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How much are benefit-sharing agreements worth to communities affected by mining?

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ABSTRACT

Benefit-sharing agreements (BSAs) determine how resource extraction companies and stakeholder communities share the economic value created by extractive activities. Besides direct financial compensation, BSAs can include preferential access to contracting opportunities for local firms and promises of direct employment for local individuals. Quantifying potential BSA benefits can have practical value for communities entering into BSA negotiations and or monitoring the implementation of agreements. This paper seeks to demonstrate that BSAs can be quantitatively modeled by estimating the expected size of net benefits from two BSAs: the Ahafo gold mine in Ghana, and the Mary River iron ore mine in Nunavut, Canada. We calculate net benefits at the time of the BSA's negotiation by estimating the gains in financial transfers, jobs, and contracting opportunities that accrue to members of the affected communities, relative to a counterfactual of the mining project occurring in the absence of the BSA, and report the relative contribution from each category of benefits. Adding up the net benefits across the three categories, we find that in the Ahafo case the impacted community's discounted benefits from the BSA amount to 1.08% of the estimated life-of-mine revenue and 2.10% in the Mary River case, with the primary contributions coming from jobs and financial transfers respectively.

1. Introduction

Conflicts surrounding mining projects have cost companies and communities human lives, significant time, energy, and money, as well as forgone potential benefits of resource extraction (Davis and Franks, 2014; Özkaynak et al., 2012; Slack, 2009; Weber-Fahr, 2002). To avoid these costs and seek mutual gain, mining companies and mining-affected communities have turned to signing contracts with one another. These agreements, herein referred to as benefit-sharing agreements (BSAs), help to lay out the rights, responsibilities, and governance mechanisms of each of the corporate and community stakeholders of a mining operation. BSAs also determine how resource extraction companies and stakeholder communities share in the economic returns from extractive activities and plan for the mitigation of mining's negative effects (Otto, 2010; O'Faircheallaigh, 2013).

BSAs can help to not only provide financial benefits to communities, but can also protect the cultural heritage of Indigenous groups when negotiations meaningfully address weaknesses in their bargaining power (O'Faircheallaigh, 2008). BSAs may allow communities to supplement sometimes woefully inadequate legislation concerning mining activities and their potential negative externalities (Kamlongera, 2013). BSAs may lock in financial gains to mining firms, as increased stakeholder support leads to higher financial valuation of firms (Henisz et al., 2014). The pursuit of BSAs in the mineral extraction sector comes partly from the idea that in order to proceed with mining operations, companies need a "social license to operate" in order to prevent protests and disruption of mining activities (Prno and Slocombe, 2012). Indeed, firms investing in extractive projects in Canada that sign BSAs are more highly valued by shareholders when the communities have strong property rights protections, experience with legal processes, and a history of protests (Dorobantu and Odziemkowska, 2017).

Even as BSAs have become widely prevalent, most of the promised benefits inside them remain unknown, since most BSAs are confidential documents (Craik et al., 2017). In spite of that practice, a number of BSAs have been made public and are collated on the Columbia Center on Sustainable Investment-curated website opencommunitycontracts.org, so their specific terms are now available. O'Faircheallaigh (2015) notes some agreements, including confidential ones, that have achieved royalty rates for the affected Indigenous community in the 0–3% range. However, BSAs contain more than just financial benefits, and even

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financial benefits tend to have allowable deductions, thus make understanding the true level of benefits a complicated task. This paper seeks to fill that gap by proposing and then executing on a methodology to estimate the net benefits to communities of entering into BSAs.

This paper estimates the expected size of benefits from two publicly available BSAs concerning two different mines: the Newmont Ahafo gold mine in Ghana, and the Baffinland Mary River iron ore mine in Nunavut, Canada. Besides sharing the rare characteristic of having publicly-available BSAs, in many ways the two mine sites could not be more different. The agreements are situated in different legal systems, use different instruments for financial transfer, feature communities with different land use and property rights, and moreover the mines themselves are for different commodities. Our goal in selecting two different BSAs is not to test hypotheses or develop theory (see, e.g. (Mahoney, 2007),), but rather to demonstrate the robust viability of the methodology and to begin to establish data points from its use. In Ahafo, Newmont signed three agreements with the surrounding communities that put forward a multi-stakeholder governing framework, set a minimum local employment target, and established a development foundation funded by contributions from the mine equal to 1% of net profits and $1/oz gold sold. In Mary River, Baffinland and the Qikiqtani Inuit Association (QIA) signed an Inuit Impact and Benefit Agreement (IIBA) that established a governance framework, agreed to a minimum Inuit employment goal, put forward bidding criteria that would favor Indigenous-owned businesses, set land and water use rates, and determined that 1.19% of net revenue be transferred to the QIA.

The paper may have some practical benefit to resource-proximate communities. The methodology put forward in this paper provides a place to start for communities to more meaningfully engage in BSA negotiations and to maximize the expected net benefits from signing an agreement. That is, communities can engage in ex ante modeling of benefits expected from different components of the BSA to inform negotiation strategy as well as to select the indicators and targets for the monitoring and evaluation of promised returns. Moreover, the results from the analysis of the two mines studied in this paper have a practical benefit: knowing the size and types of benefits that communities have received in the past can provide a reference point for the level of benefits that a community might negotiate for from the mining company involved.

Communities may need to make trade-offs between different types of benefits in BSA negotiations. However, the extent to which this happens may be limited to trade offs at the margins. O'Faircheallaigh finds that, in company-Indigenous community negotiated mining BSAs in Australia, agreements with strong provisions in one area tend to be strong in other areas. For instance, strong cultural heritage protections are paired with strong environmental protections, and the reverse is true for weak protections. It appears that the relative bargaining power of the parties, the organizational strength and negotiation experience of organizations that represent Indigenous interests, and the level of Indigenous legal protections determine the strength of all of a BSA's provisions together (O'Faircheallaigh, 2015).

Mineral development agreements (MDAs) perform similar functions to BSAs but are usually negotiated at the national level and perform the function of stabilizing the fiscal and legal environment surrounding mining projects. The corporate mining proponent and the relevant government decide on the rights and responsibilities of both parties, often covering things like environmental and socioeconomic issues resulting from mining, hiring of host country nationals, as well as royalty, tax, and other payments (Natural Resource Governance Institute, 2013). Best practice in negotiating MDAs includes the quantitative modeling of financial returns to mining companies and tax revenues to the host country, as has been the case for over 50 years (Smith and Wells, 1975). We seek to take this approach and apply it to BSA negotiations, while moving beyond those best practices by also incorporating non-fiscal benefits like employment and contracting.

Using a modified discounted cash flow methodology, we model the expected returns to each host community[1] by estimating financial transfers, employment and wages, and contracting profits, taking into account the parameters of the mine and price expectations for the resource at the time of the signing of each BSA. When figures are unavailable, we use estimates from comparable projects or previous studies. As in cost-benefit analysis, we estimate the *net* benefits to the community from signing the BSA by subtracting out any benefits from a plausible counterfactual scenario, which we define more precisely as mining without signing a BSA. To be sure, there are other categories of benefits and costs in BSAs, including environmental and social impact mitigation benefits as well as the opportunity cost of agreeing to specific terms and we do not explicitly estimate those benefits and costs. Readers hoping for a full accounting of the costs and benefits of a mining project to a community will be disappointed–in modeling expected net benefits, we do not need to estimate the most significant costs of a mining project like the environmental impact itself, since the impact would be realized with or without a BSA.

In the next section, we justify the choice of methodology for benefit estimation, noting other possible methods. We then take an inventory of the benefits and costs of the BSAs, identify those we will quantitatively estimate and why, and define the variables we will need to calculate as well as the procedure for modeling the counterfactual scenarios. Our quantification of BSA-derived benefits includes only those easily converted to monetary terms (excluded are incremental benefits to impact mitigation from signing the BSA) and that are explicitly included in each BSA. We model the benefits flowing to each community from royalty payments, direct jobs with the mining company, local preference in subcontracting, and other payments, using a methodology common in cost-benefit analysis but that has not been used in this arena before. Our outcome variable of interest is the ratio of the net present value (NPV) of BSA benefits to the NPV of life-of-mine revenues. One might be interested in using economic rents as the denominator to get a better measure of the community's share of resource rents, but getting an accurate measure of rents is beyond the scope of this work.

In sections three and four, we find that in the Ahafo case the community's expected benefits derived from the BSA amount to 1.08% of the estimated life-of-mine revenue, which is split fairly evenly between employment benefits and financial contributions; contracting was not discussed in the BSA (though Newmont did initiate a "linkages" program with the support of the International Finance Corporation). We find that the same measure in the Mary River case amounts to 2.10% of total life-of-mine revenue, driven primarily by financial contributions followed by employment, with contracting being the smallest of the three benefit streams. Using sensitivity analysis, we compare how the values change with different output prices. We also give a brief overview of the community's experience with BSA implementation, noting in both cases the challenges of achieving promised benefits from local employment and the inaccuracy of initial operational assumptions. Section five contains discussion and conclusions.

2. Estimating community benefits from BSAs

There are a host of different ways to analyze the economic impact of a mining project, including cost-benefit analysis, economic impact analysis, sustainability impact assessment, and multiple account benefit-cost analysis (Gunton et al., 2020). Cost-benefit analysis (CBA), our chosen approach, considers and quantifies in monetary terms the social costs and benefits to those members of a society who have "standing" in the calculation—in our case, the members of the affected community—relative to the status quo (Boardman et al., 2018). With the goal of

[1] Throughout this paper when referring to a relevant community, we mean to speak of those specifically targeted for receipt of benefits by a particular BSA; in these cases, we mean local residents of the towns in the Ahafo mine catchment area, and the Inuit people living in communities near the Mary River mine site.

this paper's estimation to develop capabilities around BSA negotiation and monitoring, we seek to mimic the technique of fiscal modeling used in MDA negotiations, in which the NPV of each fiscal term (e.g., income tax, royalty) can be calculated as a function of different tax/royalty rates, commodity prices, and resource assumptions. We also wish for the estimations of different categories of benefits in the BSA to be comparable to one another. To do this, we need to understand net benefits, i.e. those benefits that are truly created by the agreements rather than just reflected in them. For instance, a local worker might get hired to work for the mine, but is their income truly due to the community having signed a BSA or even to the mining project itself? In the absence of the BSA, the worker might have been hired by the mining company anyhow; in the absence of the mine, they might have been employed in construction. CBA recognizes the opportunity cost of workers or business owners (or even community governments) and factors it into the calculations.

Other ways to analyze economic impact also have value, but we do not choose them for this paper for various reasons. Economic impact analysis estimates the impact on economic growth and other sectors of the economy through input-output multipliers, allowing the analyst to estimate the economic activity, tax revenues, and jobs created (Gunton et al., 2020). A pertinent example is a study of the Ahafo mine, which estimated that the mine generated 0.95% of Ghana's GDP, added US $160 million in taxes, and directly and indirectly supported 41,000 jobs (Kim et al., 2013). For our purposes, however, such a method would be inappropriate as it does not control for the economic situation of the counterfactual, or status quo, which in our case is the precise scenario of a mine in the absence of a BSA. Sustainability impact assessment is more of a practice than a specific technique, and seeks to apply systems thinking, multiple analytical techniques, and participatory approaches to evaluate whether a project achieves "sustainability" (Bond et al., 2012), usually indicated by whether it meets project-specific benchmarks. Multiple account benefit-cost analysis also brings in a variety of tools and approaches, as appropriate, and presents different categories of benefits in a disaggregated way, not assuming that they can be measured in dollar terms and then aggregated; it may report some benefits and costs in physical or qualitative metrics (Shaffer, 2010).

Importantly, CBA can and often does play a role as part of a wider sustainability analysis or multi account benefit-cost analysis (Bond et al., 2012; Shaffer, 2010). Despite the advantages of these techniques, we utilize CBA for this paper because of the complexity in estimating the economic costs and benefits from environmental or social impact mitigation, particularly relevant to the counterfactual of a mining project without a BSA in an environment in which other instruments (like environmental impact assessments) identify impacts and specify mitigation. We are sympathetic to the critiques of CBA that the creation of a single monetary number for the net benefits of a project (or agreement, in this case) should not constitute a sufficient statistic to be able to decide on whether or not to move forward. The analysis in this paper is not meant to supplant such broader efforts at evaluation, particularly evaluation of the broader impact of a mining project, but rather is intended to produce a building block for a comprehensive assessment of community interests served through BSAs.

We estimate the predicted benefits accruing to the affected communities above the counterfactual scenario in which mining proceeds in the absence of a BSA. The first step is to identify the benefits and costs contained in the agreements that will be modeled. Since the agreements are agreed to by the communities there is little in the way of costs in them, other than vague terms about having to work together with the mining company to achieve positive outcomes. As we describe in more detail in the subsequent sections, the two BSAs contain clauses regarding jobs for community members (both), contracting opportunities (Mary River), financial transfers (both), training and education outside of that financed by the financial transfers (Mary River), land and resource access of the mining area (both), and participatory monitoring (both). Besides these benefits or impact mitigation measures, the agreements set up governance structures and monitoring procedures as well as specify how those are financed. We focus on modeling the economic costs and benefits from jobs, contracting, and financial transfers by estimating the contribution to net benefits to the community and its members from the BSA, which means that we subtract the net benefits from the counterfactual of no BSA from the estimation of net benefits with the BSA.

There are several terms which we do not specifically model, which may affect the interpretation of the results. We do not model the gains to the community from education and training, which we interpret as instrumental in achieving the benefits from employment and contracting. We do not model the benefits of participatory monitoring or land and resource access: though they may be significant, they would be hard to quantitatively model, and besides, the vast majority of environmental impact is dealt with outside of the BSA itself. We also do not model any financial transfers in the counterfactual scenario of mining in the absence of a BSA, though the company might spend on so-called corporate social responsibility even in the absence of an agreement. (As it turns out, the companies continue to have these expenditures even with a BSA.) We do not model either the costs or benefits to the community of implementing the BSAs, but at first glance it is not clear which term is larger: many of the financial costs are borne by the company and there is some employment creation and learning as a result of BSA implementation. Because of data limitations, we do not consider multiplier effects; instead, we focus on the direct effects of the BSA.[2] Finally, we do not model the meta-level costs to the community like the opportunity cost of acquiesing to the mining project through signing the BSA, or the meta-level benefits like reduced conflict or improved community planning that may result from the BSA process. With categories of costs and benefits that might lead to each of an underestimation and an overestimation of net benefits excluded from the calculation, the net effect of these omissions on the total level of benefits is impossible to say.

With regards to the estimation itself, the ideal way to perform the quantitative modeling of employment, contracting, and financial benefits flowing to the community from the BSA would be to obtain detailed mine production, hiring, and profitability predictions from a feasibility study (FS) of the mining asset. With this, one could anticipate a time path of the revenue and expenditures of the mine. These reports include geological information on mineral reserves, cost and revenue predictions, future world commodity price predictions, employment level predictions, along with other information that one would need in order to justify the investment (Pelaez, 2017). We have access to the Mary River project FS, and so use the information contained therein, along with reasonable parameter estimates from relevant literature, to construct our estimates of community benefit derived from the Mary River BSA. Our research team was not given access to an Ahafo FS.[3] Due to these data limitations, in the Ahafo case we were required to create a model of mine profitability from the ground up based on reasonable parameter values and assumptions from mining-related academic literature and industry reports, and in consultation with mining professionals.

[2] BSAs may also lead to indirect benefits. An economic impact analysis of the Newmont Ahafo mine estimates the multiplier ratio of the mine to be 2, meaning that for every dollar spent by the mine, 2 dollars of economic activity is generated locally, for example through mine employees spending money on goods and services (Kim et al., 2013). Our benefit estimates for jobs, contracting, and financial transfers are likely lower bounds, due to the existence of multiplier effects increasing total local benefits. Local workers and contractors may be more likely to spend money on local goods and services and invest in local business. Financial payments can be used to finance community public goods, which may have a high rate of economic or social return.

[3] Canadian mining companies are required to make their feasibility study public for each project. They are usually readily available on the mining company's website and/or www.sedar.com. Despite multiple attempts to locate the Ahafo feasibility study, including writing the Vice President of Investor Relations directly, we were unable to access it.

The calculations for each mine are based on information that would have been available to negotiators at the time of the relevant BSA's negotiations. We model benefits from the Ahafo mine in 2008 USD and Mary River in 2013 CAD. Benefits in future years are discounted at the rate of 3.5% (Boardman et al., 2010).

2.1. Calculation of benefits derived from the BSAs

The total benefit *TOTAL* is the discounted (at rate d) sum of the yearly expected benefit relative to the counterfactual of mining with no BSA B_t from the year of BSA signing, $t = 0$, to the end of the mine's life, $t = T$.

$$TOTAL_B = \sum_{t=0}^{T} B_t \Big/ (1+d)^t \tag{1}$$

The expected yearly value of each benefit stream can be decomposed into a set of easily interpretable terms. The following equations, in which the time subscripts are suppressed, are meant to illustrate conceptually our calculations. They could also serve as indicators to be tracked in a monitoring and evaluation program once the BSA is in the implementation phase: each variable plays a different role in determining whether the agreement is living up to the initial expectations. Below we decompose the estimates of community benefits coming from jobs, financial payments, and contracts, as these are the largest categories of benefits that we model in the examined BSAs. The equations defined below describe our estimates of the net yearly level of economic benefits attributable to the relevant BSA.

2.1.1. Jobs estimates

Expectation of economic value from jobs $= E[J]$, Average increase in salary per mining job over non-mining job $= w$, Units of output $= O$, Total mining jobs $= j$, Mining jobs above BAU, going to relevant community $= c$, Total mining jobs per unit of output $= j/O$, Ratio of mining jobs going to local community to total mining jobs created $= c/j$.

$$E[J] = O \times j/O \times c/j \times w \Leftrightarrow E[J] = c \times w \tag{2}$$

In words, the expected benefit from jobs is the mine output, multiplied by the job intensity of the mining, times the additional share of jobs going to the community, times the wage premium. Increasing c or w would increase the benefit to employment from the BSA. As noted earlier, we do not ascribe expenditures on training or capacity-building projects as a benefit to the community if the intention of those programs is to increase the local level of employment, since that would be double-counting benefits–that is, training programs can be seen as an intermediate input in the increased earnings that we do model. This modeling choice does not diminish the importance of capacity building to local workers or firms; indeed, such programs may be required to realize the benefits of the BSA.

2.1.2. Royalties estimates

Expectation of Royalties $= E[R]$, Royalty percentage of profit $= p$, Royalty percentage of sales rate $= s$, Royalty per unit of output $= u$, Revenue per unit of output $= r$, Production cost per unit of output $= c$, Profit per unit of output $= r - c$, Fixed payment $= F$.

$$E[R] = F + p \times O \times (r-c) + s \times O \times r + u \times O \tag{3}$$

In the case of Ahafo, the royalty is driven by p and u, or profit and volume of output, whereas at Mary River, the royalty is a hybrid of p and s, a royalty charged on a base that is partway between sales and profits, plus F or a fixed payment.

2.1.3. Contracting estimates

Expectation of total contracting economic value added (EVA) to the community $= E[S]$, Measure of total expenditures $= TX$, Total expenditures paid to relevant community firms above and beyond BAU $= f$, Percent of total expenditures going to local community of interest firms $= f/TX$, Average total value of a contract $= k$, Average Economic Value Added (Wages and Profits) of a contract $= e$, Average percent of contracts consisting of EVA $= e/k$, Average percent relevant community ownership and workforce participation of relevant community firms (i.e. % local Inuit ownership and workforce of 'local Inuit firms') $= l$. Opportunity cost of community firms $= W$.

$$E[S] = TX \times f/TX \times e/k \times l - W \Leftrightarrow E[S] = f \times e/k \times l - W \tag{4}$$

In words, the benefit to the community from its BSA is equal to the mine expense multiplied by the contracting share of expense, times the share of contract value that is economic value added, times the share of local participation in the contracts, adjusted for their level of business in a situation where mining proceeds in the absence of the BSA.

3. The Ahafo mine analysis

3.1. Ahafo background and context

The Ghanaian mine we analyze is located in the Brong-Ahafo region of Ghana. At the time of the 2010 census, 63% of the labor force in the Ahafo mine districts was employed in agriculture, with just 3% employed in mining (Ghana Statistical Service, 2014a, b). The 10 communities identified as affected by the Ahafo mine project are called the "mine catchment area communities" (The Agreement Forum, 2008c). These ten towns together make up the community in the Ahafo BSA. The size of the community towns ranges from 1600 to 11,000 individuals (Boakye et al., 2018). The Ahafo mine sits on a lease concession of about 137,000 acres located approximately 300 km northwest of Ghana's capital, Accra. The operation consists of 3 open pits and an underground operation. We model the open pit part of the operation, as the underground portion was not developed in 2008. During 2016 the mine produced 349,000 ounces of gold, and the site reported 9.6 million ounces of reserves. The costs applicable to sales for the Ahafo project were on average $655/oz for the first 6 months of 2016, and $743/oz for the same period in 2017. The average all-in sustaining costs for the same two 6-month periods were $888/oz and $934/oz respectively, compared to an average gold price of $1257/oz for 2017 (Newmont, 2017).

Ghanaian mineral rights and the legal framework surrounding mineral extraction are established by the Minerals and Mining Act 2006 (MMA). BSA-derived benefits are not the only possible source of financial transfers and funds for local development. The MMA requires that 10% of all mining royalties paid to the central government be given to the communities affected by mining, irrespective of any BSA.[4] It lays out the requirements for being eligible to acquire mineral rights, the governmental role in and procedures for granting such rights, as well as responsibilities of the government and any mineral extractors (Parliament of the Republic of Ghana, 2006). The Minerals and Mining regulations 2012 (MMR) further established requirements for mineral extraction, local recruitment, and local content in mining (Parliament of the Republic of Ghana, 2012).

Ghanaian law requires mining companies applying for leases to plan for the mitigation of environmental degradation, preferentially employ Ghanaians, and use Ghanaian intermediate products whenever possible. The Minerals Commission, an agency of the Ghanaian federal government, is in charge of enforcing the reporting requirements and implementation of the environmental, employment and procurement plans (Parliament of the Republic of Ghana, 2006; 2012; Columbia Center on

[4] Research has noted that the money has led to limited development due to a lack of transparency in how the money is used, no limitations on what large shares of the money can be spent on, and the fact that much of it is given to powerful individuals who are not required to spend it on community development (Lujala, 2020).

Sustainable Investment, 2014).

In the Ghanaian context, the landowners and community leaders of the mine catchment area do not have veto power over potential projects. The central government's authority over land, particularly the power of eminent domain held by the president, is regularly used to approve mining projects that are seen as advantageous to the central government's finances through taxes and royalty payments, and which are often not tied to local mine community outcomes (Oxfam, 2015). The low level of development unrelated to mining, coupled with relatively low levels of literacy and experience with formal work has prevented many locals and local businesses from taking advantage of economic opportunities (World Business Council for Sustainable Development, 2011).

3.2. The Ahafo BSA documents

We use the term "Ahafo BSA" to refer to three documents called the Ahafo Social Responsibility Forum Agreements. They outline the rights and responsibilities of, as well as the methods of communication and areas of cooperation between, Newmont and the "Chiefs and People of the Ahafo Mine Local Community" (The Agreement Forum, 2008c; The Agreement Forum, 2008a,b).

The Ahafo Social Responsibility Forum, a multi-stakeholder body created in 2006, signed the Ahafo BSA in 2008, creating the Newmont Ahafo Development Foundation (NADEF). The Forum is made up of 3 company representatives, 8 representatives from district and regional government, 20 representatives of the traditional chiefs, 18 representatives from community groups, and two representatives from local NGOs (The Agreement Forum, 2008c). In 2005 Newmont began discussion of mining and its impacts with the chiefs of the communities (Boakye et al., 2018). Through interviews we learned that the main focus of the community negotiators was on direct employment with Newmont. Some members of the community, particularly those in positions of power, were satisfied with the negotiation process. Newmont paid for the services of one lawyer to help all ten communities during negotiations. However, the lawyer is said to have only met one-on-one with the chiefs, and during negotiations mainly provided translation services, without providing advocacy (Boakye et al., 2018).

The Social Responsibility Agreement lays out the overall aims of the BSA as well as creating the institutions that administer the agreement. The employment agreement spells out how local communities should be a preferential source of mine labor, with 35% of all labor coming from the local communities being the initial goal, to be increased to 50% within ten years of the start of mine production (The Agreement Forum, 2008b).

The first two documents are agreements between Newmont and the local mine communities, and the third is between Newmont and NADEF. NADEF is managed by a board of trustees which includes a chairman nominated by the Forum on Newmont's recommendation, four members nominated by Newmont, and four members nominated by the community. In the third agreement, Newmont commits to NADEF 1% of net pretax income, as well as $1 USD per ounce of gold sold (The Agreement Forum, 2008a).

The Ahafo BSA does not require Newmont to use or support local contractors, although the company created a "linkages" program that incentivized the use of local contractors in mining operations and provided support for the development of the local subcontractors. According to the World Business Council for Sustainable Development, the linkages program did increase the level of local content used in Newmont's operations (World Business Council for Sustainable Development, 2011).

3.3. Ahafo modeling assumptions

We assume a 20-year mine life, as that is what the International Finance Corporation, a financier, expected in 2006 (Engineering and Mining Journal, 2006). A production rate of 500,000 oz/year is used based on the site's plant capacity and Newmont's predictions (Mitchell and Jorgensen, 2007; Newmont, 2009). The level of employment is based on the 2005 ratio of production-to-employment for a similar operation: the Obuasi gold mine, approximately 150 km southwest of the Ahafo mine (Roe and Samuel, 2007).

The $492/oz total production cost comes from Newmont's 2007 annual report (Newmont, 2008b). The mine's revenue is 500,000 oz/year multiplied by the expected world gold price. Since we model the future payments in real terms (2008 dollars), we do not adjust either the price or the cost up; our basic assumption is that the net profit will increase at the rate of inflation. As a reality check, gold price data from Bloomberg include a predicted price per ounce of gold for 2008–2011; the price's average growth rate for this period (2.8%) is close enough to the inflation rate that we use a constant price assumption. The standard deviation of yearly gold prices for 30 years from 1978 to 2008 ($261.21 2008 USD) was calculated from World Gold Council data (World Gold Council, 2017). This is used to create a 2 standard deviation-wide band centered around our gold price predictions, providing us with low, medium and high gold price estimates for sensitivity analysis.

Each direct job with Newmont is assumed to provide $2400 per year, 3.5 times the official minimum wage, as this is the average ratio in lower-middle income countries for similar mining projects (World Business Council for Sustainable Development, 2011; Ghana Statistical Service, 2008; Roe and Samuel, 2007; World Gold Council, 2015). The outside option level of income is calculated as the 2005 mean of per capita income in the Brong-Ahafo region as reported by the Ghana Living Standards Survey, scaled up to its 2008 level by Ghana's GDP per capita growth from 2005 to 2007; the 2008 figure comes to $466.75/year (Ghana Statistical Service, 2008; The World Bank, 2017). Each income level is assumed to increase by the average real World Bank GDP/capita growth rate for Ghana from 1997 to 2007.

The BAU proportion of Ahafo mining jobs going to local community members is assumed to be 25% based on a 2008 environmental impact statement for a Newmont Ahafo mine expansion (Newmont, 2008a). The percentage of jobs going to locals attributable to the BSA is set at 35% for 9 years after 2006, and increases to 50% in 2016 (The Agreement Forum, 2008b).

We model the potential size of local procurement to get an idea about how much a realistic provision could have increased the level of total community benefits. In general, detailed local content expenditure data are unavailable. Our industry contacts informed us that BSAs usually target expenditures on services, including energy purchases. This is due to the limited capacity of most mine host communities to provide other types of mining inputs.

According to one industry contact, in a developing country, services typically make up 20%–25% of a large mine's total expenditures, and the local content expenditure target is usually set at 5%–10% of the services expenditures. This leaves us with a proportion of total expenditures going to local sources ranging from 1% to 2.5%. These targets are typically set at 3 times the expected BAU level of local procurement. We use the range of BAU (0.3%–0.833% of total expenditures) and BSA-induced (1%–2.5% of total expenditures) local procurement estimates. The actual benefits are the level of profits and wages or "economic value added" (EVA) of contracts. We scale the estimates of contractor income by 0.536 based on the Ghana Industrial Census Brong-Ahafo manufacturing firm EVA (Ghana Statistical Service, 2006). We assume that local firms are 100% owned and staffed by locals, consistent with our interviews. We also scale the value of contracts by the ratio of the difference between BAU and BSA jobs income to the BSA jobs income to account for the opportunity cost of the contractors.

Mine profits are calculated as the 500,000 oz/year production multiplied by the predicted difference between the world gold price and the mine's cost per ounce. Royalty payments to NADEF are thus $500,000 plus 1% of estimated profits in each year.

3.4. Ahafo results

Community benefits in the Ahafo case are reported in Table 1. The total discounted life-of-mine community BSA benefit is estimated to be between $59-$92 million, measured in 2008 USD. Total benefits from the jobs category amount to $42 million and payments to NADEF range from $17-$50 million, depending on the price of gold. Estimates of possible contracting benefits range from $12-$28 m, depending on the level of local participation achieved. The benefits as a fraction of life-of-mine revenues is 1.08% and could rise to 1.44% when including local contracting at the highest estimated level, for the base gold price scenario. The table reports this percentage for each of the benefit flows, using the base gold price revenues as the denominator. The direction of the results aligns with expectations. Given that the NADEF payments are profit-based, the share going to the Ahafo communities rises with the price of gold. Yet the ratio of the NPV of total benefits to the NPV of total revenue, once jobs are included, falls with gold price since the community is getting employment irrespective of the profitability of the mine (assuming production levels are not changed).

Fig. 1 graphically shows the discounted path of estimated benefits, based on base gold price predictions, as well as the range of reasonable estimates of potential benefits from contracting.

3.5. What has happened in Ahafo?

The Ahafo BSA's local employment target, which started out at 35% and was supposed to increase to 50%, was never met. This was reflected when the Ahafo agreement was re-negotiated in 2014 and the target was lowered to 24% with the hope that it could be raised to 35% by 2016 (The Agreement Forum, 2014). This has led community members to express disappointment with the employment situation (Boakye et al., 2018). Our model predicts that NADEF would receive $24 m in royalty contributions from 2008 to 2016. This is only a slight over-estimation, as NADEF annual reports indicate $23 m in contributions over the same period, though the gold price that resulted was more than $200 per once higher than forecast.[5] Our overestimation of royalties was driven by a higher realized cost per ounce to extract the gold. The opportunities for local firms to fulfill contracts are estimated to be quite significant, however we are unable to find reliable data on the actual amount of contracting which has gone to local firms. Anecdotally, we observed many local firms participating in lower-end, labor-intensive parts of the value chain like land reclamation. Finally, conflict has not disappeared as a result of the signed BSA. In 2017, youth demonstrated against Newmont, citing a failure to deliver local jobs and contracts and to protect the environment (Boakye et al., 2018).

Table 1
NPV of Newmont Ahafo BSA benefits in 2008 USD (% of total discounted life of mine revenue).

Increase in local benefit due to:	
Jobs ($E[J]$)	
$42 million (0.60%)	Based on 500,000 oz/year
Payments to NADEF ($E[R]$)	
$17 million (0.34%)	LOW gold price
$34 million (0.48%)	MED gold price
$50 million (0.55%)	HIGH gold price
Total BSA Benefits ($E[J] + E[R]$)	
$59 million (1.18%)	LOW gold price
$76 million (1.08%)	MED gold price
$92 million (1.02%)	HIGH gold price
Local Contracting ($E[S]$)	
$12 million (0.15%)	1% of TX goes to local firms
$28 million (0.36%)	2.5% of TX goes to local firms

[5] We consulted NADEF annual reports from 2009 to 2016.

4. Mary River mine analysis

4.1. Mary River background and context

The second BSA case we analyze is the Inuit impact and benefit agreement (IIBA, in our nomenclature a type of BSA) pertaining to Baffinland Iron Mining Corporation's (BIMC) Mary River iron mine. The mine includes an open-pit, a port on Milne Inlet to the north and a Milne Inlet tote road connecting the mine to the port. Using this production chain, Baffinland mined 3.2 million tons of iron ore in 2016 (Baffinland Iron Mine Corporation, 2017a, b). The BSA was negotiated based on an earlier plan to build a railway from the mine site to a southern port, with an annual production rate of 18 million tons of ore (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013). In this case we have access to much more detailed reports concerning the mine including a detailed feasibility study.

The Mary River project contains at least nine high-grade iron ore deposits, with mining currently taking place at deposit number one. The ore being removed from the currently producing pit is very high grade, averaging 67 percent iron content (Mining Technology, 2017). The mine is located in the remote Qikiqtani region of the Canadian province of Nunavut, on the northern part of Baffin Island. The island is traditionally used for harvesting wildlife including whales, walruses, seals, polar bears, ducks, and other birds (Indigenous and Northern Affairs Canada, 2012). Due to the remoteness and frigid temperatures, there are relatively few non-mining uses for the land. The entire population of the territory is around 39,000 people, with about 11,000 living on Baffin island, mostly in the capital, Iqaluit (Nunavut Bureau of Statistics, 2017). The unemployment rate in Nunavut is generally higher than in the rest of Canada at around 15% in 2017 (Statistics Canada, 2017a). The closest communities to the mine site are at least 100 km away over rough and undeveloped terrain.

Canadian law explicitly requires consultation with Indigenous communities in a meaningful way before carrying out resource exploration or extraction on their lands. This has lead to the creation and implementation of hundreds of impact and benefit, socio-economic, exploration, participation, cooperation and other types of resource extraction agreements in place throughout the country between companies, Indigenous people groups, and the various levels of Canadian government (Natural Resources Canada, 2013, 2017). These BSA-type documents and their negotiations are almost always confidential (Gaul, 2012; Coppes, 2016).

Nunavut contains about 350,000 km^2 of Inuit-owned lands. In the case of Mary River, the land immediately adjacent to the mine site is Inuit owned (Aker Kvaerner, 2008). The Nunavut Land Claims Agreement of 1993 mandates that any organization proposing a major development project on Inuit land must sign an IIBA with the relevant designated Inuit organization, which, for the Qikiqtani region, is the Qikiqtani Inuit Association (QIA). The organization represents almost 15,000 Inuit people spread throughout 13 communities in the Qikiqtani region (Qikiqtani Inuit Association, 2017b). Revenues from the mine provide an opportunity for advancing the development agendas of the QIA communities, which generally lag behind the rest of Canada in terms of indicators such as education rates and per capita income levels (Qikiqtani Inuit Association, 2017b).

4.2. Mary River BSA document

The Mary River BSA sets minimum targets for Inuit employment and establishes preferential contracting practices with local Inuit-owned businesses. It also funds the QIA's implementation of the agreement, creates positions for those responsible for managing, monitoring, and implementing the agreement, and requires that some portion of mine profits be devoted to scholarship programs for youth. It suggests that

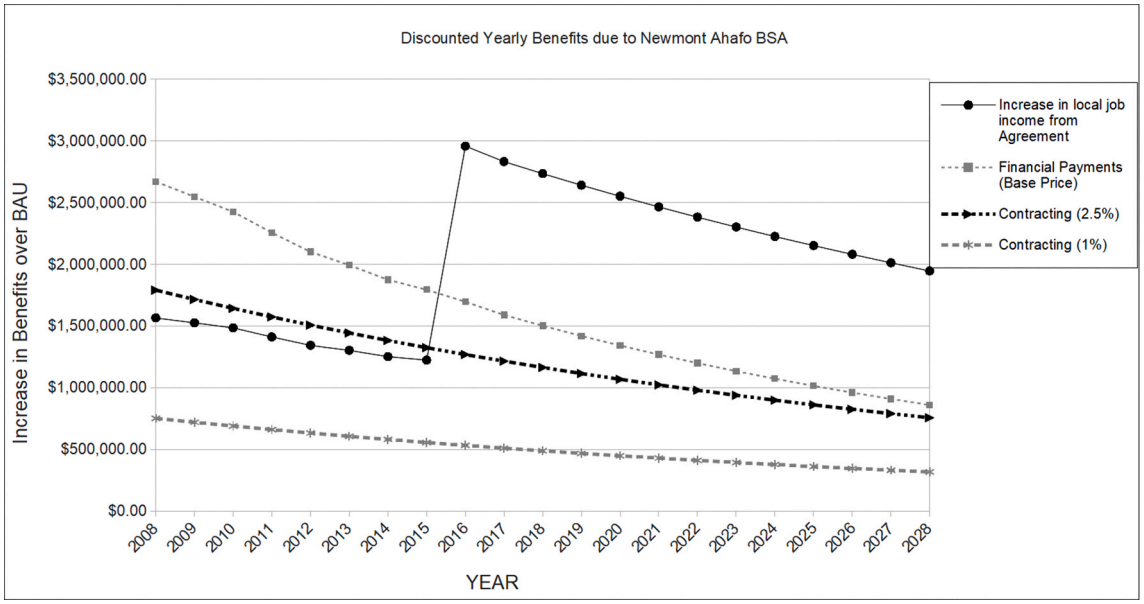

Fig. 1. Yearly Ahafo BSA benefits (2008 USD).

improvements can be realized through shipping opportunities and employment, maintaining certain workplace conditions, Inuit engagement in the mining project, and monitoring/mitigation of environmental degradation (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013). The agreement was signed by the two parties on September 6th, 2013.

The BSA creates an executive committee made up of 3 BIMC and 3 QIA representatives, which implements the agreement. The executive committee estimates yearly workforce requirements and Inuit availability to fill positions. It also establishes the minimum Inuit employment goal, a ratio of Inuit person-hours to total person-hours involved in the mining operation, and determines whether it has been met and how it will be met in the future. The agreement also establishes a management committee made up of 4 BIMC and 4 QIA representatives, which is in charge of monitoring the operation and managing the mining project in relation to implementing the BSA (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013).

The most easily quantifiable benefits are royalty and other payments by Baffinland, Inuit preference for employment, and preference for hiring Inuit-owned firms as contractors. Baffinland is required to make advance payments in the pre-production phases and royalty payments on iron produced during the mine life (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013). Royalties are 1.19% of the net sales revenue. The QIA is only responsible for the cost of BSA implementation in years where BIMC pays royalties. The maximum implementation costs that the QIA is responsible for is 10% of its yearly royalty payments.

The agreement provides for a category of payments we refer to as "other" financial payments, which includes:

- A business capacity and start-up fund into which BIMC pays $250,000 per year until commercial production begins,
- The Ilagiiktunut Nunalinnullu Pivalliajutisait Kiinaujat (community capacity building) Fund, for which BIMC matches QIA contributions up to $375,000 per year for the first six years that the BSA is in effect, with BIMC increasing its payments by 30% for the first three years to cover the fund's administrative costs,
- An education and training fund to which BIMC contributes $1,000,000 in each of the first two years of the agreement, and a minimum of $25,000 per year thereafter,
- A wildlife compensation fund with an initial contribution of $750,000 from BIMC which is optionally re-funded after its value dips below $50,000 (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013).

In addition to the publicly-available BSA, three additional agreements were signed, covering land rental, sand and gravel fees, and water compensation respectively.

4.3. *Mary River modeling assumptions*

We have ready-made estimates of yearly output, costs, revenues, and profitability in the Mary River feasibility study (Aker Kvaerner, 2008). The Mary River BSA was signed in 2013 and we assume production starts in 2016 to account for the feasibility study's 3-year lag until production.

The negotiators initially left the minimum Inuit employment goal out, to be negotiated separately. In QIA's 2015–2016 annual report, the goal is set at 25% (Qikiqtani Inuit Association, 2016a). We use this as our estimate of the BSA-induced Inuit employment level for Mary River, and assume that this figure represents three times the BAU level of Inuit employment (8.33%).

We assume that those employed by the mine would otherwise earn the median reported income in the five hamlets in North Baffin, Nunavut. The median of those five communities for 2013 is $21,864 per year, and we multiply it by real wage growth in Nunavut (1.12%), which we calculate by subtracting the Iqaluit consumer price index growth from the Nunavut average weekly earnings growth for 2004–2013 as accessed through the Nunavut Bureau of Statistics. The salary going to Inuit workers at the Mary River mine is assumed to be $71,936 per year, based on the average 2011 salary for Nunavut-based employees of the Agnico-Eagle mining company, scaled up by Nunavut's nominal wage growth from 2011 to 2013 (George, 2011; Nunavut Bureau of Statistics, 2017). The number of employees during the operating phase of the mine, 629, comes from the feasibility study (Aker Kvaerner, 2008). For the more costly start-up stage, manpower is not directly specified. The feasibility study tells us the amount of labor expenditure and total expenditure, and we divide this to get a share of capital expenditure (CAPEX) that goes into labor. Then, for each year of capital expenses, we multiply that share by the estimated CAPEX, and divide by the average salary in the operating estimates to get a number of expected jobs. That estimate

peaks the year before first production (which we assign to 2015) at 1696 workers. These numbers are not far from the reported 800 people working at the smaller, but expanding, mine in 2017 (Bell, 2017).

With respect to calculating the financial value of the 1.19% royalty, we subtract the shipping costs and other permissable deductions from total revenue and multiply that by the royalty rate. Unlike in gold mining, transportation of the iron ore from the mine's port to the buyer is a fairly significant share of the costs, representing close to 30% of total revenue, and it can be seen as a significant share of the value chain. Later, when we calculate community benefits as a share of mining revenue we also exclude shipping costs from the total revenue figure. With respect to QIA's responsibility to contribute towards the implementation budget, we do not subtract out this cost from our benefit calculations but, to be conservative, nor do we add benefits from the reimbursed expenses even though it might be leading to public goods provision and additional salary payments.

We then add the other payments detailed in the previous section. While we do not know the terms of the rental and compensation agreements outside the BSA, the QIA's annual reports list the revenue from land leases, including an expected budget from the Mary River mine. In 2016–17 the estimate was $3.1 million (Qikiqtani Inuit Association, 2016a) and in 2017–18 the estimate was $3.2 million (Qikiqtani Inuit Association, 2017a), though the actual amount received that year was $3.4 million (Qikiqtani Inuit Association, 2018). We conservatively estimate that QIA will receive an annual lease payment of $3 million in 2013 dollars. According to the BSA, all advance and extension payments are calculated with the initial payment year 2013 as the base year, and each payment thereafter is adjusted annually for yearly inflation in the city of Iqaluit (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013). For modeling purposes, we just keep them unadjusted in 2013 dollars.

We review literature concerning another northern Canadian mine that is party to a BSA, the Diavik diamond mine, to inform our estimates of the local content percentage that Inuit BSA negotiators could have realistically expected. We then use the 3-to-1 rule of thumb for BSA improvements to establish local procurement BAU levels. The Diavik average proportion of total expenditures (TX) going to Indigenous firms is 34% over the 11 year period, which is the figure we use in the Mary River benefit modeling (Rio Tinto, 2014). The Diavik BSA also gives us a categorical breakdown of the types of contracts and the proportion of spending devoted to each category. We assume that the Mary River procurement follows the same pattern when calculating the EVA attributable to procurement. To end up at an estimate of the procurement EVA we follow the calculation laid out in equation four.

For the "outsourced labor" half of local Inuit procurement we assume that of contracts for laborers, 10% of the contract value is profits to local Inuit business owners and 90% is wages paid to employees (counted in our jobs estimates) so we assume that the outsourced labor contracts have a relevant EVA of 10%. For the remainder of the contract category types, we use the average Canadian manufacturing EVA of 35% (Statistics Canada, 2017b). We scale procurement EVA by 51%, based on the minimum level of Inuit ownership needed to qualify as an Inuit firm (Qikiqtani Inuit Association and Baffinland Iron Mine Corporation, 2013). This results in Inuit firm procurement equal to 3.9% of TX. Once again, we use the 3-to-1 rule for establishing a BAU scenario, giving us a counterfactual level of Inuit procurement of 1.3% of TX. As in Ahafo, we scale the value of contracts by the ratio of the mining jobs benefit (over the mining employee's outside option) to the value of mining jobs in order to account for the opportunity cost of contractors.

4.4. Mary River results

We report the Mary River results in Table 2. The discounted values of the jobs, royalties, other payments, and contracting categories are estimated to be $122 m, $212 m, $56 m, and $32 m respectively, using the base price estimate. This leaves us with total community benefits of $422 million for the life of the mine. We estimate the ratio of total benefits to life-of-mine revenues, net of shipping costs, to be 2.10%. Given that the royalty is based on sales rather than profits, we do not see a significant change in the community's share of revenues when prices rise or fall, however the overall share correlates inversely to ore prices given that employment and contract opportunities are not sensitive to prices or profits in our simplified model.

Table 2
NPV of Baffinland Mary River BSA benefits in 2016 CAD (% of total discounted life-of-mine production revenue).

Increase in local benefit due to:	
Jobs ($E[J]$)	
$122 million (0.61%)	
Royalty Payments to QIA ($E[R]$)	
$119 million (1.06%)	LOW ore price
$212 million (1.06%)	MED ore price
$307 million (1.06%)	HIGH ore price
Other Financial Payments to QIA ($OTHER$)	
$56 million (0.28%)	
Local Contracting ($E[S]$)	
$32 million (0.16%)	3.9% of TX goes to local Inuit firms
Total BSA Benefits ($E[J] + E[R] + E[S] + OTHER$)	
$329 million (2.93%)	LOW ore price
$422 million (2.10%)	MED ore price
$517 million (1.79%)	HIGH ore price

Fig. 2 graphically shows our estimates of yearly discounted community benefits. There is a hump in the benefits from subcontracting and jobs that coincides with the capital expenditure stage, and an initial spike in royalties from the up-front payments guaranteed in the agreement.

4.5. What has happened in Mary River?

Following the signing of the BSA in 2013, Baffinland went forward with a scaled-down plan to utilize the tote road through to the northern port, and mine just 3.2 million tons per year. Iron ore prices had fallen by more than half in the two years following the signing of the agreement, leading the company to choose a production plan that required less capital up front. Meanwhile, the QIA built up its capacity to manage the implementation of the BSA, including putting together a revenue management strategy that set up a "legacy fund" and a rule, intended to preserve the organization's revenue from exhaustible resources for future generations, that just 4% of the principal be spent on programs (Qikiqtani Inuit Association, 2016b). As of October 2018, the fund held $42 million (Edgar, 2018).

Baffinland and the contractors did not meet the employment target of 25%; by 2017 the proportion of employment going to Inuit workers was only 13% (Brown, 2018). In 2018, alongside a proposed expansion of the mine output to 6 million tons per year, the BSA was renegotiated. In the new agreement, Baffinland committed to certain levels of expenditures on its own side to meet the employment goals through Inuit training, work readiness programs, recruiting, and career planning (Brown, 2018).

5. Discussion and conclusion

Using cost benefit analysis methodology to estimate the net impact for a community of entering into a benefit-sharing agreement, we quantitatively model the expected benefits in two demonstrative case studies. In so doing, we attempt to bring a similar level of quantitative rigor that has characterized the fiscal modeling of mineral development agreements or production-sharing agreements signed between natural resource companies and national governments for many decades (Smith and Wells, 1975). Of course, it is unknown whether these two cases are representative of the confidential agreements that are more typical of

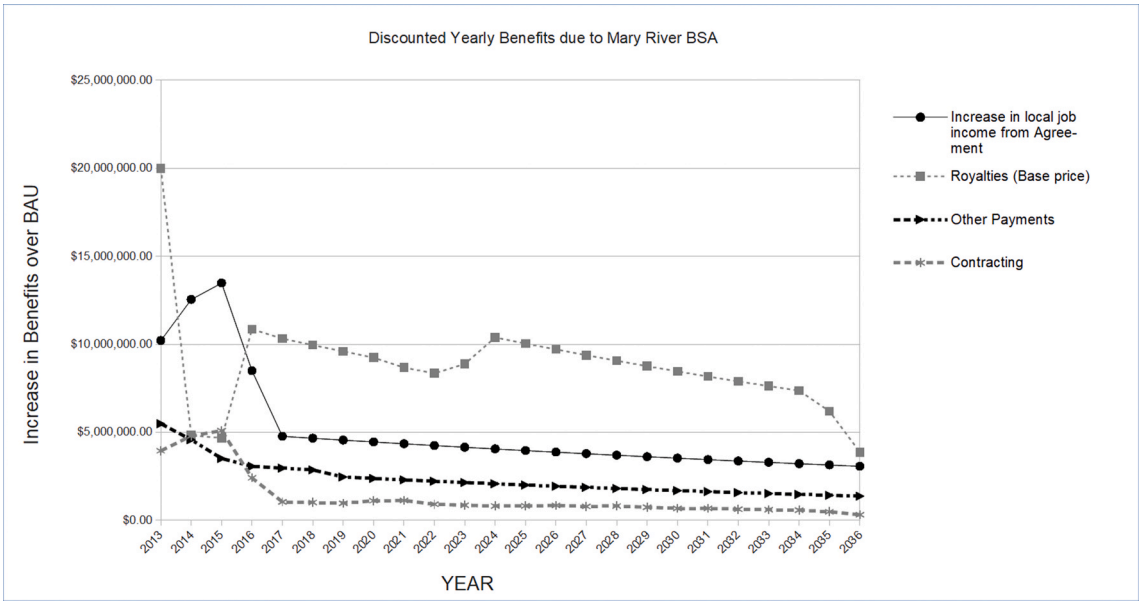

Fig. 2. Yearly Mary River BSA benefits (2016 CAD).

BSAs, yet with the text of their agreements public, they nonetheless serve as a sort of benchmark to communities negotiating BSAs. The estimated total benefits from signing the Ahafo and Mary River BSAs are 1.08% and 2.10% of estimated life-of-mine revenues respectively. To our knowledge, these are the first attempts to quantitatively model the level of benefits promised to a community through a BSA.

Through their comprehensive nature, modern BSAs promise a suite of benefits with differing yardsticks and tactics to ensure benefit delivery across each BSA. One valuable contribution of our analysis is insight into the fact that expected outcomes such as local community development or employment can differ substantially from lofty goals set out in the relevant BSA. This is important for BSA negotiators to keep in mind when negotiating over particular parameters like a royalty rate or local employment share. By quantifying the expected benefits from each of financial transfers, jobs, and contracting, the exercise allows us to estimate the relative expected contribution of each for the two mine sites. Using our base estimate for the price of gold, we find the largest benefit in the Ahafo case to be jobs for locals. In the Mary River case, the largest benefit in the base iron price scenario is estimated to be that from financial payments—mostly royalty and land rent—with the benefit from contracting falling behind jobs. The exercise has value to the wider ambition in mining and sustainability to begin to value non-fiscal benefits so that they can be understood alongside the more easily-quantified tax revenues (Woodroffe and Grice, 2019).

Undertaking sensitivity analyses of expected benefits can yield additional insights, and this paper modeled sensitivity to price assumptions. Comparing across the two mines, we note that the share of benefits coming from the financial contributions in Ahafo are increasing faster in the price of the commodity compared to Mary River. The profit-based royalty in Ahafo means the community shares more in the upside, whereas the revenue-based royalty in Mary River combined with up-front payments and land rental means that the community is more protected if the project does not progress, or if prices are low.

We note that this modeling exercise has a number of important limitations. One, it has only quantified three of the benefit streams (financial payments, jobs created, and contracting opportunities) and none of the environmental or social impact mitigation measures, however modest they may be inside the BSA itself. This could unintentionally elevate their importance above other goals like environmental or cultural protection. Our view is that some harder-to-quantify benefit streams (or impact mitigation measures) might be more meaningfully considered outside of a formal quantification, such as through a more comprehensive sustainability analysis or multiple account benefit-cost analysis. Related, by calculating each category of benefits in dollar terms, it is easy to add the expected benefits together to come up with a single number, yet that risks oversimplifying what might be more or less valuable types of benefits from the perspective of the community. In one community in need of public good investment, financial transfers might have the highest value, whereas in another with high unemployment and reliant on government transfers, worker income could trump cash. Reporting each category of estimated benefits separately would allow community members and leaders to have an informed conversation on their relative importance.

Two, the exercise is based on the relative value of the BSA to no BSA, but does not tackle the value of a project going forward relative to not going forward. This is a subtle difference, and community leaders and negotiators need to pay attention to both concepts (to the extent they have control over the latter) while being clear what the exercise can and cannot do. Three, it is based on forward projections which by definition can only be estimated. Whereas investment decisions are disciplined by the threat of financial loss, negotiation outcomes in a BSA might face less accountability, particularly if the agreement is confidential. Thus if this exercise is done in a practical situation, it would need appropriate oversight and informed debate, lest benefits be overstated for political purposes. Four, we do not model the different costs to the firm of providing each BSA-mandated benefit stream, which can make it seem like they are all equivalently costly for firms. However, one can imagine that it might be less costly for firms to provide benefits from direct employment to local communities than paying the equivalent directly to the community (Gunton, 2020).

A fifth limitation is that different market conditions and implementation efforts may result in wildly different realizations of benefits. This limitation can be mitigated with scenario analysis and monitoring, but it may be hard ex ante to model all the different scenarios. As we found when looking at the initial implementation record of the two mines, it has been higher expected costs (in Ahafo) and lower-than-expected performance in meeting local employment goals (in both mines) that have led to underperformance against the expected outcomes. Another limitation of our research is that we do not model any costs of signing a BSA, as we note in section 2. There could be time costs as well as governance and administration costs associated with abiding by a BSA, as well as the potential cost of reducing the ability of

communities to try to stop the project. Further, we are unable to determine the distribution of BSA benefits, particularly ex ante. However, we are able to measure the shares going to workers, contractors, governments, and development funds.

With all of these limitations, and with a methodology sufficiently complex that no two analysts modeling the same project would come up with the exact same figure, one might wonder whether quantitatively modeling the benefits promised in a BSA is a waste of time. Yet the total estimated, discounted benefits measured for these two mines run into the tens and hundreds of millions of dollars. Investing a small amount in order to generate informed decision making is probably a good idea in many cases. Estimates can be used to set expectations of community members whose lives might be upended by a proximate resource investment. The level of benefits may appear substantial in the case of Ahafo and Mary River, however we wish to put them in perspective. In the Ahafo case, the population of the 10 mine catchment towns according to the 2010 census, 48,504 people, would receive a total life of mine benefit of about $1500 USD per capita in net present value (Ghana Statistical Service, 2014b, a). In the Mary River case, the 15,000 Inuit represented by the QIA would only see about $28,000 CAD per capita (Statistics Canada, 2017c). While these figures are significant, they are hardly transformational.

This exercise has policy implications for negotiations, monitoring, and implementation. On the negotiation side, communities may not end up with their full wish list, particularly on marginal projects or those occurring during weak periods in the commodity price cycle. Reasonable estimates of the value of BSA provisions will allow negotiators to make informed decisions about fighting for certain provisions over others. For monitoring, the explicit breakdown of our valuation calculation equations in section two can provide community leaders an idea of which parameters in their BSAs to pay attention to. Having numerical expectations to reference would also make the process of monitoring BSA performance more straightforward as the benefits observed could be compared to the community's expectations. Regarding implementation, having estimates of the level of benefits each year can help to shape reasonable expectations of BSA and company performance. This could lead to lower levels of conflict between the parties to a BSA.

Author statement

Adebayo: Conceptualization, Methodology, Formal analysis, Investigation, Writing.

Werker: Conceptualization, Methodology, Formal analysis, Investigation, Writing.

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Declaration of competing interest

None.

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