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Global Markets Division

Lithium market

Is a quantitative solution using a tangency portfolio able to give an allocation with reduced systematic risk?

Qualitative approach leading to quantitative solution

Vienna, 20th April

Team Overview

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- B.Sc. Business Administration



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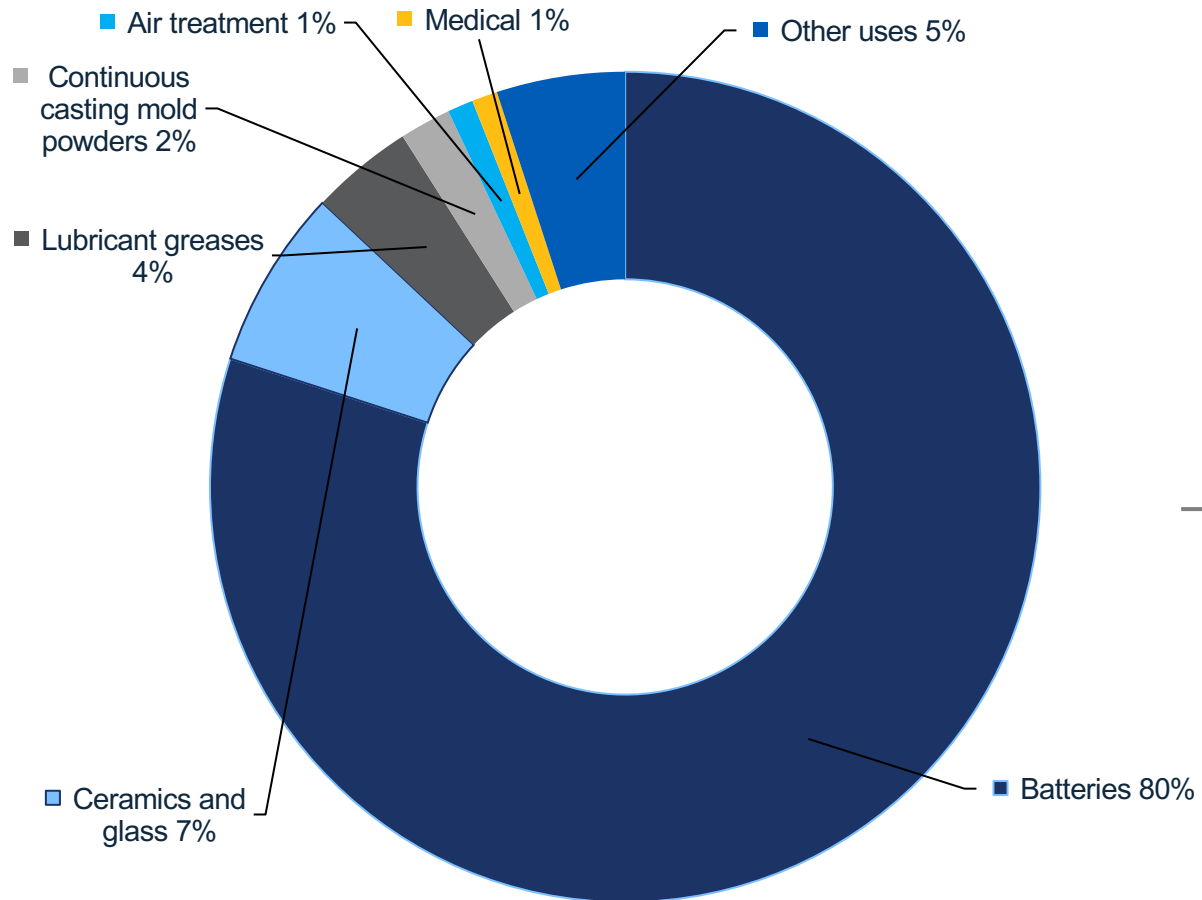
- B.Sc. Business and Economics

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The Lithium Industry 1/2

The breakdown of a commodity sector

Lithium end-usage (2022)



Key developments



EV batteries key driver of lithium demand

Share of lithium used for batteries expected to grow to 95 % by 2030



9 % of global car sales in 2021 were electric

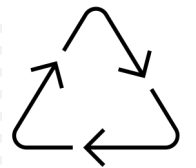
Around 8 to 10 kg of lithium per EV battery needed

Lithium recycling

Up to 80 % lithium recovery rate when recycling end-of-life batteries

Secondary supply currently insignificant

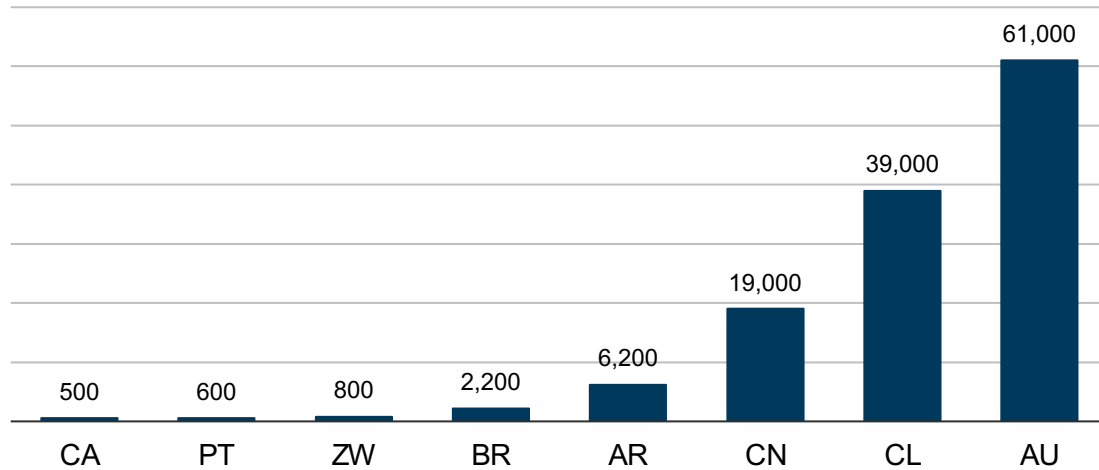
According to McKinsey modest 6 % could be secondary supply of lithium by 2030



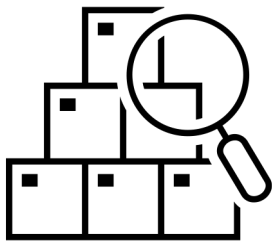
The Lithium Industry 2/2

The current state of the sector

Production in metric tons (2022)



Different lithium products



Two types of lithium products:

- Lithium carbonate
- Lithium hydroxide

Both types used for batteries

Lithium hydroxide -> more efficient for battery production

Lithium carbonate -> also used for other appliances

Lithium hydroxide on the rise, lithium carbonate on decline

Types of lithium mining



Ore mining (Australia)

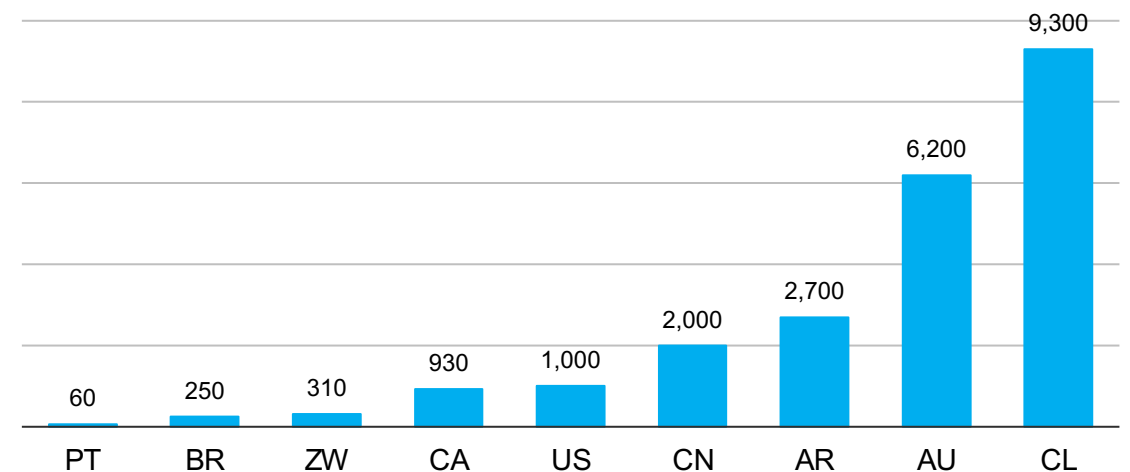
Brine vaporization (Lithium triangle, South America)

Direct Lithium Extraction (DLE)

Direct Lithium to Product (DLP)

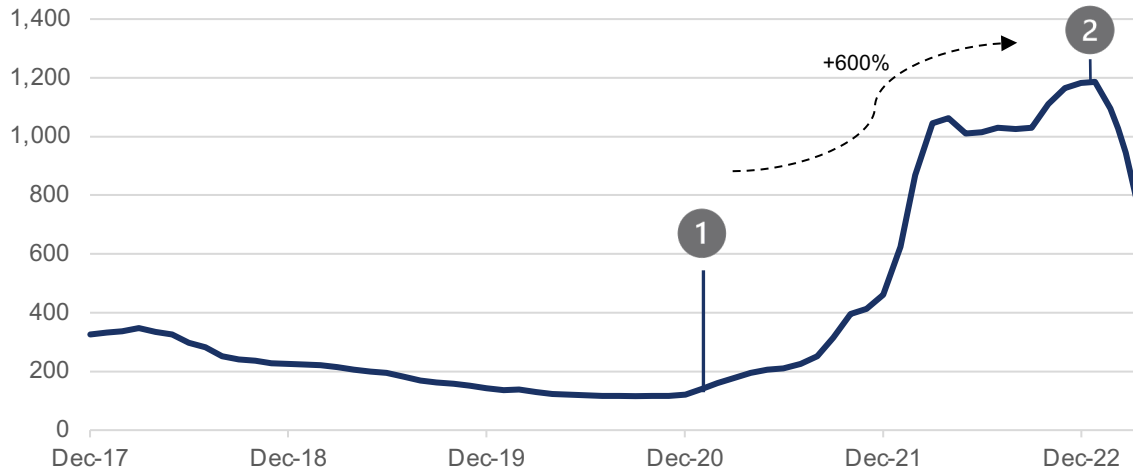
Geothermal extraction of lithium

Reserves in 1000 metric tons (2022)

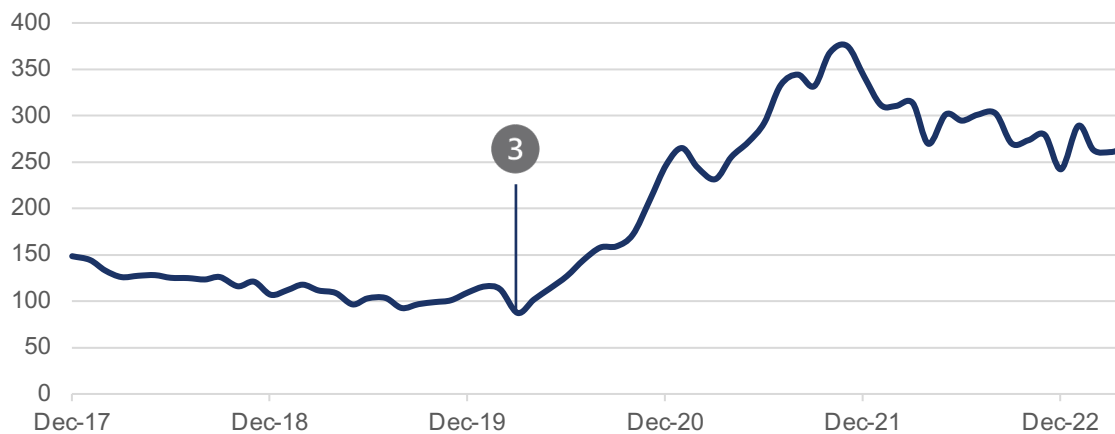


Massive revenue due to record prices

Lithium Price Index (underlying price in USD/mt)



Solactive Global Lithium Index



Events






How prices took off

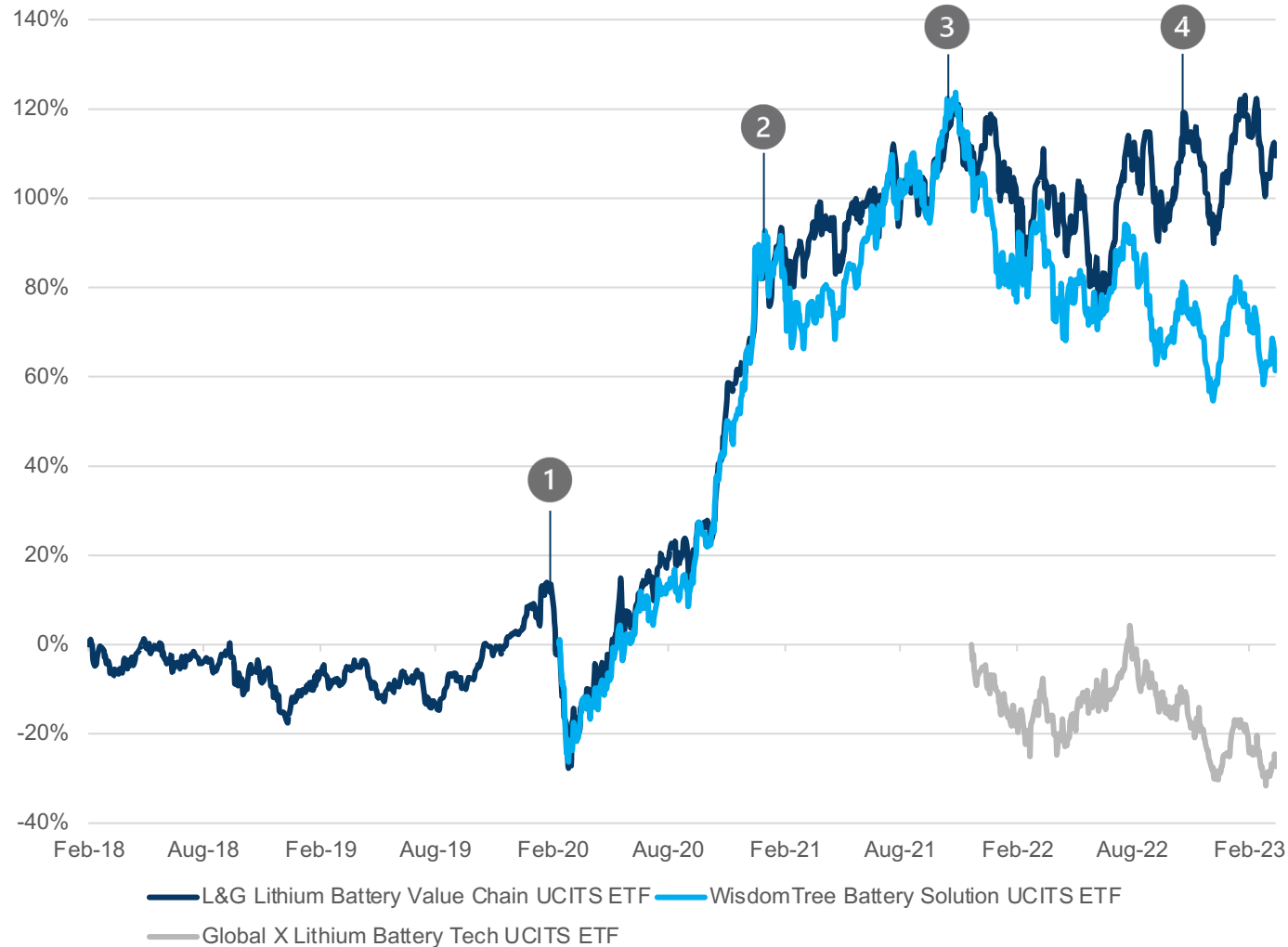
- 1 Since sales of EVs began to take off, demand soared and so did prices, also covid related labor shortage
- 2 Falling price of lithium - caused by slowing sales growth in Europe and China after subsidies for electric car purchases expired and increasing supply
- 3 The growth of the EV market made lithium related stocks very popular even before prices for lithium started to explode



Are companies able to keep revenues high even with lower prices?

-  Profit margins of up to 10 times the cost of production at current prices
-  Total cash margin on an LCE basis shows that brine operations on average are expected to achieve almost double that of hard rock producers
-  Differences in prices between various products and within individual product types make it difficult to compare different operations

Is the market represented through existing indices?



Three ETFs display the market

- 1 Covid pandemic
- 2 Supply shortages / increasing demand
- 3 Inflation sentiment
- 4 Different allocations in ETFs

All indices display different segments

- Solactive Battery Value Chain Index
- WisdomTree Battery Solution Index
- Solactive Global Lithium Index

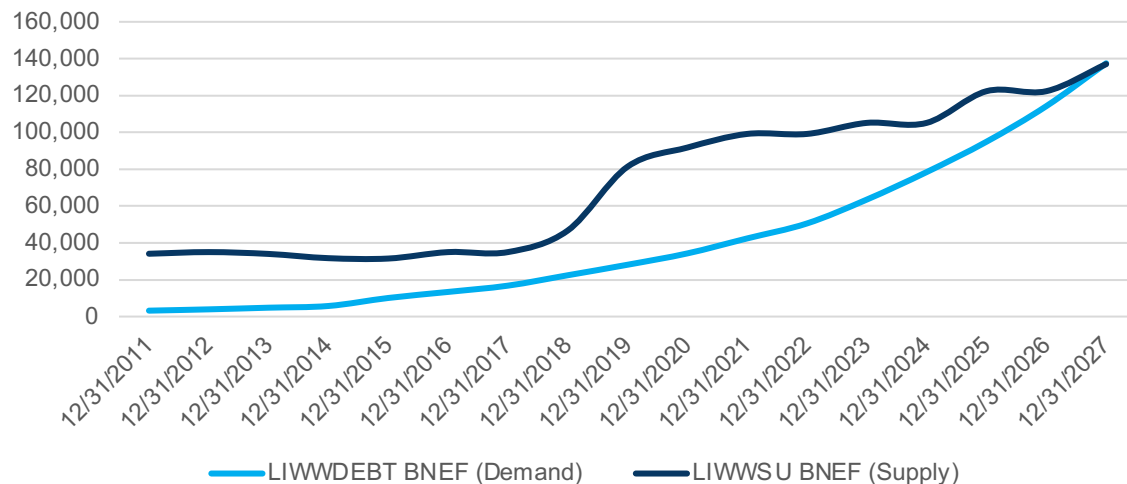
Solactive Global Lithium Index:

Solactive Global Lithium Index tracks the largest companies worldwide that are active in the mining of Lithium or the production of lithium batteries.

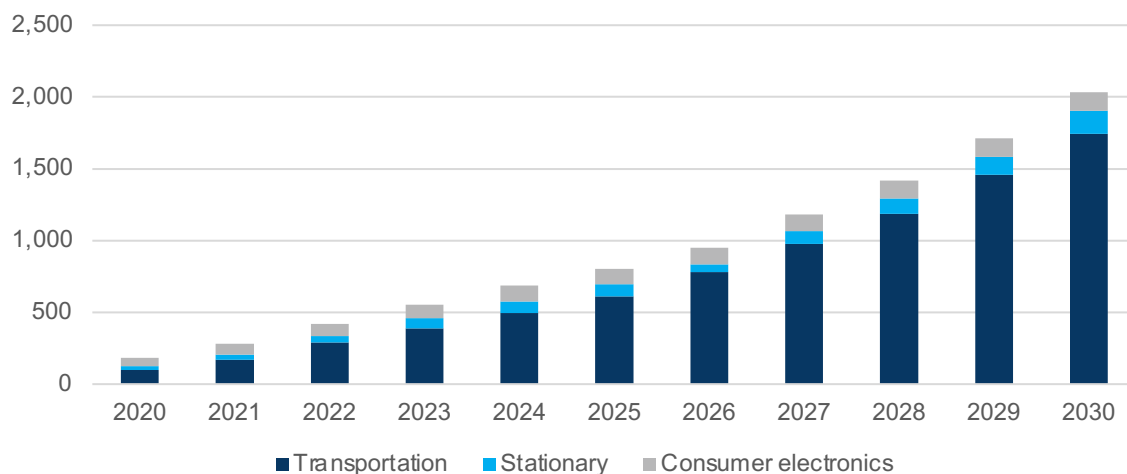
Solution → compose new portfolio with adjusted companies

Growing markets promise high growth for demand in the near future


Supply and demand of lithium (2020, in metric tons)





Battery demand (in gigawatt hours)




What is expected?

- 

Transportation makes up roughly 80% of the global battery demand
- 

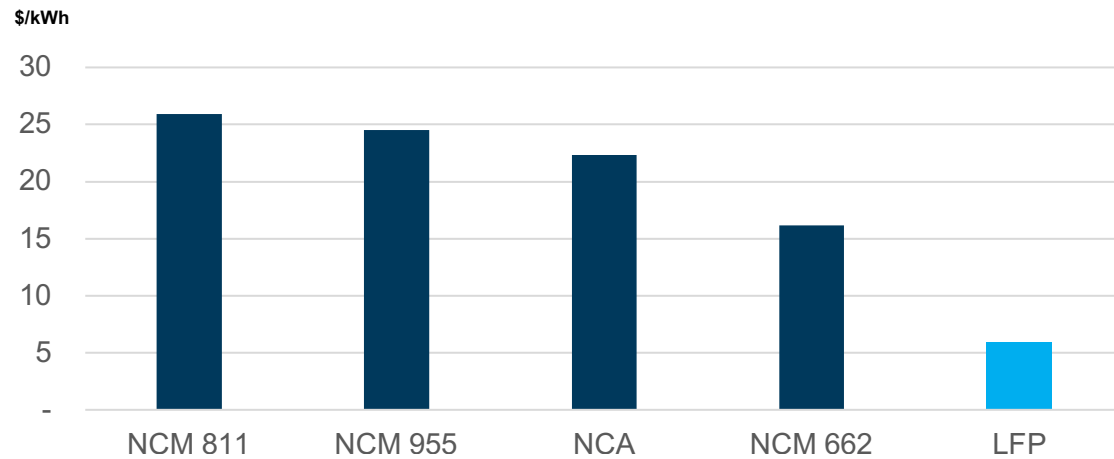
Global EV market expected to grow by 29% annually till 2030, reaching 31.1 million in total sales
- 

Expected lithium demand will outpace supply by 2027

 Creation of a bullish sector portfolio

Environmental and geopolitical uncertainty


Battery recycling credit




Country risk

Top producers	Country risk	Main type of risk
Australia	2.8	Regulatory burden
Chile	3.4	Policy instability
China	3.5	Regulatory burden
Argentina	4.5	Labour strikes
United States	2.5	State contract alteration

ESG




The lithium supply chains face geographical, political, social, regulatory and environmental challenges to keep up with the global demand.




Main environmental issues:


- Water consumption
- Air, water and soil contamination



Domestic supply not necessarily have lower environmental impact than international supply



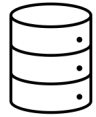
Efforts are made towards cleaner and safer operation



Lifecycle assessment

Alternatives in the works

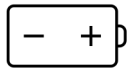
Substitution risk



Grid storage applications have other alternative technologies



Currently no substitute to meet demand in the mobility applications



Potential replacement only suitable for low performance implementations



Many alternatives in early stages of development and have yet to be widely adopted in commercial applications.

Technology risk

Technology	Description	Maturity	Lithium recovery %
Adsorbents	Adsorption process using sorbents	In use commercially	80-99.9
Ion exchange	Ion exchanger using resins, aluminates, or ceramics	Precommercial	80-99.9
Solvent extraction	Fluid solvent mixture blended with brine to extract water	Precommercial	99.9
Membrane separation	Often used in conjunction with ion exchange and adsorbents/solvent extraction; promising processes are nanofiltration and reverse osmosis	Precommercial	>99
Electrochemical separation	Electrochemical extraction of lithium from brines by adsorption or intercalation	Precommercial	>90

Subsidies



Both the European Commission (€3.2 bn) and the Biden-Harris Administration (\$2.8 bn) have lithium related subsidies in place

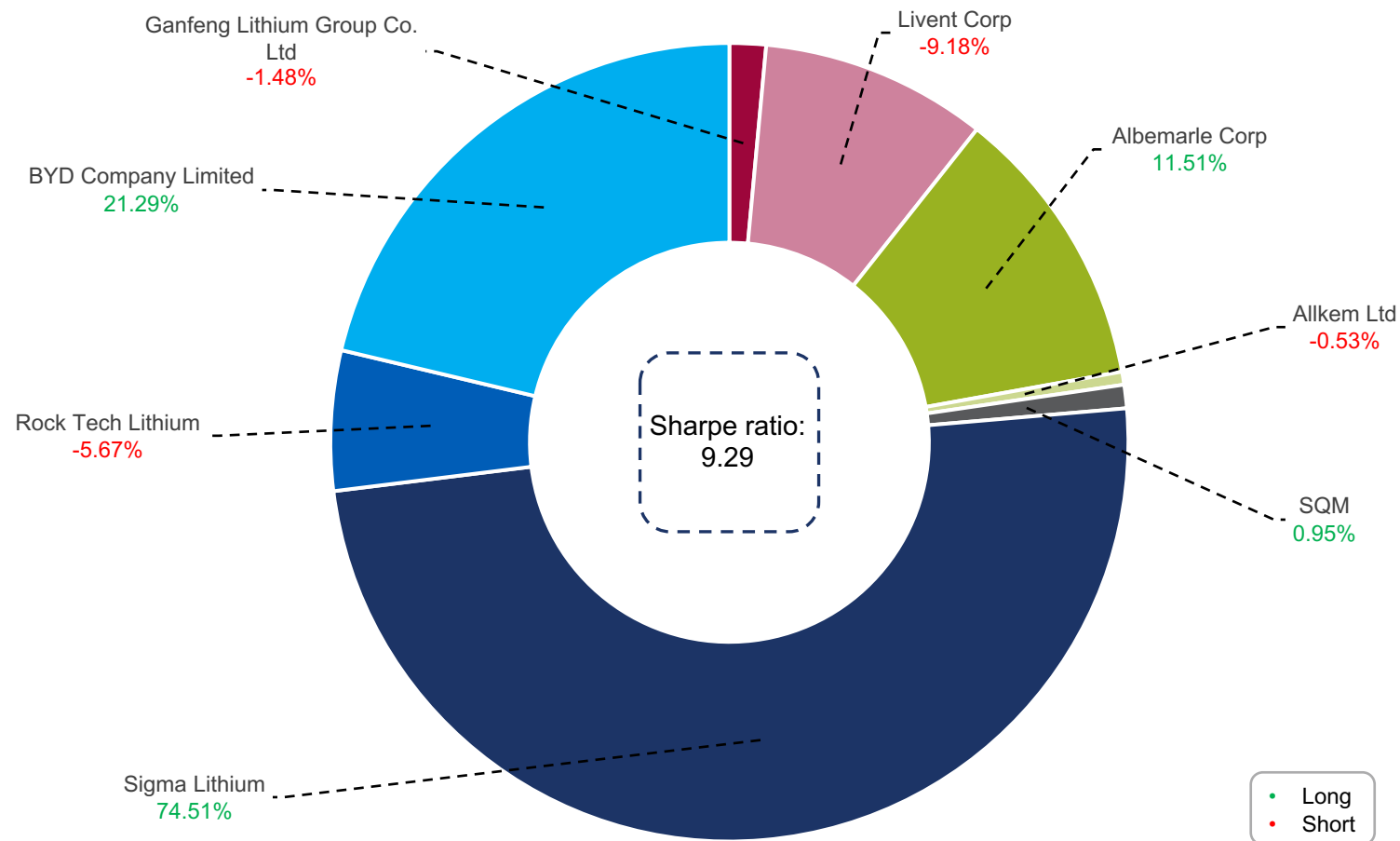


Most countries have some form of incentive in place for EVs

Stock Portfolio 1/2

Allocation for maximum risk/reward

Assets



Figures

Expected Portfolio return	102.37%
Variance	1.13%
Standard Deviation	10.62%
Sharpe ratio	9.292575246

Portfolio maximizes risk return

Portfolio had an annualized performance of 102.37% (2020 – today)

Long lithium production including major battery manufacturer

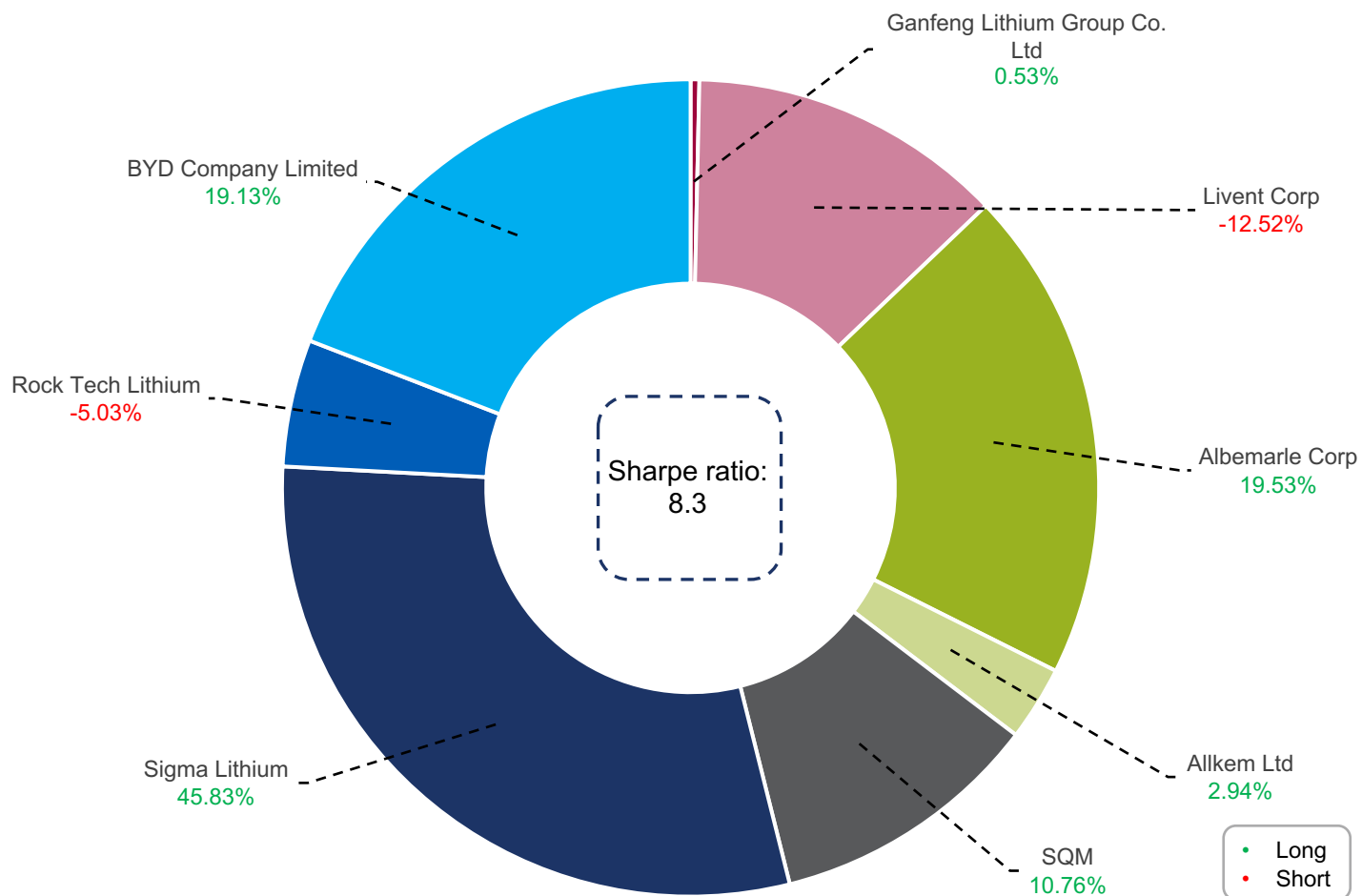
Unsystematic risk is too high with calculated weights

Stock Portfolio 2/2

Allocation to minimize risk

Assets

Figures



Expected portfolio return	82.33%
Variance	0.90%
Standard deviation	9.48%
Sharpe ratio	8.295577484

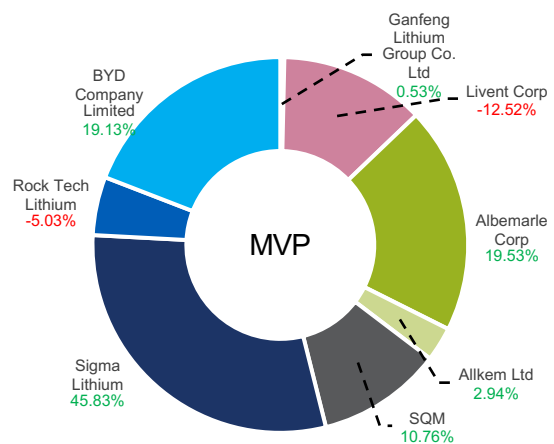
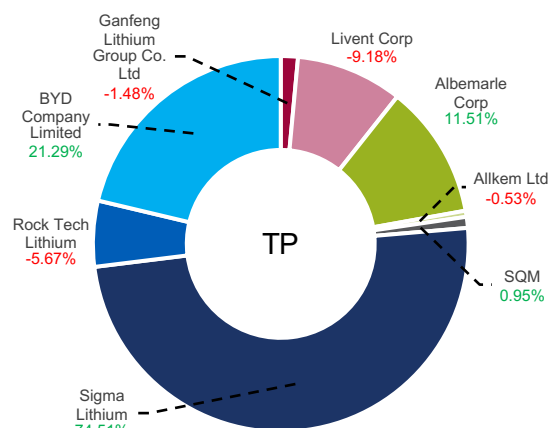
Expected portfolio return (equally weighted)	66.20%
Variance	1.67%
Standard deviation	12.93%
sharp ratio	4.833989378

Retest portfolio over similar period in the future

Find portfolio that reduces unsystematic risk (more equal weighting) but is still on efficiency frontier

Conclusion

Mathematics does not always tell the truth



Tangency portfolio calculates the weightings with best sharpe ratio based on historical returns



Minimum variance portfolio calculates the weightings with the lowest standard deviation ratio based on historical returns



Rapidly growing demand led to an equal increase in share prices during the last 3 years which explains high sharpe ratios



Due to unequally distributed weightings, unsystematic risk is too high in both solutions



The lithium sector does not contain enough companies that are publicly traded longer than 10 years to calculate portfolio weights with historical data



To go long on the lithium industry and to take profit from the value chain, rather construct an equally weighted portfolio with the selected companies



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Appendix

Stock Portfolio 1/2

Allocation for maximum risk/reward

Weights	x1	x2	x3	x4	x5	x6	x7	x8	Cov with PF	Target	Sum squared diff
Gafeng Lithium Group Co. Ltd	-1.946984408								0.420110321	0.42	0.00
Livent Corp		-12.115991							0.451277476	0.45	
Albemarle Corp			15.19192178						0.404522862	0.40	
allkem ltd				-0.693987					0.534728479	0.53	
SQM					1.250872				0.463852491	0.46	
Sigma Lithium						65.1989119			1.141577448	1.14	
Rock Tech Lithium							-7.476870402		0.918349353	0.92	
BYD Company Limited								28.09693876	0.666255598	0.67	87.50481

Adjusted weights	x1	x2	x3	x4	x5	x6	x7	x8	Cov with PF	Target	Sum squared diff
Gafeng Lithium Group Co. Ltd	-0.022250027								0.420110321	0.42	0.00
Livent Corp		-0.1384608							0.451277476	0.45	
Albemarle Corp			0.173612414						0.404522862	0.40	
allkem ltd				-0.007931					0.534728479	0.53	
SQM					0.014295				0.463852491	0.46	
Sigma Lithium						0.74508944			1.141577448	1.14	
Rock Tech Lithium							-0.085445248		0.918349353	0.92	
BYD Company Limited								0.321090211	0.666255598	0.67	100.00%

Stock Portfolio 2/2

Allocation to minimize risk

Weights	x1	x2	x3	x4	x5	x6	x7	x8	Cov with PF	Target	Sum squared diff
Gafeng Lithium Group Co. Ltd	0.59294523								1	1.00	0.00
Livent Corp.		-21.454407							1	1.00	
Albemarle Corp.			33.47784822						1	1.00	
Allkem Ltd				5.0451918					1	1.00	
SQM					18.44388				1	1.00	
Sigma Lithium						50.99298697			1	1.00	
Rock Tech Lithium							-8.622216489		1	1.00	
BYD Company Limited								32.7918646	1	1.00	111.2681
adjusted weights	x1	x2	x3	x4	x5	x6	x7	x8	Cov with PF	Target	Sum squared diff
Gafeng Lithium Group Co. Ltd	0.005328978								0.015997746	1.00	
Livent Corp.		-0.1928173							0.017642869	1.00	
Albemarle Corp.			0.300875556						0.016286276	1.00	
Allkem Ltd				0.0453427					0.015019342	1.00	
SQM					0.165761				0.013058084	1.00	
Sigma Lithium						0.458289409			0.008614669	1.00	
Rock Tech Lithium							-0.07749047		0.03569419	1.00	
BYD Company Limited								0.294710413	0.011455897	1.00	100.00%

Company	Market cap. in bn	Operating countries	Industry
Gafeng Lithium Group Co. Ltd	19.19\$	Australia, Argentina, Mexico, China	Lithium mining
Livent Corp.	4.08\$	US, England, Argentina, China,	Lithium mining
Albemarle Corp.	23.90\$	Australia, Chile, Columbia, Jordan, US	Lithium mining
Allkem Ltd	7.69\$	Argentina, Australia, Canada	Lithium mining
SQM	21.47\$	Chile	Lithium mining
Sigma Lithium	5.23\$	Brasil	Lithium mining
Rock Tech Lithium	0.216\$	Germany, Canada	Lithium mining
BYD Company Limited	99.47\$	China	Battery manufacturer

Sources

Source Name	Link	Date of Retrieval	Used for
Statista [1]	Lithium end-usage in the global market share 2022 Statista	04/07/23	Global lithium end-usage
Statista [2]	Global lithium mine production top countries 2022 Statista	04/07/23	Biggest lithium producers
Statista [3]	Lithium global reserves top countries 2022 Statista	04/12/23	Global lithium reserves
World Economic Forum (WEF)	Electric vehicle demand – has the world got enough lithium? World Economic Forum (weforum.org)	04/07/23	Developments in the lithium market
McKinsey & Company	How lithium mining is fueling the EV revolution McKinsey	04/12/23	Global lithium supply
Bisley International	Difference Between Lithium Carbonate & Lithium Hydroxide Bisley (bisleyinternational.com)	04/17/23	Differences between lithium hydroxide and lithium carbonate
The New York Times	Falling Lithium Prices Are Making Electric Cars More Affordable NyTimes	04/18/23	Lithium Price
McKinsey & Co.	https://tinyurl.com/333unmwv	04/18/23	Technology risk
Goldman Sachs Global Investment Research	https://tinyurl.com/yum66wnd	04/18/23	Recycling risk

Sources

Source Name	Link	Date of Retrieval	Used for
IHS Markit (2020 data)		04/18/23	Country risk
Just ETF	3 Lithium Tech ETFS	04/16/23	Market Environment
S&P Global Market Intelligence	Essential Insights: Lithium Costs & Margins	04/19/23	Market Environment
Irena – International Renewable Energy Agency	Critical Materials For The Energy Transition: Lihtium	04/08/23	Market Environment
Electric vehicles	Electric vehicle trends Deloitte Insights	04/20/23	Supply/demand
ALBEMARLE	https://www.albemarle.com	04/20/23	
GanfengLithium	http://www.ganfenglithium.com/index_en.html	04/20/23	
Livent	https://livent.com	04/20/23	
Allkem	https://www.allkem.co	04/20/23	
SQM	https://www.sqm.com/en/	04/20/23	
Sigma Lithium	https://sigmalithiumresources.com	04/20/23	

Sources

Source Name	Link	Date of Retrieval	Used for
Rock Tech Lithium	https://www.rocktechlithium.com/de	04/18/23	
BYD	https://www.byd.com/de	04/20/23	