

Project Data
Science

Optimizing Pharmacy
Inventories

Reinforcement Learning Approach





Apotheke



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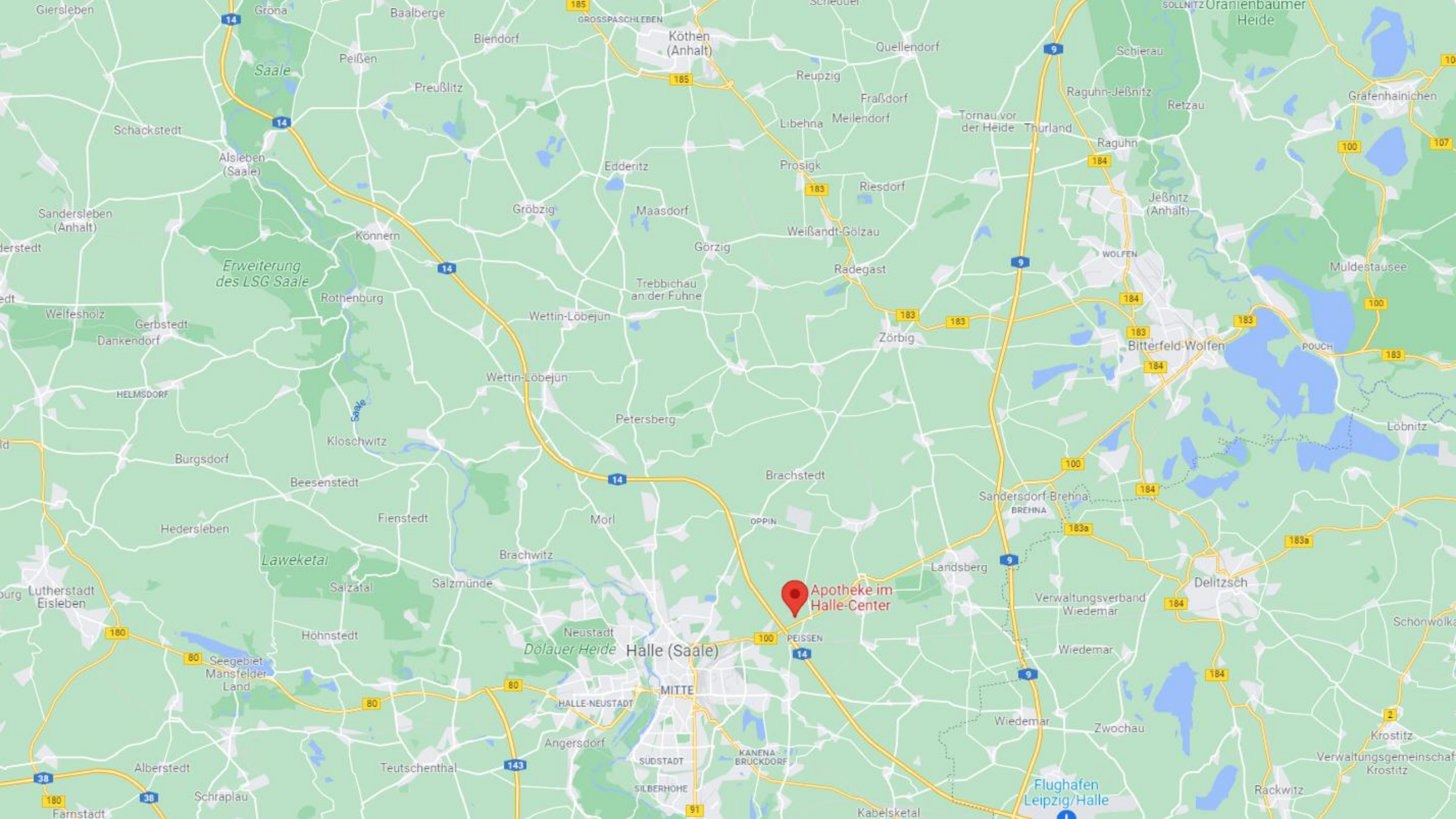


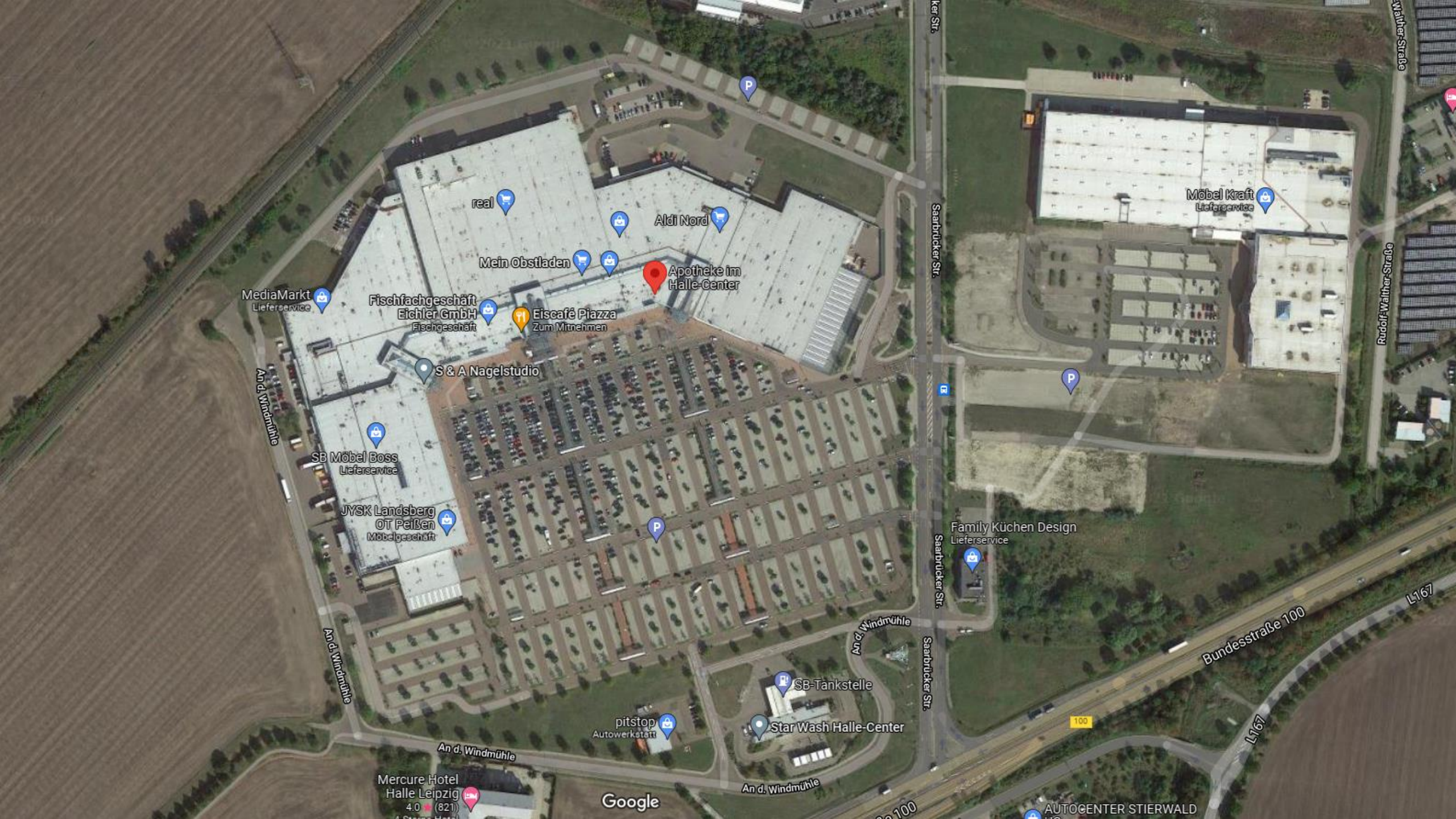
rmc **STOLZE**
Sanitätshaus



Essen







MediaMarkt
Lieferservice

Fischfachgeschäft
Eichler GmbH
Fischgeschäft

real

Mein Obstladen

Aldi Nord

Apotheke im
Halle-Center

Eiscafé Piazza
Zum Mitnehmen

S & A Nagelstudio

SB Möbel Boss
Lieferservice

JYSK Landsberg
OT Peißen
Möbelgeschäft

Family Küchen Design
Lieferservice

Möbel Kraft
Lieferservice

SB-Tankstelle

pitstop
Autowerkstatt

Star Wash Halle-Center

Mercure Hotel
Halle Leipzig
4.0 (821)
4 Sterne Hotel

Google

AUTOCENTER STIERWALD

Dataset

Transactions

- Every checkout process since 2004
- Over 1,000,000 transactions
(around 100,000 per year)
- 141 attributes
- 3.5 Gigabyte
- Excel files
- Confidential / sensible data





Datum	Uhrzeit	Wochentag	Kasse	Auftrag	Teilauftrag	Kunde
02.01.2021	10:09	Samstag	2	88492	1	Mustermann, Max (1234) [p]

KRK	PZN	Bezeichnung	HerKue	Darr	Menge	ME
AOK	2434091	PARACETAMOL 500	1APHA	TAB	20	ST



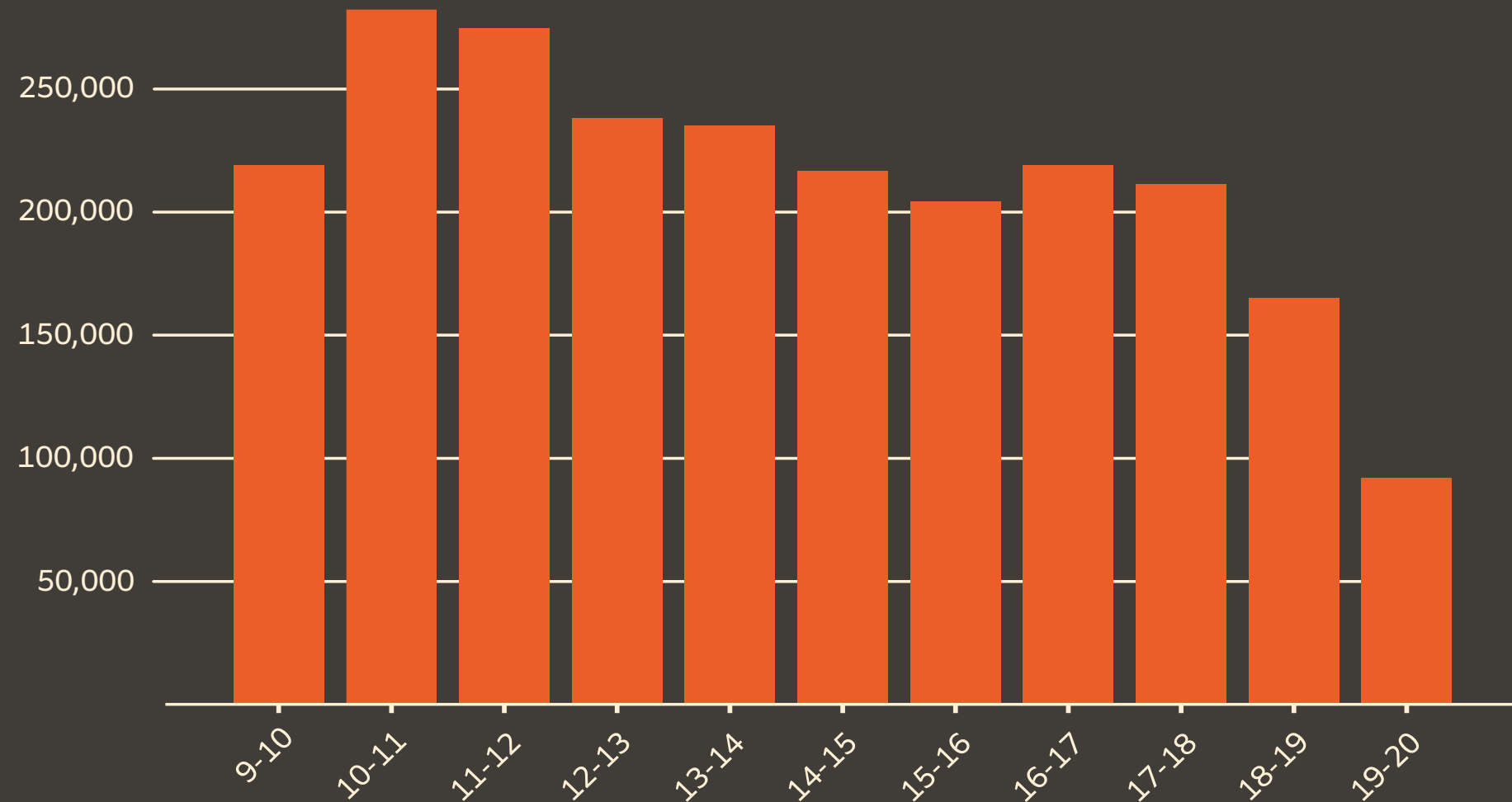
Rezeptpflichtig	Apothekenpflichtig	Lagerort	Anzahl	Wert EK	Wert VK	Zahlbetrag	Bar
Nein	Ja	G	1	0.91	1.98	1.98	Ja

Abverkauf	Retoure	Botendienst
Ja	Ja	Nein



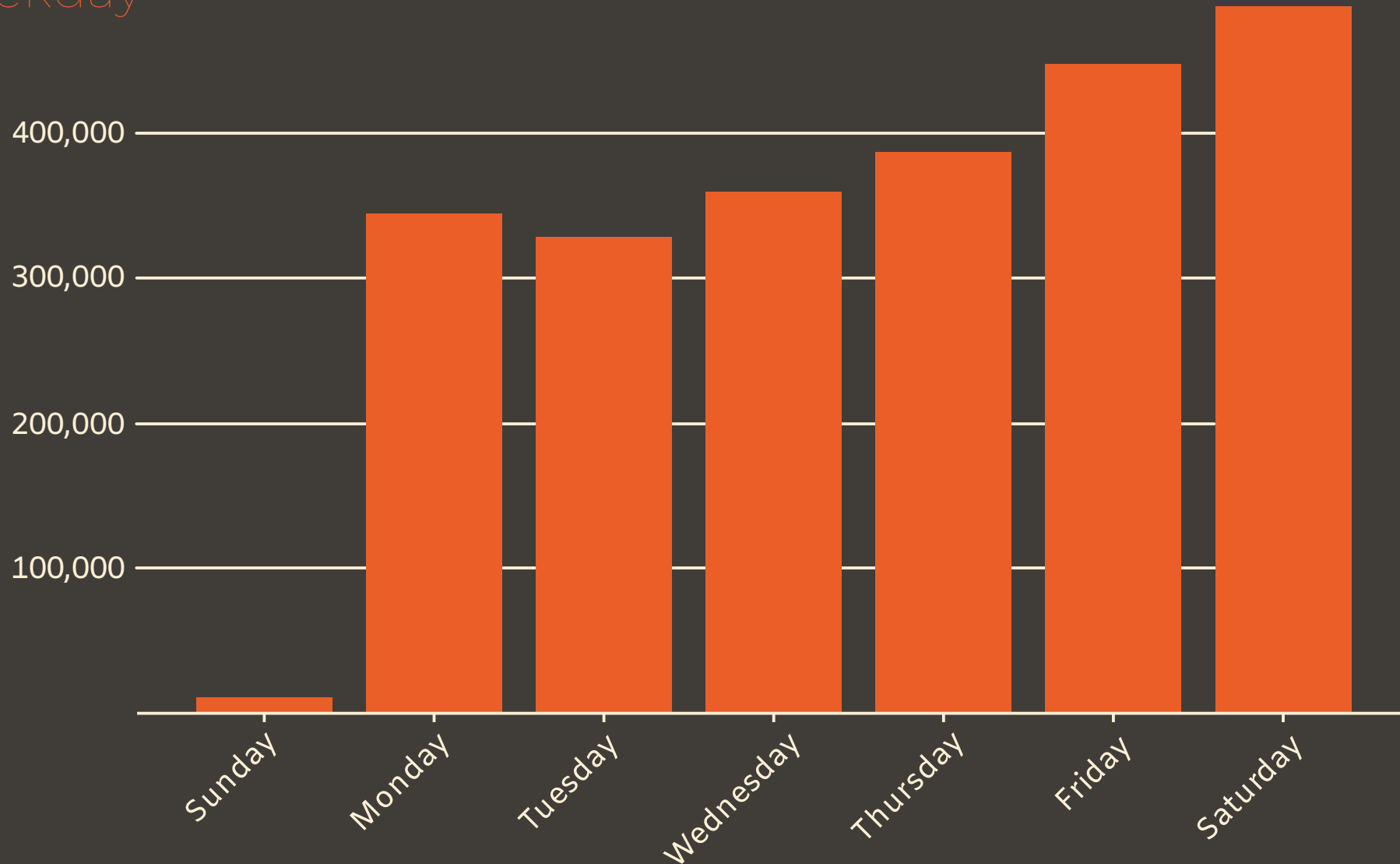
Transactions

Daytime



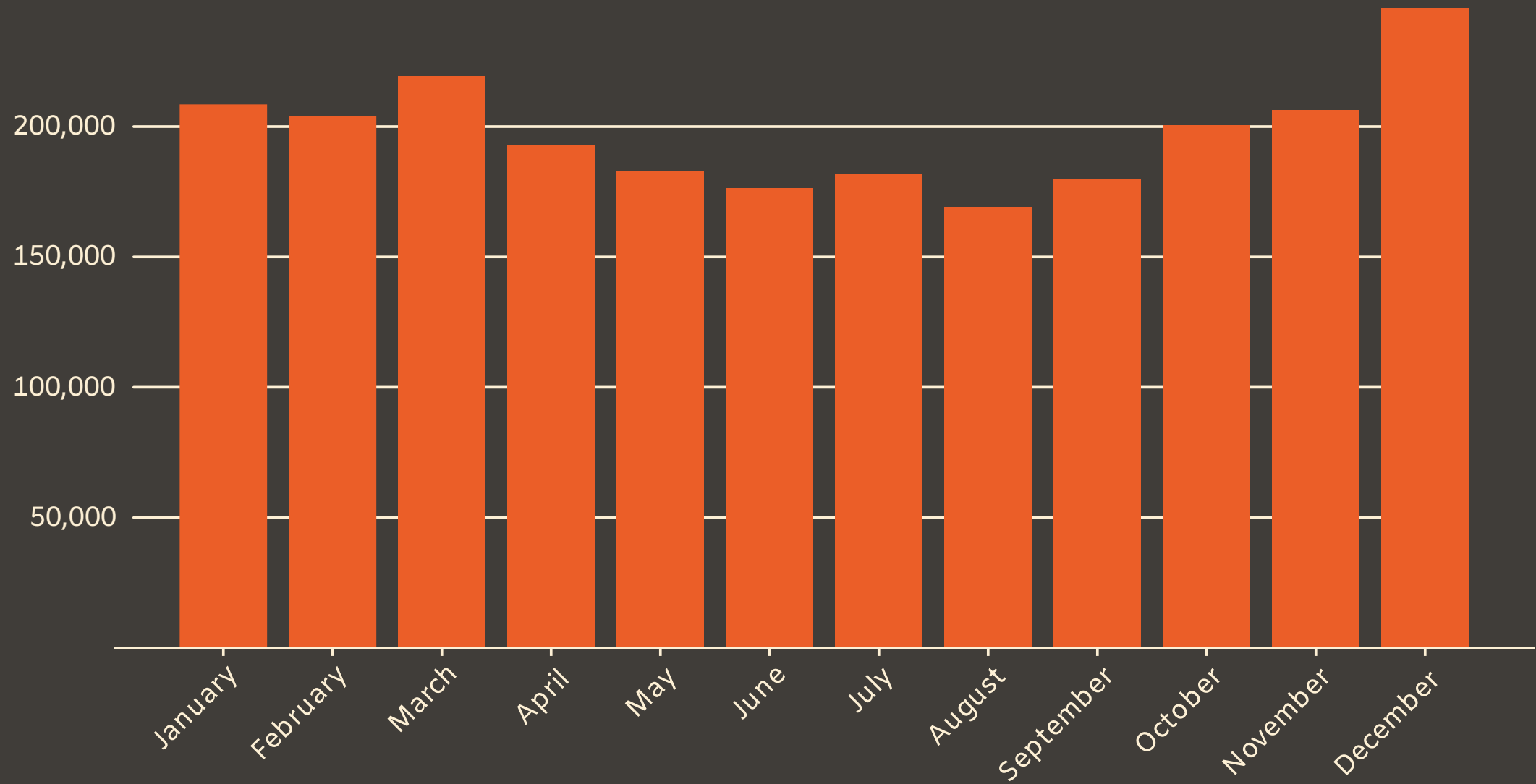
Transactions

Weekday



Transactions

Month



Drugs by Popularity

2021

Rank	Drug	Manufacturer	Sales
1 st	COVID MASKEN FFP 2	None	3915
2 nd	COVID MASKEN FFP 2	None	3080
3 rd	COVID19 ANTIGENSELBSTTEST	MAKEG	2198
4 th	NASENSPRAY-ratiopharm Erwachsene kons.frei	RATIO	1050
5 th	IBUBETA 400 akut Filmtabletten	BETAP	977



Problem

Inventory

- Limited storage capacity
~5,000 packages fit in the general alphabet
- 100,314 approved drugs in Germany
Zipf's law applies
- Physicians are free to prescribe any drug
- Same drug might exist from different companies
original and generic
- Drug shortage in Europe





- Truck Drivers
- Commuter / Working People
- Vacationers

Solution

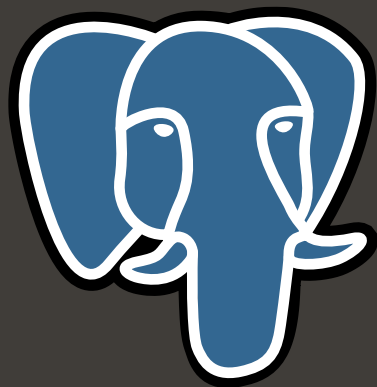
Reinforcement Learning

- Model available storage capacity
- Define rewards and penalties
- Re-simulate transactions
- Define policy algorithm
- Compare agent-managed with human-managed inventory

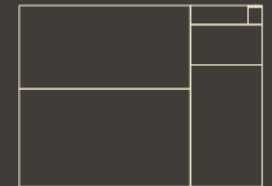
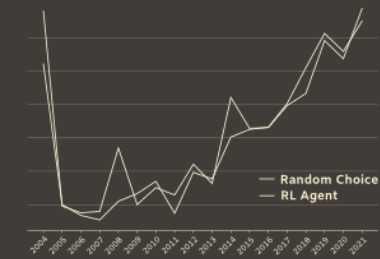
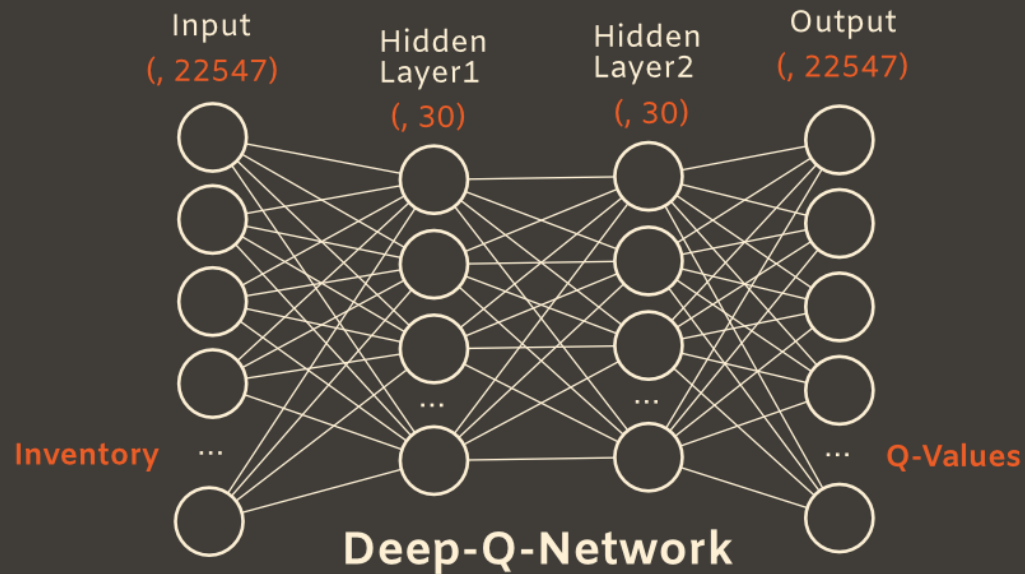
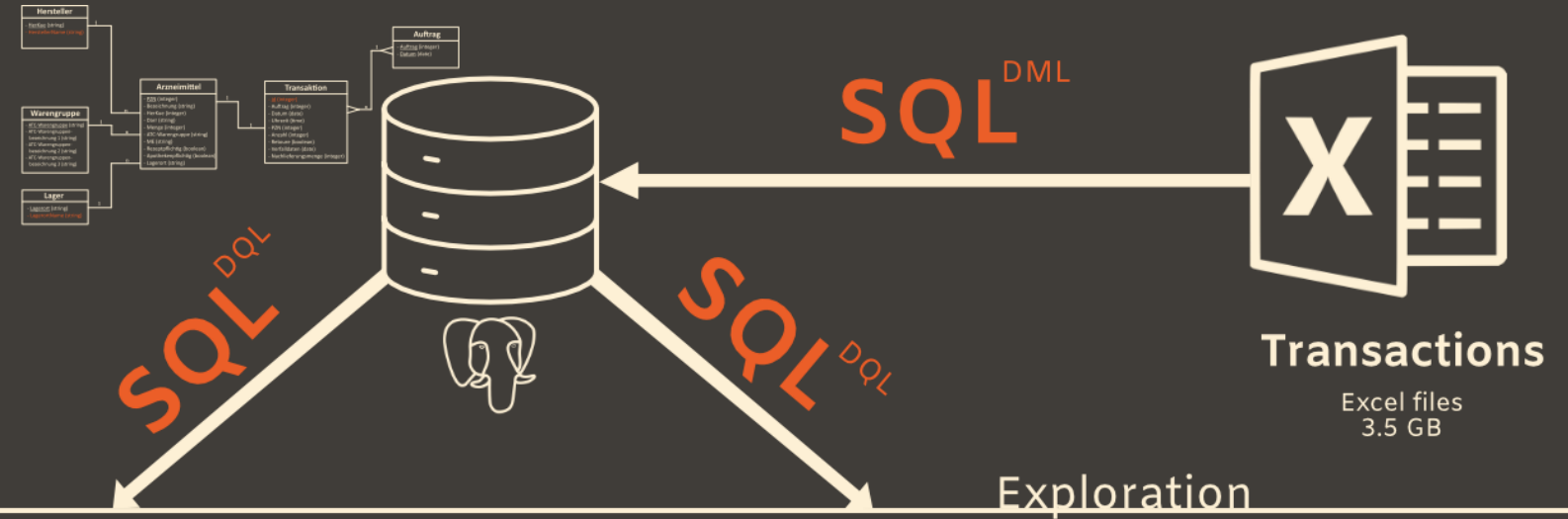


Technologies

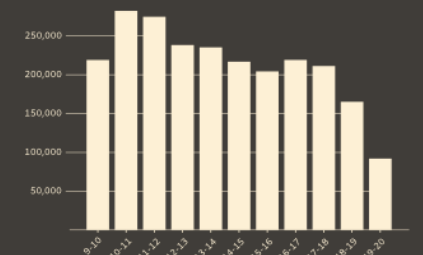
Used



Solution Sketch

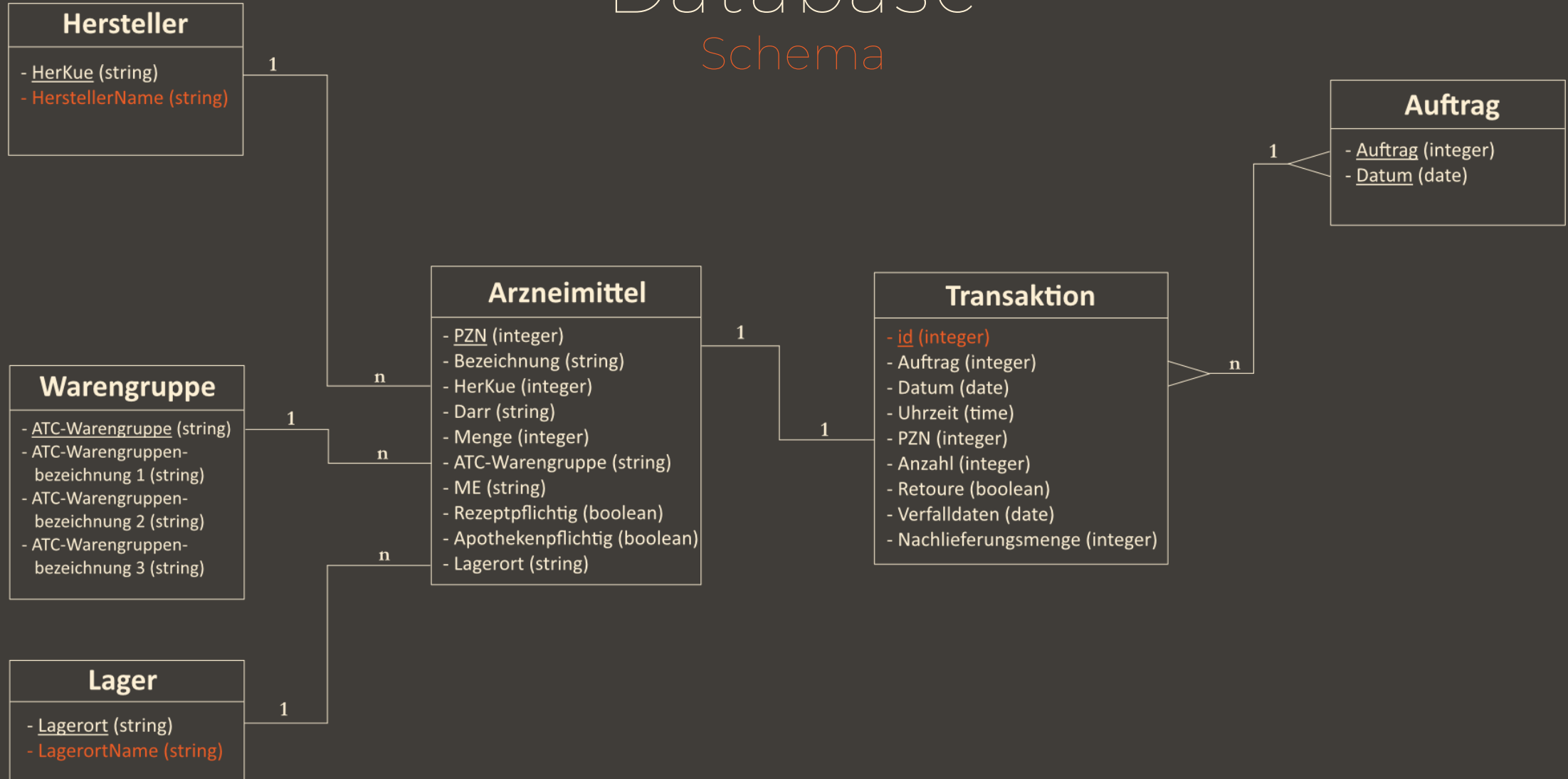


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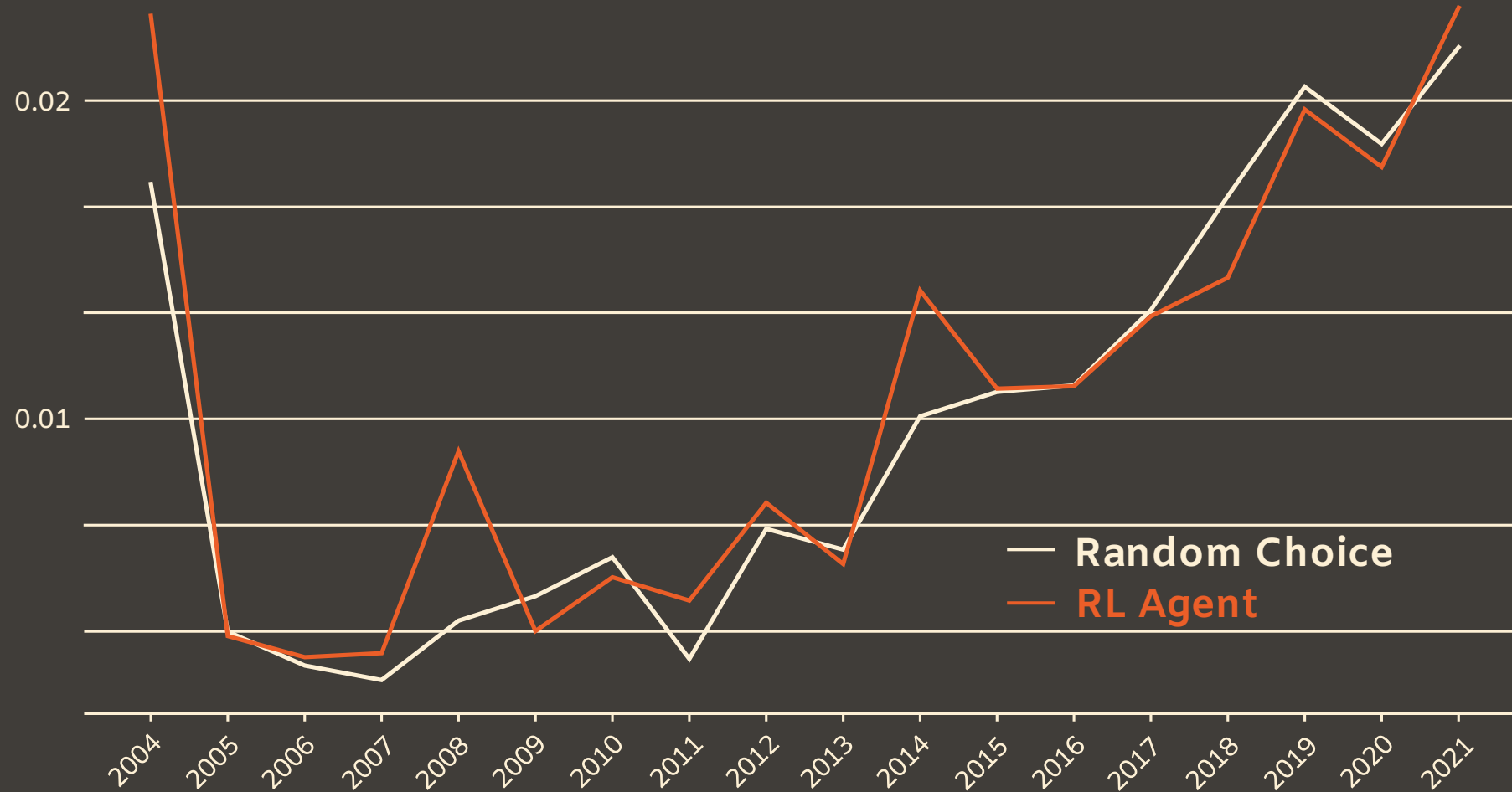
Loss Function: Mean Squared Error
 Optimizer: Adam
 Activation Hidden Layers: Exponential Linear Unit
 Activation Output Layer: Softmax

Database Schema



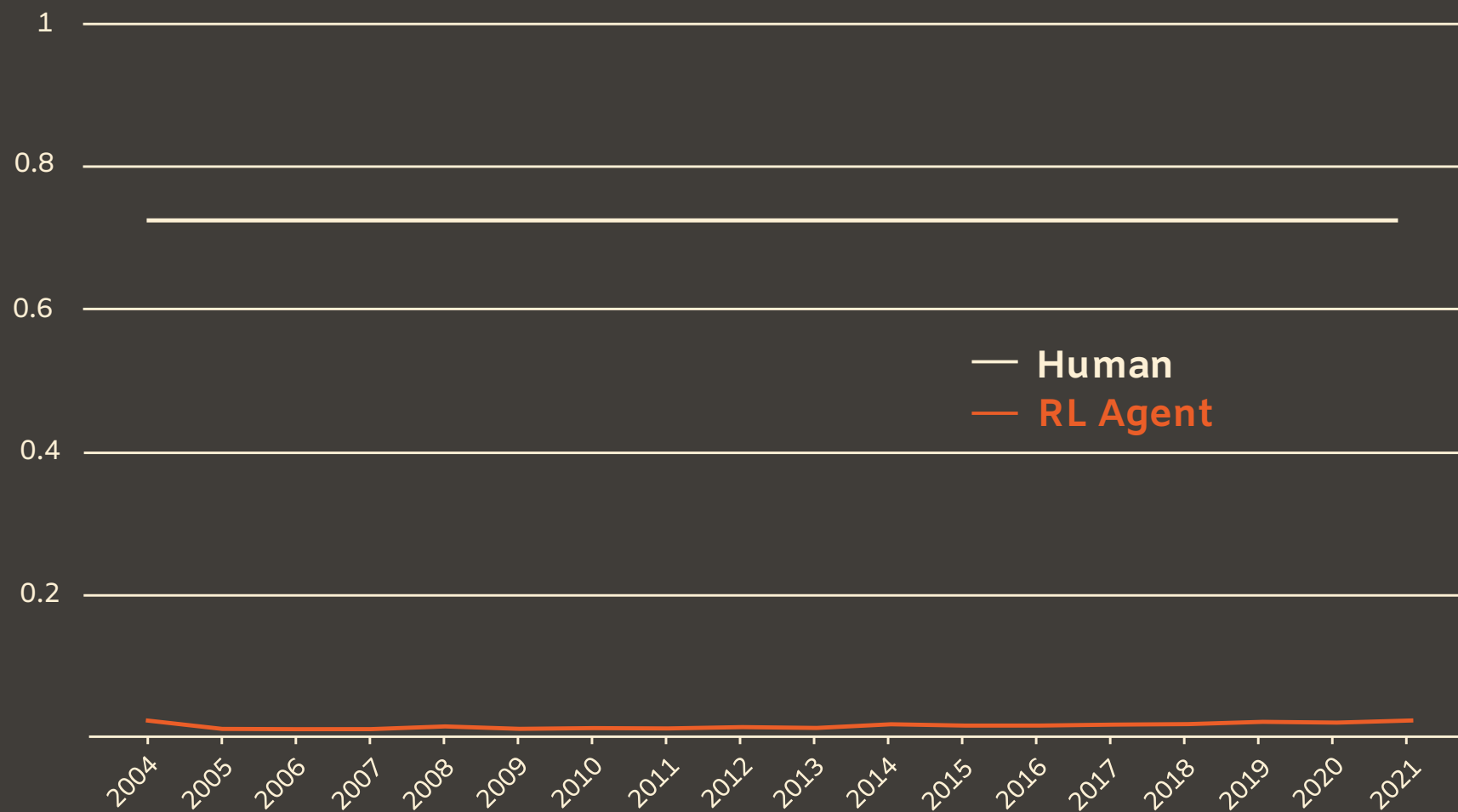
Results

Successful Transactions



Results

Successful Transactions



Takeaways

Project Data Science

- **Relational databases are powerful**
especially with pandas
- **Reinforcement learning is difficult**
Andrey Karpathy: “[Supervised learning] wants to work. [...] RL must be forced to work.”
- **Optimize code for training performance and reproducibility**
a little effort upfront will save you lots of time later
- **Domain knowledge is indispensable**
- **You can't always win**
humans - and even randomness sometimes - are hard to beat



Sources

Literature

- A. Géron (2017): „Hands-On Machine Learning with Scikit-Learn and TensorFlow“, O'Reilly Media, Inc.
- Z. Sui, A. Gosavi, L. Lin (2010): „A Reinforcement Learning Approach for Inventory Replenishment in Vendor-Managed Inventory Systems With Consignment Inventory “, EMJ 22(4).

Images, Logos & Vectors

- Google Earth & Maps
- Logos: Wikimedia
- <https://www.vecteezy.com/free-vector/storage>
- <https://www.vecteezy.com/free-vector/cashier>
- <https://www.vecteezy.com/free-vector/human>
- <https://www.vecteezy.com/free-vector/warehouse>
- https://de.m.wikipedia.org/wiki/Datei:T-Rezept_Muster_2011.svg



Project Data
Science

Thanks for your
Attention!

Do you have any questions?

