

Background

The transformation of production is a significant undertaking for the company, and the company is putting a lot of effort into transforming the manufacturing process. This involves sourcing new materials and equipment that are required for the production of electric cars. The development of a new product is also a significant focus for the procurement department. It is essential to consider the ecological and social implications when choosing suppliers for the new production lines. The department needs to ensure that the suppliers can meet the quality and quantity requirements while staying within the fixed budget of \$ 2,500,000,000 that has been set by the company management for procurement activities.

Still, some of the necessary materials are missing. One car consists of steel (600 kg), aluminum (90 kg), microchips (1,200 units), cobalt (15 kg), and lithium (14 kg). The missing materials could have a significant impact on the production process, as each material plays a crucial role in the car's structure, function, and performance

The analysis of steel prices has been completed. The department has now also identified suppliers and the prices for the other raw materials.

Suppliers - Aluminum

Rising Sun Aluminum is the world's largest producer of aluminum from China, accounting for around 60% of global output. However, the production of aluminum has come at a significant environmental cost. Mining for bauxite, the primary raw material used in aluminum production, is said to destroy agricultural areas and damage water sources. In addition, the mining activities have threatened the health of local villagers due to the vast amount of dust generated. The process of producing aluminum also emits a significant amount of greenhouse gases, particularly carbon dioxide. According to reports, the average carbon emissions for aluminum production by *Rising Sun Aluminum* are around 12.5 tons of CO₂ per ton of aluminum produced.

Fjordlight Aluminum is a significant producer of aluminum in Norway, and the industry is considered one of the country's most important export sectors. Unlike in some other companies, the production of aluminum by *Fjordlight Aluminum* has not been associated with any significant social problems. While there have been concerns about the impact of aluminum production on the environment, these have been relatively minor. *Fjordlight Aluminum* is known for its advanced production processes and technology, which have enabled it to produce high-quality aluminum at a competitive price. However, historically, *Fjordlight Aluminum* has charged some of the highest prices for its aluminum products. One area where *Fjordlight Aluminum* has made significant progress is in reducing its carbon emissions. According to reports, the average carbon emissions for aluminum production are around 2 tons of CO₂ per ton of aluminum produced. This is significantly lower than the global average and reflects the company's efforts to reduce its environmental impact.

RhineMetal Aluminum is a significant producer of aluminum in Germany, and the industry is known for its advanced production processes and technology. Unlike in some other countries, the production of aluminum has not been associated with any significant social problems. However, the production of aluminum still has an environmental impact, with carbon emissions being a key concern. According to reports, the average carbon emissions for aluminum production are around 5.5 tons of CO₂ per ton of aluminum produced. While this is lower than the global average, it still reflects *RhineMetal Aluminum's* ongoing efforts to reduce its environmental impact. *RhineMetal Aluminum* is also focused on innovation and sustainability, with many companies investing in new

technologies to reduce their carbon footprint and improve their overall environmental performance.

Suppliers - Microchips

Skytech Microelectronics Ltd. is a major global producer of microchips, and the company is critical to the Chinese high-tech ambitions. However, the production of microchips by *Skytech Microelectronics Ltd.* has come under scrutiny for a range of social and environmental issues. Reports have highlighted cases of unpaid overtime, military surveillance, and wages that are not enough to sustain a decent standard of living. This has led to concerns about the exploitation of workers in the industry. In addition to social issues, the production of microchips by *Skytech Microelectronics Ltd.* has a significant environmental impact. Carbon emissions from the company are estimated to be around 58 kg of CO₂ per unit produced. Despite these challenges, efforts are being made to improve the sustainability of the industry. *Skytech Microelectronics Ltd.* is investing in new technologies and production processes to reduce their carbon footprint, while labor organizations are pushing for better working conditions and fairer wages.

The **Silicon Innovations Corporation** is a major American player in the global microchip production industry. Compared to some other companies, the production of microchips by *Silicon Innovations Corporation* is subject to strong regulation, particularly in terms of environmental standards and worker safety. One of the key features of microchip production is the high degree of automation in the production process. This has been driven by a combination of factors, including the need to maintain high levels of quality control and the desire to reduce labor costs. As a result, the industry has invested heavily in automated machinery and robotics to streamline the production process. In terms of environmental impact, microchip production by *Silicon Innovations Corporation* is relatively low in carbon emissions, with estimates of around 34 kg of CO₂ per unit produced. This reflects the industry's efforts to adopt more sustainable production practices and invest in renewable energy sources.

NexGen Microsystems GmbH is a significant German producer of microchips, and the company is characterized by strong regulation and a commitment to sustainability. The production of microchips by *NexGen Microsystems GmbH* is subject to strict environmental standards and worker protection laws, ensuring that the industry operates in a safe and sustainable manner. Germany's microchip industry is constantly expanding its capacities to keep up with the growing demand for high-tech products. The industry is also investing in advanced technologies and manufacturing processes to increase efficiency and reduce costs. In terms of environmental impact, the microchip production in Germany has a relatively low carbon footprint, with emissions estimated at around 29 kg of CO₂ per unit produced. The industry is also investing in renewable energy sources to reduce its carbon emissions further and to promote sustainability.

Suppliers - Lithium

SolLith is one of the largest producers of lithium in Chile, a vital element in the production of batteries for electric vehicles and other high-tech products. The production process of lithium involves pumping water containing lithium from underground lakes to the surface and evaporating it in large basins under the sun. This process is highly energy-intensive and requires a significant amount of water. The water consumption during lithium processing is very high, and it has raised concerns about the impact on the environment, especially in a region that already faces water scarcity challenges. Moreover, the large-scale evaporation of water has the potential to affect local ecosystems. In terms of environmental impact, the production of lithium by *SolLith* is associated with a relatively high carbon footprint, with emissions estimated at around 15 tons of

CO₂ per ton of lithium produced. These emissions are primarily from the energy required to power the evaporation and extraction processes.

LitioAndes is also a significant producer of lithium from Argentina, and its production methods differ slightly from those used by *SolLith*. Instead of pumping water containing lithium from underground lakes, *LitioAndes* uses a process known as brine extraction, where lithium-rich brine is extracted from salt flats or salars. The production of lithium by *LitioAndes* has a lower water consumption, but it is still relatively high, and it has raised concerns about the impact on local ecosystems and water resources. Additionally, the extraction and processing of lithium can result in contamination of water sources, which could further exacerbate existing water scarcity challenges in the region. In terms of environmental impact, the production of lithium by *LitioAndes* has a carbon footprint of around 16 tons of CO₂ per ton of lithium produced. These emissions are primarily from the energy required to extract and process the lithium.

LithiumOz is a significant producer of lithium from Australia. Lithium is typically extracted from hard-rock mines using open-cast mining methods by *LithiumOz*. The *LithiumOz* mining activities are highly regulated, and there are strict regulations in place to ensure the protection of workers' rights and the environment. This includes regulations around the use of water and the management of waste and tailings. In terms of environmental impact, the production of lithium has a carbon footprint of around 18 tons of CO₂ per ton of lithium produced, which is similar to the emissions associated with lithium production in South America. These emissions are primarily from the energy required to extract and process the lithium.

Suppliers - Cobalt

CongoCobalt is the largest cobalt producer in the world and also has significant lithium production in Congo. However, there have been numerous reports of forced child labor as well as human rights violations in Congolese mines. *CongoCobalt* has promised to address these issues and has implemented measures to ensure better working conditions for its employees. Despite these efforts, concerns about labor rights and human rights in Congo's mining industry persist. In terms of environmental impact, CongoCobalt's carbon emissions are high, at around 42 tons of CO₂ per ton of cobalt. The company has stated its commitment to reducing its carbon footprint and is exploring cleaner production methods.

Auric Cobalt is a major cobalt producer in Australia. While the company has been successful in minimizing the risk of human rights violations and child labor, the mining activities have led to the displacement of local communities from their homes. The company follows strict environmental standards, and their carbon emissions during the production process are estimated to be around 38 tons of CO₂ per ton of cobalt. Despite the challenges associated with mining, *Auric Cobalt* is committed to sustainable practices and is constantly working to improve their operations.

Northern Cobalt Corporation is a notable participant in Canada's cobalt production, which ranks among the largest globally. The company operates some of the last remaining cobalt mines in Canada, which are subject to strict environmental and labor regulations. Compared to other cobalt-producing regions, such as the Congo, Canada has a lower risk of social and human rights violations associated with mining. In addition to strict regulations, the *Northern Cobalt Corporation* has also implemented special processes and technologies to reduce carbon emissions, with emissions from the production of cobalt at around 5.5 tons of CO₂ per ton of cobalt. Overall, the Canadian cobalt industry is a key contributor to the global supply of the metal, with responsible and sustainable practices in place to ensure its continued success.

Task

Calculate the daily prices for aluminum, microchips, lithium, and cobalt for the next 4,5 years, i.e. for the period from 01.06.2024 to 31.12.2028 by performing a time series analysis of the data provided. Perform the analysis for every supplier. Predict the prices for each day.

Decide which supplier you would like to select for the production of Edison AG and how much material you would like to buy by the deadline in four and a half years. You can only choose one supplier per material. Explain your decision.

Input

For this task, you will be provided with the following:

- Time series of price data of the three suppliers (per material) as a CSV file:
 - Daily prices of aluminum, lithium, and cobalt in \$ per ton
 - Daily prices of microchips in \$ per 1,500 units
- Code sample to perform a naïve linear optimization. You can also create a solution on your own in a common programming language if you prefer
- Further information for time series analysis and machine learning These are possible approaches that have different advantages and disadvantages. Of course, you can also use other approaches and resources:
 - Code quality: browserstack.com
 - Times Series Analysis: simplilearn.com
 - Linear Regression: kaggle.com
 - SARIMA: machinelearningmastery.com
 - XGBoost: machinelearningmastery.com
 - Neural Network: towardsdatascience.com
 - Linear Programming/Optimization: realpython.com

Submission

The following documents must be emailed to s3g@fim-rc.de as one zip folder by 02:00 PM on 13.05.2023:

- Code file(s) to reproduce the results. This includes both the time series analysis and the approach to supplier and quantity selection. Should the setup of a special environment or packages be necessary, a step by step guide is also needed
- Complete time series (original prices + forecasted prices) as continuous time series in CSV format. The output format must be equal to the input format
- A PowerPoint presentation explaining your approach to supplier and quantity selection. The reasoning behind the decision should be understandable and should include economic, environmental and social considerations.

Keep in mind

The content provided here serves only as a starting point. Feel free to use your own approaches and algorithms to get the best possible prediction.

Use only the pricing data provided.

The following aspects are important for the assessment of your submission:

- Code quality: The code must be executable, readable, commented, and adhere to the output format

- Price estimation: The price estimation should be as accurate as possible. The team with the best estimate receives a bonus
- Supplier and quantity selection: You should not only present your decision qualitatively, but also argue quantitatively
- Explanation of the approach should be understandable