Prescriptions for Doctors

How should hospitals replace their equipment?


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HANDLE

MIT MANAGEMENT SLOAN SCHOOL

Problem

Hospitals spend **$93B per year** on medical equipment in the US

However, they are neither able to elaborate long-term budget plans for the replacement of medical equipment nor they have an idea of how will their fleet evolve in the following years

$93B
per year

How can we help hospitals develop a replacement plan for their medical equipment over the next 5 years?

To solve this problem, we need to tackle the following questions

1. How can we estimate the cost of replacing an asset?
2. Which is the best replacement strategy for each client?
3. How can we optimally suggest which specific assets should be replaced?

HANDLE Global

Healthcare supply chain analytics platform

They collect and process data, and provide **analysis tools** for hospitals to better manage their medical equipment

Created a **0-100 score** to quantify the health of assets

Data

Clients with **hundreds of thousands** of assets

All the data was previously processed by HANDLE

Asset sample:

Age: 7 years
Product: Bariatric bed
Lifespan: 20 years
Manufacturer: Bed supplier
Item id: XA124l23b23cFc2

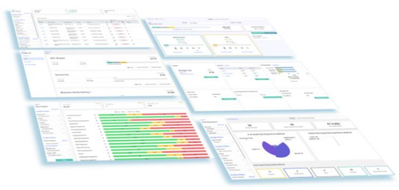
Score: 35
Category: Hospital beds
Hospital id: 15089
Purchase Price: $25.3k
Purchase Data: 08/19/2015

Methodology

Client data
ETL
HANDLE data

Replacement Cost Forecasting

Interactive 5-year Budget Planning



Optimal Budget Planning

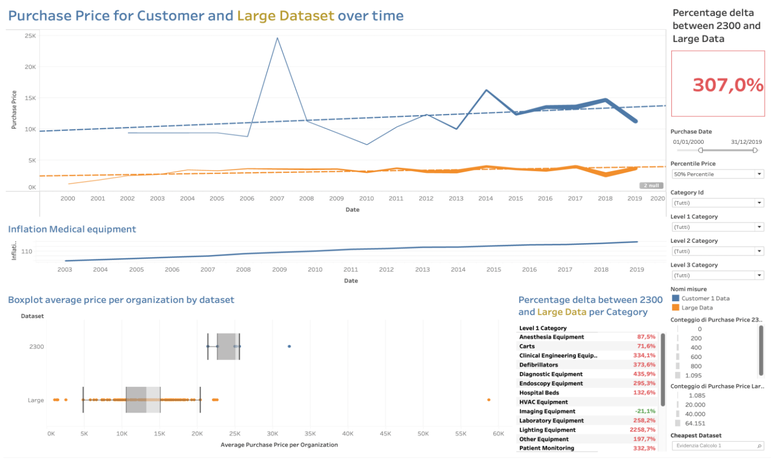
Replacement Cost Forecast

The goal is to estimate **how much will it cost** to replace an asset in the future

However, since we only have information about the past purchases, we start from the past **purchase price**, and we update it applying the **price trends** observed in the data within each product category

Purchase Price **X** Category Trend **=** Replacement Cost

Running regressions for each category, controlling on manufacturer and organization, then validating each regression separately



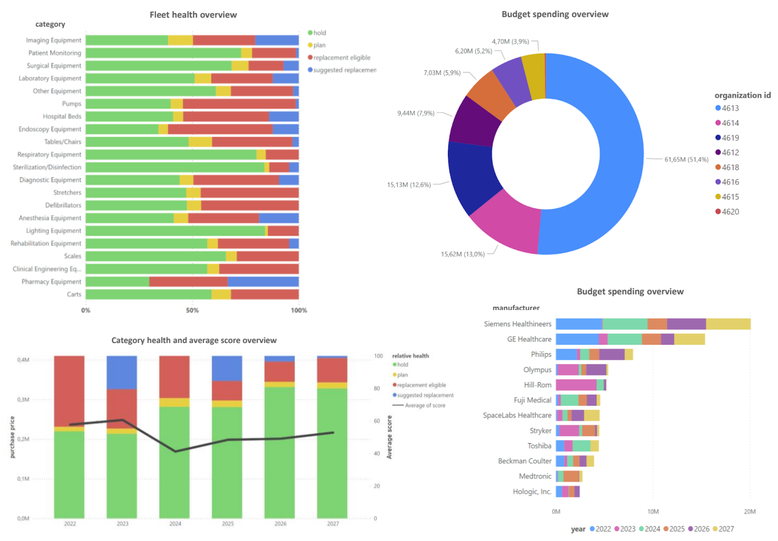
Interactive 5-year Budget Planning

Interactive dashboard for clients to define a replacement **strategy** (how to prioritize the replacement of assets) that suits their needs and preferences by **customizing the parameters** of the model

The dashboard integrates a sequential approximation of the prescriptive model to **improve the custumer's experience** by reducing the computational time

Reduction of solving time:

	Apr	May	Jun	Jul
Runtime (s)	**30.0**	**0.9**	**0.3**	**0.125**



Optimal 5-year Budget Planning

Binary optimization problem to provide the final **presciptions**: which assets and when should the client replace according to its needs and preferences

The model **maximizes the health score of replaced assets** subject to budget constraints, prioritizing urgent assets, and allowing multiple same-asset replacements within the optimization horizon

Formulation *

* Simplification of the actual formulation

$$\max_{d_0,d_1,w,z} \sum_{t=1}^{T}\sum_{i=1}^{N} cost_{i,t}\cdot(score_{i,t}\cdot d_{0,i,t} + urg\_factor\cdot score_{i,t}\cdot d_{1,i,t} + 100\cdot w_{i,t})$$

$$\text{s.t.} \sum_{i=1}^{N} cost_{i,t}\cdot(d_{0,i,t}+d_{1,i,t}+w_{i,t}) \le budget_t \quad \forall t$$

$$\sum_{t=1}^{T}(d_{0,i,t}+d_{1,i,t}) \le 1 \quad \forall i$$

$$w_{i,t+L_i} = d_{0,i,t}+d_{1,i,t}+w_{i,t} \quad \forall i, t=1,\dots,t-L_i$$

$$\sum_{i\in j} score_{i,t} \le \sum_{i\in j}[urg\_cutoff + M\cdot z_{j,t}] - \epsilon \quad \forall j,t$$

$$\sum_{i\in j} score_{i,t} \ge \sum_{i\in j}[urg\_cutoff + M\cdot(z_{j,t}-1)] \quad \forall j,t$$

$$d_{1,i,t} \le z_{j,t} \quad \forall i,t$$

$$d_{0,i,t} \le 1 - z_{j,t} \quad \forall i,t$$

$$d_0, d_1, w \in \{0,1\}^{N*T}$$

$$z \in \{0,1\}^{J*T}$$

Decision variables

$d_{0,i,t}$: replacement decision variable
$d_{1,i,t}$: urgent replacement decision variable
$w_{i,t}$: cycle replacement variable
$z_{j,t}$: auxiliary group urgency variable

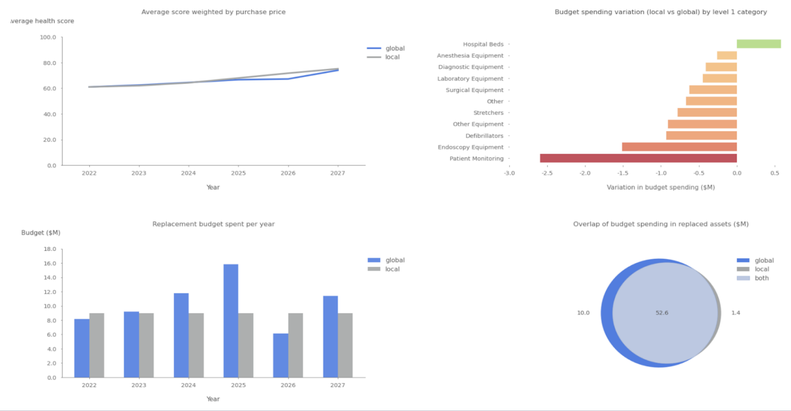
Parameters

N : number of assets
T : year horizon
J : number of asset groups
L_i : asset lifespan
urg_cutoff : max. acceptable average group score
urg_factor : score modifier for urgent assets

Strategy Comparison

We additionally developed a tool to **compare different strategies** so that clients are able to analyze the implications that one strategy may have compared to another one

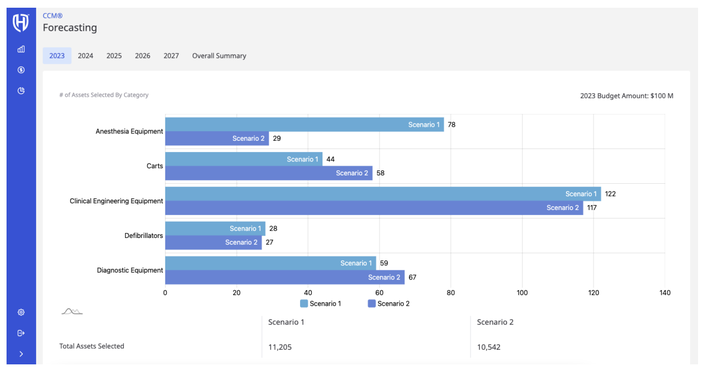
Will this tool, clients will observe the **result** of a decision in the strategy choice by comparing it to the **counterfactual**



Company adoption

HANDLE is **currently** implementing in their **platform** both *Replacement Cost Forecast* & *Interactive 5-year Budget Planning*

The *Optimal 5-year Budget Planning* adoption is subject to the feedback from clients and the purchase of a commercial license



Next steps

1. **Finalize** integration into HANDLE platform
2. **Collect** feedback from/running AB testing on real clients
3. **Implement** *Optimal Budget Planning* into production
4. **Analyze** consistency between prescriptions and actual decisions of the client

25k
times speedup

97%
of the optimal objective function

3,2%
budget saving