

NAVIGATING UNCERTAINTIES IN THE ENERGY MARKET

ICE ACCRETION, WIND TURBINES, BIDDING STRATEGIES AND THE QUEST FOR PERFECTION



UNIVERSITÉ
LAVAL

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Full professor, mech. engineering

 **Winterwind**
INTERNATIONAL WIND ENERGY CONFERENCE

Are, Sweden, March, 2024



UNDERSTANDING MACROECONOMICS (not engineering)

Electricity is a commodity product ...



<https://neoen.com/fr/actualites/2023/neoen-lance-la-construction-de-storen-power-reserve-40-mw-40-mwh-sa-premiere-batterie-en-suede/>

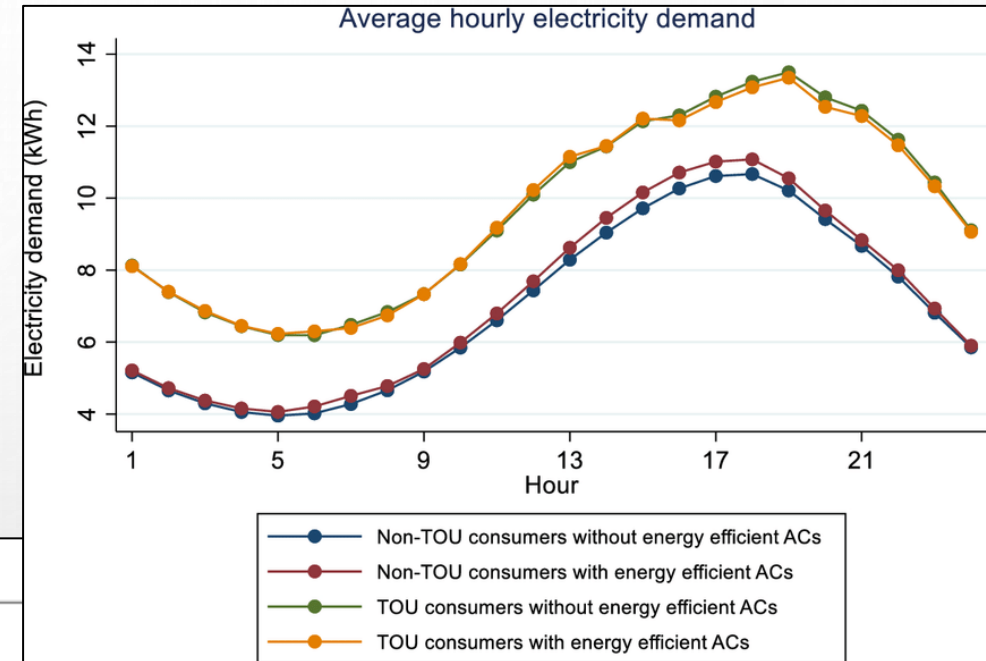
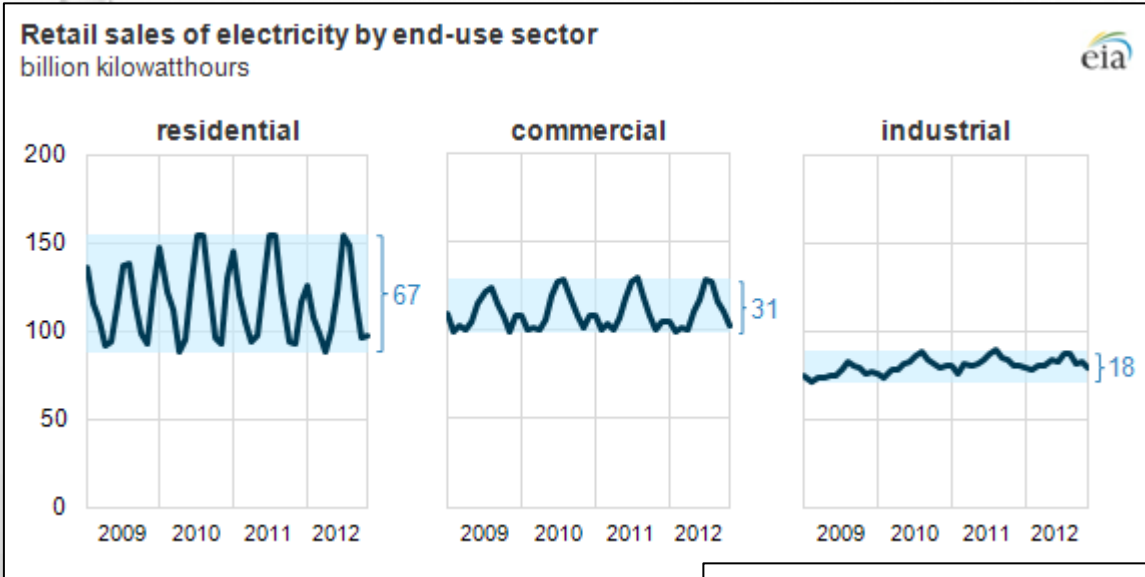


<https://www.vox.com/2016/9/19/12938086/electrify-everything>

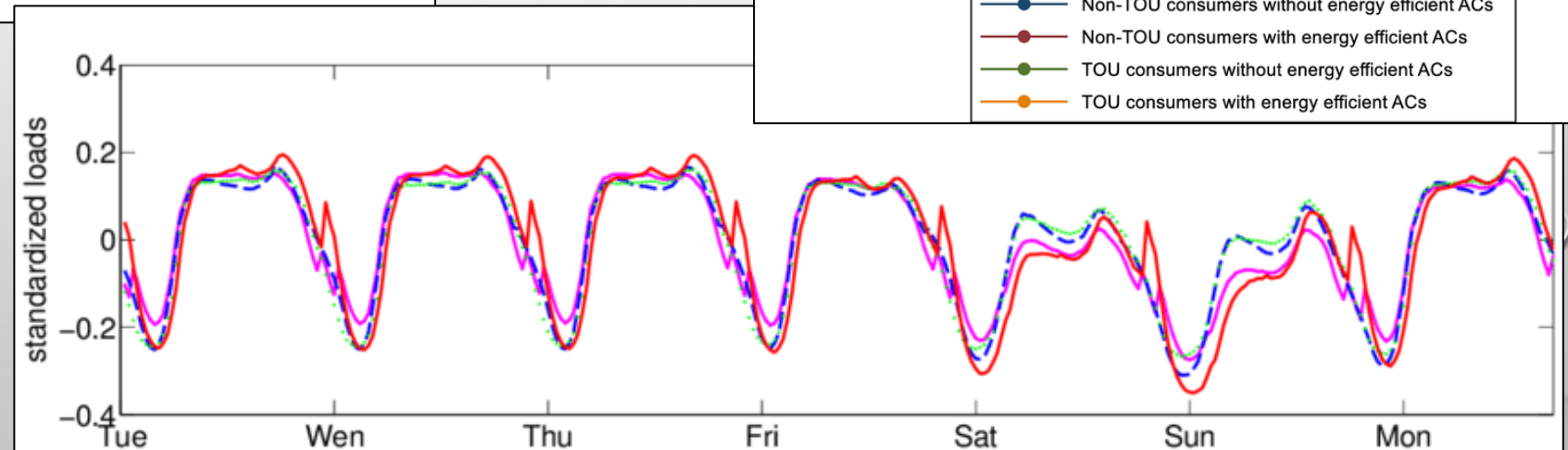
... that cannot be stored massively (yet)

SEASONALITY OF ELECTRICITY CONSUMPTION

Liang, Jing & Qiu, Yueming & Xing, Bo. (2021). Social Versus Private Benefits of Energy Efficiency Under Time-of-Use and Increasing Block Pricing. Environmental and Resource Economics. 78. 1-33. 10.1007/s10640-020-00524-y.



<https://www.eia.gov/todayinenergy/detail.php?id=10211>

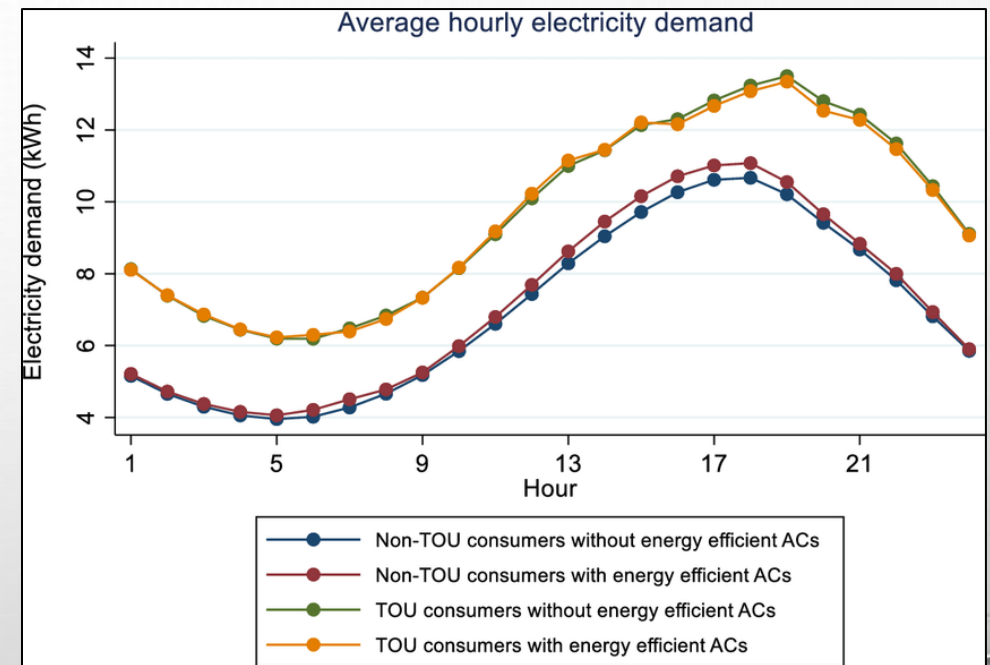


Eichler, Michael & Grothe, Oliver & Manner, Hans & Dennis, Tuerk. (2013). Models for short-term forecasting of spike occurrences in Australian electricity markets: A comparative study. Accepted for publication in: The Journal of Energy Markets.. 7. 10.21314/JEM.2014.104.

SEASONALITY OF ELECTRICITY CONSUMPTION

« Law of the 3W »

- Workforce (daily fluctuations, on demand)



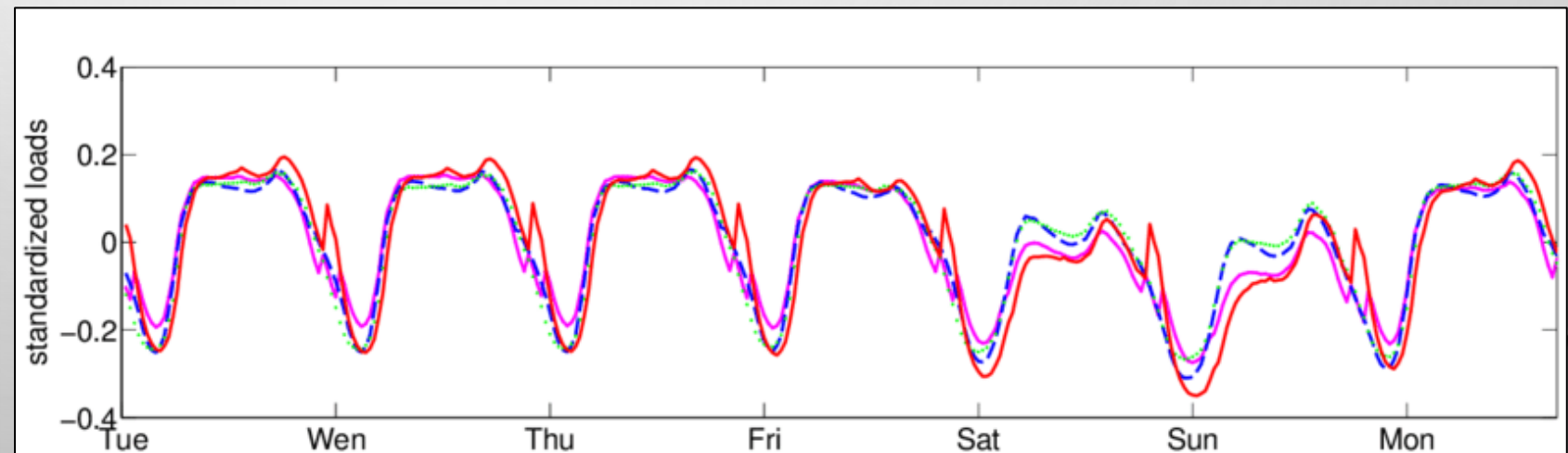
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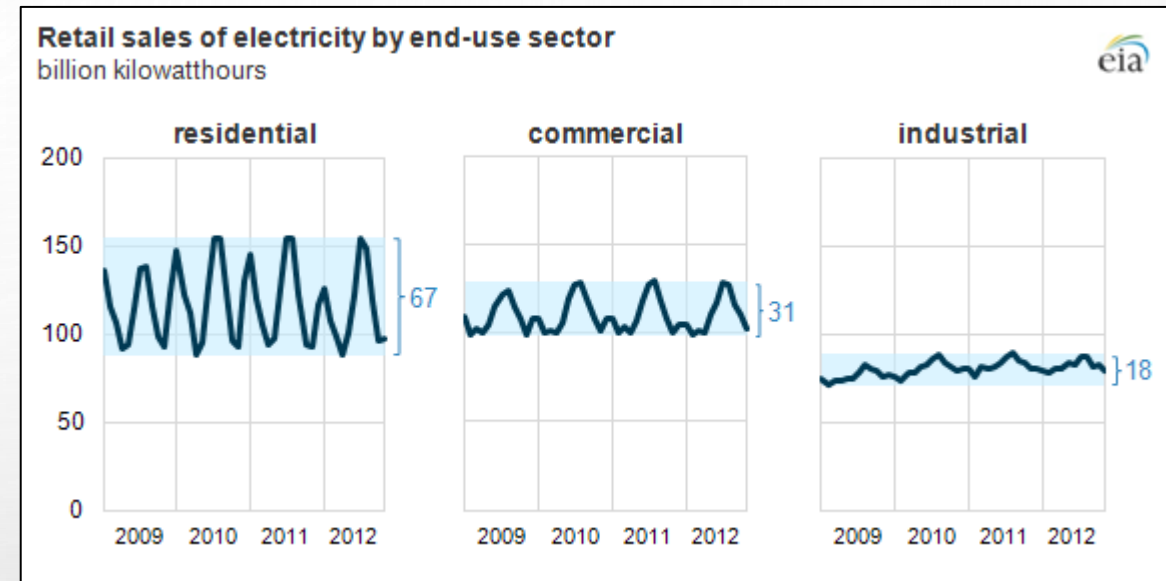
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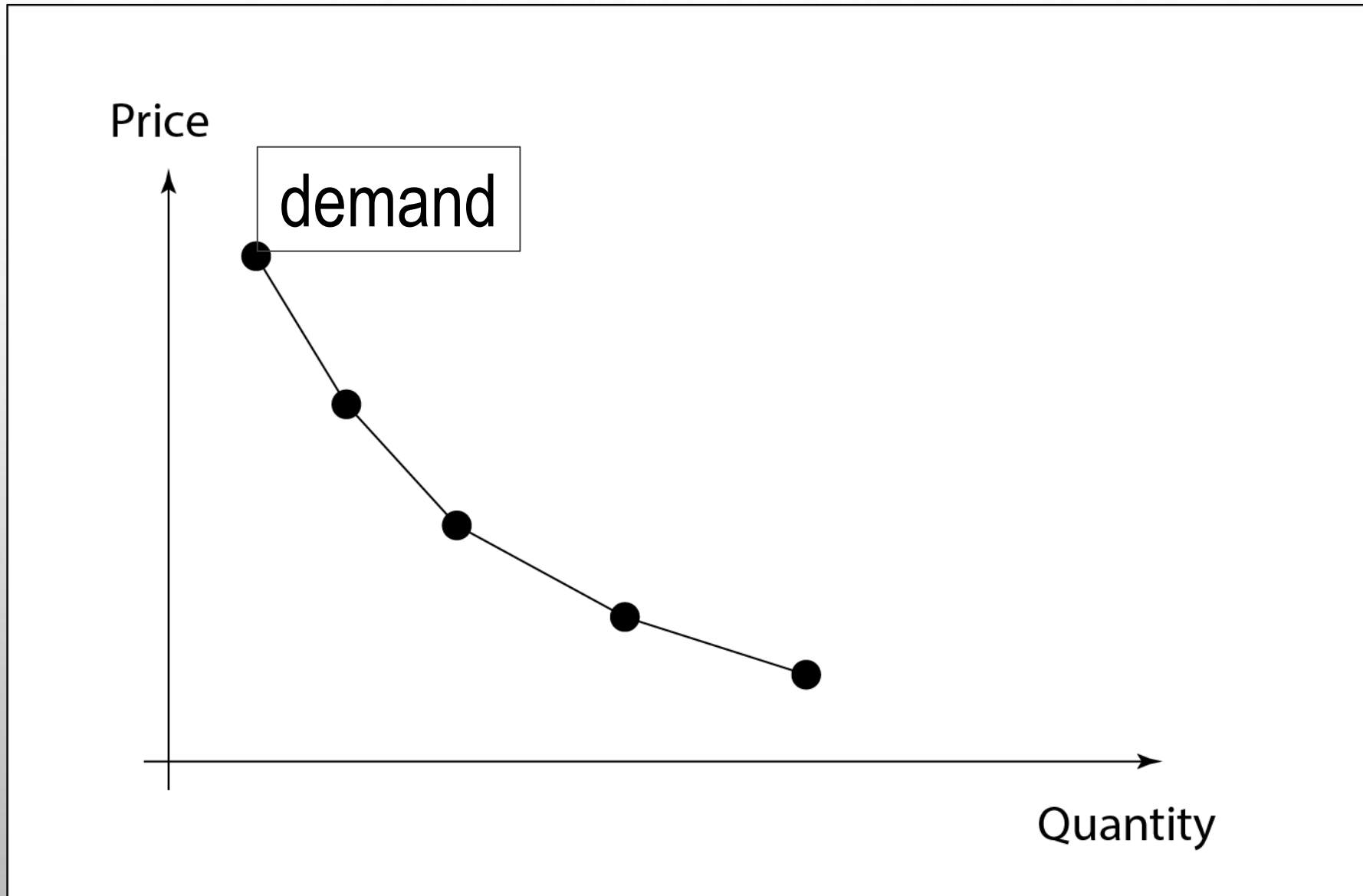
« Law of the 3W »

- Workforce (daily fluctuations, on demand)
- Weekend (weekly variations, on demand)
- Winter (annual effects, on demand and supply)



<https://www.eia.gov/todayinenergy/detail.php?id=10211>

UNDERSTANDING SUPPLY AND DEMAND

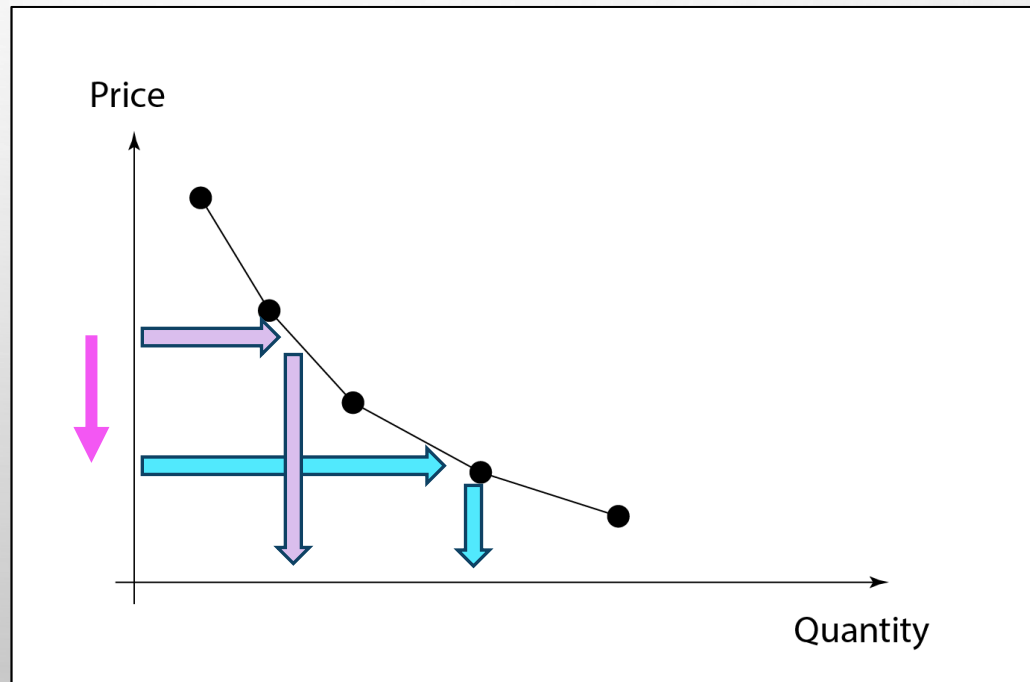




WHY IS THERE AN INVERSE RELATIONSHIP?

At least 2 reasons:

- **Substitution effect** (moving away from other products)
Lemonade vs Powerade, electricity vs natural gas!

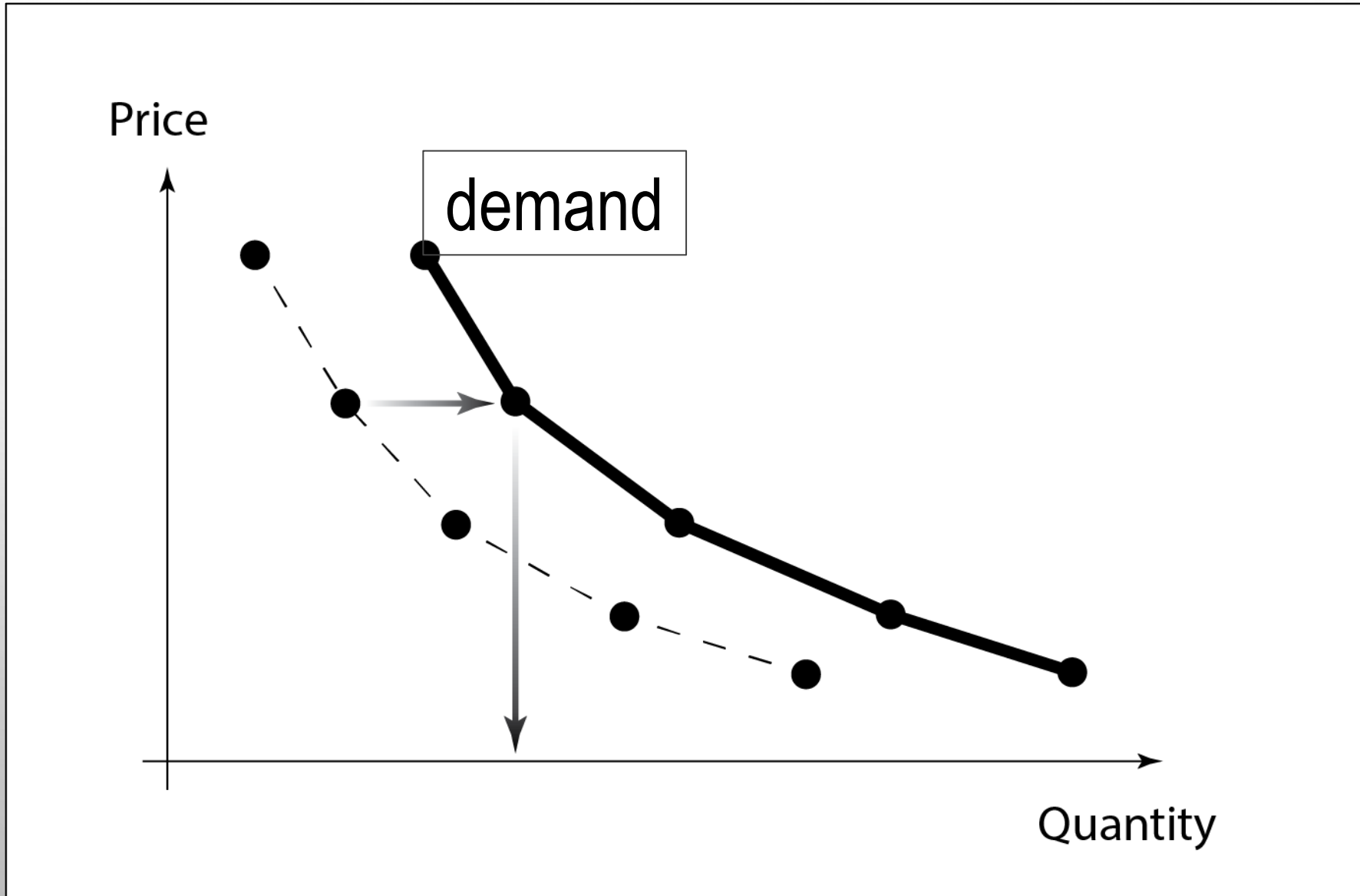


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DEMAND "SHAPE SHIFTERS" – CHANGE IN THE MARKET



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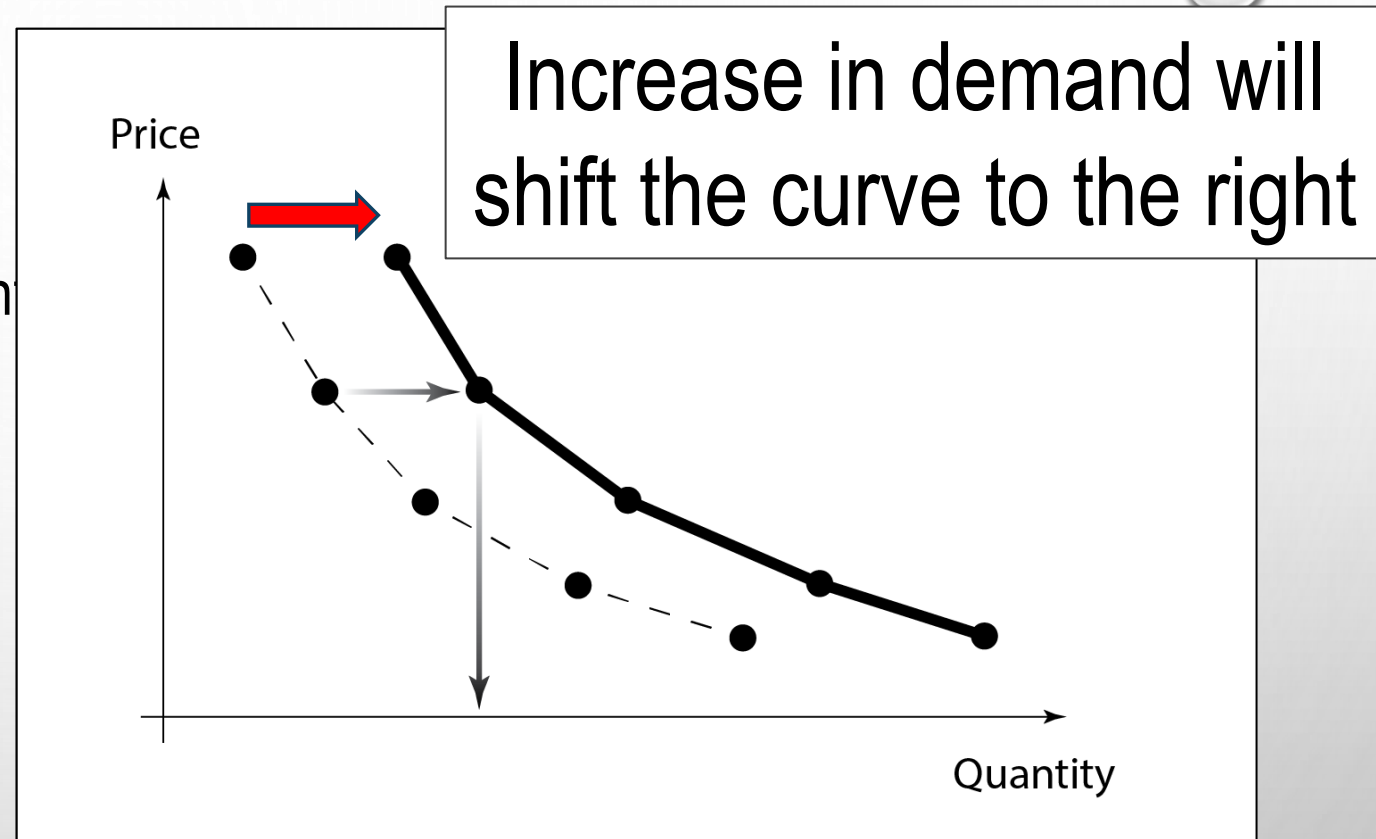
- **Preferences** → increase in demand

Lemonade will make you more intelligent, electricity will save the planet

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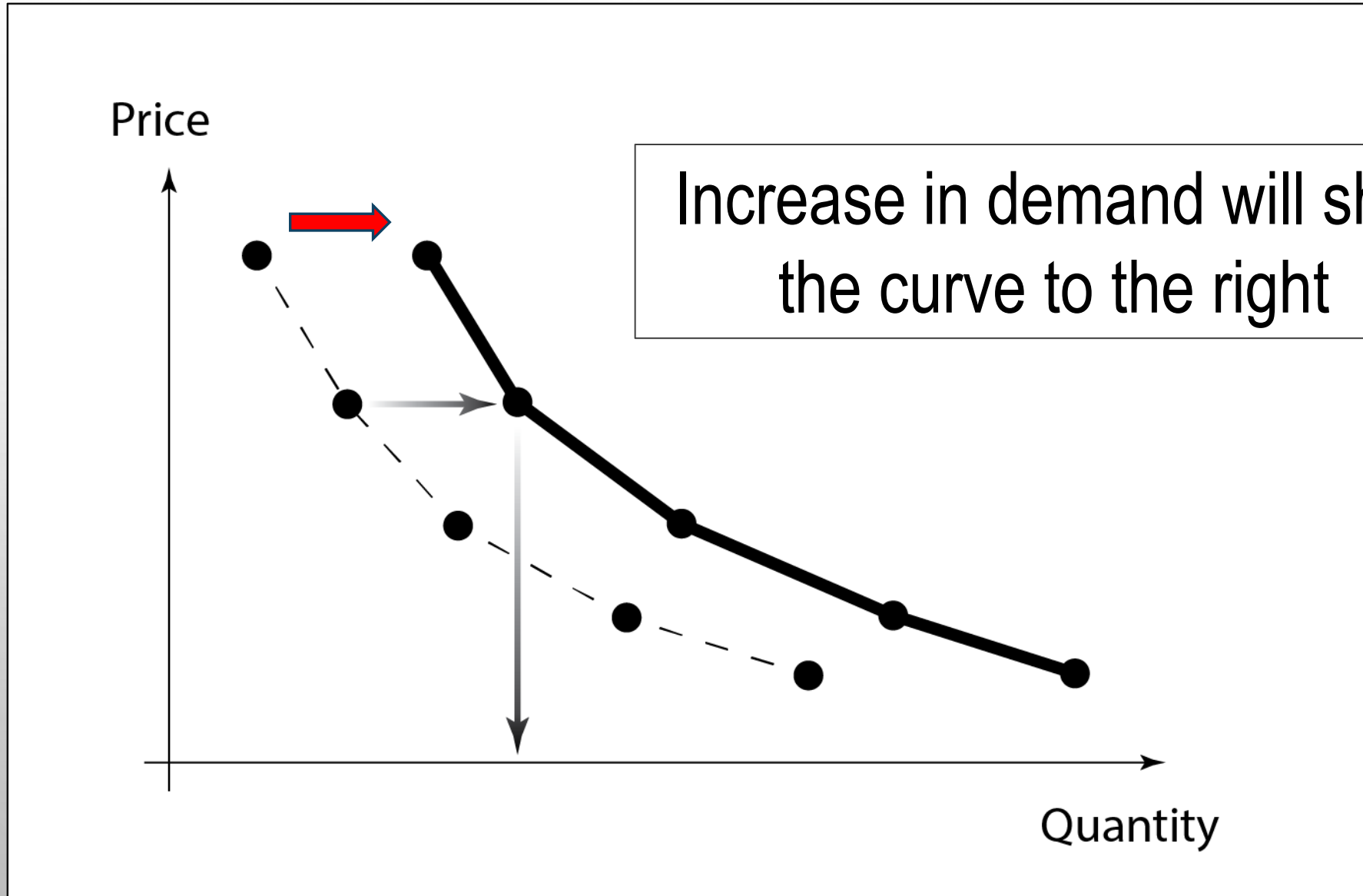
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- **Price of related goods** (relative price of substitution products)
price of Powerade goes up (substitute for lemonade) → increase in demand
price of natural gas goes up (substitute for electricity) → increase in demand

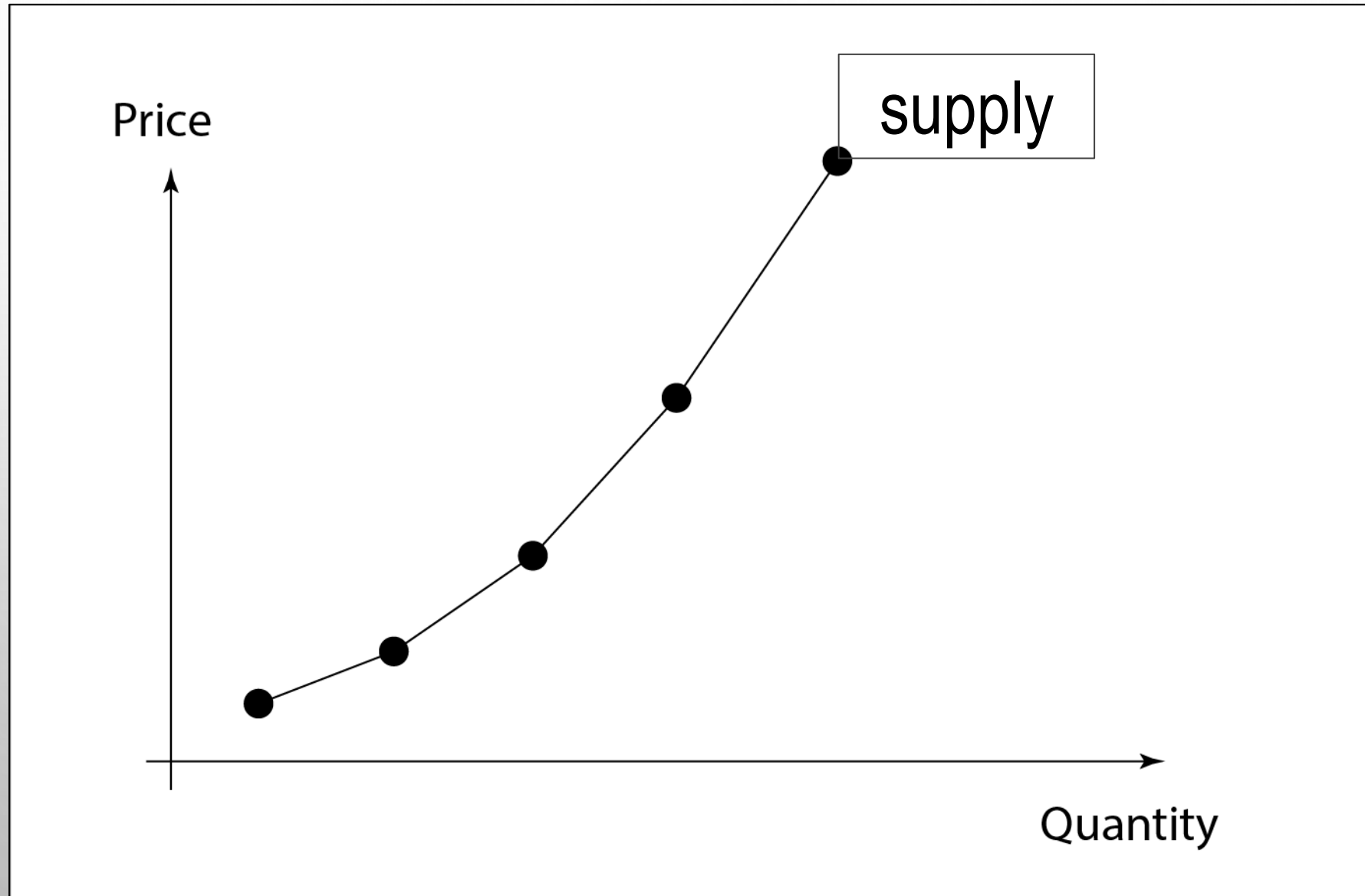
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UNDERSTANDING SUPPLY AND DEMAND



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The main reason:

PROFIT \$\$\$

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...but electricity is not a storable commodity (yet)

SUPPLY “SHAPE SHIFTERS” – CHANGE IN THE MARKET

At least 3 reasons (change in the market):

- **Price of resource**

Lemons become cheaper, cost less to produce lemonade, more profit for the same quantity produced → increase in supply

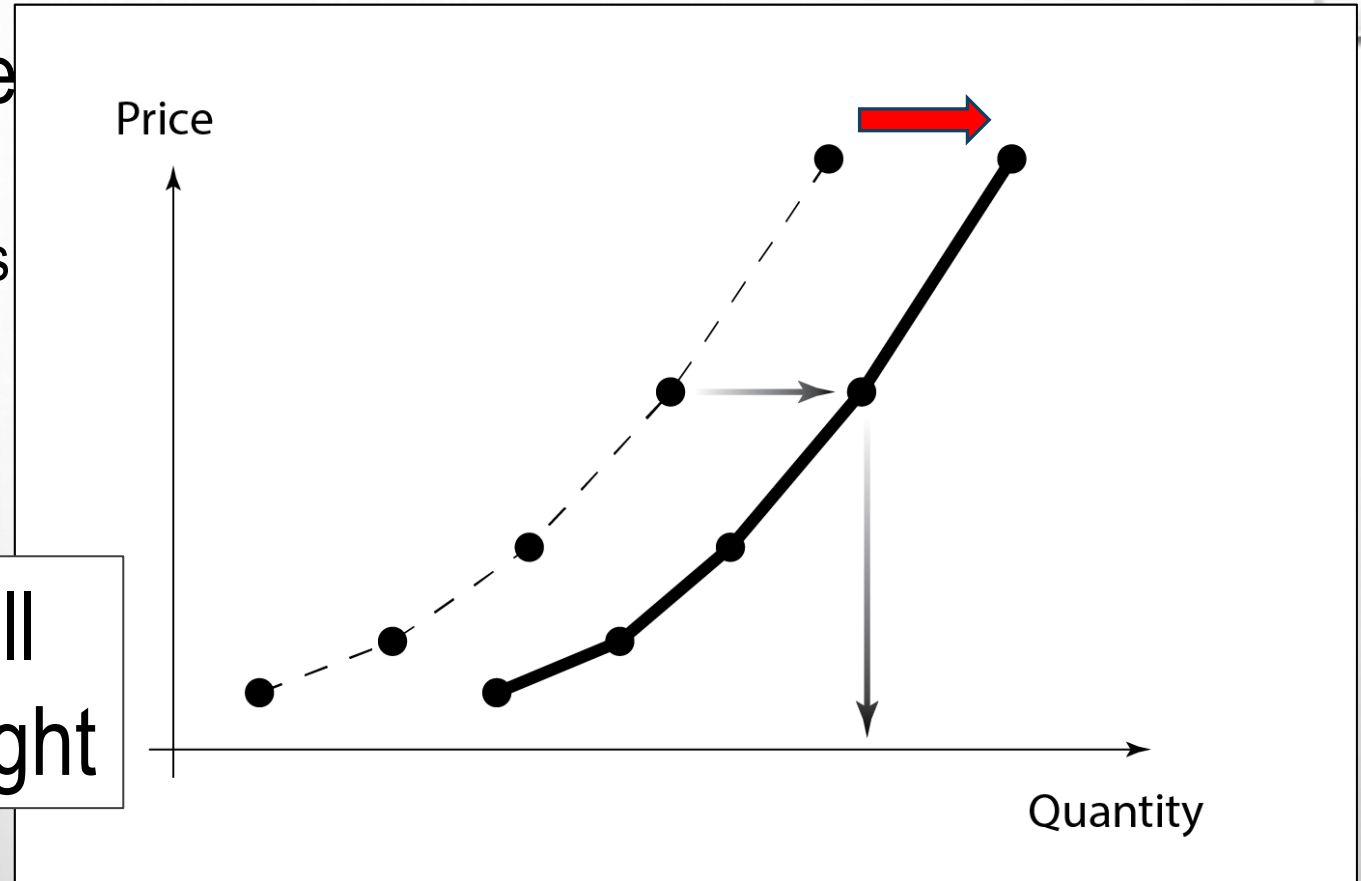
SUPPLY “SHAPE SHIFTERS” – CHANGE IN THE MARKET

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- **Price of resource**

Lemons become cheaper, cost less produced → increase in supply

Increase in supply will shift the curve to the right



For the same price, market will produce more

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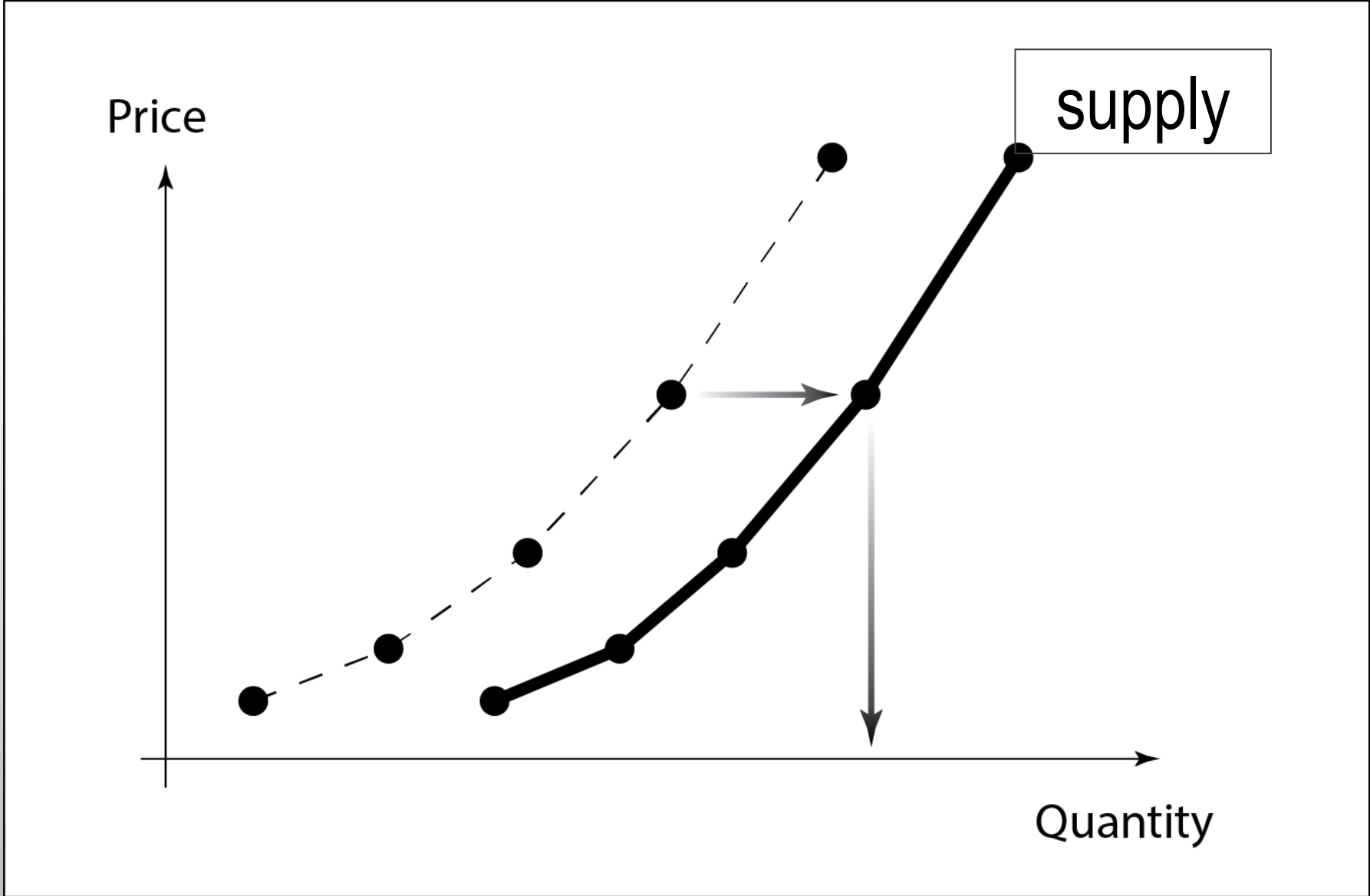
Lemons become cheaper, cost less to produce lemonade, more profit for the same quantity produced → increase in supply

- **Number of producers** → increase in supply

- **Technology** → increase in supply

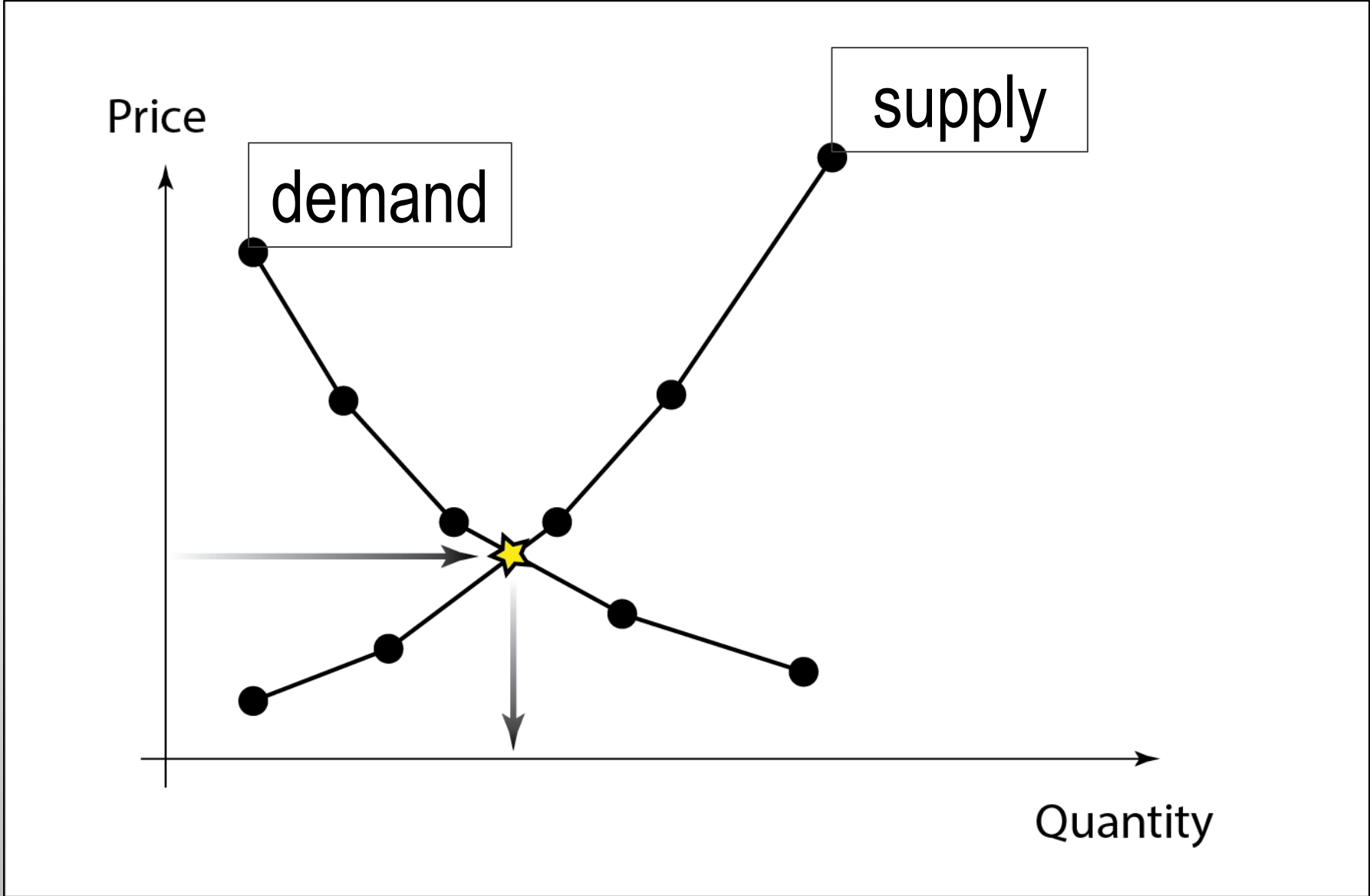
New technology helps extract 25% more of lemon juice for every lemon, more quantity produced for the same price, more profit for the same quantity produced → increase in supply

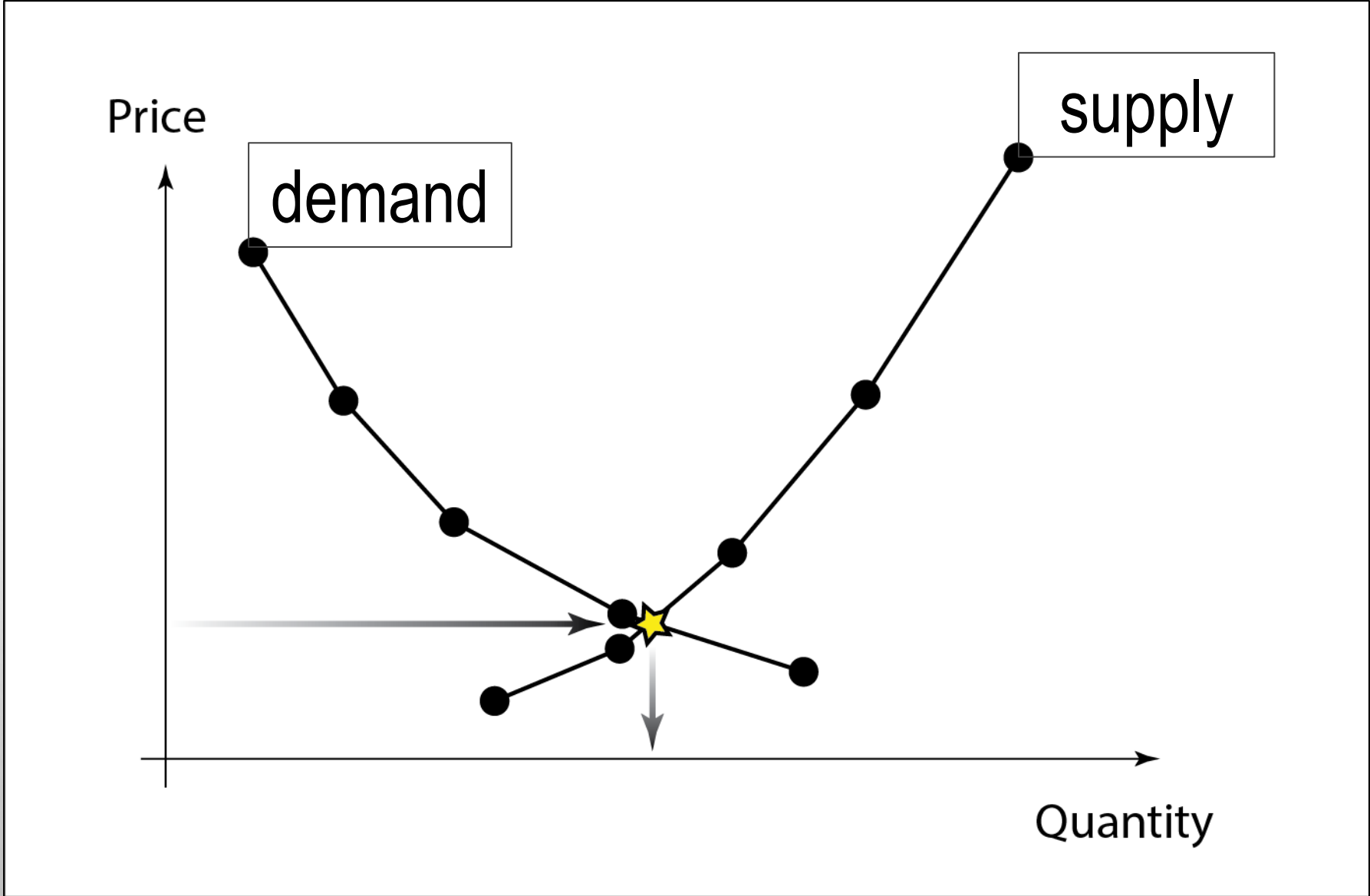
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EQUILIBRIUM SUPPLY AND DEMAND

Equilibrium determines the price and quantity traded



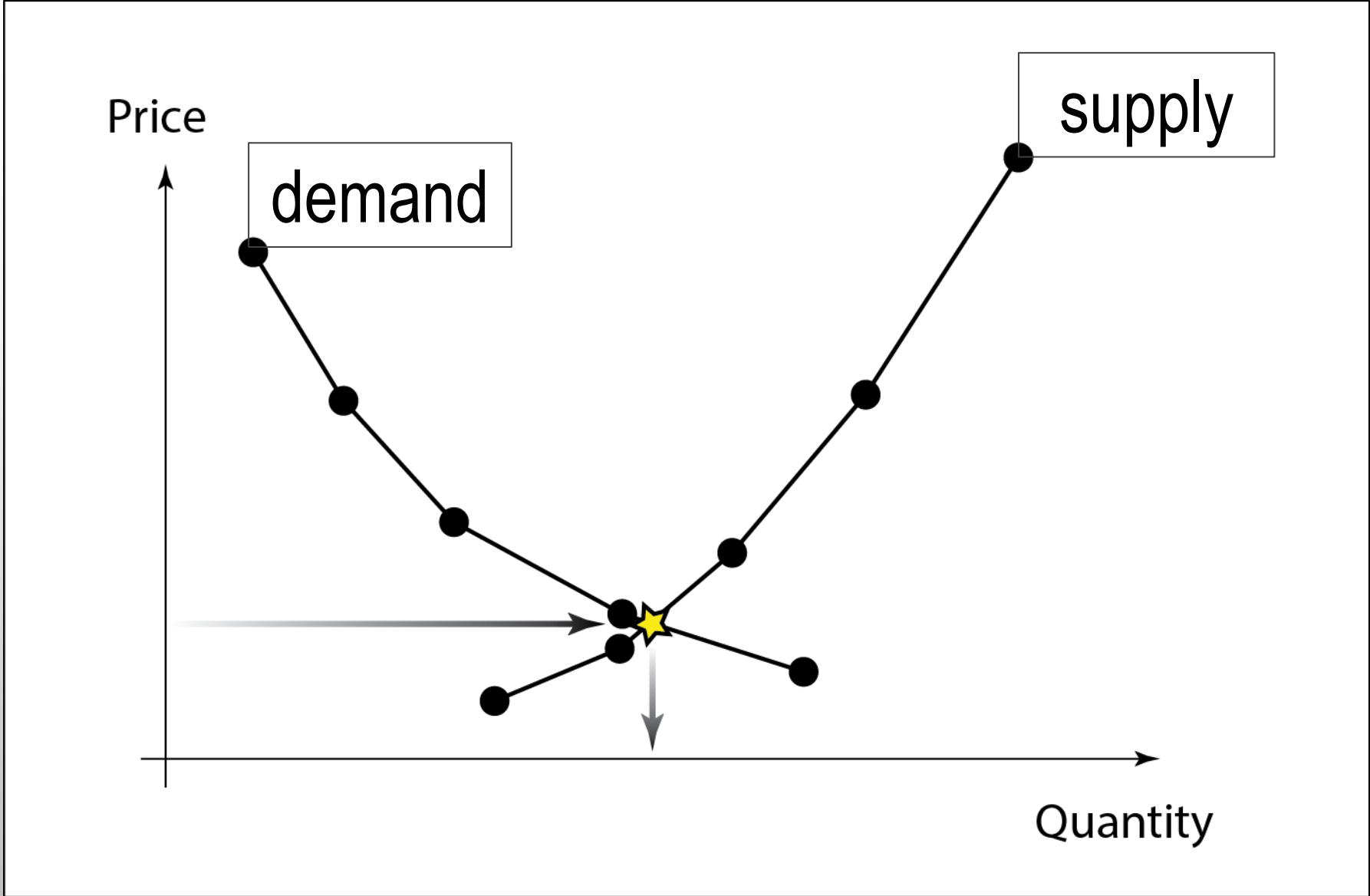


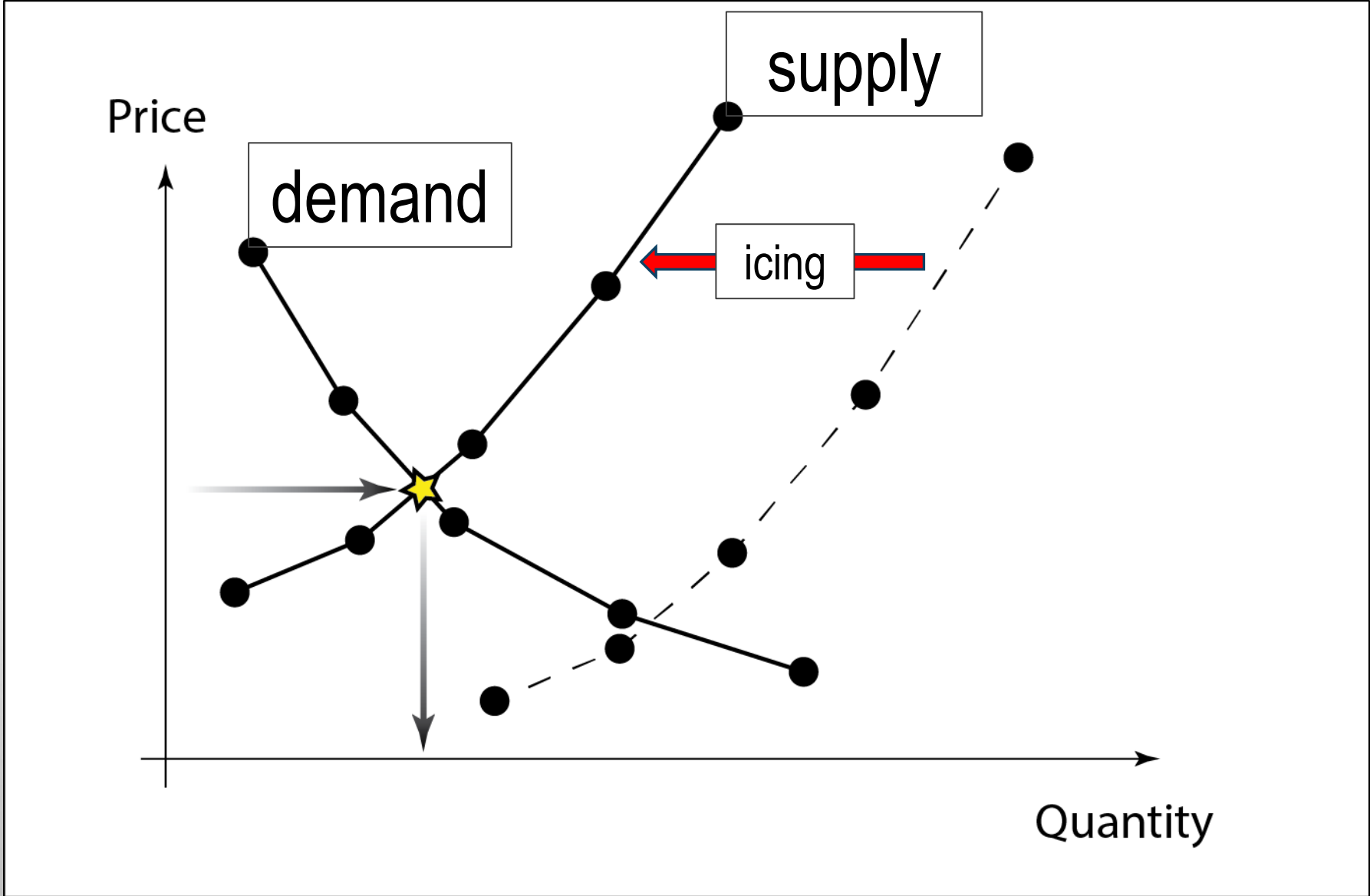
THE ICING PROBLEM!

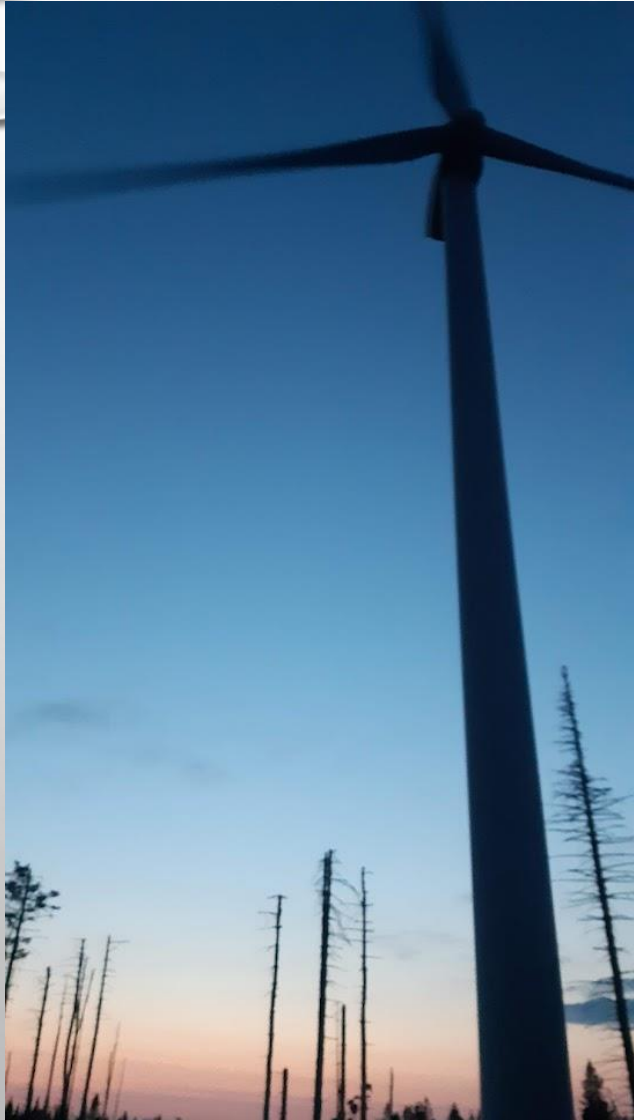


source: InnoWeek ENGIE

- Production losses
→ decrease in supply







REGULATED VS DEREGULATED MARKETS

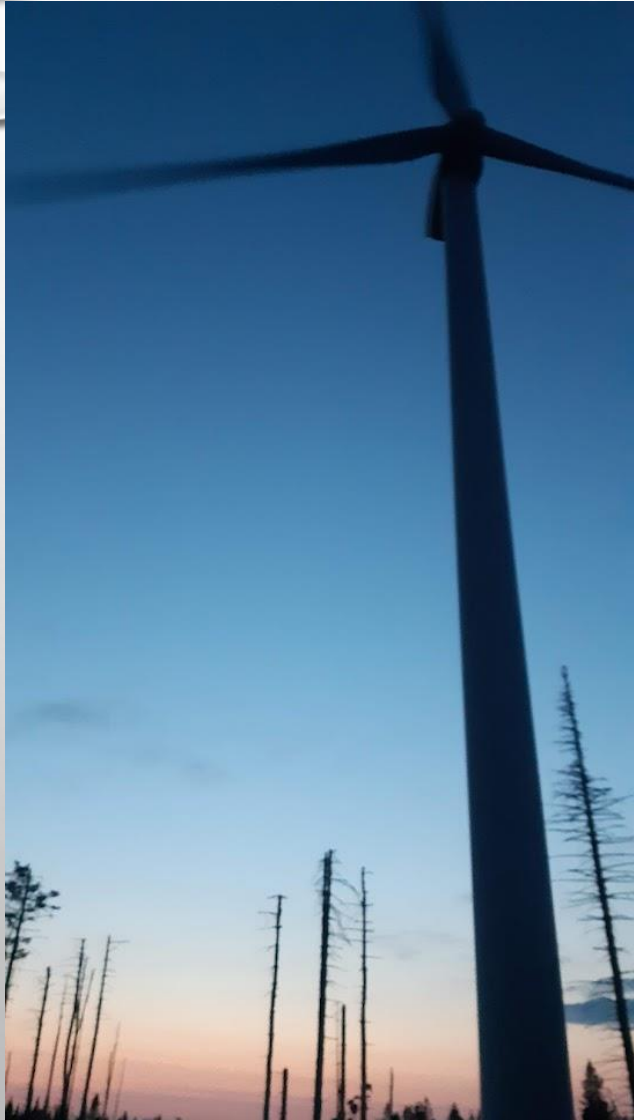
Regulated markets

Fixed PPA does not reward operators that are producing more.
The system operator needs to support the cost of icing losses.

Deregulated markets

Spot prices offer opportunities for new technologies (improved ice detection, ice protection systems, operation with ice strategies, storage, ...).

The bidding process should take icing as a serious threat/opportunity.



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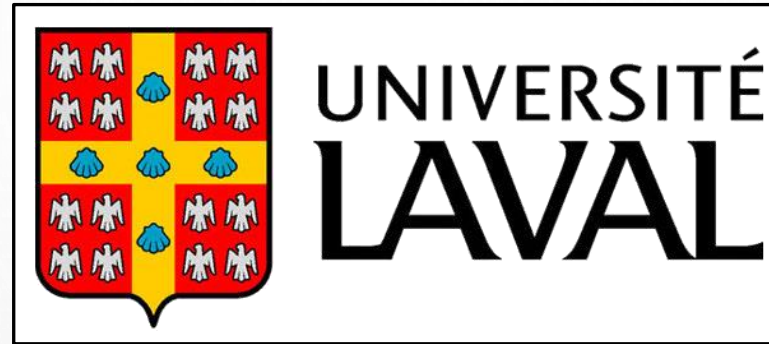
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How? More research into understanding, modeling and predicting electricity spot prices.

KEY TAKEAWAY POINTS

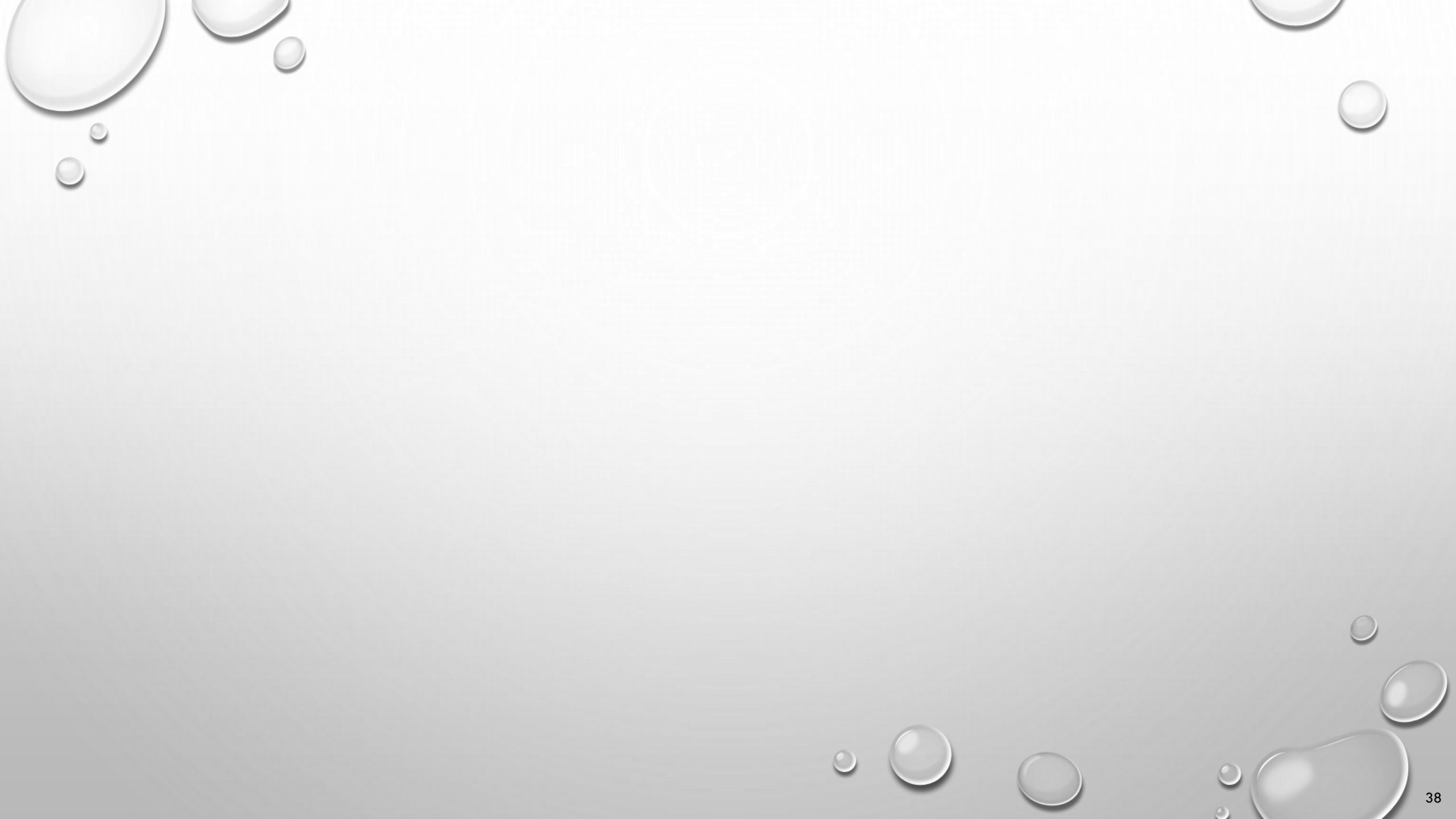
1. More research needed into understanding, modeling and predicting electricity spot prices.
2. Acknowledge that icing is a supply “shape shifter”.
3. Assessing and measuring icing on site will help develop bidding strategies according to real field data.
4. Demand is quite well modelled (e.g. law of 3W), supply is getting better with forecasting models, but the modelling of icing and its effects on power production is not there yet.
5. Knowledge of icing can help anticipate, unanticipated spike prices.

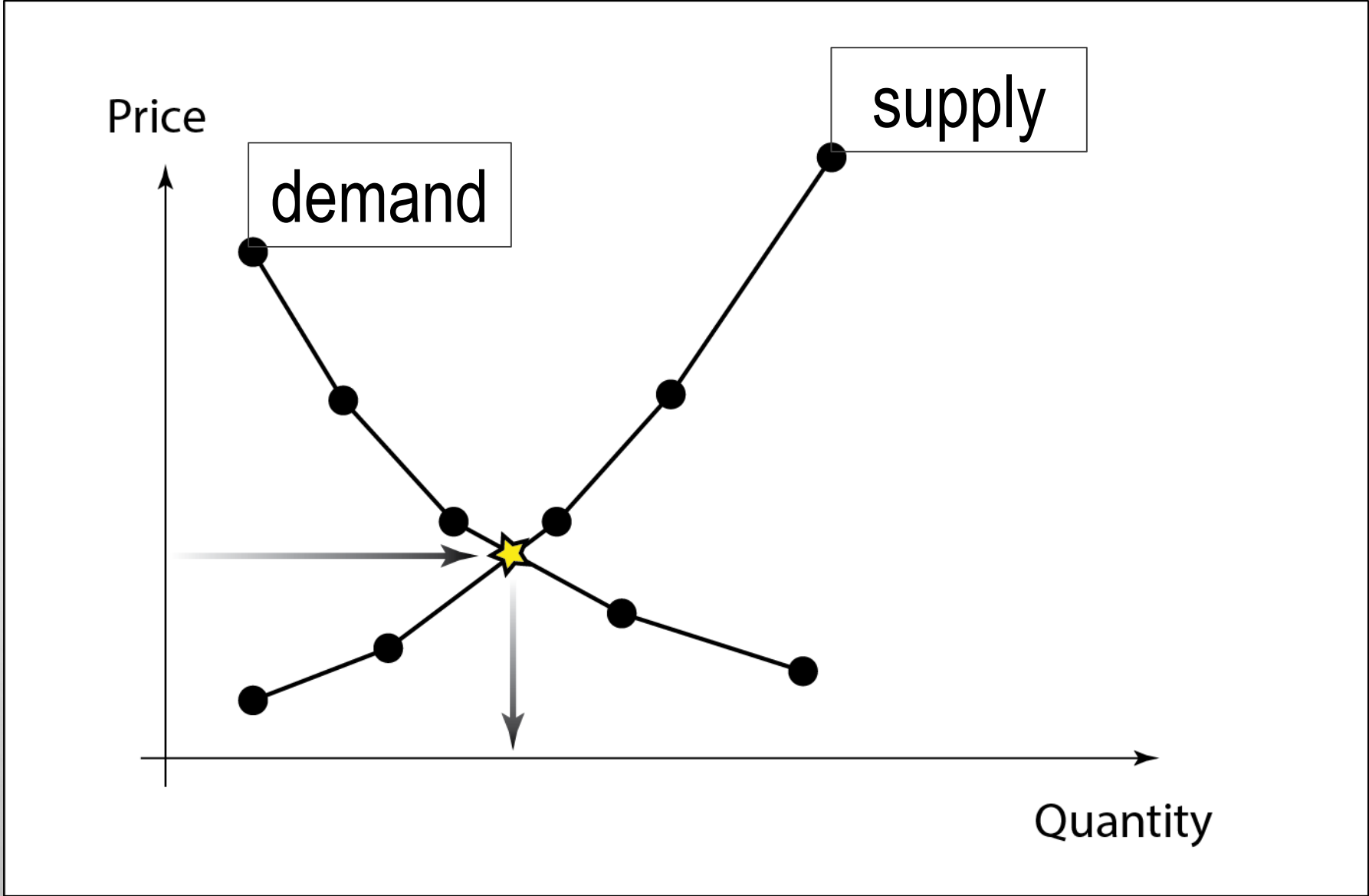


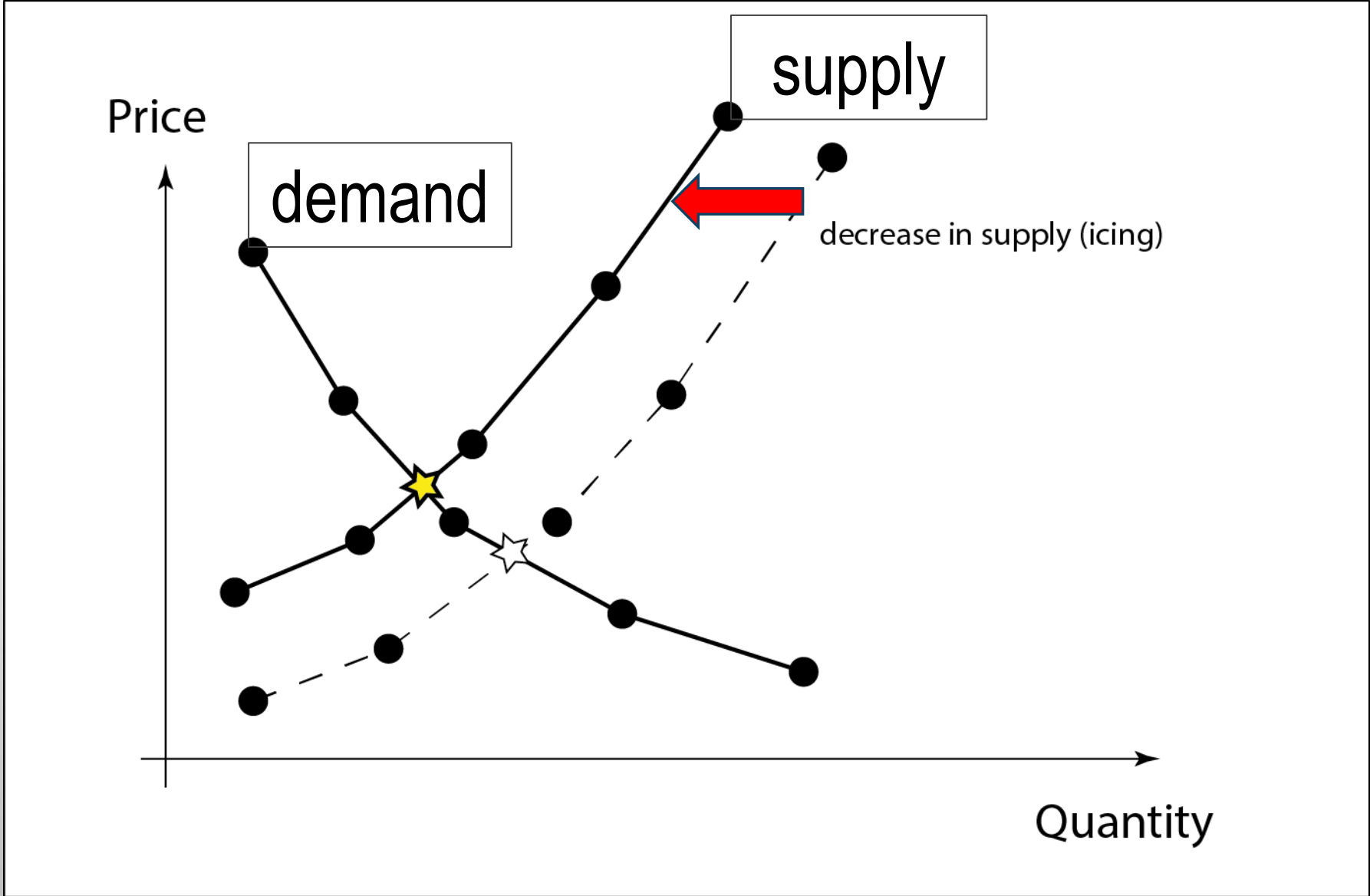
ENJOY THE CONFERENCE!

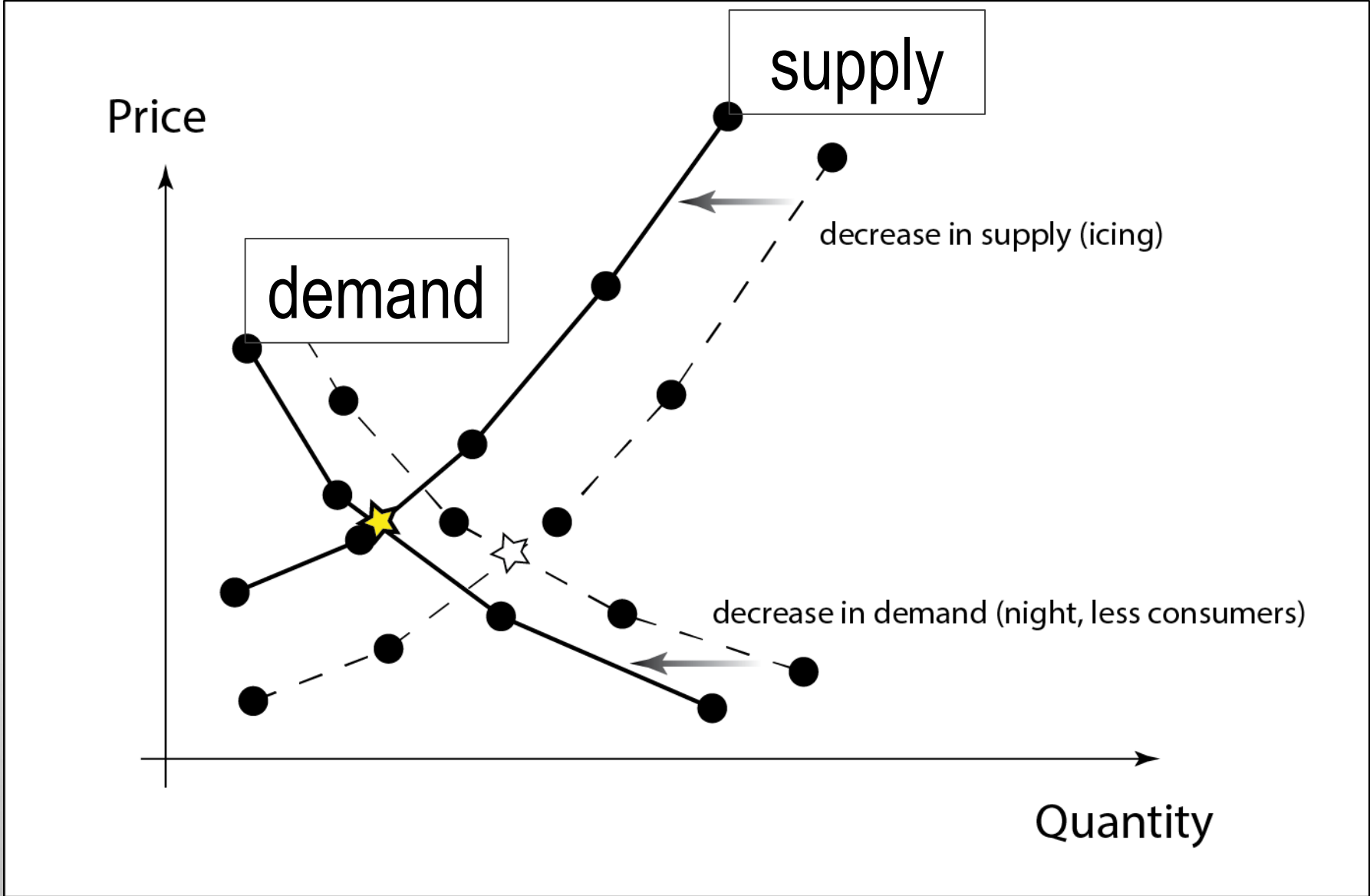
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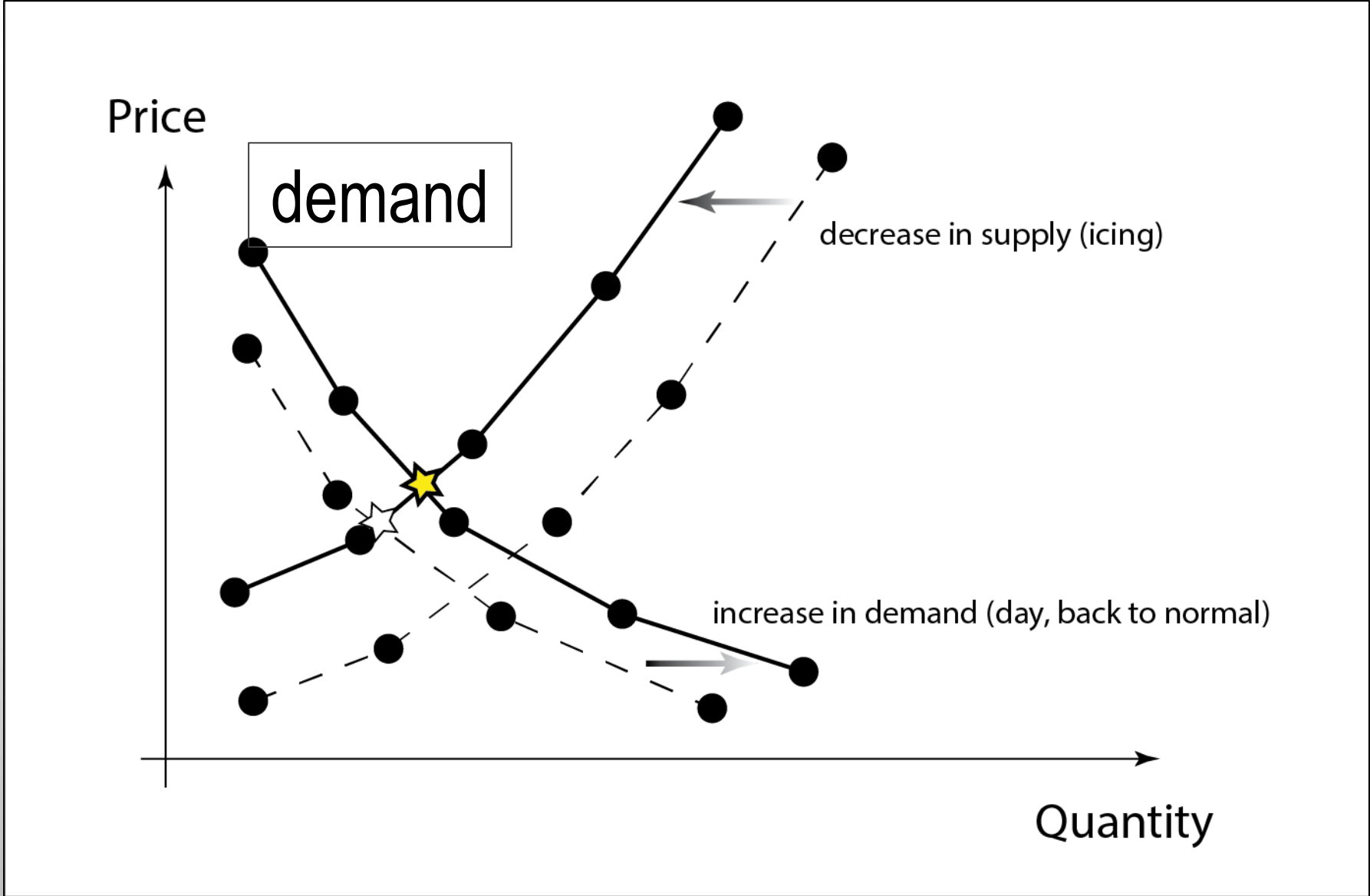


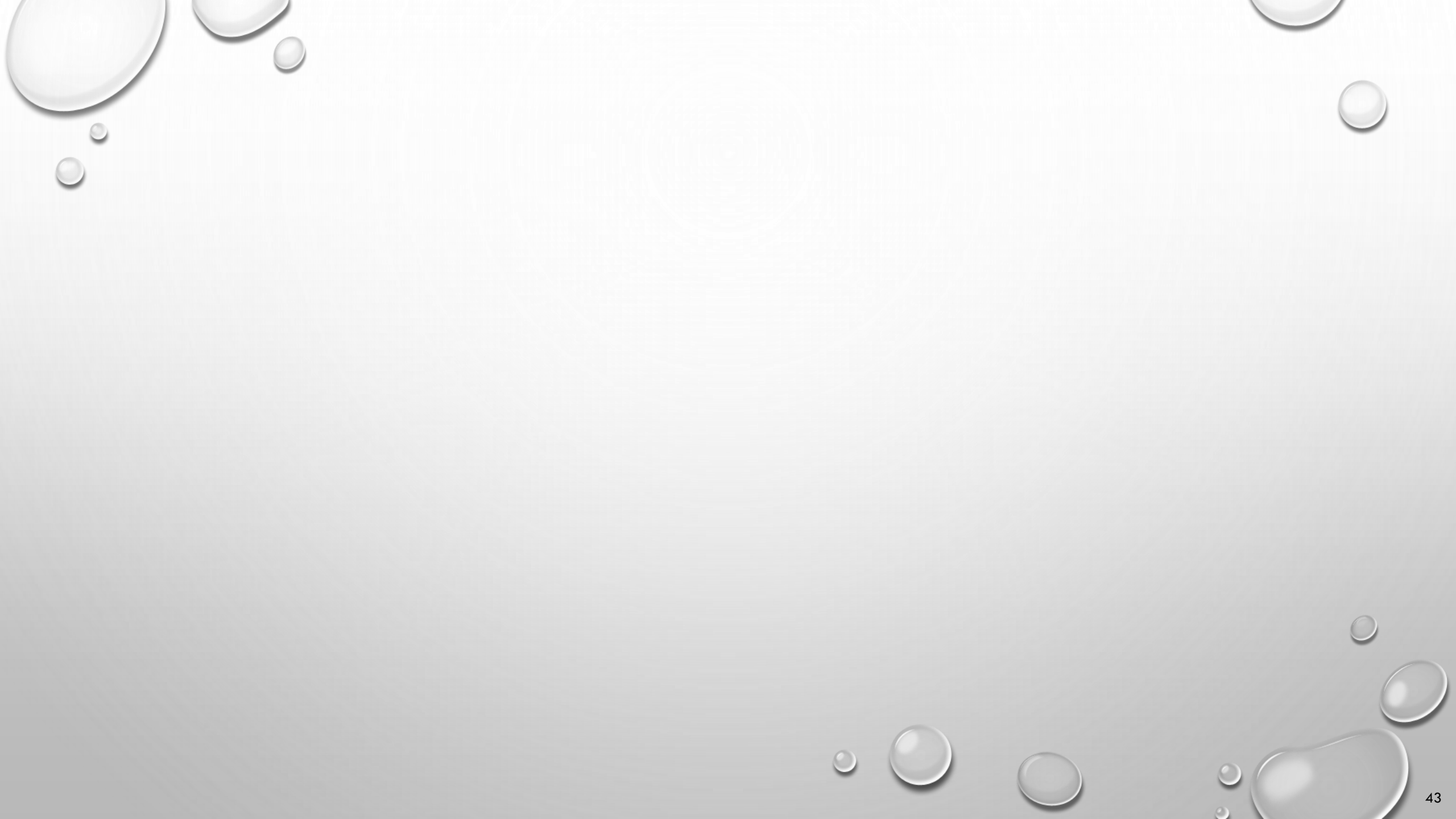












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- **Diminishing marginal utility**
additional lemonade/electricity will give you less and less utility (so price has to go lower)

