Can AI-Assisted Technology Be Used To Support The Development Of Economic Models?

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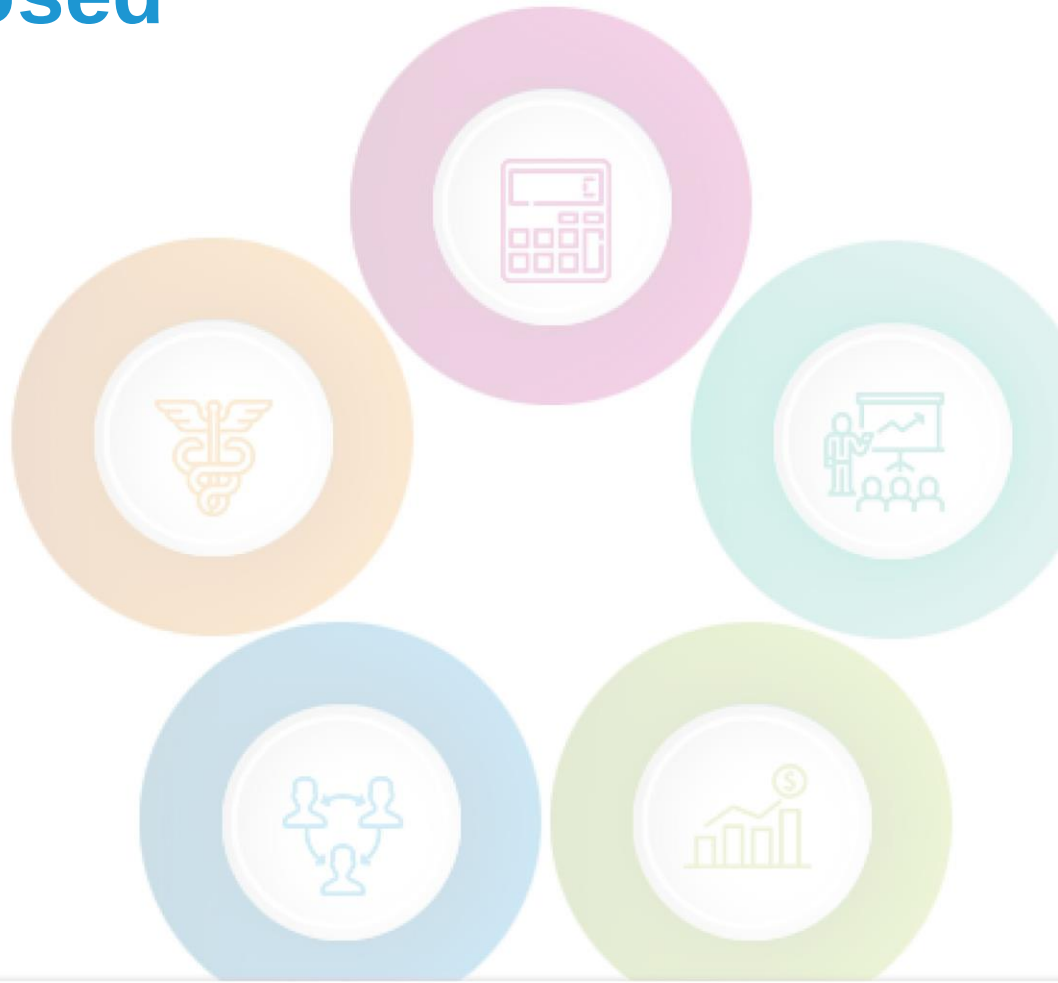

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- The study is independent work conducted by York Health Economics Consortium.
- No personal conflicts to declare.

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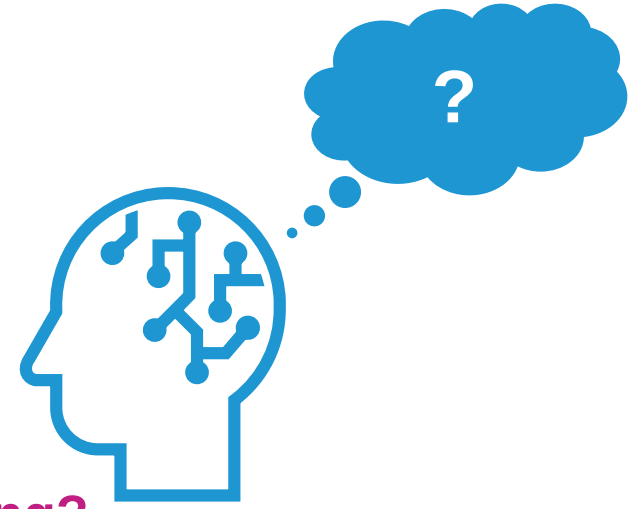
Introductory questions

- **What is artificial intelligence (AI)?**
  - AI is a field that leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind [1]



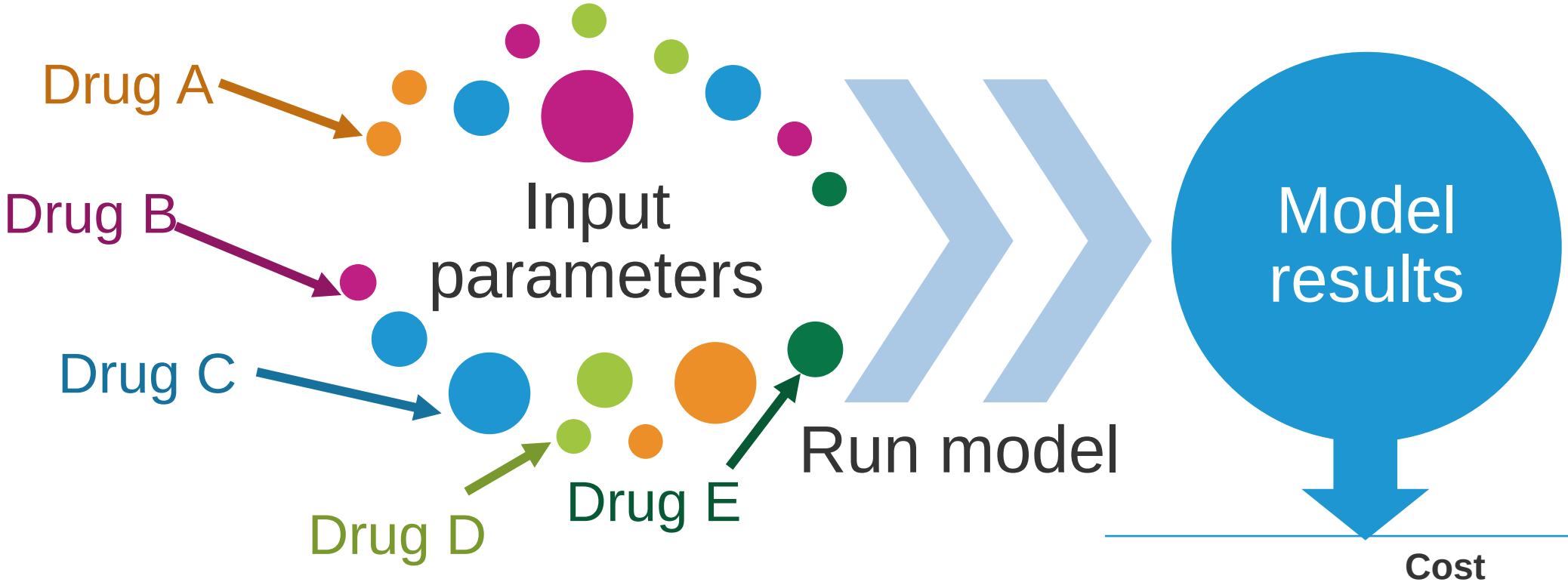
- **How is AI used in existing industries?**
  - Inspire
  - Optimise
  - Support decision making

- **How can AI be utilised for health economic modelling?**

Write standardised Visual Basic Analysis (VBA) functions → Optimise VBA code

AI, artificial intelligence; VBA, Visual Basic Analysis

A fully incremental analysis (FIA) is required for HTAs submitted to NICE [2, 3]



	Cost	Effectiveness
Drug A	£5,000	1
Drug B	£12,000	1.5
Drug C	£25,000	3
Drug D	£10,000	2
Drug E	£35,000	4

FIA, fully incremental analysis; HTA, health technology assessment, ICER, incremental cost-effectiveness ratio; NICE, National Institute for Health and Care Excellence; QALYs, quality adjusted life years.

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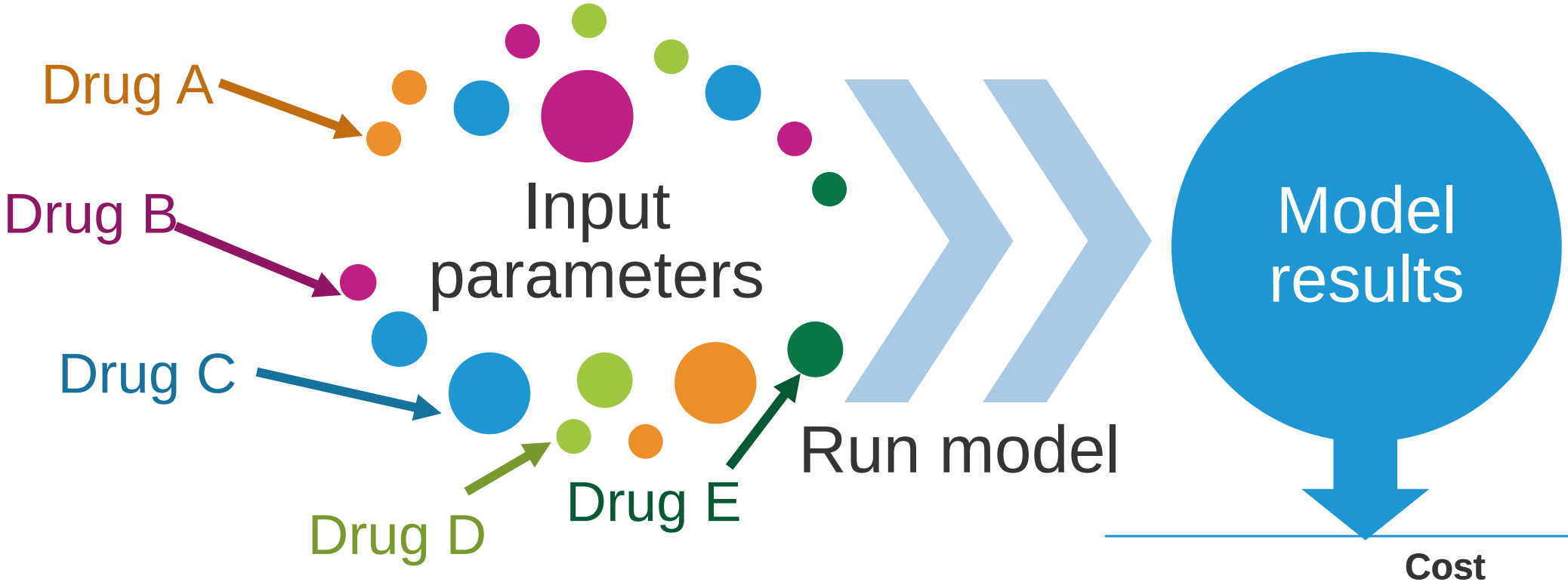

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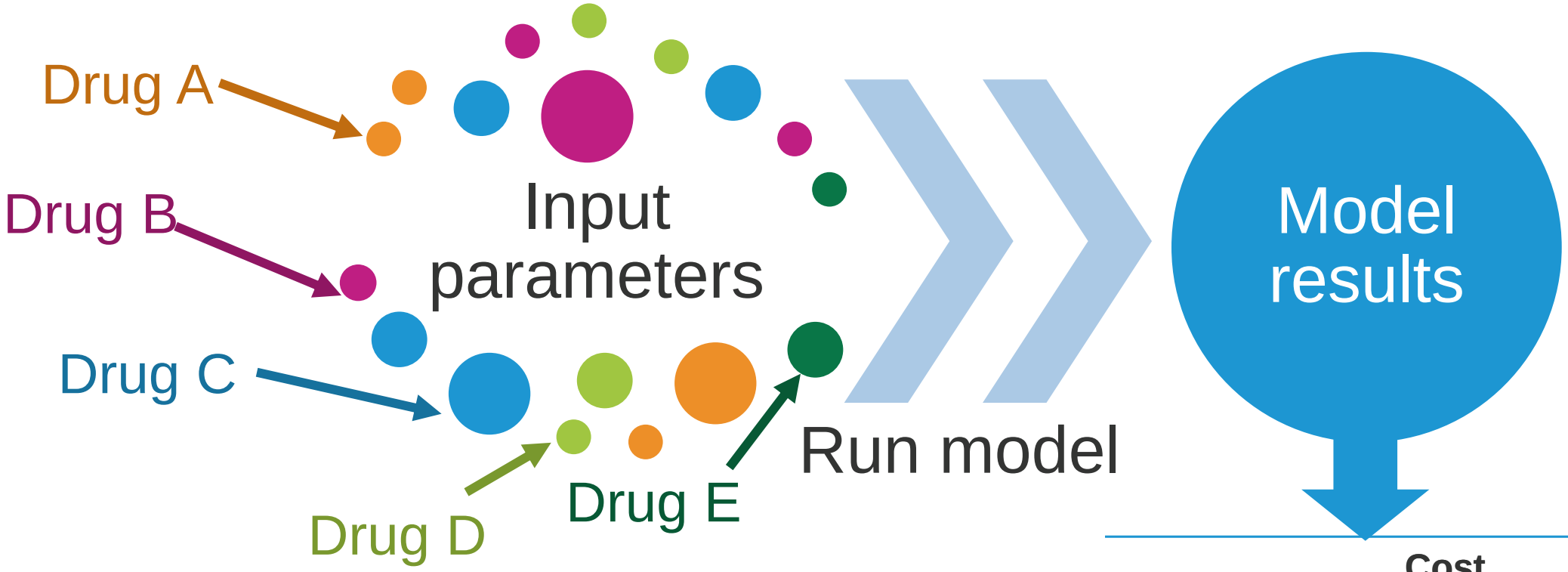

	Cost	Effectiveness
Drug E	£35,000	4
Drug C	£25,000	3
Drug D	£10,000	2
~~Drug B~~	~~£12,000~~	~~1.5~~
Drug A	£5,000	1

Dominated

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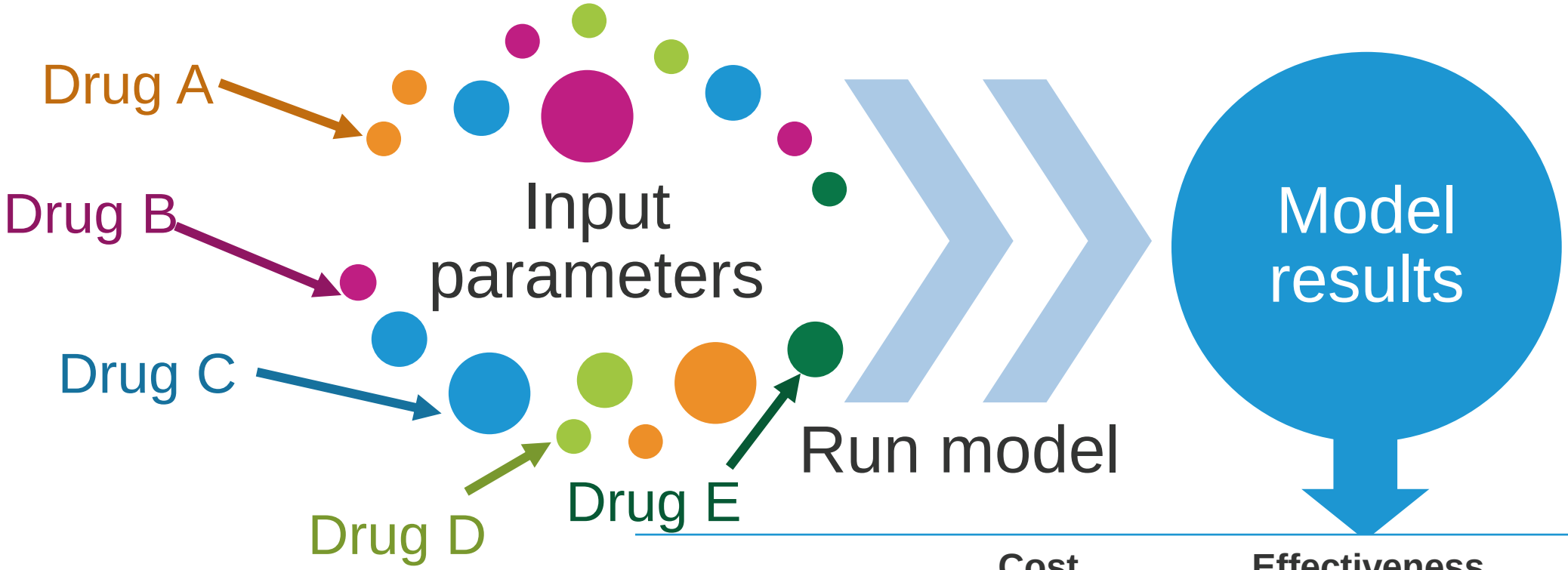

	Cost	Effectiveness	ICER
Drug E	£35,000	4	£10,000 per QALY
Drug C	£25,000	3	£15,000 per QALY
Drug D	£10,000	2	£5,000 per QALY
Drug A	£5,000	1	-

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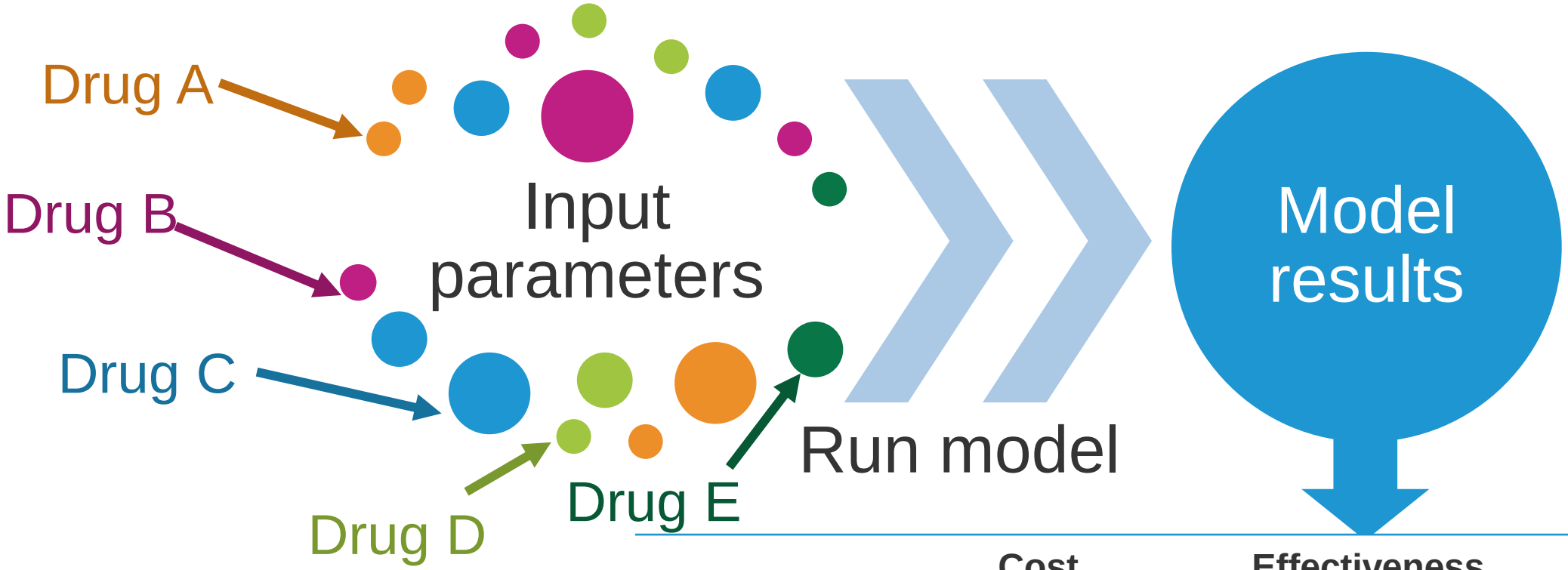

Extendedly dominated

	Cost	Effectiveness	ICER
Drug E	£35,000	4	£10,000 per QALY
~~Drug C~~	~~£25,000~~	~~3~~	~~£15,000 per QALY~~
Drug D	£10,000	2	£5,000 per QALY
Drug A	£5,000	1	-

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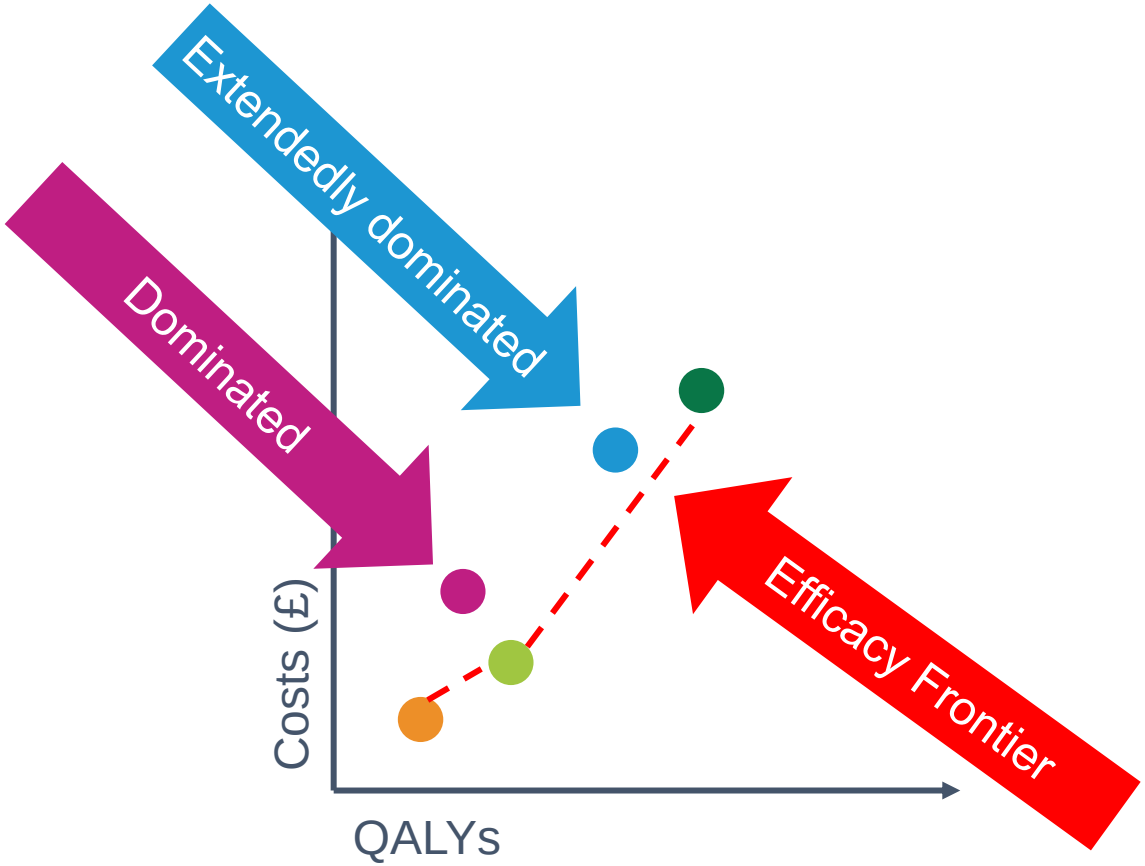
The dominance / extended dominance results can be plotted on an efficacy frontier



QALYs, quality adjusted life years.

An FIA can be timely to build in an excel-based model

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R based models?

- Using the ‘dampack’ package [4]

`calculate_icers` *Calculate incremental cost-effectiveness ratios (ICERs)*

Description

This function takes in strategies and their associated cost and effect, assigns them one of three statuses (non-dominated, extended dominated, or dominated), and calculates the incremental cost-effectiveness ratios for the non-dominated strategies

The cost-effectiveness frontier can be visualized with `plot`, which calls `plot.icers`.

An efficent way to get from a probabilistic sensitivity analysis to an ICER table is by using `summary` on the PSA object and then using its columns as inputs to `calculate_icers`.

Usage

```
calculate_icers(cost, effect, strategies)
```

Arguments

`cost`	vector of cost for each strategy
`effect`	vector of effect for each strategy
`strategies`	string vector of strategy names With the default (NULL), there is no reference strategy, and the strategies are ranked in ascending order of cost.

Value

A data frame and `icers` object of strategies and their associated status, incremental cost, incremental effect, and ICER.

See Also

`plot.icers`

Examples

```
## Base Case
# if you have a base case analysis, can use calculate_icers on that
data(hund_strat)
hund_icers <- calculate_icers(hund_strat$Cost,
                              hund_strat$QALYs,
                              hund_strat$Strategy)

plot(hund_icers)
# we have so many strategies that we may just want to plot the frontier
plot(hund_icers, plot_frontier_only = TRUE)
# see ?plot.icers for more options
```

Excel based models?

- No open-source standardised functions available.
- Timely and tricky to implement, especially when using formulas within cells.

Can AI help to…

1. **Write a bespoke VBA function to automate an FIA?**
2. **Review and optimise an existing bespoke VBA function to automate an FIA?**

AI, artificial intelligence; FIA, fully incremental analysis; VBA, Visual Basic Analysis

First, we explored whether AI could write a bespoke VBA function for an automated FIA

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ASK AI

- An AI was asked to write a VBA function to automate an FIA.
- The function was reviewed.

REPLICATE

- Feedback was provided and new code was generated.

MODEL

- Functions adapted for an example model.
- Cross checked results using the ‘dampack’ package in R

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Second, we explored whether AI could review and optimise an existing VBA function for an automated FIA

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WRITE

- A modeller wrote a bespoke VBA function to automate an FIA.

ASK AI

- AI was asked to review and provide advice on how the function could be optimised.

REVIEW

- Reviewed comments from the AI and any changes made to the code.
- Cross checked results using the ‘dampack’ package in R.

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When asked an appropriate research question, the AI generated the FIA function

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POSITIVES

FULLY COMMENTED VBA CODE WAS WRITTEN IN UNDER 2 MINUTES

- Iteration 1: 42 seconds
- Iteration 2: Instant after feedback
- Iteration 3: 1 minute, 25 seconds

2 ITERATIONS CORRECTLY CALCULATED THE DOMINANCE OUTCOMES

LISTENED TO FEEDBACK

MINOR ISSUES

ALL ITERATIONS CONTAINED MINOR ISSUES INCLUDING:

- Use of hardcoded values
- Missing arguments
- Use of key words not used in VBA
- Inefficient code
- Outputting results in an incorrect format

THESE ISSUES CAN EASILY BE IDENTIFIED AND ADDRESSED BY A MODELLER PROFICIENT IN VBA

MAJOR ISSUES

EXTENDED DOMINANCE CALCULATIONS INCORRECT IN ALL 3 ITERATIONS

- Iteration 1 applied the principal of dominance twice.
- Iteration 2 assumed all non-dominant comparators were extendedly dominant
- Iteration 3 contained an error within an overly complex loop.

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AI was asked to review and optimise a bespoke VBA function for FIA written by a modeller

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POSITIVES

THE AI CLEARLY EXPLAINED HOW TO MAKE CODE MORE EFFICIENT AND IMPLEMENTED CHANGES QUICKLY

- Sorting algorithm updated to “quick sort” from “bubble sort”

REMOVED CODE THAT WAS NOT NEEDED

MINOR ISSUES

ADDITION OF VARIABLES NOT NEEDED:

- The AI redefined variables with different names
- Variables defined at random points in the code – this was messy
- Added unnecessary variables

MAJOR ISSUES

REMOVED AN INNER LOOP FOR “EFFICIENCY” CAUSING THE PRINCIPAL OF EXTENDED DOMINANCE TO BE INCORRECTLY APPLIED.

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The results from each FIA function are presented in the table below

Intervention	Cost	QALY	FIA using 'dampack' in R	Iteration 1	Iteration 2	Iteration 3	Modeller's code	AI optimised code
Intervention A	£6,913	4.19	Dominated	Dominated	Dominated	N/A	Dominated	Extendedly dominated
Intervention B	£6,639	7.57	Not dominated	Not dominated	Extendedly dominated	N/A	Not dominated, ICER: £407	Not dominated, ICER: £407
Intervention C	£9,435	4.88	Dominated	Dominated	Dominated	N/A	Dominated	Dominated
Intervention D	£4,109	0.99	Not dominated	Not dominated	Extendedly dominated	N/A	Not dominated, Referent	Not dominated, Referent
Intervention E	£5,728	5.33	Not dominated	Not dominated	Extendedly dominated	N/A	Not dominated, ICER: £90	Not dominated, ICER: -£1041
Intervention F	£9,551	1.69	Dominated	Dominated	Dominated	N/A	Dominated	Extendedly Dominant
Intervention G	£9,553	2.16	Dominated	Dominated	Dominated	N/A	Dominated	Dominated
Intervention H	£5,457	2.31	Extendedly dominated	Not dominated	Extendedly dominated	N/A	Extendedly dominated	Not Dominant, ICER: -£6584

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The Turing test: Which conclusion was written by a person, and which was written by an AI?

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Our conclusion

Can AI write VBA code?

- AI can very quickly write fully commenting VBA code.

Should AI write VBA code?

- Lack of open-science VBA code from which the AI can learn
- Push towards being more open-science with models

Will modellers be replaced by AI?

- Its unlikely
- Instead, AI will be a tool to:
  - Save time
  - Inspire modellers
  - Optimise code

AI conclusion

Can AI write VBA code?

- AI can assist in writing VBA code by providing code suggestions and code generation tools.

Should AI write VBA code?

- It may not handle uncommon or highly specialized VBA tasks well.

Will modellers be replaced by AI?

- Human oversight and expertise are essential for ensuring:
  - Quality
  - Correctness

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Thank you for listening

Does anyone have any questions?

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Thank you

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