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METALS-AS-A-SERVICE

ECONOMIC ANALYSIS: COMPARING THE MaaS AND LINEAR BUSINESS MODELS IN THE CONTEXT OF A WIND PROJECT

A companion report

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Context of this Report

The economic and modeling analysis in this document supports the qualitative analysis provided in the CCSI - Carbon Trust report: Metals-as-a-Service: A Strategic and Investable Circular Business Model for the Wind Energy Industry and Beyond.

The current metals system is still largely linear, reliant on continuous primary extraction, and unlikely to meet the scale of demand required for the energy transition. The Metals-as-a-Service (MaaS) circular business model responds to this constraint by fundamentally changing how metals are owned and used. Instead of being sold as one-off inputs, metals are owned and retained on the balance sheet of a dedicated entity (the "Asset Owner") and provided as a service across their lifecycle to a user (the "Lessee") through a leasing operation, from manufacturing to recovery. This allows metals to be reused across multiple cycles, incentivizes recovery, and turns material flows into monetized, traceable assets. In doing so, MaaS reduces upfront capital needs for users, improves supply security by mobilizing both primary and secondary sources, and creates a more coordinated and circular system across the value chain.

Beyond operational changes, MaaS also reshapes the financial logic of metals. Replacing upfront metal purchases with predictable service payments generates steady, long-term cash flows that can be treated as investable assets. At the same time, digital tracking and design for recovery improve visibility over material use and condition, making risks easier to monitor and manage.

This enables new forms of long-term financing and aligns incentives across producers, users, recyclers, and investors. In sectors like wind energy, where material intensity is high and long-term supply is critical, MaaS offers a way to combine circularity with bankability, supporting both infrastructure scaling and the more efficient use of finite resources.

The economic analysis in this document tests and quantifies the case for the MaaS model as framed in the companion qualitative report and now assesses its financial viability from both the Lessee's and the Lessor's (Asset Owner) perspectives. In this framework, the Lessee is an onshore wind project developer that rents metals from a dedicated Special Purpose Vehicle (SPV). The companion qualitative analysis argues that this SPV structure provides the most efficient model for retaining metal ownership as the SPV can ring-fence risks, maintain a constant stock of leaseable metal through MaaS (coined the "Metals Bank" in the main report), standardize contracts, enable digital traceability (which in turn makes performance measurable and investor-ready), and eventually provide the right conditions to securitize MaaS contracts to scale the MaaS business model.

Objective

This report presents the results of an economic model, demonstrating the financial viability of a MaaS model for both the Asset Owner (in this case, the SPV) and the metal user (in this case, the wind developer). It starts with an explanation of the key metrics for measuring risk-adjusted performance.

1. Key metrics to manage total risk and systematic risk

The 4 measures presented below focus on the total risk and systematic risk, with Total risk = systematic risk + unsystematic risk. Unsystematic risk is usually managed, not measured like systematic and total risk, because financial theory assumes it could and should be either diversified away or managed contractually when systematic risk can't be transferred, diversified away, and should be managed differently and in a more sophisticated way.

In Annex I, each risk type as it pertains to each stakeholder is characterized as systematic or unsystematic. Mitigation strategies are also elaborated for each risk.

A. Sharpe Ratio

Definition: The Sharpe Ratio measures how much *excess return* (above the risk-free rate) an investment generates for each unit of total risk (volatility).

In practice: A higher Sharpe Ratio means better risk-adjusted performance. If a MaaS-enabled value chain stakeholder has a higher Sharpe Ratio than a traditional stakeholder, it means MaaS delivers returns that are more efficient relative to the risks it faces.

B. Modigliani–Modigliani Alpha (M^2 Alpha)

Definition: M^2 Alpha adjusts performance to the same total risk level as the market benchmark, then expresses the result in percentage return terms. Unlike the Sharpe Ratio (a dimensionless number), M^2 Alpha is in the same units as returns, making it easier to compare directly with benchmarks like the MSCI ACWI.

In practice: If a MaaS-enabled stakeholder has a higher M^2 Alpha, it means that once risk is normalized, its performance is closer to or better than the market.

C. Treynor Measure

Definition: The Treynor Measure looks at returns relative to *systematic risk*, which is the risk of the overall market or economy that cannot be diversified away. It isolates how well an investment compensates for the risks that everyone must face, like recessions or interest rate shocks.

In practice: A higher Treynor Measure for a MaaS-enabled stakeholder means it is more efficient at generating returns for the unavoidable risks of being tied to the economy.

D. Jensen's Alpha

Definition: Jensen's Alpha measures the return an investment delivers above (or below) what would be expected given its exposure to (systematic) market risk (beta). It shows whether the investment is truly adding value beyond what the market would predict.

In practice: A positive Jensen's Alpha for a MaaS-enabled stakeholder means it is generating returns greater than what the market expects for its specific level of risk, proving that the structural advantages of the MaaS model are adding genuine, measurable value.

When portfolios are **not well diversified**, i.e., when total volatility matters, the Sharpe Ratio and M^2 Alpha are relevant. **When portfolios are well diversified,** only market (systematic) risk matters, and the Treynor Measure and Jensen's Alpha are more relevant.

For MaaS, these metrics are essential to measure because they quantify **whether the MaaS model reduces volatility, improves efficiency, transfers risk effectively, and delivers superior risk-adjusted returns** as compared to the linear model.

2. The lessee's perspective

To illustrate the financial mechanics of MaaS, consider the example already developed in the analysis: a **wind project sponsor** acting as the lessee (either an Independent Power Producer (IPP) or a Wind Developer), and an **SPV or another stakeholder** as the lessor of steel.

The SPV-lessee level is the segment with the highest risk in the MaaS value chain. Why? Because without the lessee's ability to pay the lease payments of the metal contracted, the SPV or any Asset Owner won't receive any income, which in turn will harm the SPV or any Asset Owner's financiers, leading the entire system to go bankrupt.

The numerical analysis examines whether MaaS-enabled financial models effectively reduce risk for the lessee, and how key risk metrics differ between MaaS and non-MaaS structures. These results inform the extent of net risk transfer and help assess whether the servitization of metals meaningfully benefits lessees, an issue central to determining whether MaaS represents a viable and attractive alternative to traditional ownership models.

The metrics outlined above can be used to characterize the nature of risk transfer between the project sponsor and the SPV.

In order to observe any changes in the risk profiles of a wind project built using MaaS and one built without MaaS, two models were adopted and built:

1. **Non-MaaS-enabled Wind Project:** This is the current status quo scenario for how wind projects are financed. The wind project's Sponsor works with an EPC contractor, who is responsible for the procurement of raw materials needed for the construction of the project.
2. **MaaS-enabled Wind Project**: here, the wind project's Sponsor becomes the lessee, providing the metal procured to the EPC contractor.

Note that there is only one leasing agreement - one between the SPV and the wind developer.

Assumptions

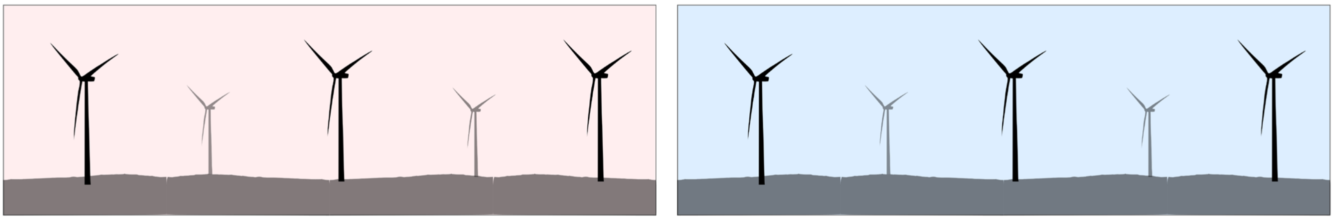
	Project type	Onshore Wind
Project Details	Size of project	400 MW
	Number of wind turbines	200 turbines of 2MW
	Electricity rate	$0.144 per kWh (arranged under a fixed 20 -year PPA)
	P-50 Capacity Factor	31%
	Debt-Equity Split	70/30
Financial Rates	Leasing Fee	7.66% (Risk-free-rate: 4.16%, Credit Spread: 3.5%) - yield compression to 6.66% over 20 years due to risk reduction
Materials & Costs	Metal Type	High Strength Low Alloy (HSLA) Steel
	HSLA Steel quantity	56,000 tonnes (280t per turbine)
	HSLA Steel spot price	$3,300
	HSLA Steel spot price annualized appreciation based on historical performance	3.14%
	MaaS debt	$187 Million (HSLA + transportation costs)
	Recovery cost per tonne	$398 per tonne
	Percentage of HSLA recoverable at EoL	100% (due to high recycling rate and fungibility)
	Decommissioning cost per turbine	$195,000 per turbine

Table 1. Wind Model Assumptions

Results

The MaaS-enabled sponsor achieves an **Internal Rate of Return (IRR) of 19.94%**. In addition, the MaaS-enabled model improves both the Equity IRR and the DSCR (showing a higher ability to pay back debt) - all of this being the result of transferring expenses from CAPEX to OPEX.

Non-MaaS-enabled Onshore Wind | **MaaS-enabled Onshore Wind**



Non-MaaS-enabled Onshore Wind: Average DSCR (31% capacity factor): **3.18**
Equity IRR: **15%**

MaaS-enabled Onshore Wind: Average DSCR (31% capacity factor): **4.02**
Equity IRR: **19.94%**

Figure 1. Performance for MaaS-enabled vs. non-MaaS-enabled wind project

Risk-Adjusted Performance

The analysis compares a **non-MaaS sponsor** with a **MaaS-enabled sponsor** across several metrics to test risk-adjusted performance, which is key to determining if the MaaS-enabled sponsor is bankable.

- **More stable returns: Sharpe is 14% higher.**
- **Better risk-adjusted performance: Treynor improves ~14%, more return per unit of market risk.**
- **Outperform the market benchmark by a greater degree: a much higher alpha delivered for the MaaS- enabled sponsor.**

However, the MaaS-enabled sponsor is more exposed to cash-flow volatility than under a traditional CAPEX-intensive project structure, reflecting a shift from upfront capital expenditure to ongoing operating expenditure. In a conventional non-MaaS model (with higher CAPEX), the higher upfront investment is typically financed with relatively low-cost, long-tenor debt, resulting in lower and more predictable debt service obligations (principal + interest) over the project life. This produces comparatively stable, though lower, average cash flows.

By contrast, under a MaaS model, a larger share of project costs is incurred as OPEX and distributed over time. This leads to higher average operating cash flows but also greater sensitivity to market conditions and project-specific performance. As a result, the distribution of cash flows exhibits a higher standard deviation of returns (and a higher beta[I]) relative to the non-MaaS model. Despite this increase in exposure to volatility, risk-adjusted performance improves under the MaaS structure. When evaluated using the Sharpe ratio (return per unit of total risk) and the Treynor ratio (return per unit of systematic risk), the MaaS-enabled onshore wind project delivers superior risk-adjusted returns compared to the traditional CAPEX-based model.

Further, the MaaS-enabled model was found to exhibit a slightly higher unsystematic risk. This assessment was derived from the assumption that unsystematic risk = total risk – systematic risk. While unsystematic risk is inherently stakeholder-specific and therefore intangible, an indicative estimate was undertaken, suggesting that unsystematic risk is higher under the MaaS structure. This increase may reflect several factors, including additional contractual and operational liabilities borne by the lessee when metals are leased rather than owned. At the same time, it is important to note that some elements of unsystematic risk are structural and may not be fully quantifiable within a numerical framework.

I Beta is a measure of co-movement with the market. It answers the following question: when the market moves, how much does this asset tend to move with it? Specifically, beta increases when project returns are more strongly correlated with market returns and when their variability is high relative to overall market volatility. In a simplified way it is inferred from the correlation between the project's returns and market returns, multiplied by the ratio of the project's return volatility (standard deviation) to the volatility (standard deviation) of the market.

Metric	Net Transfer between SPV and Wind Developer	Is this good for the MaaS-enabled Sponsor?	Explanation
Beta differential	27.44%	No	Cash flows from the MaaS-enabled Wind project fluctuate 27.44% more than the non-MaaS wind project. Fluctuations may not be preferred, as they represent volatility.
Total risk (Sharpe) differential	14.22%	Yes	Adopting the MaaS model through the SPV results in about a 14% superior return for every unit of total risk the Sponsor takes on, with improved capital efficiency due to lower upfront CAPEX.
M2 Alpha differential	41.46%	Yes	About 41% difference - an indicator of value creation, showing the MaaS-enabled Sponsor has closer financial performance with the MSCI ACWI market benchmark on a truly comparable, risk-adjusted basis
Systematic risk (Treynor) differential	14.22%	Yes	The MaaS-enabled Sponsor is about 14.22% more effective at generating returns from its exposure to unavoidable, systematic market risks.
Jensen's Alpha differential	46.87%	Yes	With a 46.87% higher Jensen's Alpha, the MaaS model proves its superior ability to generate "true" alpha for the Sponsor, delivering excess returns far beyond what would be expected for its level of market risk
Unsystematic risk differential	2.96%	No	The MaaS-enabled sponsor sees an unsystematic risk increase of about 3% from taking on the liability of the metal as a lessee and shifting risks from CAPEX to OPEX

Table 2. **Net transfer analysis**

Sensitivity analysis

In order to test how resilient MaaS-enabled onshore wind performs against a set of different sensitivity cases, a set of ten scenarios was explored against the Debt Service Coverage Ratio (DSCR) (measuring the ability to pay back the debt) and the Equity IRR (measuring the return on investment for the equity holders). The outcome revealed a breakeven point under the conditions of a PPA priced at $0.089 kWh and a capacity factor of 22%, where the minimum Debt Service Coverage Ratio (DSCR) in year 1 fell to 1x. As the PPA price is increased beyond this point, both the DSCR and Equity IRRs improve. The analysis also revealed that, across various capital structures with MaaS debt, the model remained resilient even in the worst-case scenarios, where the Onshore Wind project's capacity factor was pegged at 22% over the 20-year lifetime of the MaaS contract.

A note on negative Equity IRRs in cases 3 and 4: these are scenarios where the worst-case scenario was considered, representing very low PPA prices and the capacity factor of 22% (at P-99). The likelihood of both coming into effect for 20 years is extremely low, which is when the Equity IRRs become negative. The capacity factor of 31% (at P-50) case represented in scenario 2 is more likely - there, the same low PPA price impacts the Equity IRR, but the more probable and higher capacity factor keeps it from running into the negative.

Scenario		Debt-Service Coverage Ratio (DSCR)					Average DSCR	Equity IRR
		Year 1	Year 2	Year 3	Year 4	Year 5		
0	Sponsor's Base Case (70% debt and 30% equity), Capacity Factor 31% (P-50), PPA at $0.144/kWh. $470 CAPEX to OPEX shift per kW	2.82	2.92	3.02	3.12	3.23	4.02	19.94%
1	Base Case at 22% Capacity Factor (P-99)	2.00	2.07	2.14	2.22	2.29	2.85	8.40%
2	Base case at 0.093$/kWh PPA price (based on July 2025 U.S electricity price average for the Industrial sector), P-50 case.	1.52	1.57	1.62	1.68	1.74	2.17	-1.58%
3	0.093$/kWh PPA with P-99 capacity factor of 22%	1.08	1.11	1.15	1.19	1.24	1.54	-8.53%
4	PPA breakeven case at 0.089/kWh and 22% capacity factor (minimum DSCR falls to 1x in year 1)	1.01	1.04	1.08	1.11	1.15	1.44	-13.38%
5	Base case with CAPEX to OPEX shift of $100/kW	2.39	2.47	2.55	2.64	2.73	3.39	14.14%
6	Scenario 5 under CAPEX to OPEX shift of $100/kW under P-99	1.70	1.75	1.81	1.88	1.94	2.40	3.16%
7	Base case with CAPEX to OPEX shift of $200/kW	2.49	2.58	2.67	2.76	2.85	3.54	15.56%
8	Scenario 7 under CAPEX to OPEX shift of $200/kW under P-99	1.77	1.83	1.89	1.96	2.02	2.51	4.51%
9	Non-MaaS Sponsor case under 70-30 split (P-50)	2.31	2.38	2.46	2.54	2.62	3.18	15.00%
10	Non-MaaS Sponsor case under 70-30 split (P-99)	1.64	1.69	1.75	1.80	1.86	2.26	-13.07%

Table 3. **DSCR and Equity IRR under different scenarios**

LCOE Analysis

To identify whether MaaS is capable of facilitating the clean energy transition by lowering the Levelized Cost of Energy (LCOE) of wind projects, we compared the LCOEs of the two identical non-MaaS and MaaS-enabled onshore wind projects, described above.

If MaaS reduces the upfront cost of building an onshore wind farm, one might expect that to lower the LCOE over time, since less capital is tied up at the start. But in practice, the ongoing payments to rent the metals can offset much of that benefit.

Our findings show the contrary. The reduction in CAPEX of about 22% lead to the reduction in LCOE of MaaS-enabled onshore wind by 15% (Fig 2). This suggests that renewables, such as wind, competing with fossil fuels could ultimately gain a further competitive edge when their project sponsors enter into MaaS contracts.

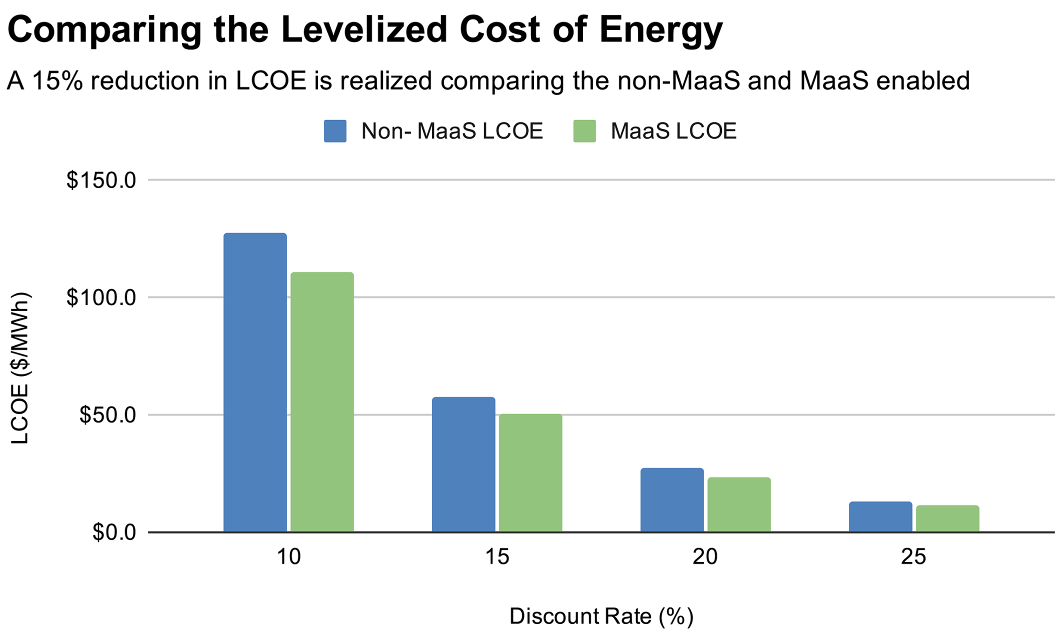


Figure 2. **Comparing the Levelized Cost of Energy**

3. The lessor's perspective

This section presents the results from the model built to cover the MaaS SPV leasing HSLA steel to the same wind developer for the onshore wind project mentioned above. SPV's role is to absorb the metal price risk and ensure that it receives a guaranteed return. From the Sponsor's perspective (regardless of whether it is MaaS or Non-MaaS), the SPV is a counterparty that provides a service (risk absorption) for a fee. The above should be established as context before interpreting the calculations below.

Assumptions

Cost assumptions	Amount
Total HSLA Steel cost (same assumptions as above)	$184.8 Million
All-inclusive costs of setting up SPV[II]	$89,000
Contract formation legal fees	$11,000
Total Cost	$184. 9 Million
Cost overrun buffer (attributed to commodity spot price fluctuations)	5%
With the cost overrun buffer included, the cost of setting up the HSLA SPV	$194 million

Table 4. **Model Assumptions for the lessor**

II "What Are the Costs Associated with Running an SPV on AngelList?" AngelList Help, https://help.angellist.com/hc/en-us/articles/36051437392781-What-are-the-costs-associated-with-running-an-SPV-on-AngelList.

Capital structure: The model assumes a 50% equity and 50% debt mix, with a deliberately high cost of capital to reflect the early-stage nature of MaaS. As a novel model with no operating track record, MaaS is unlikely to attract lenders willing to underwrite more than half of the capital structure, and any debt provided would likely carry a significant credit spread. The inclusion of debt, rather than assuming a fully equity-funded structure, can nevertheless be justified if innovative financing tools supported by strong industry relationships and social capital are available. Under such conditions, it is plausible to secure debt financing without the cost of debt exceeding the average yield generated by MaaS.

Depreciation: The model assumes the SPV's metal asset is CAPEX, as the SPV owns the metal in the developer-operator's equipment (the wind tower). Hence, the metal assets may be depreciated evenly over their estimated useful life using the straight-line method (as per the accounting standards - US GAAP and IFRS). Non-depreciable setup costs associated with establishing the SPV were first identified as a share of total project costs and deducted from the asset base, resulting in an average annual depreciation of approximately USD 11.2 million over 20 years. This depreciation expense generates material tax shields, that is passed on to the investor.

Derivatives: Another key feature of this model was the implementation of derivatives to manage the price risk of HSLA steel. The instrument of choice was a futures contract traded on the Chicago Mercantile Exchange (CME). Using options would have still been possible, but inspection of the daily volume of traded contracts of hot rolled coil steel revealed that Futures are the most liquid instrument.[III]

Fees: Three different structures were considered in this analysis. An LLC to Pilot MaaS, an MLP to scale MaaS, and a CIT (ETF) to further operate at scale. The following fees were used as part of the assumptions for each structure:

I. LLC - 1.5% on Fee Earning Assets Under Management (FAUM).
II. MLP - 1.25% on FAUM.
III. ETF - 1% on FAUM.

Holding the debt-to-equity ratio constant at 50/50, differences across MaaS structures (LLC, MLP, or CIT) are driven primarily by these asset management fees. Given the operational and financial complexity of MaaS, these fees are expected to be relatively high, reflecting the need for specialist commodity and asset management expertise. Structurally, an LLC is a business entity and may also be organized as an MLP, whereas a commodity investment trust is not a company but an investment vehicle used to acquire, hold, and lease physical metal, governed by trustees with fiduciary duties to beneficiaries.

III CME Group, U.S. Midwest Domestic Hot-Rolled Coil Steel (CRU) Index, retrieved from CME Group, March 19, 2026, https://www.cmegroup.com/markets/metals/ferrous/hrc-steel.html.

Results

Risk-Adjusted Returns

The model produces an IRR in the range of 8.68–9.0%. Given the long-lived, capital-intensive nature of infrastructure investments, these returns are broadly comparable to those typically observed in greenfield projects such as onshore wind. To enhance returns, the model assumes that interest repayments received from the lessee are reinvested to purchase additional metal for leasing, at a fixed spot price of USD 3,300 per tonne. A further assumption is that recovered HSLA steel retains its value over time. Using historical Hot Rolled Coil steel prices, which is the most traded proxy for HSLA steel on CME[IV], the model derives an annualized price appreciation of 3.14%.

Our SPV model represents an early-stage snapshot of MaaS, producing IRRs that may appear modest in absolute terms but are attractive on a risk-adjusted basis (see Figures 3 and 4). These returns offer diversification benefits relative to the risk-free rate, inflation, and public equity markets, reflecting the natural negative correlation embedded in the MaaS model. This is because the commodity market is negatively correlated with the risk-free rate.[V]

Across the three MaaS structures, the standard deviation ranges from 18.59 to 21.05%, which is above the benchmark, the S&P GSCI Industrial Metals Index[VI] (which has a standard deviation of 17.15%[VII] over a 10-year period). This standard deviation is primarily structural, resulting from the SPV's obligation to manage the asset's lifecycle and price risks through actively hedging, as well as compensate a skilled asset manager to operate and implement MaaS.

The SPV has a negative Beta between -0.23 and -0.27, meaning it is negatively correlated with the broader market and will outperform when the market underperforms, and vice versa.

IV U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Hot Rolled Steel Bars, Plates, and Structural Shapes [WPU101704], retrieved from FRED, Federal Reserve Bank of St. Louis, March 19, 2026, https://fred.stlouisfed.org/series/WPU101704.

V "The Effects of Interest Rates on Commodity Prices," Jeffrey Frankel: James W. Harpel Professor of Capital Formation and Growth, Harvard Kennedy School, https://frankel.scholars.harvard.edu/effects-interest-rates-commodity-prices.

VI "S&P GSCI Industrial Metals," S&P Global, https://www.spglobal.com/spdji/en/indices/commodities/sp-gsci-industrial-metals/#overview.

VII S&P Dow Jones Indices, Commodities: S&P GSCI Industrial Metals (February 27, 2026), https://www.spglobal.com/spdji/en/idsenhancedfactsheet/file.pdf?calcFrequency=M&force_download=true&hostIdentifier=48190c8c-42c4-46af-8d1a-0cd5db894797&indexId=10003477.

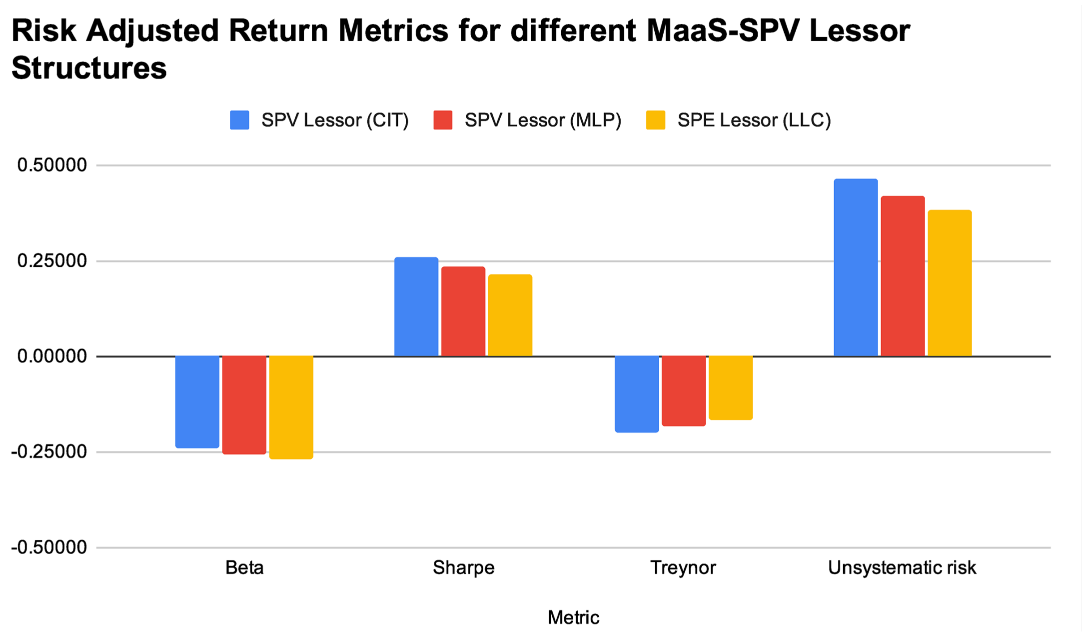


Figure 3. **Risk-adjusted return metrics for different MaaS-SPV structures**

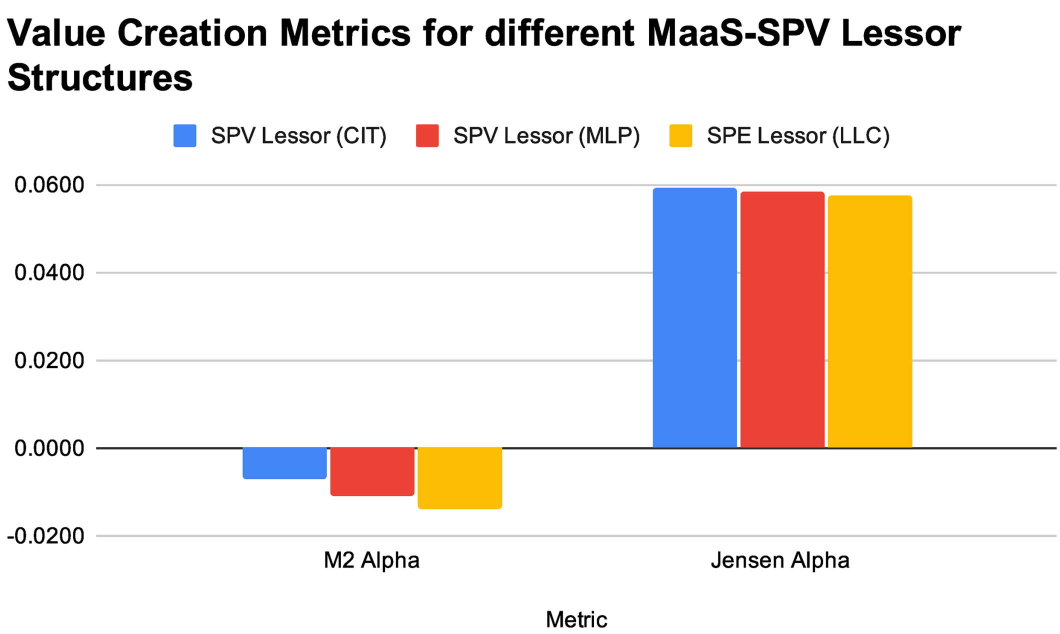


Figure 4. **Value creation metrics for different MaaS-SPV structures**

Risk Management

Price risk: The SPV manages price risk through "delta hedging[VIII]": targeting a net-zero exposure by offsetting its long position in physical metal with short futures contracts. Although conceptually simple, this approach requires significant asset-management expertise, as maintaining a neutral position entails frequent rebalancing and associated transaction costs and commissions. These frictions are reflected in the model by hedging all metal using derivative contracts. In addition, a 5% cost overrun buffer serves as an internal cushion against short-term market volatility and may result in an effective acquisition cost

VIII James Chen, "Delta Hedging Strategy: Understanding and Implementing Real-World Examples," Investopedia (blog), https://www.investopedia.com/terms/d/deltahedging.asp.

above the assumed spot price of USD 3,300 per tonne. The analysis assumes direct spot-market procurement, but an alternative structure (such as an offtake agreement between a steel producer and the HSLA SPV) could reduce price volatility and lower the required buffer, potentially by up to 5%. This benefit, however, would come at the cost of increased counterparty risk, making the choice between spot procurement and offtake a trade-off between price stability and exposure to counterparty failure.

Counterparty (Credit) Risk: The SPV's revenue is derived from the 7.66% leasing rate paid by the Wind Project. If the Lessee (Wind Project) faces operational failure (e.g., low wind capacity factors) or market failure (low electricity prices), the SPV receives no income. To mitigate this, the SPV requires 1.1x overcollateralization ($206.69 million in collateral against $187.9 million in metal value) as discussed in Sections 6 and 9 of the qualitative companion report.

The model assumes the Lessee's credit risk decreases over time as the project stabilizes. The Credit Spread charged by the SPV compresses from 3.50% in 2026 to 2.50% by 2046, reflecting this reduced counterparty risk.

Structural Risk and Capitalization: The SPV maintains an average DSCR of 1.45, which, may not be entirely ideal for a lender if this were **not** a pilot, but with future forms of MaaS supporting greater credit bearing capacity to take on more leverage, the DSCR is bound to improve towards sustainable levels that can not only pay the debtors but also support securitization in the future.

Asset Recovery and Fungibility Risk: The SPV faces the risk that the asset returned at the end of the lease is unusable or unrecoverable. As previously noted, the SPV relies on the concept of fungibility to mitigate the risk of specific asset damage. The SPV does not have the obligation to pay for recycling ($41.49 million), which, under the model, is the lessee's contractual responsibility. A good practice in this regard is that the MaaS agreement should have the lessee work with a designated recycler agreed upon by both parties at the time of signing, unless circumstances change.

Sensitivity analysis on the asset recovery risk.

To measure the extent to which the HSLA SPV's profitability ratios would change in the event that less than 100% of the metal rented is recovered, a sensitivity analysis tied to recovery rates for the three forms - LLC, MLP, and CIT were executed. The results show that the DSCRs remain unchanged (as the impact of metal recovery is not tied to the SPV's ability to repay debt), hence showing that the model remains resilient and risk-free for creditors lending to the HSLA SPV.

The equity tranche naturally takes the hit, leading to an exponential marginal decline in IRR for every 5% decrease in the recovery rate. Our research suggests that HSLA won't ideally experience a decline in recovery rate below 95%. The 5% loss is attributed to the introduction of impurities during the recycling process, resulting from corrosion and natural factors affecting the wind towers over the 20-year MaaS contract period.

Assuming an extreme scenario in which 50% of the HSLA wind towers are destroyed in a natural disaster in the 20th year of the contract period, the equity IRR will range from 5.49% to 5.91%, which remains tolerable, demonstrating the resilience of this MaaS model.

Parametric insurance (coverage triggered by predefined events or indices and increasingly used in renewable energy[IX]) could provide an additional protection layer for the MaaS SPV. Coverage could address extreme recovery shortfalls beyond contractual thresholds, with policies procured at the lessee level but structured to benefit the SPV. Complementary policies at the lessee level could address climate-related operational disruptions, while SPV-level coverage could protect against supply-chain delays and associated revenue losses.

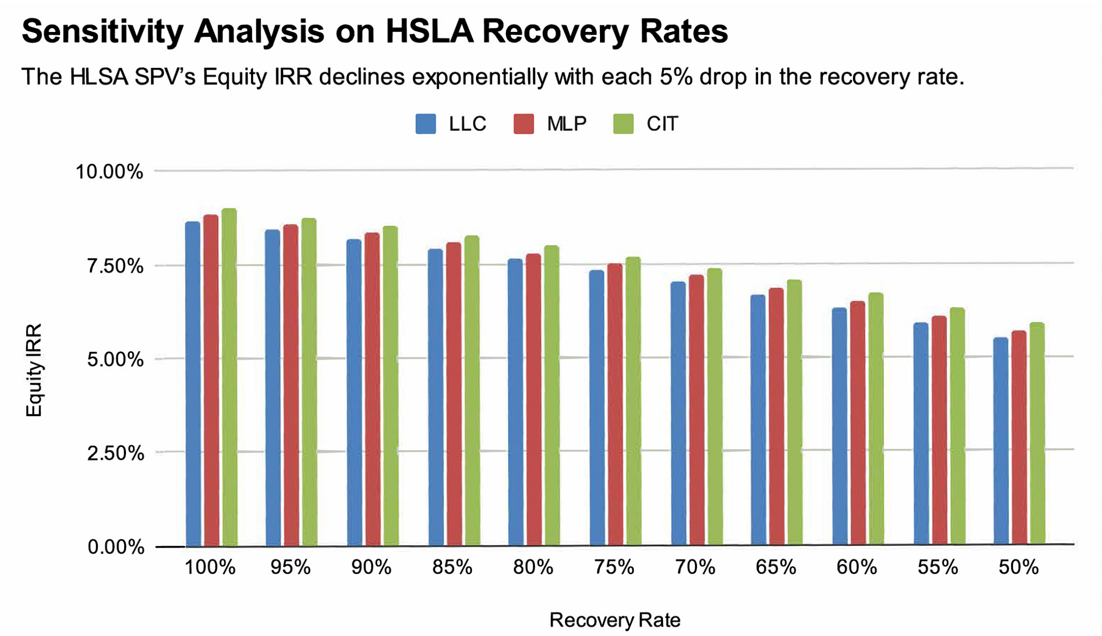


Figure 5. Sensitivity analysis- impact of HSLA recovery rates on equity IRRs

IX Emmalina Glinskis and Daniel Murphy, "What is Parametric Insurance and How is it Building Climate Resilience?" World Economic Forum (blog), January 8, 2025, https://www.weforum.org/stories/2025/01/what-is-parametric-insurance-and-how-is-it-building-climate-resilience/.

ANNEX I - Identification of risks by stakeholder and Mitigation Strategies

Total risk = systematic risk + unsystematic risk. Unsystematic risk is usually managed, not measured like systematic and total risk, because financial theory assumes it could and should be either diversified away or managed contractually when systematic risk can't be transferred, diversified away, and should be managed differently and in a more sophisticated way.

Stakeholder	Risk Type	Specific Risk	MaaS-specific Risk Mitigation Strategy	
Metal Asset Owner	Systematic	Metal Price Volatility	• Implement dynamic pricing mechanisms with commodity price floors/ceilings • Diversify metal portfolio across different commodity cycles	• Use financial hedging instruments (futures, options) • Negotiate pass-through clauses for extreme price movements on the basis of the convenience yield
	Systematic	Interest Rate Risk	• Use fixed-rate financing for long-term assets • Implement interest rate swaps and caps	• Match lease duration with financing terms • Build interest rate escalation clauses into long-term leases
	Systematic	Inflation Risk	• Include inflation adjustment mechanisms in lease agreements	• Use real asset backing as a natural inflation hedge
	Unsystematic	Credit Risk (Lessee)	• Implement robust credit screening and monitoring • Require security deposits and guarantees • Use credit insurance products	• Diversify lessee portfolio across industries and geographies • Implement early warning systems for financial distress
	Unsystematic	Residual Value Risk	• Invest in advanced metal tracking and condition monitoring • Implement strict quality standards and inspection protocols • Use predictive analytics for residual value estimation	• Require lessee compliance with usage guidelines • Partner with certified recyclers for value recovery assurance
	Unsystematic	Asset Recovery Risk	• Implement blockchain-based asset tracking systems • Use IoT sensors for real-time location monitoring • Establish legal frameworks with clear recovery rights	• Pre-negotiate with certified recycling partners • Require asset location disclosure and access rights • Consider developing regional recovery hubs
	Systematic	Environmental Regulation	• Stay current with regulatory developments • Design compliance into lease agreements	• Partner with certified environmental service providers • Maintain regulatory compliance reserves
	Systematic	Trade Policy Risk	• Diversify geographically across trade zones • Monitor trade policy developments actively	• Build flexibility into supply chain arrangements • Use political risk insurance where appropriate
	Unsystematic	Obsolescence Risk	• Focus on metals with broad industrial applications • Implement technology roadmap monitoring	• Build upgrade and substitution rights into leases • Maintain relationships with metal processors and recyclers for recycling options

Stakeholder	Risk Type	Specific Risk	MaaS-specific Risk Mitigation Strategy	
Metal Lessee	Systematic	Metal Price Volatility	• Lease metal using MaaS to avoid exposure to fluctuating metal prices.	
	Systematic	Economic Downturn	• Build flexible lease terms with volume adjustments • Negotiate payment deferrals and restructuring options	• Maintain adequate working capital reserves • Diversify revenue streams and customer base
	Unsystematic	Operational Cash Flow	• Align lease payment schedules with revenue cycles • Negotiate seasonal payment adjustments • Maintain credit facilities for working capital	• Use revenue-based lease structures where possible (tracking the recurrent revenue cash flows of the lessee)
	Unsystematic	Supply Disruption	• Build buffer inventory (metal stock) within lease agreements (leasing more than required as a cautionary buffer) • Establish backup supply arrangements	• Implement supply chain traceability systems • Negotiate service level guarantees with Asset Owners
	Unsystematic	Quality Risk	• Establish clear quality specifications in lease agreements • Implement incoming quality inspection protocols	• Negotiate quality guarantees and replacement rights • Use certified suppliers and quality management systems
	Systematic	Product Liability	• Clarify liability allocation in lease agreements • Use comprehensive product liability insurance	• Implement quality assurance and documentation systems • Negotiate indemnification clauses where appropriate
	Unsystematic	New Process Integration Risk	• Conduct thorough technical due diligence • Implement phased integration approaches	• Invest in process flexibility and adaptability • Maintain close technical collaboration with suppliers
Financier	Systematic	Metal Price Volatility	• Use sophisticated commodity risk models • Implement dynamic loan-to-value ratios	• Require additional collateral for high-risk metals • Use commodity-linked interest rates
	Systematic	Interest Rate Risk	• Use asset-liability matching strategies • Implement interest rate risk management tools	• Build rate sensitivity into loan pricing • Maintain diversified funding sources
	Unsystematic	Counterparty Credit Risk	• Implement enhanced due diligence for MaaS models • Use specialized MaaS risk assessment frameworks	• Require operational performance covenants • Monitor real-time asset utilization and performance
	Unsystematic	Asset Recovery Risk	• Require asset tracking and monitoring systems • Pre-arrange relationships with metal recyclers	• Use asset recovery specialists and legal frameworks • Maintain asset recovery insurance coverage
	Systematic	Basel III/IV Requirements	• Maintain strong capital ratios above regulatory minimums • Use regulatory capital optimization strategies	• Monitor regulatory developments and impact • Engage with regulators on MaaS-specific issues
	Unsystematic	Due Diligence Risk	• Develop MaaS-specific risk assessment expertise • Use specialized advisors and consultants	• Implement comprehensive due diligence checklists • Build industry knowledge and benchmarking capabilities

Table 5. Stakeholder-specific risk and mitigation strategies

Columbia Climate School
Columbia Center on Sustainable Investment

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