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Optimizing Risk Allocation in Public-Private Partnership Projects by Project Finance Contracts. The Case of Put-or-Pay Contract for Stranded Posidonia Disposal in the Municipality of Bari

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Abstract: This paper investigates the impact of the adoption of public support on the performance of public–private partnership (PPP) projects as perceived and measured by the different actors involved. In particular, the public support investigated by this study is put-or pay contracts, which are often used in PPP projects financed through project finance to optimize risk allocation. In order to quantify the benefit gained by each party with and without the put-or-pay contract, cash flows of the project have been modeled by using the concept of real option, defined as the right without the obligation to make an action if it is convenient to do so. This concept enabled us to model and quantify the inner flexibility mechanism of put-or-pay contracts. With a put-or-pay agreement signed between the municipality, a (private) owner, and operator of a disposal facility, the owner of the facility has the faculty, without any obligation, to require the payment of penalty, if the municipality fails to meet its obligations. This means that the owner of the facility holds a series of European put options that can be exercised if it is convenient for the holder. The developed model has been used for studying the effectiveness of put-or-pay contracts for financing the treatment plant of a special dispose through project finance, i.e., the plant for disposal of marine plant posidonia.

Keywords: waste management; public private partnership; project finance; risk allocation; real option theory

1. Introduction

Recent studies have promoted public–private partnership (PPP) in the waste management sector as a delivery method for infrastructure service provision to reduce the waste burying rate and improve environmental quality [1–3]. PPP may prove an effective way for delivering waste infrastructure since it allows the exploitation of private expertise and finance in such a capital-intensive sector, characterized by the high asset specificity of infrastructure and the uncertainty due to long-term horizon of investments. PPP allows local governments to overcome the growing budget restriction that constrains their actions. At the same time, the control of the infrastructure by the public party ensured by these governance models (other than fully privatization) is a chance to ensure economic sustainability without much public protest [4,5].

Despite the great appeal of the PPP financing model for waste infrastructure, many uncertain factors affect the implementation of PPPs throughout the lifecycle of PPP projects, due to PPP inner characteristics such as huge investments, high concession periods, and great number of actors [6].

Among the critical risk factors (CRFs) that affect the construction and operation of waste treatment and management PPP projects, insufficient waste supply, disposal of non-licensed waste, environmental risk, payment risk, and lack of supporting infrastructure are mentioned as the most important ones [1]. It is clear that the main issue in such projects is often represented by the high level of risks characterizing them, that, if not well managed, may even cause their failure. Risk management in this type of project becomes even more important due to the financial structure mostly adopted. Such capital-intensive deals, in private and public sectors, and in PPPs, are often financed through non-recourse project financing [7,8]. In order to avoid on-balance sheet financing for such initiatives, which can considerably affect project sponsors and often can be hard to sustain [9,10], non-recourse project financing is usually preferred where the project revenue represents the main (or even exclusive) source of loan repayment, operating expenditure, and project assets is the sole collateral or debt security [11,12].

A special purpose vehicle (SPV) fully containing project cash flows and taking on project-related risks is the mean used to structure a deal with non-recourse financing. This ensures that the debt raised to finance the initiative relies only on the project cash flows. Hence, only project cash flows can be demanded by project lenders to repay principal and interest (non-recourse financing), and assets owned by the SPV may be used as collateral guarantee in case of default [13,14]. At the same time, the debt contracted by the SPV is off-balance sheet for the sponsor, thus limiting its impact on sponsors' creditworthiness and on their rating.

Risk allocation in these types of transactions becomes fundamental to structure sustainable non-recourse project financing. Sponsors will protect their own assets from the risk of failure of large-scale capital-intensive projects through off-balance sheet financing. Lenders contrarily seek a secure source as a potential reimbursement. These tensions and divergence of interests are at the basis of the negotiations for the financing of projects in which parties try to agree, so as to have a minimum recourse to the sponsor together with sufficient credit support for the lenders, for example through guarantees or commitments to be part of sponsors or third parties.

In this sense, project finance contracts such as engineering, procurement, and construction (EPC), operations and maintenance (O&M), off taking, and purchase agreement are recognized as key for optimizing risk allocation, ensuring that risks of the initiative are allocated to the party most able to manage and deal with them [15].

Although the literature has already discussed and investigated the effect of project finance contracts on PPP waste infrastructure projects [16], to the best of authors' knowledge, this has been addressed by the standpoint of specific stakeholders, often analyzed one per time. For instance, [17] addressed the effect of project finance contracts on PPP projects focusing on the lender perspective, [18,19] analyzed the effect of introducing flexibility through specific clauses into these contracts by reporting the point of view of the community who is the final user paying this service through taxes, and [4] investigated the performance of private partners in the waste sector. The main gap resulting from the literature review is the effect of such contracts on the performance of the main stakeholders of PPP projects, which often show different interests and expectations on the project itself. This is a crucial point for PPP transaction, since, as we already discussed, the essence of these tools (namely, contracts such as engineering, procurement and construction, operations and maintenance, off taking, and purchase agreement) is the optimization of risk allocation through the allocation of risk to the party who is best able to manage them. But, if the effect of using such contracts is actually not investigated at all, and it is not done for all the actors, this essence remains only a theoretical concern. Hence, the open questions are: Are such contracts really able to optimize the risk allocation, and therefore the performance of all the considered actors? How does structuring such contracts ensures the optimization of risk allocation and performance among all the considered actors?

To pursue this main objective, this paper focuses on put-or-pay contracts, an off taking and purchase agreement often used in waste infrastructure.

Put or pay contracts are used in project financing to allocate risks during the operating period. In force of a put-or-pay agreement, the guarantor must put a predefined minimum input amounts at a given price during a time horizon or to pay the deficit [20,21]. This arrangement ensures that capital and operating costs of the facility are covered by guaranteed revenues, and it transfers the risk of unpredictable supplied input to the guarantor.

Focusing on this contract, we address the research questions by investigating whether, and in which conditions, such a contract is really able to optimize the risk allocation, and therefore the performance of all the considered actors.

The methodology developed for this specific contract may be easily applied for the other types of contracts used in project financing transactions to allocate risks, also in other sectors.

The paper is organized as follows. Section 2 formulates the problem and presents the computation model to assess the impact of put-or-pay contracts on PPP waste infrastructure project performance, from the standpoint of the main actors involved in the project: the government, the private sector, and the lender. In Section 3, the model is then used to study the effectiveness of put-or-pay contracts for financing a treatment plant of a special dispose through project finance, i.e., the plant for disposal of marine plant *posidonia*, focusing on the case of the municipality of Bari. Conclusions end the paper.

2. The Problem Formulation

Disposal contracts between municipalities and waste treatment plants often use put-or-pay contracts to assure waste supplies at a set price, thus ensuring production cost targets [20,21]. The case of the City of Springfield provides an example [22]: the municipality “pays” for a predefined amount of waste, even if less than the amount is put [23]. Such guaranteed revenue allows the (private) facility owner and operator to cover capital and operating costs, with a fixed amount of waste or a cash penalty.

Put-or-pay agreements may therefore support private partners and lenders, but if not well set, they may become a burden for the government and the whole community. Put-or-pay provisions in fact require an estimation of the amount of waste generated by the community for the next 5, 10, 15, or 20 years from now and to commit to it. In light of this, as we already discussed, a deep analysis of risk allocation to main stakeholders for these contracts is crucial for the success of the project itself. Are such contracts really able to optimize the risk allocation, and therefore the performance of all the considered actors? How does structuring such contracts ensure the optimization of risk allocation and performance among all the considered actors?

In order to answer to these research questions, we developed a model to assess the impact of put-or-pay contracts on PPP waste infrastructure project performance, from the standpoint of the main actors involved in the project: the government, the private sector, and the lender. This is done based on an economic approach.

We quantified the net benefit gained by each party with and without the put-or-pay contract, expressed in monetary terms, thus identifying the condition of satisfaction of the involved actors (in terms of minimum requirement for the project) and analyzed the risk if such a condition is not achieved for each party involved in the transaction.

Also, in order to quantify benefit gained by each party with and without the put-or-pay contract, we modeled the cash flows of the project by using the concept of real options. In fact, a real option is the right, not obligation, to make an action if it is convenient to do it [24]. This concept enables us to model and quantify the inner flexibility mechanism of put-or-pay contract. When a put-or-pay agreement is signed by the municipality with the (private) owner and operator of a disposal facility, the latter has the right, without any obligation, to require the payment of penalty if the municipality fails to meet its obligations. This means that the owner of the facility holds a series of European put options that will be exercised if convenient for the option holder.

Let us assume that the municipality agrees to guarantee a minimum annual flow of waste W (ton/year) at a fee p (€/ton). In case of a delivered quantity of waste $Q_P(t)$ less than W , $Q_P(t) < W$ (the municipality does not meet its obligation), then the municipality pays for the shortfall $[W - Q_P(t)]p$.

Equation (1) computes the annual option payoff.

$$\Pi_p = \max(W \cdot p - Q_P(t) \cdot p, 0) \quad (1)$$

Once we have estimated the impact of put-or-pay contract on project cash flows, we can quantify the net benefit gained by each party with and without the put-or-pay contract.

In order to assess the net benefit gained by private and public parties, we use one of the most used profitability indexes for investment projects, the net present value (NPV) method [25]. NPV is calculated as the difference between the present value of cash inflows and the present value of cash outflows gained by the two parties by project.

The net benefit gained by the private party is computed by (2).

$$NPV_C = \sum_{t=t_{constr.}+1}^{\tilde{T}_C} \frac{CF_t}{(1+r)^t} - I_C \quad (2)$$

where:

- \tilde{T}_C is the actual concession period;
- r is the discount rate;
- $t_{constr.}$ is the construction period;
- $I_C = \sum_{t=0}^{t_{constr.}} \frac{I_t}{(1+r)^t}$ is the concessionaire's investment for the infrastructure, with I_t = investment (capital expenditures) in year t .

As for the computation of cash flows, their value will be different with and without put-or-pay agreement.

In particular, if R_t = revenue in year t and OC_t = operational expenditures in year t , we can calculate the CF_t^C as follows (3):

$$CF_t^C = \begin{cases} R_t - OC_t + \Pi_p & \text{with put or pay contract} \\ R_t - OC_t & \text{without put or pay contract} \end{cases} \quad (3)$$

If the NPV is used as the profitability index of the investment for the private party [26,27]), the private sector satisfying condition is that the investment is economically and financially viable for the private investor, as mathematically expressed by Equation (4):

$$NPV_C \geq 0 \quad (4)$$

In the same way, the net benefit gained by the government is computed by (5).

$$NPV_G = \sum_{t=t_{constr.}+1}^{\tilde{T}_C} \frac{CF_t^G}{(1+r)^t} \quad (5)$$

where the value of the cash flows for the government will be different with and without put-or-pay agreement. If $S(t)$ is the saving the government has when the disposal is managed by the private party (actually the costs of treating the waste no more sustained by the government c_{waste}), the cash flows for the government in the two scenarios may be calculated as

$$CF_t^G = \begin{cases} S(t) - \Pi_p & \text{with put or pay contract} \\ S(t) & \text{without put or pay contract} \end{cases} \quad (6)$$

As for the lender, the satisfying condition is the bankability of the project, given that in PPPs the cash flows from the project are the only source for serving the debt. The loan life covers ratio (LLCR) is the most prominent method for assessing the borrowing company capability to repay an outstanding loan. LLCR is calculated as the ratio between the present value of cash-flow available for debt service (CFADS) and the amount of debt owed by the company at a given time elected for the evaluation. Lenders generally require values ranging between 1.2 and 1.6 [28].

Equation (7) expresses the condition that the LLCR is higher than 1.2:

$$\frac{\sum_{t=t_{constr.}+1}^{\tilde{T}_C} \frac{CF_t^G}{(1+r)^t}}{\sum_{t=n}^m \frac{DS_t}{(1+r)^t}} \geq 1.2 \quad (7)$$

where DS_t is the installment at year t .

DS_t depends on the selected amortization schedules, which is the schedule of periodic instalments DSt , showing for each DSt , the amount of payment earmarked to the loan principal P_t and the amount covering the interest INT_t (as shown below (8)):

$$DS_t = P_t + INT_t \quad (8)$$

The interest paid at year t , INT_t , depends on the residual debt at $t-1$, CR_{t-1} (as shown below (9)) with the interest rate i :

$$INT_t = CR_{t-1} \cdot i, \text{ with } CR_t = CR_{t-1} - P_t \quad (9)$$

The values of DS_t , P_t , and INT_t depend also on the type of amortization schedule. In this paper, we use an amortization schedule with fixed principal payment, where the principal amount P_t is constant, which the interest INT_t decreases over each payment period (Equation (10)):

$$P_t = \frac{D_{tot}}{(m-n)} \quad (10)$$

where D_{tot} is the total amount of debt and $(m-n)$ is the number of years available to service the debt.

Finally, in order to take into account the uncertainty affecting some input variable, the Monte Carlo simulation was employed, which is a useful tool able to include more uncertainty sources and their relationship into the decisional process, as it is in the real world [29]. Probability distributions of each uncertain model input have been determined based on historical data and experts' opinions. As a consequence, the result of the simulation is the probability distribution of the investigated output variable, instead of a deterministic value.

3. Case Study: Financing the Treatment Plant for Disposal of Stranded Posidonia

The developed model has been used for studying the effectiveness of put-or-pay contracts for financing the treatment plant of a special dispose through project finance, i.e., the plant for disposal of marine plant *Posidonia oceanica* (L.) Delile, PO).

One of the greatest environmental, economic, social, and hygienic problems in the Mediterranean region is represented by the residues of the stranded marine plant *Posidonia* PO in tourist areas. This issue is of particular importance in the Apulia Region, disturbing bathers and population, and causing high costs for local authorities in charge of their removal and disposal [30].

Several uses of *Posidonia* have been proposed during the history. For instance, the PO leaves were used in packing for fragile items transportation in Mediterranean regions, and to move fresh fish from the coast to cities [31,32]. *Posidonia* leaves have been used as a filling material for mattresses and pillows [33]; as roof insulation [31]; PO leaves have been also used to feed animals in different areas [34], due to their antifungal and antibacterial properties [35]. Since these alternative exploitations of *Posidonia* have disappeared, *Posidonia* residues, especially the in the esplanades and tourist beaches,

represent a nuisance to citizens and bathers because of the bad smell resulting from organic material decomposition. This represents a serious and huge environmental problem that needs to be addressed by the public administration. [34] conducted a survey in the period March–May 2008 on about one third of the Apulia coastline, which shows that more than 28,000 m³ of offshore residues need to be removed from heavily-used beaches and esplanades.

To date, while the landfill still remains the main destination of the removed posidonia, other treatments are possible, such as energy or material recovery [36–38]. The attention to these alternative treatments has increased during the last years, due to relevance reserved to environment, renewable energies, and the circular economy.

In this paper, we consider the use of posidonia for producing panels that can be used in the construction sector.

The production process of the panels consists in subjecting the collected stranded posidonia to a particular treatment process for its mixing with additives, compaction, and drying. The panels thus produced can therefore be sold on the market. It is clear that in a similar process, the availability of posidonia is crucial and it may be guaranteed through a put-or-pay contract.

With the main aim of studying how such a contract performs in risk allocation and whether it optimizes the risk allocation among the main PPP actors (Equations (2), (5) and (7)), in the following we model the cash flows associated to this treatment plan.

In order to estimate the revenues, let us assume that $Q_P(t)$ is the quantity of stranded posidonia collected each year and δ_{W_P} is the density of wet posidonia; hence, the volume of posidonia collected each year $V_P(t)$ is: $V_P(t) = \frac{Q_P(t)}{\delta_{W_P}}$.

If we indicate with δ_{D_P} the density of dried posidonia, μ_P the yield, and γ the quantity of posidonia leaves required for each panel, the total number of panels produced in each year t is (11):

$$N_{Panels}(t) = \frac{V_P(t) \cdot \delta_{D_P}(t) \cdot \mu_P(t)}{\gamma} \quad (11)$$

Let us indicate with $p_{Panels}(t)$ the market price of panels, and with $\alpha_{Panels}(t)$ the share of panels totally sold at t . The revenue at year t can be calculated as in (12):

$$Revenue(t) = N_{Panels}(t) \cdot \alpha_{Panels}(t) \cdot p_{Panels}(t) \quad (12)$$

where the unsold panels are assumed to be stored at a unitary cost c_{inv} .

In order to understand costs of the panel production process from posidonia, let us analyze the costs associated to each phase of the production process.

Phase 1. Collection of Stranded Posidonia

The stranded posidonia collection requires the use of trucks or other means of transporting the collected posidonia and cleaning the beach.

The total operating cost of collecting stranded posidonia is therefore calculated as:

$$C_{Coll\&Clean} = \text{cost of vehicles hire} + \text{personell cost} \quad (13)$$

The number of means depends on the volume of posidonia collected each year $V_P(t)$ [39,40]. If q_c is the capacity of the mean, the number of means needed is given by:

$$N_{means_Coll\&Clean}(t) = f\left(\frac{V_P(t)}{q_c}\right) \quad (14)$$

In a similar way, it is possible to determine the number of people. Assuming that it is twice (double) compared to the number of means, $N_{person_Coll\&Clean}(t) = 2 \cdot N_{means_Coll\&Clean}(t)$, and assuming that the annual cost for vehicles hire is $C_{veh_hire_Coll\&Clean}$ and the annual cost for personnel for collection is $C_{person_Coll\&Clean}$, we have (15):

$$C_{Coll\&Clean}(t) = N_{means_Coll\&Clean}(t) \cdot C_{veh_hire_Coll\&Clean} + N_{person_Coll\&Clean}(t) \cdot C_{person_Coll\&Clean} \quad (15)$$

Phase 2. Mixing of Biomass with Adhesives

The second step of the production process for posidonia panels consists in mixing the posidonia with adhesives, which requires the use of means of mixing (mixers).

The total operative cost of mixing phase can therefore be calculated as:

$$C_{Mix} = \text{cost of vehicles hire} + \text{personell cost} \quad (16)$$

The number of means depends on the quantity of posidonia collected each year $Q_P(t)$ [39,40]. If q_m is the capacity of the mean, the number of means needed is given by:

$$N_{means_Mix}(t) = f\left(\frac{Q_P(t)}{q_m}\right) \quad (17)$$

In a similar way, it is possible to determine the number of people. Assuming that it is equal to the number of the required mixers, $N_{person_Mixer}(t) = N_{means_Mixer}(t)$, and assuming that the annual cost for vehicles hire is $C_{veh_hire_Mix}$ and the annual cost for personnel for collection (per employee) is C_{person_Mix} , we have (18):

$$C_{Mix}(t) = N_{means_Mix}(t) \cdot C_{veh_hire_Mix} + N_{person_Mix}(t) \cdot C_{person_Mix} \quad (18)$$

Phase 3. Compaction

The third phase of the process is the compaction of the material resulting from the previous phase, which requires a special mean for this. This stage requires the purchase of this special mean at the beginning of the process.

Let us assume that C_{means_Comp} is the cost of acquiring this special mean, and C_{person_Comp} is the annual cost for personnel for compaction (per employee). Hence, the investment cost at yeat 0 will be:

$$C_{Comp}(t = 0) = C_{means_Comp} \quad (19)$$

The operating cost for compaction at each t will be (20):

$$C_{Comp}(t) = N_{person_Comp}(t) \cdot C_{person_Comp} \quad (20)$$

Phase 4. Seasoning

The fourth phase of the process is the seasoning of the material resulting from the previous phase, which requires a special climatic chamber along with an industrial building housing it. This stage requires the purchase of this special mean at the beginning of the process, as it is for the compaction means.

Let us assume that C_{means_Seas} is the cost of acquiring this special mean, $C_{ind_building_Seas}$ is the annual rent paid for the industrial building and C_{person_Seas} is the annual cost for personnel for compaction (per employee). Hence, the investment cost at year 0 will be:

$$C_{Seas}(t = 0) = C_{means_Seas} \quad (21)$$

The operating cost for seasoning at each t will be (22):

$$C_{Seas}(t) = C_{ind_building_Seas}(t) + N_{person_Seas}(t) \cdot C_{person_Seas} \quad (22)$$

Phase 5. Storage and Packaging

The last phase is the storage and packaging, which requires three special means. Let us assume that $C_{means_Sto\&Pack}$ is the annual cost for renting these means and $C_{person_Sto\&Pack}$ is the annual cost for personnel for storage and packaging (per employee). Hence, the annual cost for storage and packaging phase is (23):

$$C_{Sto\&Pack}(t) = C_{means_Sto\&Pack}(t) + N_{person_Sto\&Pack}(t) \cdot C_{person_Sto\&Pack} \quad (23)$$

According to this model, the cash flow at each t , without put-or-pay contract, may be calculated as:

$$CF_t^C = \left[\begin{array}{l} Revenue_t - (C_{Coll\&Clean}(t) + C_{Mix}(t) + C_{Comp}(t) + C_{Seas}(t) + C_{Sto\&Pack}(t)) \text{ at year } t \\ -(C_{means_Comp} + C_{means_Seas}) \text{ at year } 0 \end{array} \right] \quad (24)$$

As it is calculated by (3), the cash flows with put-or-pay contract may be calculated by adding the payoff of the option Π_p .

Once we modeled cash flows, we verified the model with experts, to make sure it represents the case we have considered.

In order to estimate the operating revenues and costs, we have used historical data, data gathered on similar projects, and/or provided by experts.

The input variables are either deterministic or uncertain. In the case we have considered, i.e., the case of the municipality of Bari, the input data are reported in Table 1. In particular, as for the quantity of posidonia collected each year $Q_p(t)$, it has been assumed to vary stochastically in time according to a mean reverting process (MRP) [41–44]. The following equation models the stochastic evolution of quantity (Q_p) in accordance with the MRP:

$$dQ_p(t) = \alpha \cdot (q^* - Q(t))dt + \sigma dW_t \quad (25)$$

where:

- q^* is the long run mean (the mean reversion level)
- σ is the annual volatility of the quantity
- α is the mean reversion rate
- dW_t is a Brownian motion (so $dW_t \approx N(0, \sqrt{dt})$).

MRP modeling implies that the model random variable is always positive and its evolution is determined, if the initial value $Q_p(0)$, the long run mean, the mean reversion rate, and the volatility of the posidonia quantity are known. We estimate all these parameters by using historical data of posidonia collected by the municipality of Bari in the period 2015–2019.

Table 1. Deterministic and stochastic input variables.

Input variable-description	Deterministic	Stochastic
γ [kg/panel]	16.34	
c_{inv} [€/panel]	0.2	
q_c [m ³ /mean]	40	
$C_{veh_hire_Coll\&Clean}$ [€/mean]	6000	
q_m [kg/mean]	3,240,000	
$C_{veh_hire_Mix}$ [€/mean]	4000	
$C_{person_Mix} = C_{person_Comp} = C_{person_Sto\&Pack}$ [€/employee]	12,000	
C_{means_Comp} [€/mean]	60,000	
$N_{person_Comp}(t)$ [number of employees/year]	4	
$C_{means_Sto\&Pack}$ [€/mean]	22,400	
$N_{person_Sto\&Pack}(t)$ [number of employees/year]	3	
		Mean reverting process
		$\alpha = 37.19\%$
		$q^* = 1,294,735$ kg
		$\sigma = 1.64$
$Q_P(t)$ [kg/year]		BetaPERT (87; 204; 419)
$\delta_{W_P}(t)$ [kg/m ³]		Uniform (20; 30)
$\delta_{D_P}(t)$ [kg/m ³]		Uniform (25%; 50%)
$\mu_P(t)$		BetaPERT(8; 10; 12)
$p_{Panels}(t)$ [€/panel]		BetaPERT(0.5; 0.9; 1.2)
$\alpha_{Panels}(t)$		Uniform(8640; 11,520)
$C_{person_Coll\&Clean}$ [€/employee]		
Data on put-or-pay contract		
W [kg/year]	4,000,000	
p [€/ton]	110	
r	3.15%	
\widetilde{T}_C [year]	20	
$t_{constr.}$ [year]	1 (year 0)	
$I_C = C_{means_Comp} + C_{means_Seas}$ [€]	50,000 + 60,000	
$m - n$ [year]	20	
$D_{tot} = I_C$ [€]	110,000	
i	2%	
$c_{waste}(t)$ [€/ton]		Uniform(130, 150)

The simulation model of the net benefit gained by each party with and without the put-or-pay contract is constructed using @Crystal ball software.

The Monte Carlo simulation approach was used for calculating them. In particular, based on the statistical distributions of stochastic input variables, random values were generated in each simulation run, and this was done for 10,000 computer iterations. Outputs of the simulation are probability distribution of the investigated variables, namely, NVP_C , NVP_G and $LCCR$, calculated by Equations (2), (5), (7), in the two cases of adoption and no-adoption of put-or-pay contract, as described in the following.

Figure 1a–c shows the simulation outputs for the base-line model, i.e., the probability distributions of the net benefit gained by each party in absence of the put-or-pay contract.

Looking at Figure 1, it is possible to observe that in absence of public support, the project is not attractive for the private sector since the expected value of the NPV_C (mean of the distribution) is negative (−3.3 mln €), with a private risk of a loss of 100% (measured as the probability of the NPV_C being less than 0).

In an analogous way, LCCR is always less than 1.2, hence the project does not satisfy the interest of the lender (risk of loss equal to 100%). Finally, the NVP_G is also negative. In this base-case case, the collection of posidonia is assumed to be done by the private against the payment of a fixed fee by the government (c_{waste}).

Figure 2 shows the probability distributions of the net benefits gained by the three main parties in PPP projects (i.e., government, private, and lender) in case of adoption of put-or-pay contract.

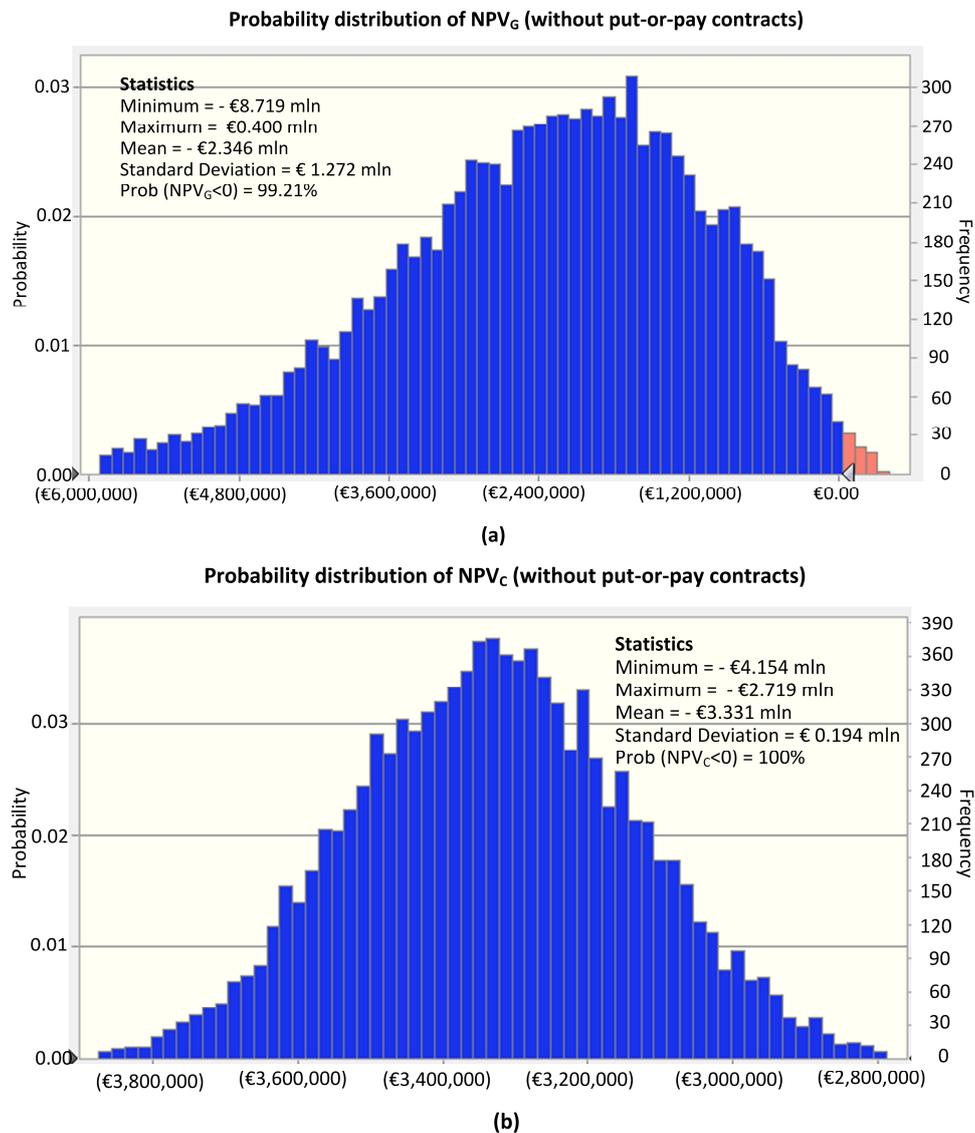


Figure 1. Cont.

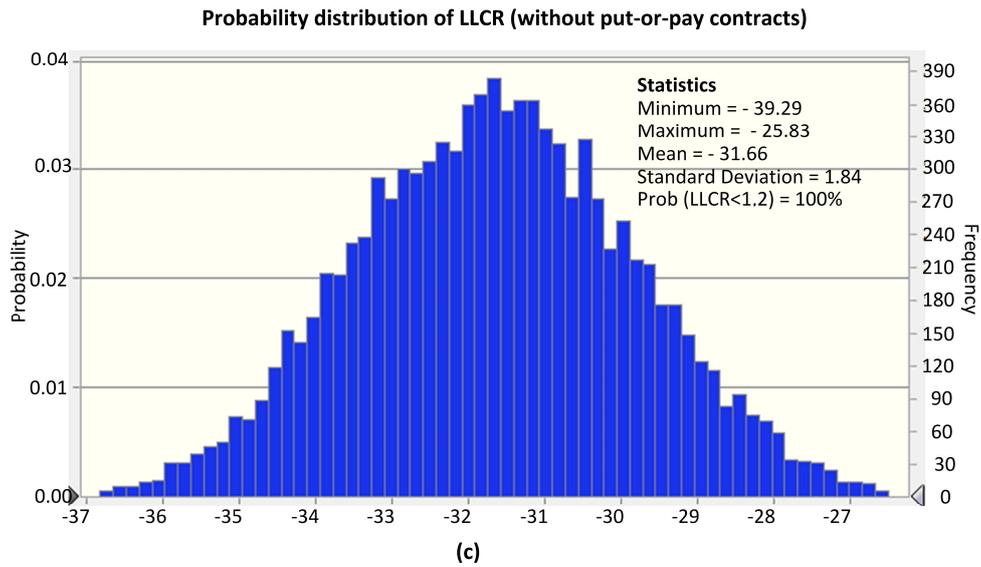


Figure 1. Simulation results for the base-line model without put-or-pay contract; (a) Probability distribution of NPV_G (The net benefit gained by the government) (without put-or-pay contracts); (b) Probability distribution of NPV_C (The net benefit gained by the private party) (without put-or-pay contracts); (c) Probability distribution of LLCR (Loan Life Covers Ratio) (without put-or-pay contracts).

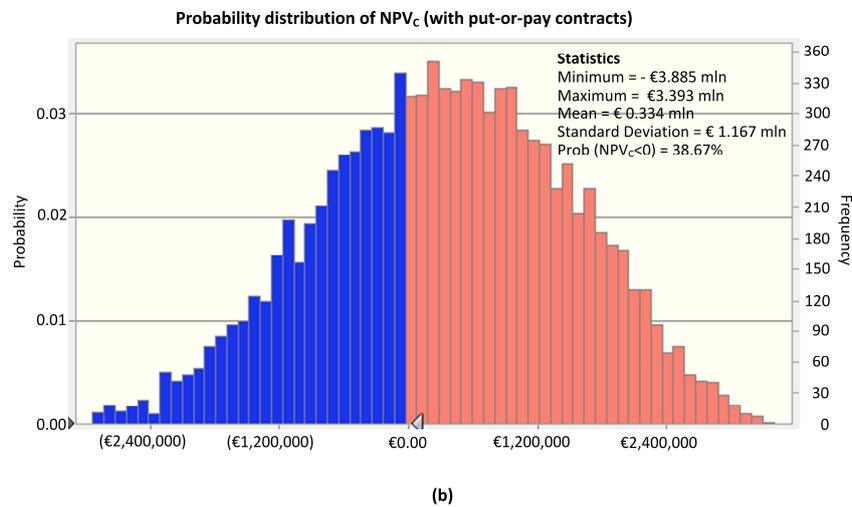
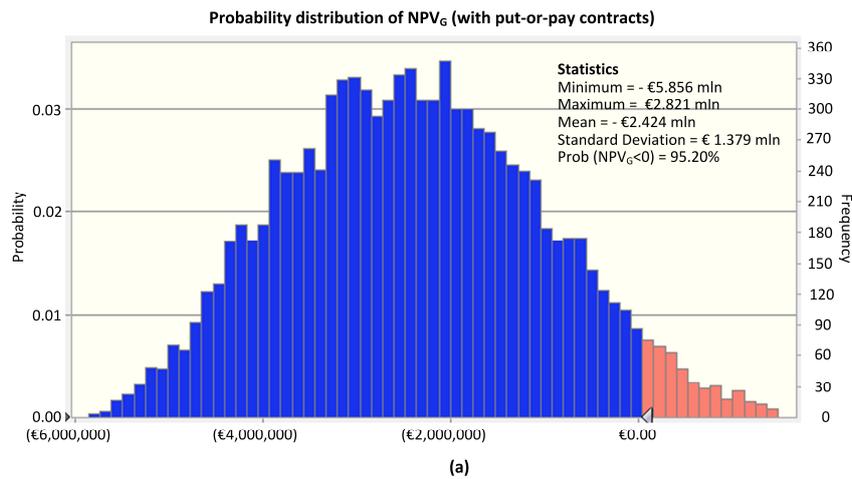


Figure 2. Cont.

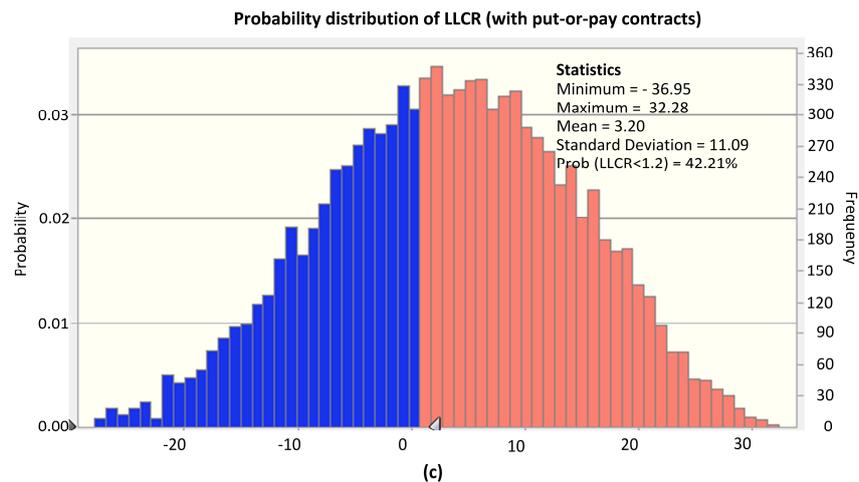


Figure 2. Simulation results for the base-line model with put-or-pay contract; (a) Probability distribution of NPV_G (The net benefit gained by the government) (with put-or-pay contracts); (b) Probability distribution of NPV_C (The net benefit gained by the private party) (with put-or-pay contracts); (c) Probability distribution of LLCR (Loan Life Covers Ratio) (with put-or-pay contracts).

Analyzing the statistics of the three distributions in comparison with the ones in absence of put-or-pay contracts, it is possible to support the implication that the introduction of a put-or-pay contract into the project is positive for all the parties. For the private, the expected NPV_C jumps from -3.3 mln € without put-or-pay contract to 0.334 mln€ in case of put-or-pay contract use, with a risk of loss of about 39% (against a risk of 100% in case of absence of put-or-pay contract).

Analogously, the expected LLCR for the lender is 3.68 in case of put-or-pay contract adoption, with a lender's risk ($\text{Prob}(\text{LLCR} < 1.2)$) equal to 41%.

The situation improves also for the government: the expected NPV_G does not change significantly, but other statistics change. In particular, the risk of loss for the government is now 95%, against the value of 99% in case of absence of put-or-pay contract.

Although the government risk is higher, it is interesting to note that, contrary to expectation, the presence of a put-or-pay contract does not increase the risk to government and therefore that of the community.

This finding supports the conclusion that introducing this type of contract may improve the performance not only of the private partner, but also of the other main actors involved in PPPs.

In other terms, the model provides a positive answer to the first research question: such contracts may really optimize risk allocation and improve the performance of the main PPP actors.

In order to answer the second research question and support parties in structuring contracts, so as to ensure the optimization of risk allocation and performance among all the considered actors, we performed a sensitivity analysis. In particular, we varied some contract parameters as well as other parameters representing different level of uncertainty.

Table 2 reports the results of the sensitivity analysis.

Table 2. Sensitivity analysis results.

		-20%			-10%			Basel-Case			10%			20%							
		NPVG [€mln]	NPVC [€mln]	LCCR	NPVG	NPVC	LCCR	NPVG	NPVC	LCCR	NPVG	NPVC	LCCR	NPVG	NPVC	LCCR					
W	With PoP	Mean	-1.321	-0.693	-6.93	Mean	-1.837	-0.196	-1.77	Mean	-2382	0.334	3.68	Mean	-2.931	0.886	8.6	Mean	-3.569	1.427	15.1
		St. Dev.	1.225	1.018	10.62	St. Dev.	1.313	1.1	10.32	St. Dev.	1.371	1.158	12.08	St. Dev.	1.441	1.208	11.43	St. Dev.	1.478	1.259	13.11
		Risk	85.10%	74.13%	77.45%	Risk	91.24%	55.91%	60.18%	Risk	95.10%	61.71	59.02	Risk	97.36%	23.39%	25.76%	Risk	98.74%	13.69%	14.8
	Without PoP	Mean	-2.353	-3.331	-31.67	Mean	-2.246	-3.331	-31.66	Mean	-2.351	-3356	-34.71	Mean	-2348	-3.372	-31.64	Mean	-2.318	-3.328	-34.69
		St. Dev.	1.274	0.192	1.85	St. Dev.	1.278	0.193	1.86	St. Dev.	1.272	0.191	2.01	St. Dev.	1.27	0.191	1.82	St. Dev.	1.27	0.194	2.04
		Risk	99.24%	100.00%	0.00%	Risk	99.21%	100.00%	0%	Risk	0.89	0	100	Risk	99.20%	100.00%	0.00%	Risk	0.80%	0%	0
α_Panels	With PoP	Mean	-2.368	0.298	3.36	Mean	-2.394	0.335	3.59	Mean	-2382	0.334	3.68	Mean	-2.378	0.344	3.72	Mean	-2.391	0.35	3.84
		St. Dev.	1.389	1.177	12.3	St. Dev.	1.389	1.178	12.03	St. Dev.	1.371	1.158	12.08	St. Dev.	1.375	1.16	12.07	St. Dev.	1.386	1.153	12.02
		Risk	94.93%	39.46%	42.52%	Risk	95.49%	37.94%	41.01%	Risk	95.10%	61.71	59.02	Risk	95.02%	37.70%	40.82%	Risk	95.20%	37.27%	40.32%
	Without PoP	Mean	-2.368	0.352	-3455	Mean	-2.394	-3.34	-34.81	Mean	-2.351	-3356	-34.71	Mean	-2.346	-3.322	-34.63	Mean	-2.391	0.35	-34.57
		St. Dev.	1.281	0.199	2.09	St. Dev.	1.281	0.197	2.07	St. Dev.	1.272	0.191	2.01	St. Dev.	1.274	0.189	1.99	St. Dev.	1.367	1.153	1.99
		Risk	0.80%	0.00%	0.00%	Risk	0.86%	0.00%	0.00%	Risk	0.89	0	100	Risk	0.75%	0.00%	0.00%	Risk	95.20%	37.27%	0.00%
Qp - σ	With PoP	Mean	-2.391	-0.342	3.78	Mean	-2.373	0.326	3.6	Mean	-2382	0.334	3.68	Mean	-2.366	0.32	3.53	Mean	-2.392	0.34	3.73
		St. Dev.	1.367	1.157	12.07	St. Dev.	1.374	1.162	12.11	St. Dev.	1.371	1.158	12.08	St. Dev.	1.368	1.157	11.95	St. Dev.	1.37	1.161	12.1
		Risk	95.22%	38.10%	40.96	Risk	95.97%	38.79%	41.51%	Risk	95.10%	61.71	59.02	Risk	95.11%	37.55%	40.89%	Risk	95.24%	37.80%	40.83%
	Without PoP	Mean	-2.332	-3.328	-34.69	Mean	-2.357	-3.33	-34.71	Mean	-2.351	-3356	-34.71	Mean	-2.348	-3.332	-34.73	Mean	-2.338	-3.331	-34.72
		St. Dev.	1.266	0.191	2.01	St. Dev.	1.285	0.192	2.02	St. Dev.	1.272	0.191	2.01	St. Dev.	1.261	0.19	2	St. Dev.	1.272	0.193	2.03
		Risk	0.92%	0.00%	0.00%	Risk	0.87%	0.00%	0.00%	Risk	0.89	0	100	Risk	0.79%	0.00%	0.00%	Risk	0.73%	0.00%	0.00%
Qp - q*	With PoP	Mean	-2.399	0.349	3.83	Mean	-2.38	0.333	3.66	Mean	-2382	0.334	3.68	Mean	-2.406	0.353	3.88	Mean	-2.367	0.323	3.57
		St. Dev.	1.381	1.168	12.27	St. Dev.	1.383	1.169	12.18	St. Dev.	1.371	1.158	12.08	St. Dev.	1.362	1.153	12.01	St. Dev.	1.371	1.158	12.07
		Risk	94.90%	37.92%	40.70%	Risk	95.06%	38.51%	41.53%	Risk	95.10%	61.71	59.02	Risk	95.22%	36.92%	39.88%	Risk	94.80%	38.05%	41.30%
	Without PoP	Mean	-2.335	-3.328	-34.69	Mean	-2.348	-3.331	-34.72	Mean	-2.351	-3356	-34.71	Mean	-2.327	-3.327	-34.67	Mean	-2.364	-3.33	-34.71
		St. Dev.	1.279	0.193	2.03	St. Dev.	1.282	0.193	2.03	St. Dev.	1.272	0.191	2.01	St. Dev.	1.257	0.191	2.01	St. Dev.	1.272	0.192	2.02
		Risk	0.94%	0.00%	0.00%	Risk	0.99%	0.00%	0.00%	Risk	0.89	0	100	Risk	0.77%	100.00%	0.00%	Risk	0.75%	100.00%	0.00%

Table 2. Cont.

		NPVG	NPVC	LCCR				NPVG	NPVC	LCCR				NPVG	NPVC	LCCR				NPVG	NPVC	LCCR
i	With PoP	Mean	-2.368	0.324	3.77	Mean	-2.366	0.34	3.63	Mean	-2382	0.334	3.68	Mean	-2.389	0.341	3.64	Mean	-2.36	0.315	3.44	
		St. Dev.	1.383	1.167	12.64	St. Dev.	1.363	1.167	12.25	St. Dev.	1.371	1.158	12.08	St. Dev.	1.371	1.157	11.84	St. Dev.	1.396	1.181	11.69	
		Risk	95.04%	38.67%	40.77%	Risk	95.13%	37.72%	41.58%	Risk	95.10%	61.71	59.02	Risk	95.20%	37.70%	41.20%	Risk	94.61%	38.91%	41.67%	
	Without PoP	Mean	-2.36	-3.331	-36.08	Mean	-2.364	-3.329	-35.39	Mean	-2.351	-3356	-34.71	Mean	-2.34	-3.329	-34.05	Mean	-2.373	-3.333	-33.46	
		St. Dev.	1.276	0.192	2.11	St. Dev.	1.262	0.192	2.05	St. Dev.	1.272	0.191	2.01	St. Dev.	1.27	0.191	1.97	St. Dev.	1.294	0.195	1.97	
		Risk	0.89%	100%	0%	Risk	0.60%	100%	0%	Risk	0.89	0	100	Risk	0.87%	100%	0%	Risk	0.78%	100%	0%	
	m-n	With PoP	Mean	NPVG	NPVC	LCCR	Mean	NPVG	NPVC	LCCR	Mean	NPVG	NPVC	LCCR								
			St. Dev.	-2.385	0.336	3.18	St. Dev.	-2.381	0.331	3.41	St. Dev.	-2382	0.334	3.68								
			Risk	1.375	1.163	10.98	Risk	1.367	1.158	11.02	Risk	1.371	1.158	12.08								
Without PoP		Mean	95.04%	38.06	42.37	Mean	94.94	38.11	41.06%	Mean	95.10%	61.71	59.02									
		St. Dev.	-2.346	-3.331	-31.61	St. Dev.	-2.351	-3.33	-31.63	St. Dev.	-2.351	-3356	-34.71									
		Risk	1.276	0.191	1.81	Risk	1.265	0.191	1.84	Risk	1.272	0.191	2.01									
	Risk	99.24%	100	0	Risk	99.17%	100	0	Risk	0.89	0	100										

Analyzing the results of the sensitivity analysis, it is possible to observe that there are some variables that may affect the performances of the project for the actors considered, and therefore need to be taken into account when the put-or-pay contract is designed, in order to ensure an optimal risk allocation that is considerate to all parties.

When the demand risk increases, i.e., the share of panels sold to the market α_{panels} decreases, the NPV_G does not change significantly, while the NPV_C decreases. The demand or market risk is fully managed by the private party, and of course it is not affected by the put-or-pay contract that instead mitigates the risk of supply.

Small changes of the amount of collected posidonia, ranging between 0–20% (either in terms of α or q^*), seem to not affect consistently the performance of the project for the parties. However, it is W , the guaranteed amount of podisonia, that has a great impact on the performance of the project as perceived by the actors. In particular, when W increases, the expected NPV_G decreases and the government risk of loss increases. The performance for the public sector becomes worse, while the situation becomes more positive for the private sector. The expected NPV_C improves as well as the private risk of loss. The latter situation is also confirmed for the lender. Of course, when W increases, the risk allocation becomes unbalanced in favor to one party against the other.

Finally, it is interesting to note that also the borrowing conditions (namely, the interest rate i and the length of borrowing $m-n$) seem to have a low impact on the performance of the project for the parties.

This is of course verified for a small range of variations, like those we have considered.

4. Conclusion

The paper investigates the impact of the adoption of public supports on the performance of PPP projects as perceived and measured by the different actors involved. In particular, the public support investigated by this study is the put-or-pay contract, which is often used in PPP projects financed through project finance for optimizing risk allocation. Although such project finance contracts are widely recognized as key for risk allocation, we remarked that there were no studies investigating how they perform in terms of risk allocation, by considering the perspective of the main actors involved rather than focusing on the standpoint of one single actor.

Addressing this issue is of fundamental importance in order to promote the sustainability of PPP projects. PPP is in fact an agreement involving different actors, the private sector, the public sector, and the lender, among others. Structuring an agreement that does not satisfy the interests of those actors in a balanced way and that does not ensure a fair risk allocation, favoring the private sector against the government, or *vice versa*, may lead to costly renegotiation and, in extreme cases, to the failure of the project.

The contribution of this research is twofold. First, we contributed to fill the gap in the academic literature on project finance contracts by investigating whether such contracts are really able to optimize the risk allocation, and therefore the performance of all the considered actors. This ensures parties to understand whether to use these public supports, thus optimizing the use of public resources. Second, we contributed to the practice by providing a practical tool that enables the defining and structuring of such contracts so as to ensure the optimization of risk allocation and performance among all the considered actors. This may support those called to structure these arrangements, ensuring that they structure these agreements in a fair and sustainable way.

Furthermore, the application of the model to the real case of posidonia treatment has an additional advantage, which is to support local authorities in identifying and defining the best alternatives to solve important local environmental problems, i.e., pollution, preserving the environment in benefit of the local community, using public funds to finance only projects that really need such public support, optimizing the use of public resources, and exploiting private expertise for managing issues that traditionally have been managed by public authorities, thus promoting the development of new local private businesses.

The study is not without limitations. One may observe that the model was developed for one specific contract, namely the put-or-pay one, and therefore, the conclusion may not be considered generalizable to other types of supports. While this is true in general since the results cannot be considered of general validity, we can certainly state that beyond the specific numbers obtained as output of this specific case, the approach can certainly be replicated. In particular, other types of project finance supports, such as take-or-pay contracts, could be investigated with the same approach, namely by considering the risk allocation holistically and not just focusing on one perspective. Also, the same approach can be adopted for a benchmark study among project finance supports, namely to benchmark and compare the performance of different types of supports in order to select the one optimizing the risk allocation for all the considered PPP actors. All these tasks may be objects of further research.

Author Contributions: A.L., R.P., G.M., L.R. conceived the study; R.P. conducted the literature review, A.L., R.P. developed the model and designed the experiments; R.P., G.M. performed the experiments; L.R., G.M., R.P. analyzed the data and results; and L.R., G.M. edited the final version of the paper. All authors have read and agreed to the published version of the manuscript.

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