growth. The current study is based on the global, and local, importance of FDN. The financial appraisal of the project is a major cornerstone in the development of it.

Discounted Cash Flow analysis has been performed on Fruta Del Norte under plausible assumptions. In particular, given the cost headwinds facing the mining industry during the last decade, costs and capital expenditures have been raised by 30% from the pre-feasibility study estimates published by Kinross Gold in 2011. Taxation parameters have been clearly defined from an agreement in principle reached between Kinross and the Government of Ecuador. The idiosyncratic nature of the fiscal regime of Ecuador is characterized by profit sharing tax, a sliding scale royalty, pre-paid royalties upon signing of contract, and a windfall tax. Recent events to reform the Mining Law and improve the fiscal regime to attract mining investment have yielded new rules for taxation. The latest fiscal regime was implemented in this analysis.

The investment unattractiveness of FDN is demonstrated by a net present value of US$ -238.86M along with an internal rate of return of 5.18% (assuming Au price of US$ 900/oz and weighted average cost of capital of 8.17%). A payback period of 12.44 years (out of a 16 year LOM) as well as a maximum cash exposure of US$ 1,389M, are further detrimental to the prospects of investment. Expectedly, all investment metrics are substantially worse from the pre-feasibility study published by Kinross Gold. A sensitivity analysis proved the NPV of FDN is most sensitive to Au price, recovery, grade, and to a lesser extent to capital expenditures. Even though cash cost for the project sits at US$ 655/oz on phase 1, and US$ 450/oz for phase 2, a hefty capital outlay overwhelms the good operating margins of the mine.

Monte-Carlo simulations were applied to understand the probability behaviour of the investment metrics. Explicitly, Au price, grade, recoveries, capital expenditures, and operating expenses were simulated. Maximum cash exposure, payback period, and NPV were forecast. FDN profiles a virtually equal chance to have negative or positive NPV; however, the downside is more limited than the upside. Maximum cash exposure is substantial and is forecast in the range US$ 1,849M to US$ 930M with a 90% confidence. Finally, payback period is within the project life with a 76.40% certainty. Overall, FDN is a breakeven investment, likely to attract mostly equity given slight potential for extraordinary upside. The high capital commitment and long wait for payback make FDN uninviting.

In order to further elicit the value of FDN, the optionality of the project was considered; namely, a real option assessment was undertaken. Using the Black-Scholes-Merton model, the price of a call option was estimated as a reasonable proxy for the value of a deferral option. The value of the option is substantially higher than the base case NPV, with a maximum value for a 6-year deferral option and a minimum value for a 1-year deferral. The enhancement in the value of FDN is demonstrated by real options appraised in the range US$ 206M to US$ 399M.
for a variety of deferral periods. Moreover, the excess value of the real option, defined as $ROV = \text{delayed NPV}$, reaches a peak in the 5th year, when the value of the option exceeds the customary NPV by US$ 555M. The next owner of FDN shall delay the project for 5 years before starting production.

Overall, the assessment of FDN is exemplary of high costs pervading the industry along with a resource-nationalist fiscal regime. Pascua-Lama, the premier investment of Barrick Gold, is the poster child of high costs overwhelming the industry. Originally estimated to cost US$ 3,000M, the updated CAPEX of Pascua-Lama sits at US$ 8,500M (Jamasmie, 2012). In such context, FDN budget estimates should be critically analysed when the new operator performs the feasibility study. Most importantly, given the Ecuadorian law requires the “Contract of Mining Exploitation” where forecasts of the costs are fixed for the project life, the new operator of FDN should take a defensive view when negotiating with the government.

Looking closely at the cost structure of FDN, the potential of the project is stifled by the refractory nature of the ore. In fact, two processing plants demand the most of the CAPEX with the WOPOX plant, which processes refractory ore, absorbing most of the cost. Nevertheless, the project holds substantial exploration potential and expanding the reserves are highly likely. The opportunity to explore underground once the declines are operational is absolutely necessary given the results of the current financial evaluation (Roa, 2010).

On the fiscal regime side, the Government of Ecuador would do well in following its neighbour Peru in implementing a windfall tax based on the profitability of the mining operations, not just on the price of the metal. Furthermore, flexibility on the cost-structure of the project should be addressed on the Contract between the miner and the government. Unexpected cost increases and unmet schedules have proved a headache for projects like Oyu Tolgoi and the Mongolian government. Additionally, the Cordillera del Cóndor is a remote area in need of the public infrastructure of a major mining district. With major open pits building not far away from FDN, the government is advised to invest in roads and bridges in order to make the Ecuadorian mining industry competitive. Finally, according to El Beze and Chung (2013), salaries in the mining industry command important premiums over average national salaries. The Ecuadorian government would greatly benefit from relaxing the taxation rules for mining in order to gain a skilled, well-paid labour force.
7. References


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