Dynamic Valuation Frameworks for Budget Impact and Cost-Effectiveness Modeling Using the DynamicPV Package for R

MSR210

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Introduction

- Single-cohort cost-effectiveness (CE) models are routinely used in the decision-making of health technology assessment (HTA) bodies and are widely published in the scientific literature[1]
- Despite their utility, such models have been criticized as overly limited in scope, omitting important elements of value[2] and health equity[3]
  - Anticipated pricing dynamics are routinely ignored, meaning that the long-run opportunity cost for drugs may be misrepresented[4]
  - Single-cohort modeling is criticized as not tailored to properly inform decision-making that will impact future cohorts of patients[5]
- Case studies have shown how modeling pricing and uptake as dynamic can have substantial effects on reported incremental cost-effectiveness ratio (ICER) values[6]
- A mathematical framework is described for evaluating budget impact (BI) and cost-effectiveness models in the presence or absence of dynamic (life cycle) pricing and/or dynamic uptake (multiple cohorts)
- The framework has been implemented in the R package DynamicPV, which is publicly available on the CRAN repository[7]
- The framework is illustrated for cost-effectiveness and budget impact modeling in oncology

Methods

We evaluate the budget impact and cost-effectiveness of an illustrative new treatment in an advanced oncology setting that would displace a single standard of care (SoC), with and without dynamic pricing and dynamic uptake, at a date of evaluation of September 1, 2025 (varied in graphical analysis).

The total present value, *TPV(l)*, of a cash flow p_k for the u_j patients who began treatment at time *j* and who are in their *k*th timestep of treatment is as follows:

$$TPV(l) = \sum_{j=1}^{T} \sum_{k=1}^{T-j+1} \frac{u_j \cdot p_k \cdot R_{j+k+l-1}}{(1+i)^{j+k-2}}$$

where *i* is the discount rate representing time preference (per timestep), p_k is the cash flow amount in today's money, R_{j+k-1} is the nominal amount of the cash flow at the time it is incurred, and *l* is a time offset relative to the date of evaluation (to facilitate calculations with the price index over time).

CE is measured as in the incremental cost-effectiveness ratio per quality-adjusted life year (QALY) gained, per patient, over a 20-year horizon, with a (real) discount rate of 3% per year. BI is measured over 5 years. The key assumptions of the BI and CE models are given in **Table 1**.

Table 1. Key assumptions of the BI and CE models

Attribute	Assumption
CE model structure	Three-state partitioned survival
PFS with SoC	Exponential distribution, with median 50 weeks
OS with SoC	Lognormal distribution, with mean and SE of 4 and 1 log-weeks, respectively
Efficacy of new intervention	HR of PFS and OS of 0.5 and 0.6 vs SoC, respectively
Health utility	0.8 in PF, 0.6 in PD
Drug acquisition costs per week in PF	$400 with SoC, $1500 with new intervention
Drug administration costs per week in PF	$50 with SoC, $75 with new intervention
Disease management costs per week	$80 in PF, $20 in PD
Risk of AEs per week while in PF	0.08% with SoC, 0.10% with new intervention
Unit cost of treating AE	$2000 per event
Subsequent treatment costs per week in PD	$1200 with SoC, $300 with new intervention

AE, adverse event; CE, cost-effectiveness; HR, hazard ratio; OS, overall survival; PD, progressive disease; PF, progression free; PFS, progression-free survival; SE, standard error; SoC, standard of care.

Under the static approach, pricing is assumed constant in real terms and uptake is immediately 100%. Assumptions instead for dynamic pricing and uptake are given in **Table 2**.

Table 2. Dynamic assumptions relating to pricing and uptake

Attribute	Assumption
Price inflation	+2.5% per year
LoE for SoC	Price reduction of 70% on January 1, 2028
LoE for new intervention	Price reduction of 50% on January 1, 2031
Eligibility for new intervention	Newly incident patients only
Incidence of new patients	One patient per week
Share of patients adopting new intervention	Rising from 0% to 100% each timestep over 2 years (ie, by September 1, 2027)

LoE, loss of exclusivity; SoC, standard of care.

Results

The BI and CE results are shown in **Tables 3** and **4**, respectively.

Table 3. Budgetary costs and budget impact ($m) of new intervention with and without dynamic pricing and uptake

Dynamic pricing?		No	Yes	No	Yes
Dynamic uptake?		No	No	Yes	Yes
World without	SoC	12.923	11.516	12.923	11.516
	New	0	0	0	0
	Total	12.923	11.516	12.923	11.516
World with	SoC	0	0	3.508	3.460
	New	32.381	34.360	23.457	25.076
	Total	32.381	34.360	26.965	28.536
Budget impact	Abs	19.458	22.844	14.041	17.020
	Rel	151%	198%	109%	148%

Abs, absolute; Rel, relative; SoC, standard of care.

The BI varies between $14.041m and 22.844m absolutely and 109%-151% relatively, depending on the scenario.

Table 4. Cost-effectiveness of new intervention, per patient, with and without dynamic pricing and uptake

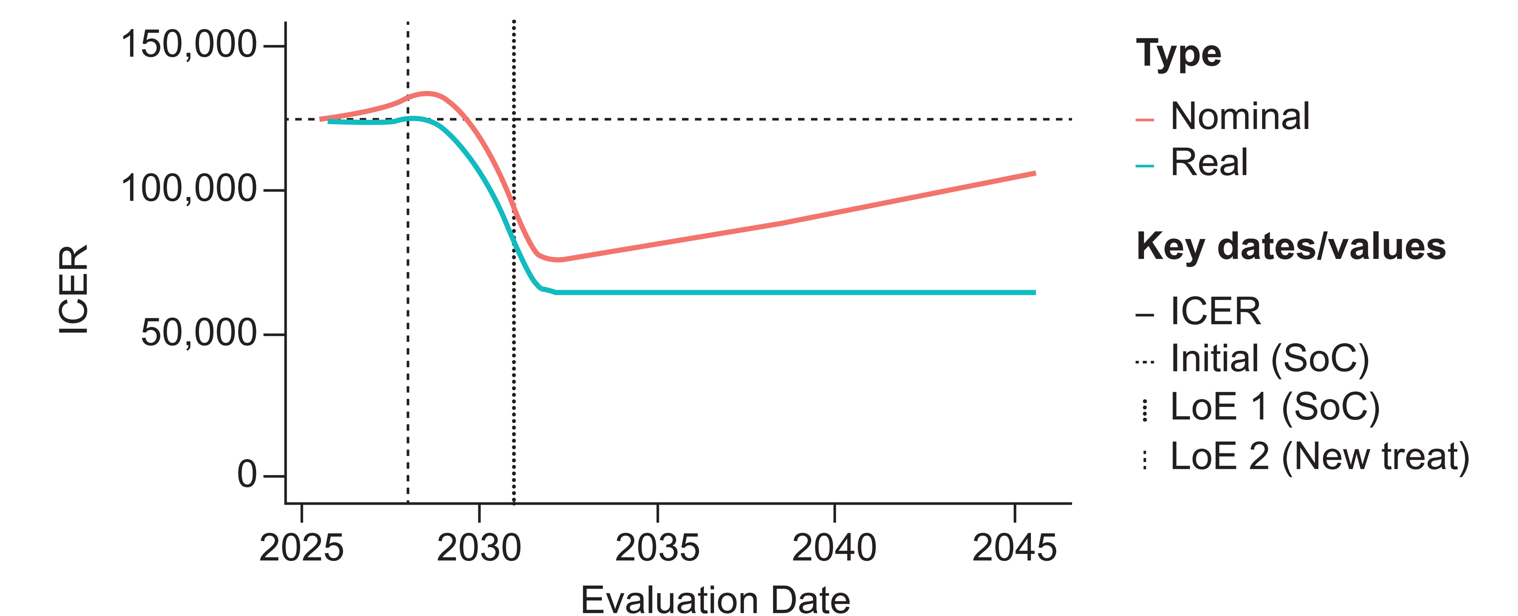
Dynamic pricing?		No	Yes	No	Yes
Dynamic uptake?		No	No	Yes	Yes
Costs	New	$194,157	$191,248	$130,380	$92,391
	SoC	$77,123	$76,428	$51,779	$42,764
	Incr	$117,034	$114,820	$78,600	$49,627
QALYs	New	2.080	2.080	1.319	1.319
	SoC	1.154	1.154	0.794	0.794
	Incr	0.926	0.926	0.525	0.525
ICER		$126,451	$124,059	$149,782	$94,570

ICER, incremental cost-effectiveness ratio; Incr, incremental; QALY, quality-adjusted life year; SoC, standard of care.

The CE results for this example show that, compared to static evaluation, dynamic pricing reduced the ICER slightly (-$2,392) and dynamic uptake increased the ICER (+$23,331), but together dynamic pricing and uptake were strongly synergistic and substantially reduced the ICER (-$31,881).

The **Figure 1** examines how the static ICER changes according to the date of evaluation and may be presented in real terms at today's prices, or in nominal terms.

Figure 1. Nominal and real static ICERs calculated across different dates of evaluation



Conclusions and discussion

- The mathematical framework described enables practical, transparent, and reproducible CE and BI evaluation with dynamic pricing and/or dynamic uptake (or neither)
- Uptake is not a new concept for BI models, and data exists to inform dynamic pricing assumptions. This need not be challenging
- CE and BI results were sensitive to the assumed rate and timing of pricing changes for both the new treatment and standard of care, as well as the timing of dynamic uptake relative to the models' time horizons
- The effects of dynamic pricing and dynamic uptake on CE results were strongly synergistic
- Further work would be valuable to connect this work to a more general system dynamics framework

References

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