The authentic Bee-Coin: A tokenized financial instrument for revenue-generating projects with social or environmental impact

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Abstract This paper proposes an innovative financial instrument to fund projects that combine profit-making with significant social or environmental goals, specially in emerging or low-income economies. The proposal is based on improvements to the typical impact bond model with the aim of better aligning the parties' incentives, and also making it more transparent, traceable and compatible with revenue-generating projects. It is applied to a pilot project to fund the establishment of a robust supply chain of green propolis in Minas Gerais, Brazil. Propolis is a natural product with benefits for human health, which has been consumed by humans for decades and raised substantial global interest after the Covid-19 pandemic. This project addresses some industry issues (in terms of product quality and supply stability) and aims to provide biodiversity recovery, subsistence farming and resocialization through work. A financial model with stochastic variables is simulated, incorporating a reward system based on the impact outcomes. The results confirm that the instrument improves risk-return trade-off and advocate for its use in projects with sustainability objectives.

Keywords: Impact bonds; Green propolis; Sustainable finance; Resocialization; Biodiversity; Subsistence farming; Tokenization.
JEL Code: Q01, O13, O16, Q57.

1. Introduction

Impact bonds are contracts based on outcomes, in which private funding from investors is used to cover the upfront capital required for a provider to deliver a social or environmental service (Agusti Strid et al., 2021). If predicted outcomes are achieved, a bond guarantor (typically a government entity or a philanthropic or multilateral organization) repays the investor's capital. Impact bonds have gained prominence and been increasingly adopted in

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several countries. However, some limitations hinder its adoption, such as possible misalignment of incentives and undesirable risk-return profile (Saenz, 2022). Moreover, the projects that are funded typically do not generate revenue, at least not enough to cover the costs to achieve the social or environmental outcomes. This paper describes a financial instrument to fund revenue-generating projects with features adapted from the impact bonds framework. It also presents the financial implications of the use of this instrument in a real case that involves beekeeping and vegetation cover restoration in the Brazilian cerrado (savanna) biome.

Pay for success mechanisms are used to foster structural changes in how social policies or environmental projects are developed. Enthusiasts of impact bonds highlight that they increase the focus of public policies on results, shifting the orientation from activities to outcomes. Studies show that these instruments can overcome perennial government challenges, such as the fragmentation of public services, a short-term political and financial focus and lack of collaboration and innovation (Agusti Strid et al., 2021; Dowling, 2017). Azemati et al. (2013) point that impact bonds help overcome barriers such as political constraints that prevents governments from investing in prevention, inability of non-profits to access capital and limited capacity to raise evidence about what works.

According to Carter et al. (2018), while traditional service deliver results in siloed budgets or redundant assignments, impact bonds focus on mutually dependent or aligned outcomes, which determine payment and hence foster the coordination of a variety of commissioners across different units and levels of government. Moreover, resources are traditionally directed to crisis-point situations and costly remedial services, resulting in short-term orientation and reactive services. Social impact bonds (SIBs), on the other hand, are based on invest-to-save and upstream interventions, funding preventative measures that decrease the need on further remedial services when the outcomes are achieved. SIBs also foster innovation, in terms of performance management and choice of intervention or provider, by transferring financial risk from commissioners and service providers to investors.

While potentially beneficial, impact bonds can be complex and expensive to design and require reliable data and stable regulatory environment (Acevedo and Live, 2016). Agusti Strid et al. (2021) point that the high complexity and costs arise from the need to bring together several different participants with distinct incentives and that may not be familiar with the technical aspects of the arrangement, such as results measurement and pricing of outcomes. Moreover, they require a high level of commitment and capacity but, at the same time, the amount involved in the contract may not be large enough

to break even those costs or to arouse market interest. Since performance defines payments, its evaluation requires a robust and rigorous methodology and available data, with treatment and control samples, to be reliable. Stable political and economic environment is also determinant, since SIBs take time to design and implement, therefore institutional or macroeconomic turmoil affect SIB continuity and the willingness to pay for outcomes.

Impact projects in developing economies, even the ones that are expected to generate revenue, typically have challenges that limit the access to capital from private investors, specially in moments of higher risk aversion (Bartzokas, 2022). Political and institutional instability, inflation, liquidity, currency or technological risk, lack of skilled labor or of law enforcement affect investment inflows (Asiedu, 2006). Even with higher expected returns and positive sustainability impact, projects in developing economies typically struggle to access capital from private investors worldwide (Diamonte et al., 1996). Risk-averse investors are reluctant to invest in bold projects and prefer allocate in highest-income countries and/or in low yield fixed-income assets (Bartzokas, 2022; Schlumpf, 2017).

Financial innovations have a key role in the development of instruments to make those opportunities more attractive or more compatible with investors expectations or preferences. There is also positive feedback, since the availability of capital and the development of financial markets decisively influence the way in which new technologies are created and projects are structured. Considering this context, we propose the creation of a mechanism similar to impact bonds to revenue-generating projects with relevant impact potential in developing economies. The goal is to improve the risk and return trade-off of those projects to investors, in a way that they can profit from operational performance as well as from the achievement of social or environmental impact. The reward for impact, granted by the outcome payer (or a bond guarantor), benefits not only financial investors, but other relevant stakeholders that commit upfront capital to the project (land owners and large customers) or that provide services to the project (beekeepers and farmers). This aligns incentives and improves the liquidity of the security that represents the ownership of these impact award rights.

This paper addresses the problem of lack of capital to projects that combine profitability with sustainable outcomes in developing economies. It attempts to answer whether an adapted structure of impact bonds can be useful to funding those initiatives and better aligning stakeholders' incentives. It adds to the field by proposing an innovative financial instrument to increase private funding likelihood of projects in developing countries. Such instruments aim at the development of the capital markets and the global financial

system by providing new means for encouraging private funding for impact investing, leading to a more sustainable economy and ultimately mitigating harmful effects of climate change. It also contributes to a more socially responsible society, since the proposal covers aspects such as inclusion and employability. This security is in line with other less granular innovations such as the green and sustainable bonds, a market that has already reached more than one trillion dollars (Sartzetakis, 2021), despite a still low presence in Latin America or emerging economies in general.

This study relates to the strand of the literature about financial innovations aimed at preserving the environment or improving social welfare (Bhutta et al., 2022; Maltais and Nykvist, 2020). They contribute to aligning the objectives of firms and economies towards a more sustainable growth path (AlAhbabi and Nobanee, 2020; Park, 2019). Such innovations help close the spending gap of approximately USD 1 trillion annually, in low- and middle-income countries, necessary to achieve the 17 Sustainable Development Goals defined by world leaders (Anderson et al., 2022; Colglazier, 2015; Kharas and McArthur, 2019).

Some innovative mechanisms have been developed and applied to contribute to higher capital allocation in projects oriented to sustainability goals. Besides green and sustainability bonds, impact bonds are an interesting instrument to provide more effectiveness to public policies. The Rhino Bond is an impact bond (specifically a wildlife conservation bond) with the goal to protect and increase black rhino populations in South Africa (Endsor et al., 2020). Social impact bonds are also very common in projects to improve public education or health outcomes (Fraser et al., 2018).

Despite relative complexity and higher structuring costs, impact bonds are a promising instrument, but some shortcomings limit their usage. The first one is that, in the classical model, investors carry all the execution risk (Liang et al., 2014). This means that the service provider payment is usually not sensitive to its performance, which may create a conflict of interest. The instrument we propose overcomes this limitation by allowing the risk to be shared between capital and service providers. Moreover, impact bond models often determine payments without considering the revenue that the project may generate (Jackson, 2013). This occurs because they are usually applied to public policies such as social services for vulnerable population or environmental conservation. The proposed model is an improvement on impact bonds as it has a mechanism that combines socio-environmental outcomes with financial results.

Some recent technological features can also have a significant role in boosting financial innovations. The most prominent one is the blockchain,

which basically uses cryptography and a peer-to-peer computer network to securely link together the transaction records (Zheng et al., 2018). Blockchain has allowed the release of interesting digital securities, such as tokens or smart contracts, with the potential benefits of more transparency and lower regulatory and intermediation costs (Belotti et al., 2019). After created, tokens can be used for the consumption of the issuer's goods or services or to represent fractions of the ownership of the company, representing future profits.

The literature on tokens offerings is growing significantly. Studies have been reporting the release of digital tokens with a wide range of applications, from gaming to biodiversity conservation (Arora et al., 2022; Oberhauser, 2019). Chod and Lyandres (2021) point that utility token financing mitigates entrepreneurial effort underprovision but increases underproduction risk. They show that token financing signals venture quality to investors and is more suitable when production costs are low, entrepreneurial effort is crucial and payoff volatility is low. Gan et al. (2021) emphasize that tokens better align incentives but show that, depending on margins and demand characteristics, coin offerings can lead to relevant agency costs, underproduction and loss of value in unregulated environments. The model we propose in this paper includes the issuance of marketable tokens to define the performance measurement and payment rules in a more transparent and traceable way. Due to its application in a beekeeping pilot project, we name it Bee-coin.

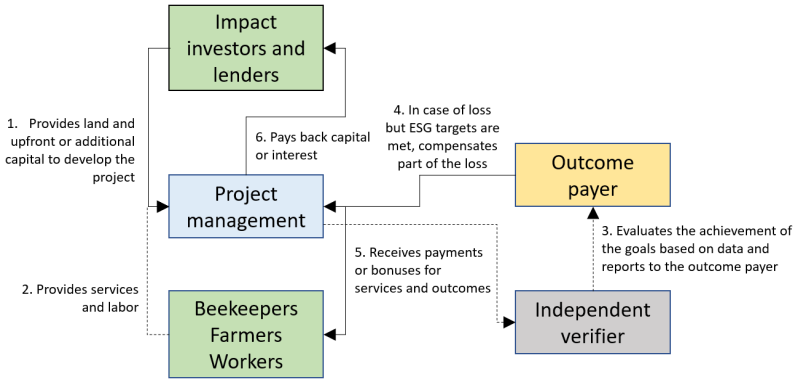
The structure of this document is as follows: in the next section we describe the instrument in general terms, comparing it with other funding alternatives. After that, we apply it to the real case (Project *Baccharis*) and present relevant model parameters and assumptions. Finally, we present the results of the simulation that combines the project operational and impact performance. Finally, we analyse the results and make final considerations.

2. Financial structure

Figure 1 describes the framework that relates the project execution and investment with the impact bond designed to compensate possible losses when ESG targets are met. Investors may include senior lenders, subordinate lenders and grant makers. The independent verification can be done by evaluators and validators. For simplification, the framework omits some typical roles such as intermediaries, lawyers and technical assistance providers.

When the project is released, production and sustainability goals are defined for the current year. One or more outcome payers are also identified. When investors and lenders provide upfront capital for the project, they receive tokens issued by the firm. Workers and service providers also receive tokens as they develop the work necessary for production and sustainability

Figure 1
Project investment, payment, implementation and verification structure



Note: Model describing the steps and relationships between project stakeholders.

goals.

When the year ends, an independent verifier check whether sustainability goals were achieved. If the project recorded a financial loss over that year (compared to a benchmark) but achieved the predefined sustainability goals, the outcome payer compensates part of the loss. The project management receives this compensation from the outcome payer and transfers part of it to workers. The compensation also reduces the additional capital from investors and lenders necessary to resume operations.

On the other hand, if the project records a net profit but does not achieve the sustainability targets, it compensates the outcome payer, transferring part of the profit that could have been used as dividends or bonuses. Hence, different from classical SIBs, part of the risk is shared by service providers and outcome payers are compensated when ESG targets are not achieved.

Table 1 presents a comparison between Bee-coin and extant funding alternatives for early-stage projects. Assuming that in typical startups the service provider is the entrepreneur itself, in all alternatives but SIBs he/she shares the risks of the project. Traditional funding instruments (banks and venture capital) are heavily regulated and typically lead to control rights. In crowdfunding alternatives, retail consumers and speculators are the ones who fund the project. Digital coin offerings also have risk sharing but also allow secondary trading. Equity alternatives (both in crowdfunding and coin offerings) have higher regulation and risk sharing. Bee-coin combines the sensitivity to sustainability outcomes, typical of impact bonds, with features of equity

offerings.

Table 1
Comparison of financial instruments for early-stage projects

			Crowdfunding		Coin offering		Impact bonds	
Financing method	Bank	VC	Reward	Equity	Utility	Equity	SIBs	Bee-coin
Upside through profit sharing	✗	✓	✗	✓	✗	✓	✗	✓
Upside through revenue sharing	✗	✗	✗	✗	✓	✗	✗	✗
Downside demand risk sharing	✓	✓	✗	✓	✓	✓	✗	✓
Heavily regulated	✓	✓	✗	✓	✗	✓✗	✓	✓✗
Voting/control rights	✓✗	✓	✗	✗	✗	✓✗	✗	✓✗
Funds from retail speculators	✗	✗	✗	✓	✓	✓	✗	✓
Funds from retail consumers	✗	✗	✓	✓	✓	✓	✗	✓
Secondary trading	✗	✗	✗	✗	✓	✓	✗	✓
Sensitivity to ESG outcomes	✗	✗	✗	✗	✗	✗	✓	✓
Risk shared by service provider	✓	✓	✓	✓	✓	✓	✗	✓

Note: A checkmark indicates that the feature is characteristic of the instrument, while an ex indicates that it is nonexistent or secondary. Dual notation indicates that the feature is sometimes present. VC means Venture Capital. Adapted from Gan et al. (2021).

Equation 1 describes the cash flow to investors in terms of the cash flow generated by the project ($\mathrm{FCF}_{\mathrm{project}}$) and the reward or penalties associated with the sustainability impact. For simplicity, only equity is considered, although debt funding can be used as well.

$$\begin{aligned}\mathrm{PV}(\mathrm{FCF}_{\mathrm{total}}) = {} & \mathrm{PV}(\mathrm{FCF}_{\mathrm{project}}) \\ & + \mathrm{PV}(\mathrm{ID}_{\mathrm{profit}<P1} \times \mathrm{ID}_{\mathrm{impact}>R2} \times \mathrm{Rate} \times \mathrm{FCF}_{\mathrm{project}}) \\ & - \mathrm{PV}(\mathrm{ID}_{\mathrm{profit}>P2} \times \mathrm{ID}_{\mathrm{impact}<R1} \times \mathrm{Rate} \times \mathrm{FCF}_{\mathrm{project}})\end{aligned} \tag{1}$$

The main goal is to reduce the variance of the cash flows using the reward system. Hence, whenever the profit is above certain threshold, part of it is offset whether the sustainability targets are not reached. On the other hand, when the profit is below another certain threshold, it can be compensated by the reward system in case those sustainability targets are reached. The model variables define this rational: $\mathrm{ID}_{\mathrm{profit}<P1}$ is an indicator variable that is equal to 1 when the profit is below the threshold $P1$; $\mathrm{ID}_{\mathrm{profit}>P2}$ is an indicator variable that is equal to 1 when the profit is above the threshold $P2$; $\mathrm{ID}_{\mathrm{impact}<R1}$ is equal to 1 when the index that consolidates the impact targets is below $R1$; finally, $\mathrm{ID}_{\mathrm{impact}>R2}$ is equal to 1 when the index that consolidates the impact targets is above $R2$.

3. Project *Baccharis*

Baccharis dracunculifolia (alecrim-do-campo) is a native plant in Brazil with a key role in the propolis production. The honeybee collects resin from

the main budding buds of alecrim-do-campo and uses it to produce propolis in the hive (Righi et al., 2011; Zabaiou et al., 2017). Propolis, particularly the Green Propolis, not only helps to protect the hive but also has several benefits for human health (antibacterial, antifungal, anti-inflammatory, antitumor and immunostimulating properties, among others) due to its complex composition, making it a highly attractive product (Bankova et al., 2000; Chan et al., 2013; Oliveira et al., 2021; Silva-Beltrán et al., 2022). Alecrim-do-campo, in turn, can be used to recover areas of degraded vegetation, which benefits local biodiversity (Fernandes et al., 2016).

Brazil, and particularly the state of Minas Gerais, produces and exports a relevant volume of propolis, having a prominent global position (Ramos Junior, 2017). Despite some seasonal instability, producing propolis is potentially profitable (Mountford-McAuley et al., 2021). After the pandemic, prices in the international market increased substantially, with Japan being an important consumer (Oliveira et al., 2021). However, this Brazilian industry still has a high level of informality in the upstream and concentration of few players in the downstream (Wilkinson et al., 2017). Furthermore, there is significant room for research and development initiatives, limited reliability in terms of quality and sustainability impacts are far from being measured or targeted (Ramos Junior, 2017).

In order to tackle these issues, the Project *Baccharis* aims to develop a robust supply chain of Green Propolis in Minas Gerais. It is a partnership between researchers from the Federal University of Minas Gerais (UFMG), the Development Company of the same state (Codemge, state-owned), among others institutions. The project funding, or a relevant part of it, can be done through impact bonds due to the social and environmental results it potentially generates.

The project encompasses a facility that produces propolis extract units using raw propolis supplied by a network of individual beekeppers. After receiving the seedlings, they are responsible for the cultivation, the maintenance of the hives and the extraction or raw propolis, with technical support from the project management. Beekeeping does not require large land, time or high start-up costs (if performed in a decentralized medium-sized scale) and can be developed not only by subsistence farmers in rural communities but also from inmates or ex-inmates in a government program of resocialization.

The project contributes to mitigating the level of informality and low predictability of supply in the sector. With the creation of a robust supply network, designed by researchers with extensive experience and knowledge in this industry, propolis production becomes more stable and presents better quality assurance.

Table 2 presents some operational projections for the project, considering an average production volume of 150 thousand bottles per month. Raw propolis is estimated considering that bottles have 30mL and 18% concentration. Moreover, each beekeeper should produce around 15kg of propolis per month with 25 hives. This number of hives corresponds to two thousand seedlings and 20 hectares. Figure 2 shows the break-even point at around 75 thousand bottles per month. It reduces to 50 thousand bottles if gross margin is 5% higher than expected, but increases to 150 thousand bottles if gross margin is 5% lower.

Table 2
Monthly operational figures of the project

	2024	2025	2026	2027	2028	2029	2030	2031	2032
Seedlings (k)	167	333	500	500	500	500	500	500	500
Cultivation area (ha)	1,667	3,334	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Hives	2,084	4,167	6,251	6,251	6,251	6,251	6,251	6,251	6,251
Beekeepers	83	167	250	250	250	250	250	250	250
Raw propolis (kg)	1,250	2,500	3,750	3,750	3,750	3,750	3,750	3,750	3,750

Note: Expected values of the main operational indicators of the project. After Alecrim-do-campo is cultivated with supplied seedlings, bees collect resins from it in the pollen baskets on their hind legs and carry them back to the hive to produce raw propolis, which is extracted by beekeepers.

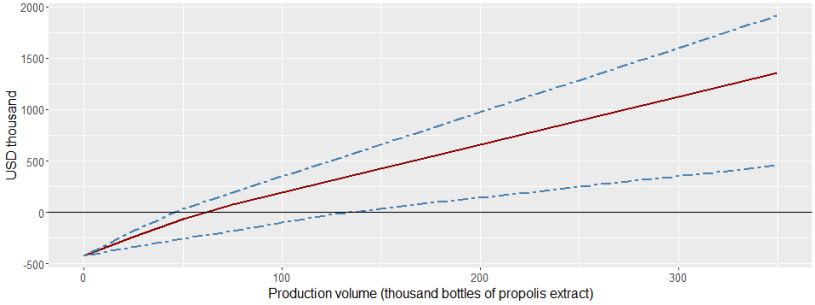
Besides the production facility managers, the beekeepers and the outcome payer, the project structure includes customers, landowners and investors as most relevant stakeholders. They can provide the upfront capital or the assets to implement the project and obtain returns according to the operational performance and the achievement of sustainability objectives. The tokenized impact bond is then a blockchain solution codified with rules that condition the earnings also to the achievement of pre-defined impact goals. Using blockchain technology to divide the project ownership into tokens can be beneficial in terms of decentralization, traceability and transparency.[1]

The focus of this work is not on the technical specificities of the blockchain solution to be adopted, nor the operational details of the project and product,[2] but to present a simulation of the results of this financial instrument after defining the most critical inputs.

[1] It is important to mention, however, that the proposition do not necessarily require the adoption of blockchain as a mechanism for dividing the project ownership and recording the related transactions. Competitive technologies could be adopted to regulate the relationship between the main stakeholders.

[2] These details can be found in other project documents, such as Fernandes et al. (2022).

Figure 2
Financial performance of the project as a function of monthly volume and gross margin



Note: Long-term annual free cash flow for different values of production output, in USD thousand. Dashed lines correspond to plus and less 5% of gross margin, with respect to the expected value.

4. Model parameters

Table 3 shows the current and average project projections, in real value. This level of consolidation preserves some strategic aspects of the business plan. For this current version, we considered some premises that simplify the business model. Firstly, all the raw propolis is supposed to be supplied by independent beekeepers. This is most likely to occur but own production can complement the supply and does not materially affect the analysis. Decentralized and outsourced production justifies the relevance of a financial instrument that can better align incentives and promote compensation for sustainability goals.

Besides that, projections are conservative in the sense that average prices are in line with domestic Brazilian prices. This means that the option to export part of the production is a relevant upside for the project results. Moreover, the main product adopted is the 30mL bottle of green propolis extract with a concentration of 18%. Other products can complement the portfolio and also improve the project financials. The assumptions that defined the projections were obtained through research with the project's technical team, secondary information collected on the internet and other specialists. The simplification of the business model eases the analysis of simulated effects of the financial instrument. Improvements do not materially affect the analysis of the contributions of the financial instrument, but can affect the calibration of the compensation system.

The output of the simulation is the internal rate of return and the present value of the project free cash flow, considering a cost of capital of 15% and no

Table 3
P&L Statement of the Project (in USD thousand)

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Net revenue		**2,016**	**4,032**	**6,048**	**6,048**	**6,048**	**6,048**	**6,048**	**6,048**	**6,048**
Cost of goods sold		**(1,845)**	**(3,468)**	**(5,092)**	**(5,092)**	**(5,092)**	**(5,092)**	**(5,092)**	**(5,092)**	**(5,092)**
Seedlings		(72)	(72)	(72)	(72)	(72)	(72)	(72)	(72)	(72)
Gross propolis		(1,350)	(2,700)	(4,050)	(4,050)	(4,050)	(4,050)	(4,050)	(4,050)	(4,050)
Consumables		(274)	(548)	(822)	(822)	(822)	(822)	(822)	(822)	(822)
Labor		(149)	(149)	(149)	(149)	(149)	(149)	(149)	(149)	(149)
Expenses		**(371)**	**(482)**	**(617)**	**(617)**	**(617)**	**(617)**	**(617)**	**(617)**	**(617)**
SG&A		(159)	(235)	(315)	(315)	(315)	(315)	(315)	(315)	(315)
R&D		(156)	(156)	(78)	(78)	(78)	(78)	(78)	(78)	(78)
Depreciation		(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)	(56)
Income taxes		(35)	(168)	(168)	(168)	(168)	(168)	(168)	(168)	(168)
Net income		**(200)**	**82**	**339**	**339**	**339**	**339**	**339**	**339**	**339**
Main equipment	(227)									
Infrastructure	(335)									
Working capital	(260)	(40)	(40)							
Sustaining	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)
Free cash flow	**(839)**	**(201)**	**81**	**378**	**378**	**378**	**378**	**378**	**378**	**378**

Note: Annual expected values of the main financial indicators of the project. Revenue, net of indirect taxes, is obtained through sales of bottles of propolis extract to customers. The model encompasses the production and supply of seedlings, and the purchase of raw propolis thereafter. Raw propolis is then used with other consumables to manufacture propolis extract in the production facility. SG&A expenses include marketing, logistics, commercial and administrative costs. R&D expenses include consumables and labor to develop new products or improve the quality of current ones. Figures within parentheses are negative.

real growth after the horizon of the projection. As explained in Section 2, the payments related to three of the main stakeholders of the project (investors, landowners and large customers) are adjusted according to the achievement of social and environmental targets. When those targets are achieved, beekeepers and the plant management receive a reward through the surplus of such payments, limited to the cash balance. If, on average, more than 100% of the targets are achieved, they receive a 15% bonus; if they reach between 80% and 100%, a 10% bonus is due. Otherwise, investors, landowners and large customers get the surplus back.

Four types of social and environmental achievements are considered: number of subsistence farmers or beekeepers, recovered vegetation area, number of honeybees and number of workers hired in the context of the resocialization program. Table 4 presents the rational, benefits and targets for each objective. Those goals are considered the most relevant and, also important, they do not correlate substantially with the project financial or operational performance. Equal weights and linear relationships were considered for the reward system. This is a realistic assumption since all targets are meaningful and the linearity is plausible in the range of each indicator. Although some objectives can be verified in a higher frequency, reward verifications are planned to be done yearly.

Table 4
Sustainability objectives included in the system

Objective	Rational	Benefits	Target
(1) Percentage of raw propolis supplied by subsistence farmers or beekeepers	A relevant part of the propolis should be produced by a disperse network of farmers and beekeepers in rural communities	Employment and income generation in rural or disadvantaged areas, as well for minority groups	50% of the total required volume
(2) Recovered vegetation area (ha)	Cultivation activities should be also applied in areas with degraded vegetation	Recovery of part of the biodiversity, improved erosion control, lower levels of soil contamination, improved diversity of native species	4,167 (half of the total required area)
(3) Number of hives	Beekeeping activities maintain or increase the population of honeybees in some areas, which is good provided it does not harm native pollinators	Improved pollination services, increasing crop yields and agriculture productivity. Biernath (2022) mentions that hives near soybean plantations increase the production of this grain by 12 to 15%.	10,418 hives (necessary for planned capacity)
(4) Percentage of workers/beekeepers who are part of the resocialization program	Part of the cultivation, beekeeping and manufacturing activities should be performed by inmates or ex-inmates	Resocialization and rehabilitation, improving support and reducing reoffending	20% of the headcount

Those goals and sales volume were considered as probabilistic values. We considered triangular distributions due to its better compatibility with the nature of the project variables. Table 5 presents minimum, most likely and maximum values considered in the simulations, obtained after discussions with the technical team. It is important to mention that a capacity expansion is also a project upside for the future, in case expected demand is confirmed.

Table 5
Distribution parameters of the stochastic variables considered in the simulation

	Minimum	Most likely	Maximum
Monthly sales volume of bottles of propolis extract (thousand)	150	250	350
Percentage of raw propolis supplied by subsistence farmers or beekeepers	10%	50%	70%
Recovered vegetation area (ha)	2,500	4,167	5,834
Number of hives	6,251	10,418	14,585
Percentage of workers and beekeepers who are part of the resocialization program	0%	20%	30%

In terms of the additional cost that the project would have to incur to develop the sustainability goals, this analysis treats it as negligible. Partnerships with subsistence farmers and beekeepers are not costlier than those with other farmers. Moreover, according to the technical specialists, recovering vegetation is a natural effect of *Baccharis* cultivation. The number of hives is consequential of the production of raw propolis. Labor costs of workers from the resocialization program are about the same as costs of regular workers (TJDFT, 2022). Part of the administrative expenses should cover the coordination of this reward system, including measurement, target definition, monitoring and audit processes as well as partnership management.

The cash flow to investors, as a result of the flow generated by the project and the reward or penalties associated with the sustainability impact, was described in equation 1. The compensation or penalties based on the sustainability outcomes are due to any token holder.

The equation variables were calibrated for the simulation: the threshold $P1$ was set to 10% of the project initial committed capital and $P2$ to 30%. The references $R1$ and $R2$ were set to 80% and 100% of the pre-defined targets, with equal weights for them. The percentage considered for the reward and penalty was set to 30%. This calibration should be adapted to each project, with the goal of improving risk-return trade-off for investors without being an excessive burden to the bond guarantor.

5. Simulation results and analysis

Figure 3 presents the frequency distribution of the simulation results with 1,000 iterations, in scenarios with and without the impact reward system. Both the internal rate of return and the present value of the free cash flow are presented. It is possible to see that the reward system reduces the frequency of lower rates and present values, with more frequent results around the median. This means that the proposed financial instrument indeed reduces the project risk and improves risk-adjusted returns.

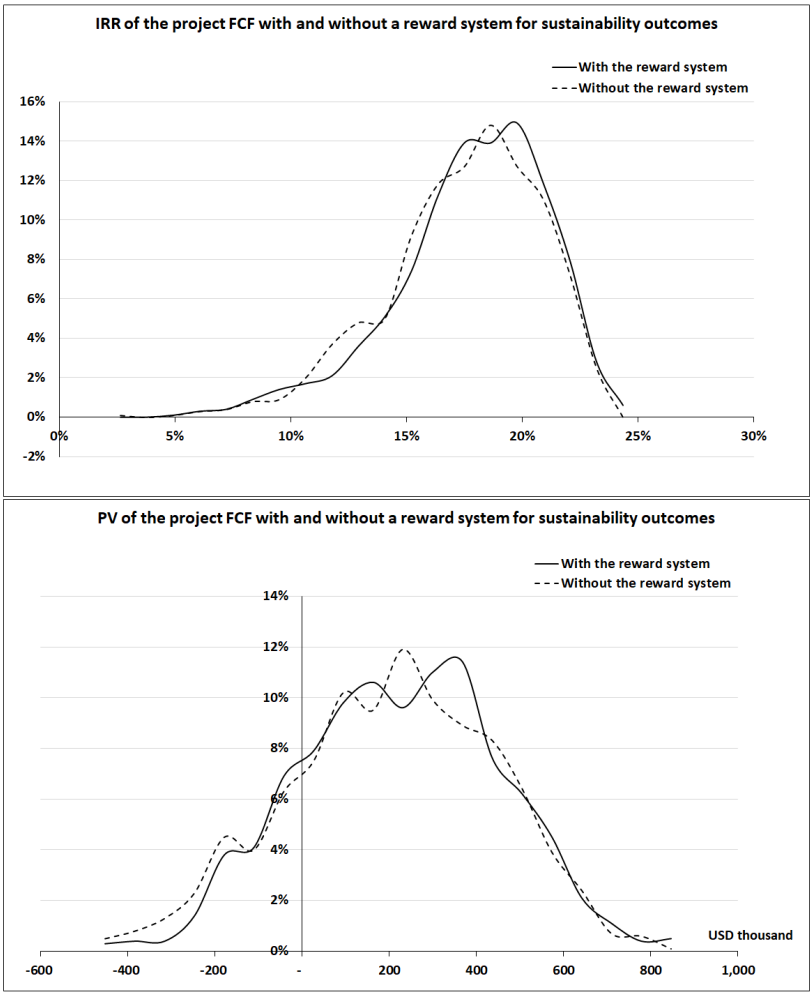
The distribution of rates of return and net present value without the reward system has averages of 17.47% and USD 1,020 thousand, respectively. With the reward system, the values improve to 17.80% and USD 1,119 thousand. More importantly, the standard deviations of those same variables reduce from 3.37% and USD 1,212 thousand to 3.34% and USD 1,158 thousand. Sharpe ratios went from 5.19 to 5.34.

Some observations can be derived by the effect of the reward system. First of all, it does not change dramatically the financial outcomes of the project, which means it would not be unattractive for the bond guarantor. Second, it does contribute as an additional incentive for managers and investors to achieve the sustainability targets. Even considering the uncertainty related to the achievement of the sustainability outcomes, the system reduced the percentage of cases with project negative present value from 20% to 18%. It is worth mentioning that the parameters can be adjusted to consider preferences and expectations of both investors and outcome payers.

6. Final considerations

In this analysis, we propose a funding instrument to contribute to the development of for-profit projects with relevant impact in developing countries.

Figure 3
Frequency distribution of the FCF and IRR of the Project, with and without the reward system



Note: Simulation results of the project financial performance with and without the compensations based on ESG outcomes.

The instrument is based on impact bonds, which are outcome-based contracts typically applied to public policies, with some improvements to be adapted to projects that are economically self-sustainable but may have a risk-return trade-off that is not compatible with certain private investors preferences. It considers the use of digital tokens to regulate the ownership and transactions and it works similarly to an insurance security, or to a derivative aiming to improve risk-adjusted returns and, at the same time, encourage the achievement of sustainability impact.

In order to investigate how this instrument affects a real case, we performed a simulation of the financial outcomes of a pilot project with relevant sustainable dimensions. The project aims to develop a production chain of green propolis in Minas Gerais, with a decentralized network to produce raw material and a central facility to develop R&D initiatives and to produce the extract to be sold.

Not all the features of the instrument need to be considered in a first place. Some aspects may still be better understood in future studies, such as the capital cost and possible methods for measuring each impact and the correlation between them and operational variables. Scale-up implications also deserve further refinements. Portfolio securitization may result in diversification gains that are not treated in our model as well.

The instrument proposed in this paper can be applied in other projects that generate revenue and social or environmental impact. However, some of the simplification assumptions made here may have to be adapted to the case, such as the equity-only funding.

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