The determinants of change in the cost-effectiveness threshold

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Abstract

In health care systems with a constrained budget, the cost-effectiveness threshold is determined by the cost-effectiveness of health care services displaced in order to fund new interventions. Using comparative statics, we review a number of potential determinants of the threshold, including the budget for health care, the demand for existing health care interventions, the technical efficiency of existing interventions, and the development of new health technologies. We consider the direction of impact that changes in each of these determinants would be expected to have upon the threshold.

Where the health care system is technically efficient, an increase in the health care budget unambiguously increases the threshold, while an increase in the demand for existing non-marginal health interventions unambiguously lowers the threshold. Improvements in the technical efficiency of existing interventions may result in a higher or lower threshold, depending upon the cause of the improvement in efficiency, whether the intervention is already funded and, if so, whether it is marginal. The development of new technologies may also raise or lower the threshold, depending upon whether the new technology is a substitute for an existing technology and, if so, whether the existing technology is marginal.

Our analysis allows health economists and decision makers to consider whether the cost-effectiveness threshold is likely to be changing over time, and in what direction. This has implications for the appropriate methods to use for economic evaluation, including the derivation of discount rates. It is also important consideration when determining which technologies are cost-effective.

Introduction

The cost-effectiveness threshold is a simple decision rule used to determine if a candidate intervention is sufficiently cost-effective to be reimbursed. The appropriate basis for the threshold has been the subject of considerable debate [1-5]. Nevertheless, the position that the threshold ought to reflect the opportunity cost of funding technologies within a budget constrained health system has gained increasing support over recent years [6-9], in part because this basis is most consistent with cost-effectiveness analysis's objective of maximising health gain from finite health budgets. Under this interpretation, the threshold serves as a proxy for the opportunity cost of funding new interventions in terms of the health gain forgone due to the displacement of other health care services.

Increasing acceptance of opportunity cost as the rational basis for determining the threshold has been paralleled by recent empirical work to estimate the threshold from the cost-effectiveness of displaced services [10]. Similarly, there has been growing interest in the role of social values within economic analysis [11, 12]. These include a concern for equity, transparency, severity of illness, orphan conditions, wider social benefits, innovation and child health, among other considerations [12]. Recent work has shown that integrating equity considerations into economic analysis requires consideration of the threshold if methodological consistency is to be maintained [13, 14].

There is also a growing understanding of the threshold's numerous determinants, and why they are unlikely to remain constant over time. A number of authors have noted that changes in the health care budget over time have implications for the threshold, as does the adoption of new health technologies [8, 15-17]. However, the budget is not the only determinant of the threshold, and to our knowledge there has been no detailed consideration of the many ways in which these various determinants may change the threshold over time. The potential for change in the threshold over time has important implications for the determination of which technologies are cost-effective, since it must be considered when determining the appropriate discount rates and also when calculating the net health benefit or net monetary benefit associated with new technologies [18]

In light of these recent developments, there is a clear value in broadening understanding of the threshold, its determinants, and how these may change over time. The purpose of this paper is to present an accessible framework for understanding how the threshold is determined and how and why it might change. It builds on previous work by McCabe et al. that described a simple graphical model of the threshold in terms of the opportunity cost of health care forgone [8][9]. It expands on this previous work by adapting the graphical framework and sequentially explaining how changes in various determinants of the threshold may impact upon the threshold over time.

This paper is organised as follows. The methods section describes the simple graphical framework in which we represent the budget impact and cost-effectiveness of health care interventions and the budget constraint. This description includes an explanation of the framework's assumptions and shows how to identify the appropriate threshold. Next, the analysis section considers how the threshold might change with a number of important factors, including the health care budget, demand for services, changes to the costs and effects of existing technologies and the development of new technologies. The discussion section interprets these results and considers what alternative assumptions could be employed to make the analysis more representative of real world resource allocation.

Methods

The cost-effectiveness 'bookshelf'

The cost-effectiveness 'bookshelf' is a graphical representation of the health system in which each available health technology is represented as a unique 'book' on the bookshelf. This is simply a graphical representation of the model for determining the appropriate threshold, or "critical ratio", as initially described by Weinstein and Zeckhauser [19]. A broad definition of 'technology' is adopted for this purpose, which includes any health care intervention or service that consumes resources and provides value to the health system.

The width of each book represents each technology's budget impact if funded (i.e., the incremental cost of providing the technology to all patients in the relevant indication), while the height of each book represents each technology's incremental cost-effectiveness ratio (ICER). For the purpose of this paper, effectiveness is measured in quality-adjusted life years (QALYs), such that the height of each book represents the incremental cost per additional QALY provided by the technology. However, the insights in the paper are also applicable when other measures of effectiveness are used.

The books are stacked in order of cost-effectiveness such that the most cost-effective technologies (represented by the shortest books, as measured by the ICER on the vertical axis) are at the far left of the bookshelf (the horizontal axis of the figure) and the least cost-effective technologies (the tallest books) are at the far right (Figure 1). Since the health budget is constrained, not all technologies can be funded. It is assumed that the decision maker aims to maximizes the effectiveness of the health system by funding the technology at the far left of the bookshelf first (e.g., technology A in Figure 1) and then funding each technology to its right in turn (B, C, D, etc.) until the budget is exhausted [19]. The interventions lying to the left of the budget constraint are funded, while those to the right are not. The least cost-effective technology funded (G) is referred to as the 'marginal' technology. (In each figure in this paper, the funded technologies are shaded green while the remaining non-funded technologies are shaded red).

The cost-effectiveness threshold

We can use the cost-effectiveness bookshelf to identify the appropriate threshold. Since the budget is constrained, adopting a technology that is not currently funded (a candidate technology) will inevitably displace one or more currently funded technologies.

Candidate technologies with 'marginal' budget impact

We first consider the case where the budget impact of a candidate technology is small (i.e., 'marginal'). In this case, funding the candidate technology requires displacement of only one existing technology. Since the least desirable funded technology is the 'marginal technology' (G), this is the preferred technology to displace. Funding a candidate technology with marginal budget impact will increase the net QALYs provided by the health system (i.e., improve population health) only if its ICER is less than that of the marginal technology.

For example, suppose the ICER of the marginal technology is \$50,000 per QALY, and a candidate technology with marginal budget impact has an ICER of \$100,000 per QALY. If the candidate technology is funded then it will displace the marginal technology. For every \$100,000 spent on the candidate technology, one QALY is gained directly but two QALYs are forgone through the displacement of the marginal technology, for a net loss of one QALY. Now suppose the candidate technology has an ICER of \$25,000 per QALY. For every \$100,000 spent on the candidate technology, four QALYs are gained directly but two are forgone through displacement, for a net gain of two QALYs. It can be seen that a net gain in QALYs will arise only if the candidate technology has an ICER below that of the marginal technology.

It follows that the cost-effectiveness 'threshold' for appraising a candidate technology with marginal budget impact should be determined by the ICER of the marginal technology. The height of the book representing the marginal technology (G) provides a graphical representation of this threshold (Figure 2a).

Candidate technologies with 'non-marginal' budget impact

Alternatively, if the budget impact of a candidate technology is large (i.e., 'non-marginal'), then funding it requires displacement of more than one existing technology. To minimize the population health forgone, the first to be displaced is the marginal technology (G), the next to be displaced is the technology to its immediate left (F), and so on. The appropriate threshold is the ratio of the total incremental costs to the total incremental QALYs across all the displaced technologies.

For example, suppose the ICER of the marginal technology (G) is \$50,000 per QALY, while the ICER of the next least desirable technology (F) is \$40,000 per QALY. Further suppose that \$200,000 is currently spent on each of these technologies, and that the budget impact of the candidate technology is \$400,000, such that funding it would displace both these technologies but no others.

The appropriate threshold to apply to the non-marginal candidate intervention can be found by considering its opportunity cost. Since the ICER of technology G is \$50,000 per QALY, the \$200,000 of existing funding provides 4 QALYs. Meanwhile, the \$200,000 of funding for technology F provides 5 QALYs. If the candidate technology displaces both G and F, then a total of 9 QALYs will be forgone. The candidate technology will be cost-effective only if it provides at least 9 QALYs for its \$400,000 funding, which requires that it has an ICER less than \$400,000 / 9 QALYs = \$44,444 per QALY. This is the appropriate threshold to use. In Figure 2b this threshold is shown with a bold horizontal line, while the dashed horizontal lines show the ICERs for the two displaced technologies . appraising technologies with marginal budget impact.

Two things should be noted about the threshold for technologies with non-marginal budget impact:

1. First, this threshold is lower than the threshold for appraising new technologies with marginal budget impact. This is because funding new technologies with marginal budget impact displaces only the existing technology with the highest ICER, whereas funding new technologies with non-marginal budget impact displaces additional technologies with progressively lower ICERs. This leads to a key finding: the greater the budget impact of a new technology, the lower the threshold that should be used to appraise it [8].

2. Second, this threshold is a weighted average of the ICERs of the displaced technologies. These weights are determined in part by the amount currently spent on each displaced technology. However, even when equal amounts are spent on each technology, the weights placed on their ICERs are not identical (e.g., when $200,000 is spent on both F and G, the threshold is less than the midpoint of the ICERs of F and G). This is because displacement of a technology with a lower ICER results in a disproportionately greater amount of forgone health compared to displacement of a technology with a higher ICER, skewing the threshold downwards.

Assumptions adopted in this paper

Since the purpose of this paper is to provide a clear exposition of the determinants of the threshold, we will make a number of simplifying assumptions to improve tractability.

The appropriate threshold depends upon the objective adopted by the decision maker [9]. For the purpose of this paper, it will be assumed that the decision maker's objective is to maximise population health given the available health care budget, although our findings remain valid for many alternative specifications of this objective. Accordingly, decision makers only choose to adopt a candidate technology if it provides more QALYs than are forgone through the displacement of other technologies. We also assume that the decision maker is free to displace any intervention in order to fund a candidate intervention and will always chose to displace the least cost-effective intervention first. Furthermore, we assume that the health system is initially in a technically efficient state.

For the remainder of the paper, it will also be assumed that the new technology has marginal budget impact, so that the threshold is determined by the ICER of the marginal technology. We will assume that technologies are independent (such that the value of each technology does not depend upon funding for other technologies) and indivisible (such that technologies must be funded for all patients in the relevant indication or not at all).

In practice each of these assumptions may be violated, with implications for the determination of the appropriate threshold. A full discussion of these implications is beyond the scope of this paper.

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Results

There are a number of factors which impact upon the ICER of the marginal technology, and hence the appropriate threshold. In this section, we use the cost-effectiveness bookshelf to demonstrate how changes in each of these factors may cause the threshold to increase or decrease over time.

1. The health budget

An increase in the health budget allows for additional technologies to be funded. Since these technologies have higher ICERs than previously funded technologies, this causes a switch in the marginal technology to one with a higher ICER, resulting in an unambiguous increase in the threshold.

In Figure 3a, an increase in the budget allows for technologies H and I to be funded. Consequently, technology I now becomes the marginal technology, whereas previously the marginal technology was G. This results in an unambiguous increase in the threshold from the ICER of technology G to the ICER of technology I.

Conversely, a decrease in the health budget results in an unambiguous decrease in the threshold. In Figure 3b, a reduction in the budget causes technologies G and F to be displaced, resulting in a switch in the marginal technology from technology G to technology E and a fall in the threshold from the ICER of technology G to the ICER of technology E.

2. The demand for existing technologies

The demand for existing technologies may change over time. For example, demographic aging may lead to an aggregate increase in the demand for existing, funded treatments for age related conditions such as cancers and neurological conditions. A greater demand for existing, funded technologies will increase their budget impact and cause other funded technologies with higher ICERs – including, but not necessarily limited to, the marginal technology – to be displaced. Following this displacement, the marginal technology switches to another technology with a lower ICER, resulting in an unambiguous fall in the threshold.

For example, in Figure 4, an increase in demand for technology C increases its budget impact (as shown by a widening of the book representing technology C), resulting in technology G being displaced. The marginal technology switches from technology G to technology F, causing the threshold to fall from the ICER of technology G to that of technology F.

Conversely, an aggregate decrease in demand for existing technologies would reduce their budget impact and allow for additional technologies with higher ICERs to be funded, unambiguously increasing the threshold.

An important assumption here is that the overall budget impact of existing services is increasing due to the increase in demand. In reality, it is possible that demand for some services will increase while the demand for others will decrease, resulting in ambiguity in the overall net effect on the budget impact and therefore on the threshold.

3. The technical efficiency of existing technologies

The technical efficiencies of technologies may change over time for a number of reasons, including changes in their effectiveness or costs. Changes in effectiveness impact upon a technology's ICER but not its budget impact, whereas changes in cost will impact upon both the technology's ICER and its budget impact. These changes in a technology's ICER and/or budget impact may have implications for the threshold, depending upon whether the technology in question is the marginal technology, a non-marginal funded technology, or a technology that not currently funded.

Effectiveness of the marginal technology

A small increase in the effectiveness of marginal technology G lowers its ICER, resulting in a fall in the threshold to this new ICER (Figure 5a). However, a large increase in the effectiveness of marginal technology G, such that its ICER falls to below that of technology F, results in the marginal technology switching from technology G to technology F and the threshold falling to reflect the ICER of technology F (Figure 5b). An improvement in the effectiveness of the marginal technology, large or small, therefore causes an unambiguous reduction in the threshold, with the ICER of technology F representing the lowest point to which the threshold may fall. Conversely, a reduction in the effectiveness of marginal technology G would increase its ICER and hence unambiguously increase the threshold, with the highest resulting threshold representing the ICER of technology H. Accordingly, changes to the effectiveness of the marginal intervention result in changes in threshold bounded by the ICERs of its neighbouring technologies on the bookshelf.

Effectiveness of funded non-marginal technologies

An improvement in the effectiveness of a non-marginal intervention will reduce its ICER and may result in a change in its rank order within the bookshelf, but this will not affect the threshold. Similarly, a small reduction in the effectiveness of a non-marginal intervention will increase its ICER and may change its rank order on the bookshelf, but this will not affect the threshold as long as the new higher ICER is lower than that of the marginal technology.

A large reduction in the effectiveness of a funded non-marginal technology however, such that it now has the highest ICER of all funded technologies, will affect the threshold. For example, if the ICER of technology E increases such that it exceeds that of technology G but is less than technology H, then it will become the new marginal intervention and its ICER will define the threshold. Alternatively, if the reduction in the effectiveness of technology E is so large that its ICER exceeds that of technology H (Figure 5c), then technology E is displaced, technology H is funded and designated the marginal technology, and the threshold increases to match the ICER of technology H. In either case, the result is an unambiguous increase in the threshold, bounded between the ICERs of technologies G and H.

Effectiveness of non-funded technologies

A decrease in the effectiveness of a non-funded technology has no implications for the threshold, since the marginal technology would not change. Similarly, any increase in the effectiveness of a non-funded technology that is too small to reduce the ICER to below that of marginal technology G will also have no effect on the threshold. Conversely, a large increase in the effectiveness of a technology that is not currently funded, such that it now has a lower ICER than marginal technology G, would result in displacement of the marginal technology in order to fund the technology in question. Since this technology has a lower ICER than technology G, this would result in an unambiguous reduction in the threshold. This fall in the threshold is bounded by the ICER of technology F.

Cost of the marginal technology

A decrease in the cost of marginal technology G has the combined effect of both lowering its ICER and reducing its budget impact. The implications of such changes for the threshold are ambiguous.

If the cost decrease is small, then technology G remains the marginal technology and the fall in its ICER results in a decrease in the threshold, with the lowest possible resulting threshold reflecting the ICER of technology F (Figure 5d). However, where the cost decrease is large, the reduction in the budget impact of technology G may be sufficient to allow technology H to be funded (Figure 5e). Although the ICER of technology G falls, the switch in the marginal technology from technology G to technology H results in an *increase* in the threshold. Accordingly, the effect on the threshold of a decrease in the cost of the marginal technology is ambiguous and depends upon whether the resulting change in its budget impact is sufficient to allow an additional technology to be funded.

An increase in the cost of marginal technology G will cause its budget impact to increase, requiring that a technology be displaced. Depending on the budget impact and ICERs of technologies F, G and H, the optimal strategy is to either (a) displace the marginal technology G, in which case the most efficient use of the released resources is to fund technology H, increasing the threshold; or (b) displace technology F, allowing technology G to still be funded, also increasing the threshold due to its higher ICER. In either case the threshold increases to somewhere between the current ICERs of technologies G and H.

Cost of funded non-marginal technologies

A reduction in the cost of a funded non-marginal technology reduces its budget impact, resulting in changes akin to an increase in the budget. If the reduction in budget impact is sufficient to allow an additional technology to be funded then the threshold will unambiguously increase, otherwise there will be no implications for the threshold.

An increase in the cost of a funded non-marginal technology increases its budget impact. If the cost increase is small, such that the technology's ICER remains lower than that of the marginal technology, then the marginal technology will be displaced and another technology with a lower ICER will be designated the new marginal technology, causing an unambiguous fall in the threshold.

Alternatively, the cost increase may be sufficiently large for the technology to now have the highest ICER of all funded technologies, and hence be designated as the marginal technology. Since the technology's budget impact has increased, continuing to fund the technology would require that another technology be displaced; however, since the technology is now the marginal technology, the decision maker's objective may be better satisfied by displacing this technology and using the released resources to fund technology H. Since technology H would now be the marginal technology, the threshold would increase. The change in the threshold is therefore ambiguous, as it depends upon whether the resulting change in the ICER is sufficient for the technology to now be designated as the marginal technology. In either case, the new threshold is bounded between the ICERs of interventions G and H.

Cost of non-funded technologies

A reduction in the cost of a non-funded technology that is sufficiently large for its ICER to fall below that of the marginal technology will have a similar impact to an increase in its effectiveness – the decision maker will displace the marginal technology, fund the technology in question, and the threshold will unambiguously fall. A smaller reduction, or an increase, in the cost of a non-funded technology will have no implications for the threshold, as the marginal technology would not change.

4. Funding for newly available technologies

New technologies may become available over time. Within a technically efficient health system, a new technology will be funded only if its ICER is less than the prevailing threshold. The impact on the threshold of funding a new technology depends upon whether or not it is a substitute for an existing funded intervention.

If the new technology is not a substitute, then funding it will displace the existing marginal technology. Following this displacement, the marginal technology will switch to another technology with a lower ICER, resulting in an unambiguous decrease in the threshold. For example, funding new technology N with an ICER below the threshold displaces marginal technology G. If the ICER of new technology N is above the ICER of technology F then new technology N becomes the marginal technology and its ICER determines the threshold. Alternatively, if the ICER of new technology N is below that of technology F, then technology F becomes the marginal technology and its ICER determines the threshold (Figure 6). In either case, the threshold falls but no lower than the ICER of technology F.

If the new technology is a substitute for an existing technology, then the impact on the threshold is ambiguous. The impact depends upon whether the intervention replaces the marginal or non-marginal interventions in the currently funded set of interventions and whether the net budget impact of the replacement is positive, negative or neutral.

If the new technology replaces an existing intervention with equal budget impact, this will not influence the threshold unless it becomes the marginal intervention, in which case it will lower the threshold. The new lower threshold will be bounded between the ICERs of G and F.

If the new technology has a lower budget impact than the technology it replaces then this *may* allow another (previously unfunded) technology with a higher ICER into the funded set. If another technology cannot also be funded then, if the replaced technology is the marginal technology, the threshold will fall to the ICER of the new technology, which is bounded between the ICERs of G and F in this case. If the new technology is not the marginal technology, then technology F becomes the marginal technology and the threshold falls to its ICER. If another technology *can* also be funded then the threshold will rise to the ICER of the previously unfunded technology.

Conversely, if the new technology has a greater budget impact then it will both replace the existing intervention and displace another funded technology. If the replaced intervention is the marginal technology then the neighbouring funded technology on the bookshelf (technology F) must be displaced. Since the new technology has a lower ICER than the previous marginal technology, the threshold will fall to either the ICER of the new technology or the ICER of the *next* funded technology along the bookshelf (technology E), whichever is higher. If the replaced technology is *not* the marginal technology then the increased budget impact will displace the marginal technology, lowering the threshold to the ICER of technology F.

Discussion

Health policy makers and analysts typically assume that the cost effectiveness threshold is known and fixed over time. The cost-effectiveness 'bookshelf' provides a simple model for demonstrating how the threshold ought to be determined within a budget constrained health system and the many factors that determine how this threshold might change over time.

The potential for change in the threshold has important implications for economic evaluations of new technologies. Generally, the costs and effects of health technologies are spread over time. An understanding of how the threshold is expected to change over time is necessary to determine how future costs and effects should be discounted and also the net health benefit or net monetary benefit associated with technologies in future years – it is therefore critical for understanding whether a technology is cost-effective [18, 20].

The bookshelf model provides a number of insights. The first is that changes in some of the determinants of the threshold will necessarily result in changes in the threshold in some cases, but will not in others. The second is that whilst some changes in the determinants of the threshold result in unambiguous changes in the threshold, for others the consequences can be ambiguous. For example, an increase in the health budget or a reduction in the demand for funded health services will both unambiguously lead to an increase in the threshold. However, a reduction in the cost of funded health services may have an ambiguous effect on the threshold. A summary of the various insights from this model is provided in Table 1.

The magnitude of any threshold changes will, of course, depend on the magnitude of the changes in the underlying causal factors, such as the extent of budget expansion, demand growth, medical inflation and the pace of innovation. The rate of change of the threshold will also depend on how much the ICERs vary between interventions; i.e. how much taller the books become as we move along the bookshelf. If the ICERs of interventions increase rapidly along the bookshelf, then the impact on the threshold associated with any given change in one of the determinants may be greater. The relative sizes of the ICERs of currently unfunded interventions will depend in part on the suppliers' pricing decisions, which in turn may depend on the level of competition for positive reimbursement decisions.

The combined effect of the multiple countervailing effects on the threshold mean it is not possible to draw definitive conclusions as to how the threshold will change in practice. It is clear, however, that understanding both the direction and magnitude of changes to the threshold over time requires empirical analysis. However, analysts and decision makers need to understand the dynamic and uncertain nature of the cost effectiveness threshold that lies at the heart of many health care resource allocation processes.

Assumptions and limitations

The bookshelf analogy presented in this paper adopts a number of strong assumptions. All technologies are assumed to be independent, indivisible and exhibit constant returns to scale. Decision makers are assumed to have perfect information and freedom to disinvest and reallocate resources according to their objectives. While the framework presented here can be used to illustrate the effect of relaxing these assumptions, that is beyond the scope of this paper.

Technical inefficiency

A further important assumption made here is that of technical efficiency in the existing distribution of funded and unfunded interventions. In other words, that the books are stacked in the correct order between and within the funded and unfunded parts of the bookcase. If decision makers face imperfect information, do not consistently make decisions in line with their objective, or if they face historical inefficiencies in the allocation of resources within the health system, then the assumption that the health system is technically efficient cannot be sustained.

In the case of an initially inefficient allocation, the books may not initially be in the optimal order. Although extending the bookshelf analogy to address inefficient initial allocations is beyond the scope of this paper, Eckermann and Pekarsky provide a further exploration of the consequences of such inefficiencies for determining the threshold [6].

Another assumption made by the simple model used here is that decision makers displace currently funded services optimally. In reality, the services displaced may not be that at the margin of the funded set [10]. In such a case, the threshold may be informed by the ICERs of those interventions actually displaced to fund new interventions.

It should be noted that, even if the initial allocation is inefficient, provided that technologies are ranked on the bookshelf in a manner that is 'better than random' (i.e. with shorter books *tending* to be placed towards the left, and taller books *tending* to be placed towards the right), it follows that our findings may be *expected* to hold, albeit under conditions of uncertainty. For example, an increase in the budget is *likely* to increase the threshold, while a decrease in the budget is *likely* to reduce the threshold. While real world health systems are unlikely to allocate resources with complete technical efficient, they are also arguably unlikely to allocate resources in a manner that is entirely random (or worse). Therefore, while the precise findings in this paper do not necessarily apply in the case of a technically inefficient health system, the insights may usefully guide decision makers considerations in the presence of inefficiency.

Conclusion

The simple bookshelf model shows how the threshold can be expected to vary with a number of determining factors. Although in some cases the consequent direction of change in the threshold can be predicted, in other cases it is ambiguous. Moreover, the countervailing nature of many of the factors means that the direction of change in the threshold is likely to be uncertain in practice. This highlights the importance of empirical analysis in determining the threshold and any expected change in it. It also emphasises the need to consider uncertainty in the threshold and how this uncertainty may change over the time horizon of an economic evaluation.

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Table 1: Implications of changes in each determinant of the threshold

Determinant	Change in determinant	Change in threshold (marginal technology, if known)
The health budget	↑ Increase	↑ Increase to ICER of new marginal technology
	↓ Decrease	↓ Decrease to ICER of new marginal technology
The demand for existing technologies	↑ Increase	↓ Decrease to ICER of new marginal technology
	↓ Decrease	↑ Increase to ICER of new marginal technology
The technical efficiency of existing technologies *		
Effectiveness of the marginal technology (G)	↑ Small increase	↓ Decrease to ICER of marginal technology (G)
	↑ Large increase	↓ Decrease to ICER of marginal technology (F)
	↓ Small decrease	↑ Increase to ICER of marginal technology (G)
	↓ Large decrease	↑ Increase to ICER of marginal technology (H)
Effectiveness of funded non-marginal technologies (A-F)	↑ Small increase	↔ No impact
	↑ Large increase	
	↓ Small decrease	
	↓ Large decrease	↑ Increase to ICER of marginal technology
Effectiveness of non-funded technologies (H-L)	↑ Small increase	↔ No impact
	↑ Large increase	↓ Decrease to ICER of marginal technology
	↓ Small decrease	↔ No impact
	↓ Large decrease	
Cost of the marginal technology (G)	↑ Small increase	↑ Increase to ICER of marginal technology (G or H)
	↑ Large increase	
	↓ Small decrease	↓ Decrease to ICER of marginal technology (F or G)
	↓ Large decrease	↑ Increase to ICER of marginal technology (H)
Cost of funded non-marginal technologies (A-F)	↑ Small increase	↓ Decrease to ICER of marginal technology (F)
	↑ Large increase	↑ Increase to ICER of marginal technology
	↓ Small decrease	↔ No impact
	↓ Large decrease	↑ Increase to ICER of marginal technology (H)
Cost of non-funded technologies (H-L)	↑ Small increase	↔ No impact
	↑ Large increase	
	↓ Small decrease	
	↓ Large decrease	↓ Decrease to ICER of marginal technology
Funding for newly available technologies **		
<u>Not</u> a substitute for any existing technology	N/A	↓ Decrease to ICER of marginal technology
Substitute for the marginal technology (G)	Equal budget impact	↓ Decrease to ICER of marginal technology*
	Smaller budget impact	? Increase/decrease to ICER of marginal technology
	Larger budget impact	↓ Decrease to ICER of marginal technology*
Substitute for a non-marginal technology (A-F)	Equal budget impact	↔ No impact
	Smaller budget impact	? No impact/increase to ICER of marginal technology
	Larger budget impact	↓ Decrease to ICER of marginal technology

* "Small" increase/decrease refers to a change in the determinant that is insufficient to change the ICER of the technology in question such that it becomes greater than or smaller than the ICER of neighbouring interventions.
** "Budget impact" refers to the net budget impact of the candidate technology relative to the existing, funded technology for which it is a substitute.

Figure Legends

Figure 1: The cost-effectiveness ‘bookshelf’

Figure 2a: The threshold for appraising candidate technologies with ‘marginal’ budget impact

Figure 2b: The threshold for appraising candidate technologies with ‘non-marginal’ budget impact

Figure 3a: An increase in the health budget unambiguously increases the threshold

Figure 3b: A decrease in the health budget unambiguously decreases the threshold

Figure 4: An increase in demand for a funded non-marginal technology decreases the threshold

Figure 5a: A small increase in the effectiveness of the marginal technology reduces its ICER and lowers the threshold to this ICER

Figure 5b: A large increase in the effectiveness of the marginal technology reduces its ICER, results in a switch in the marginal technology, and lowers the threshold to the ICER of the new marginal technology

Figure 5c: A very large decrease in the effectiveness of a funded non-marginal technology increases its ICER to above that of technology H, resulting in a switch in the marginal technology and an increase in the threshold

Figure 5d: A decrease in the cost of the marginal technology reduces both its ICER and its budget impact. If the reduction in budget impact is insufficient to fund a new technology then the threshold will fall

Figure 5e: A decrease in the cost of the marginal technology reduces both its ICER and its budget impact. If the reduction in budget impact is large enough to fund a new technology then the marginal technology will switch and the threshold will increase

Figure 6: Funding a new technology with an ICER below the threshold reduces the threshold, with the lowest possible resulting threshold representing the ICER of technology F

Figures

Figure 1: The cost-effectiveness 'bookshelf'

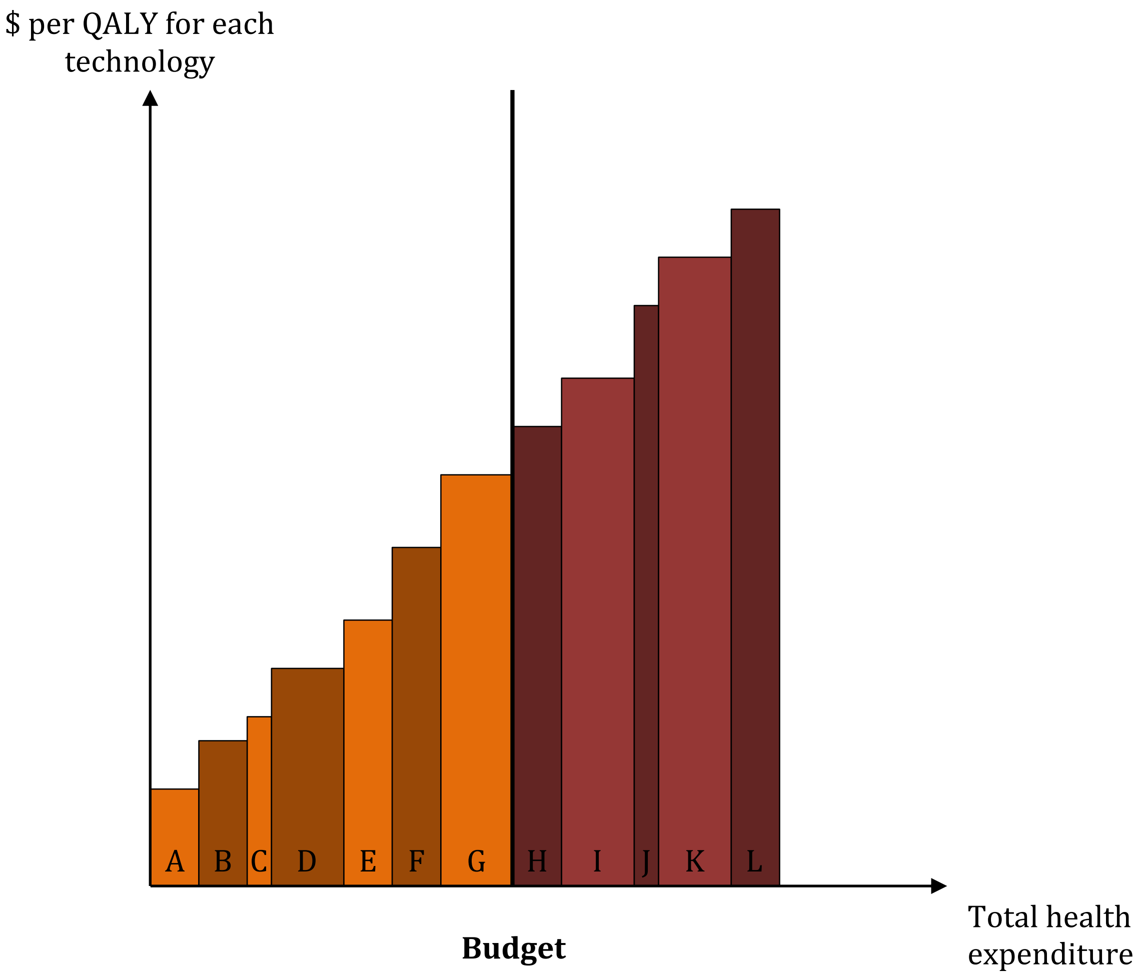

Figure 2a: The threshold for appraising candidate technologies with 'marginal' budget impact

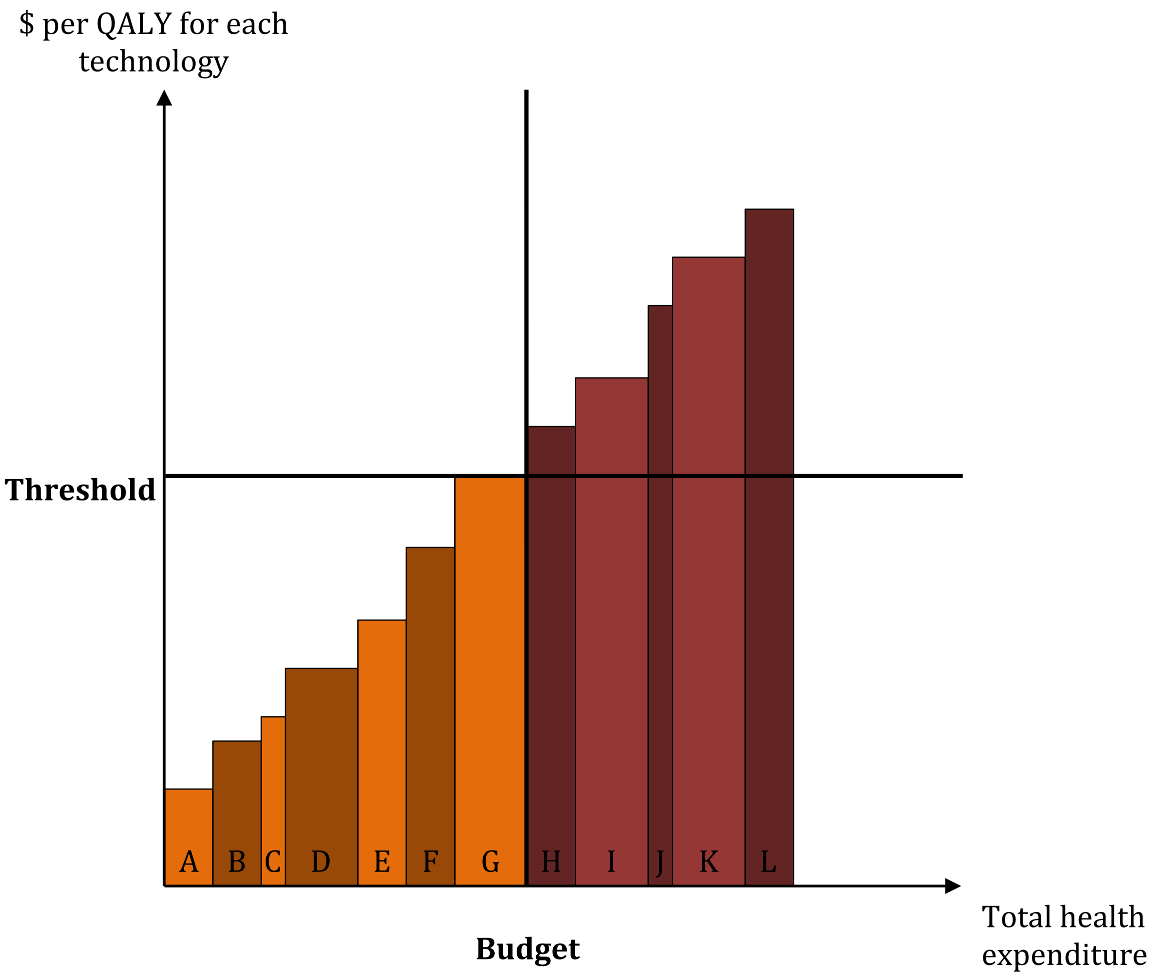

Figure 2b: The threshold for appraising candidate technologies with 'non-marginal' budget impact

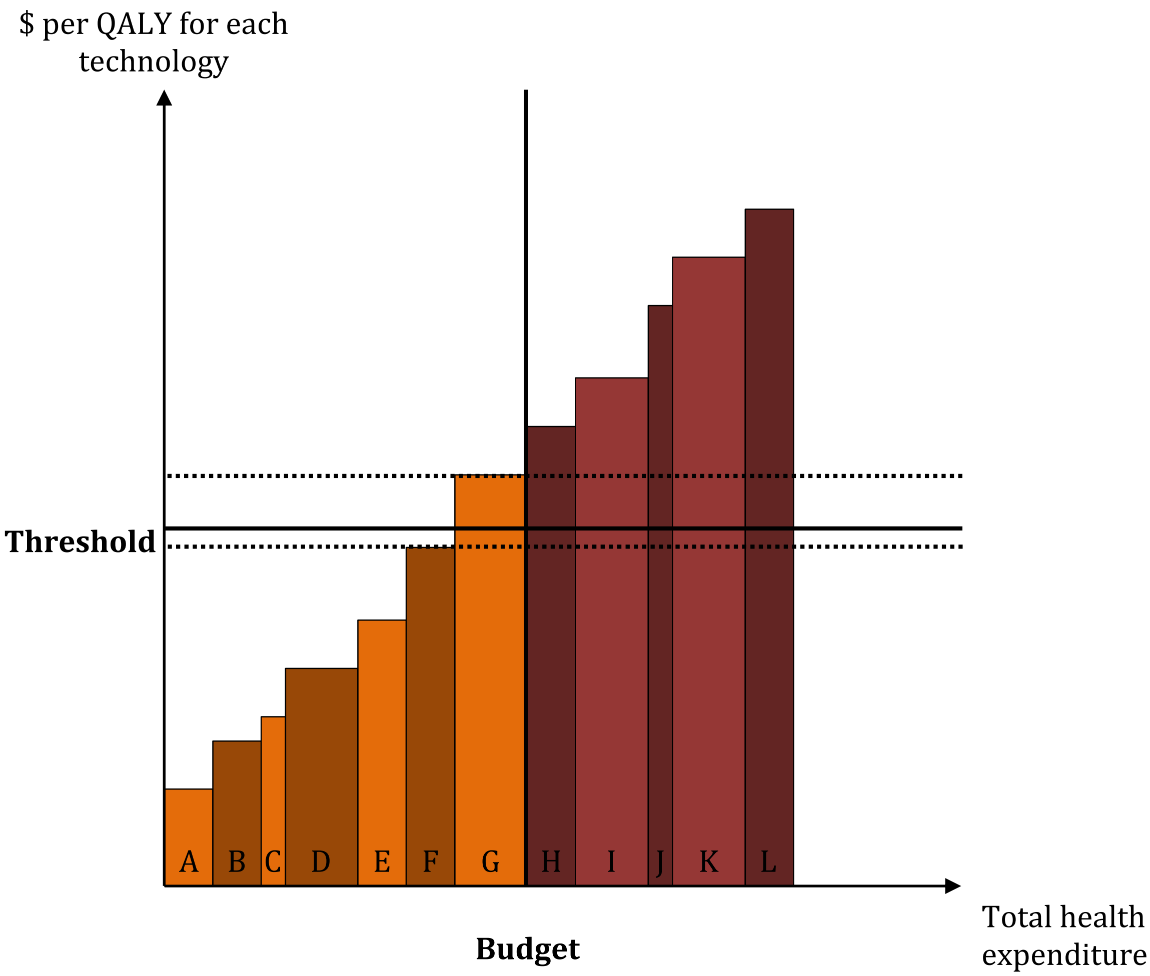

Figure 3a: An increase in the health budget unambiguously increases the threshold

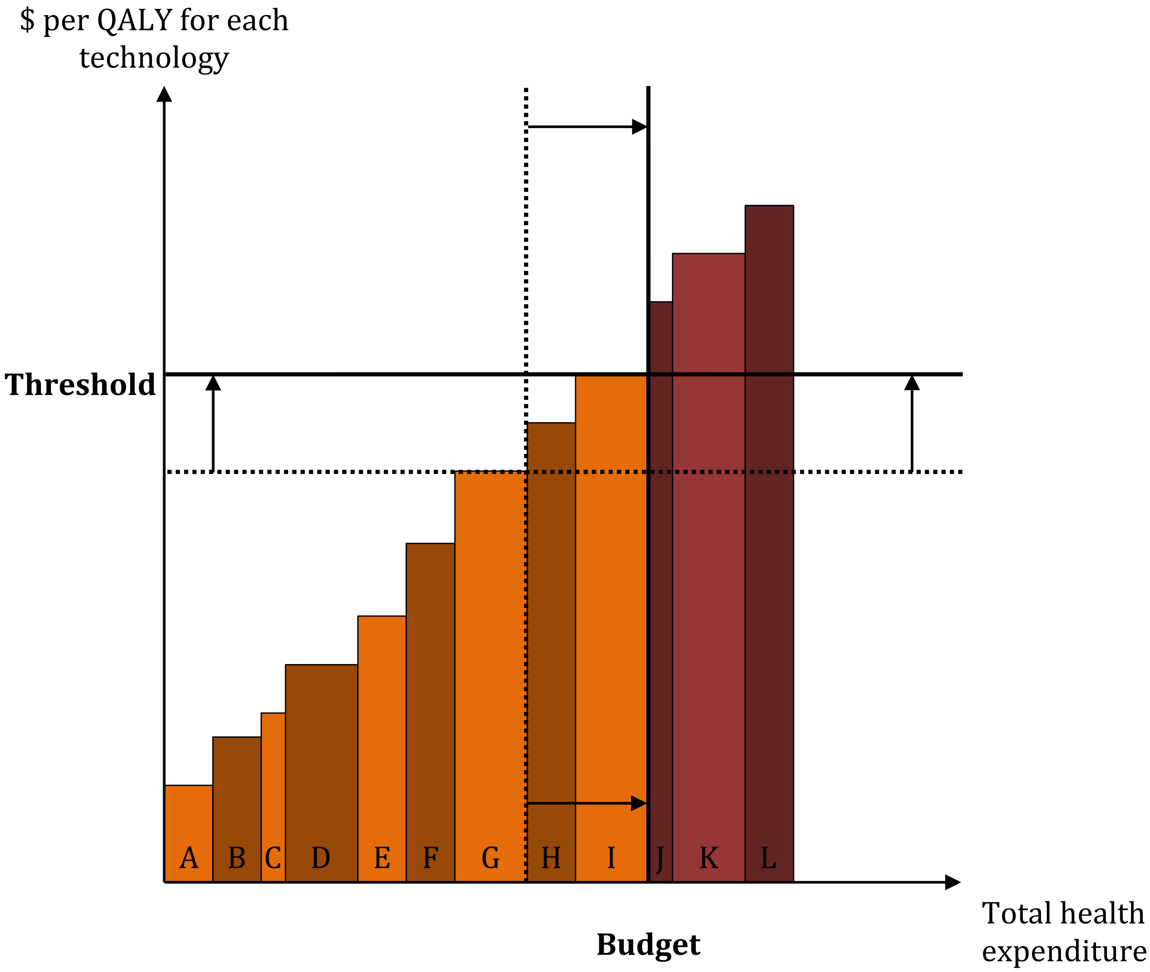

Figure 3b: A decrease in the health budget unambiguously decreases the threshold

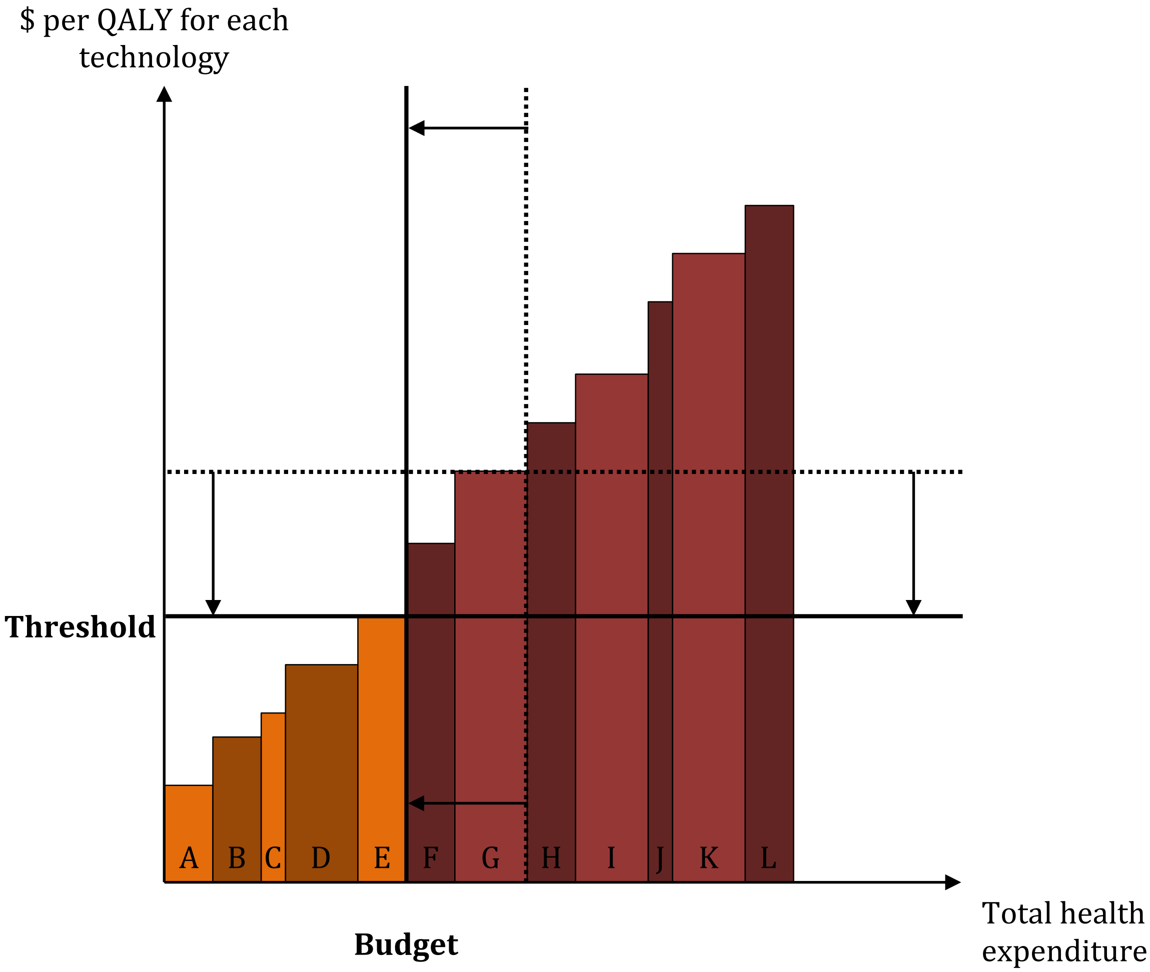

Figure 4: An increase in demand for a funded non-marginal technology decreases the threshold

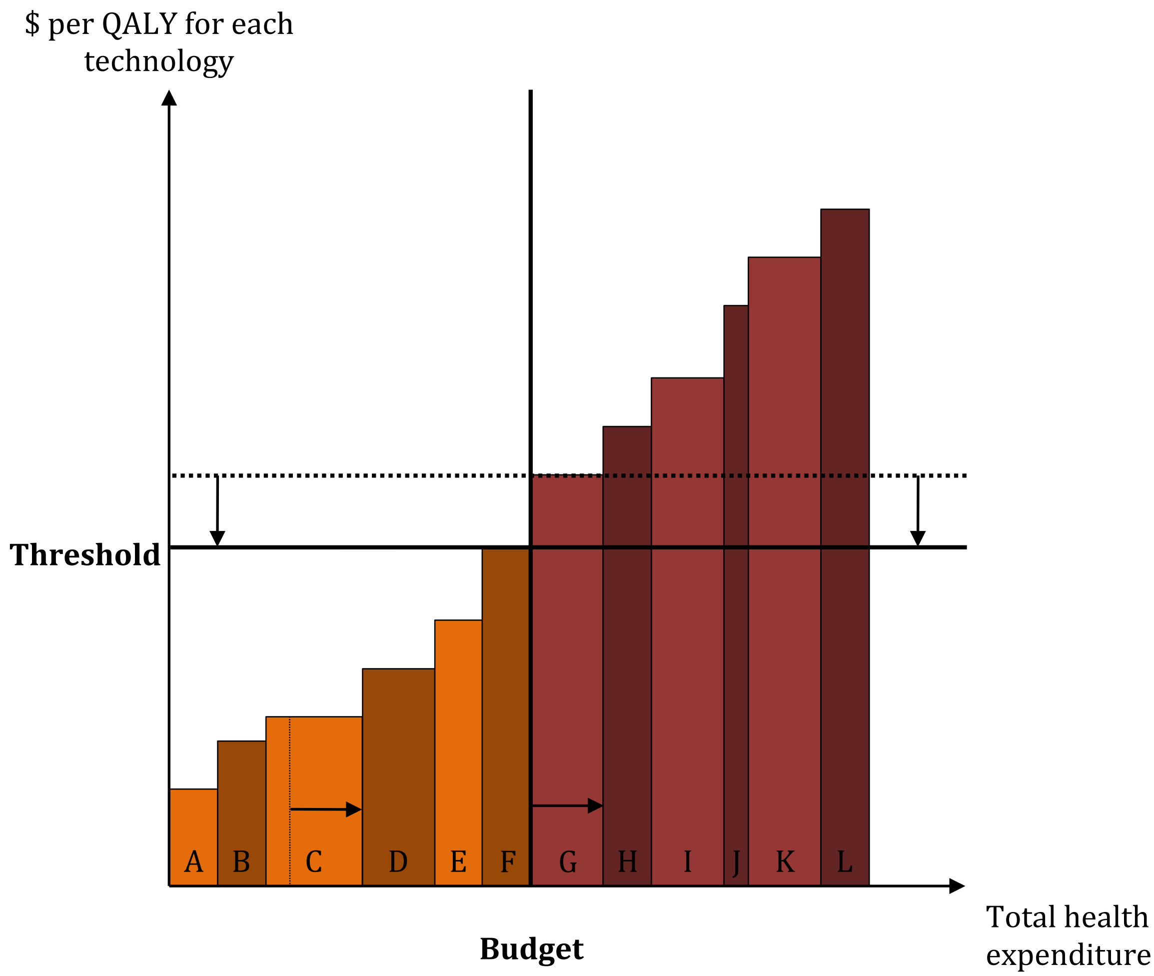

Figure 5a: A small increase in the effectiveness of the marginal technology reduces its ICER and lowers the threshold to this ICER

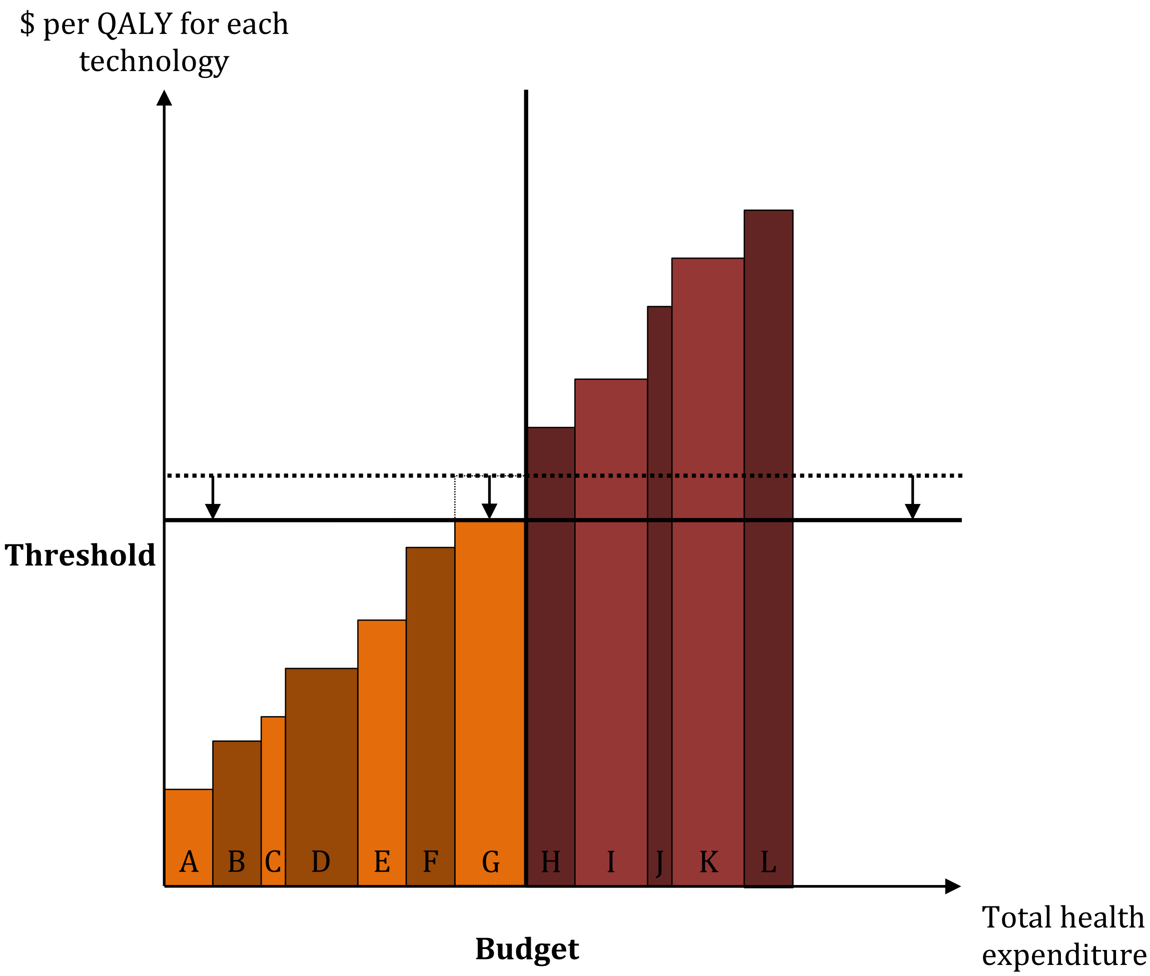

Figure 5b: A large increase in the effectiveness of the marginal technology reduces its ICER, results in a switch in the marginal technology, and lowers the threshold to the ICER of the new marginal technology

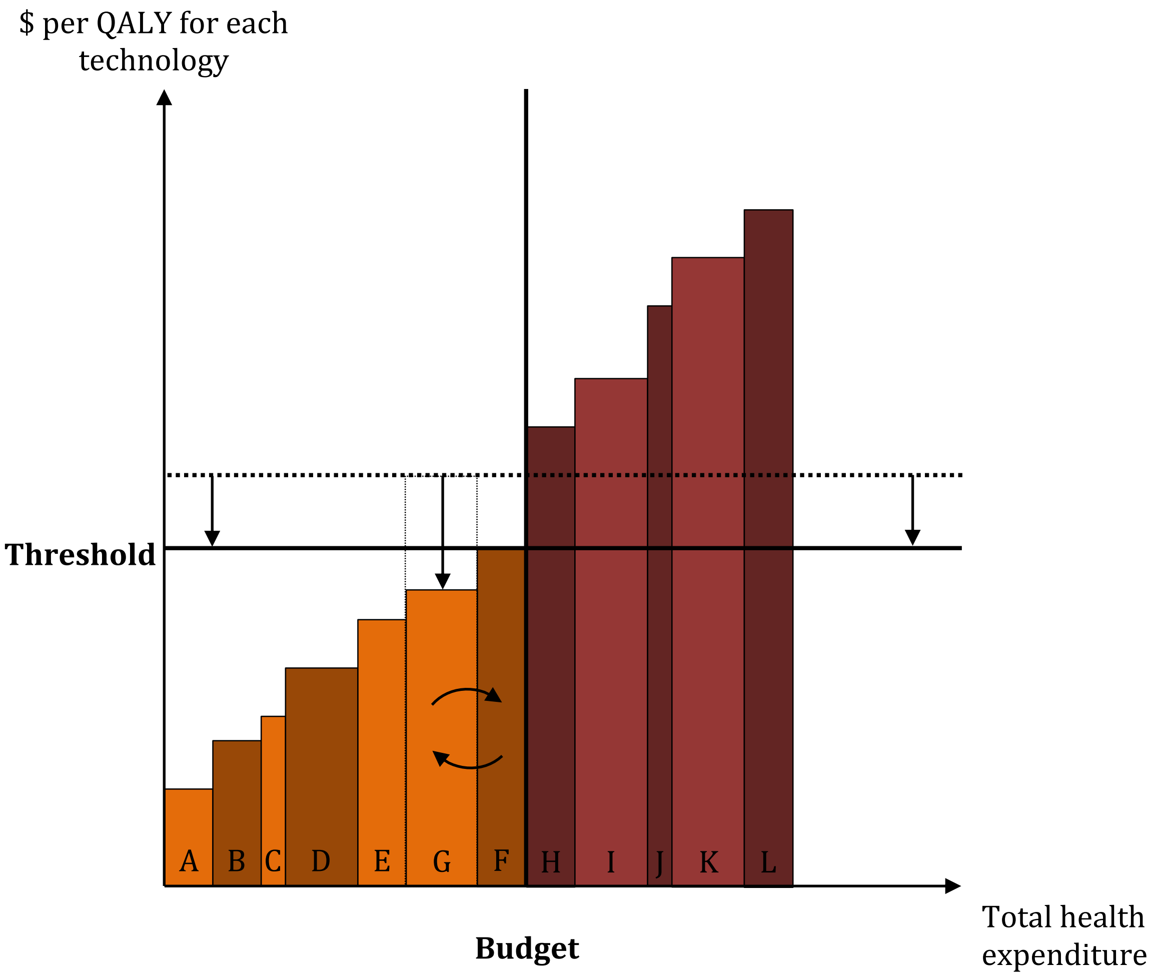

Figure 5c: A very large decrease in the effectiveness of a funded non-marginal technology increases its ICER to above that of technology H, resulting in a switch in the marginal technology and an increase in the threshold

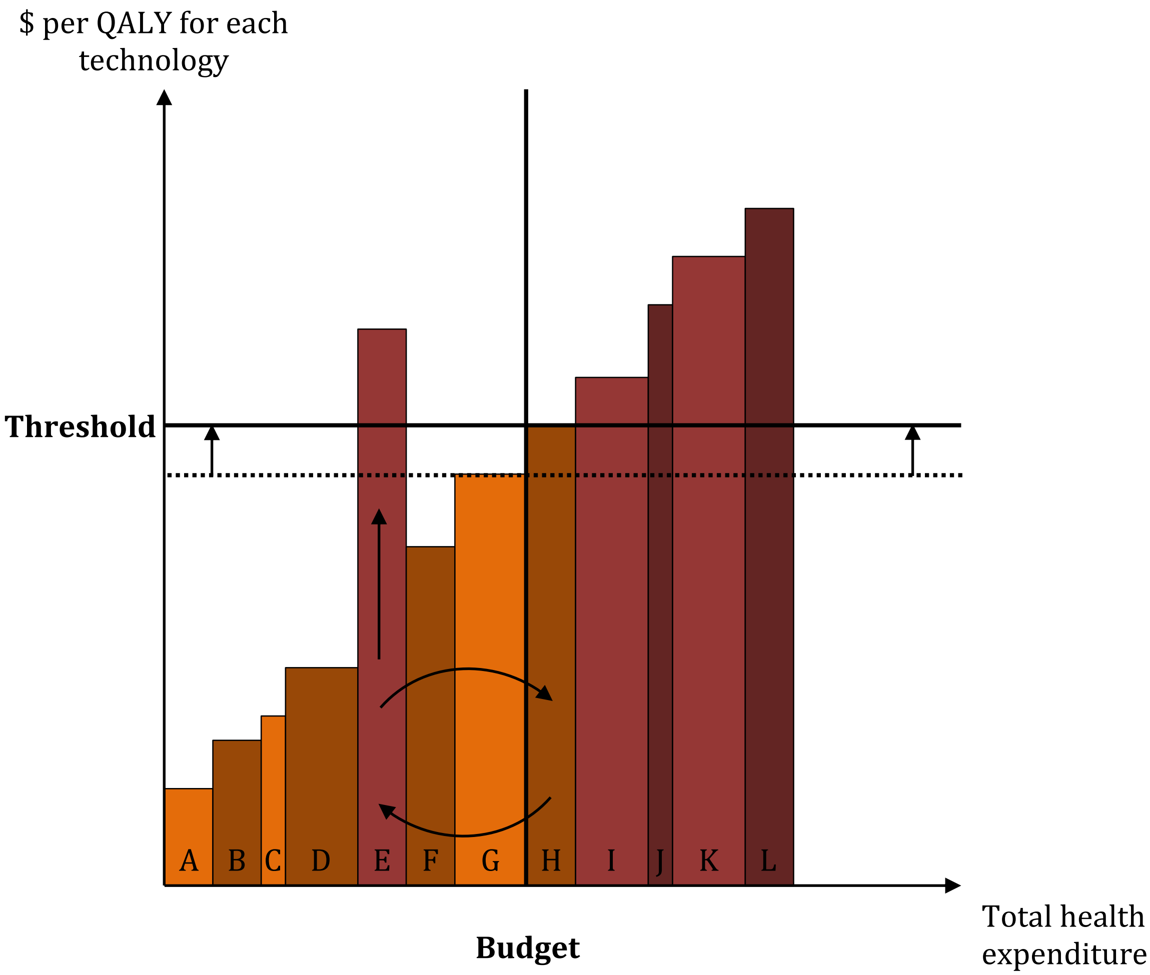

Figure 5d: A decrease in the cost of the marginal technology reduces both its ICER and its budget impact. If the reduction in budget impact is insufficient to fund a new technology then the threshold will fall

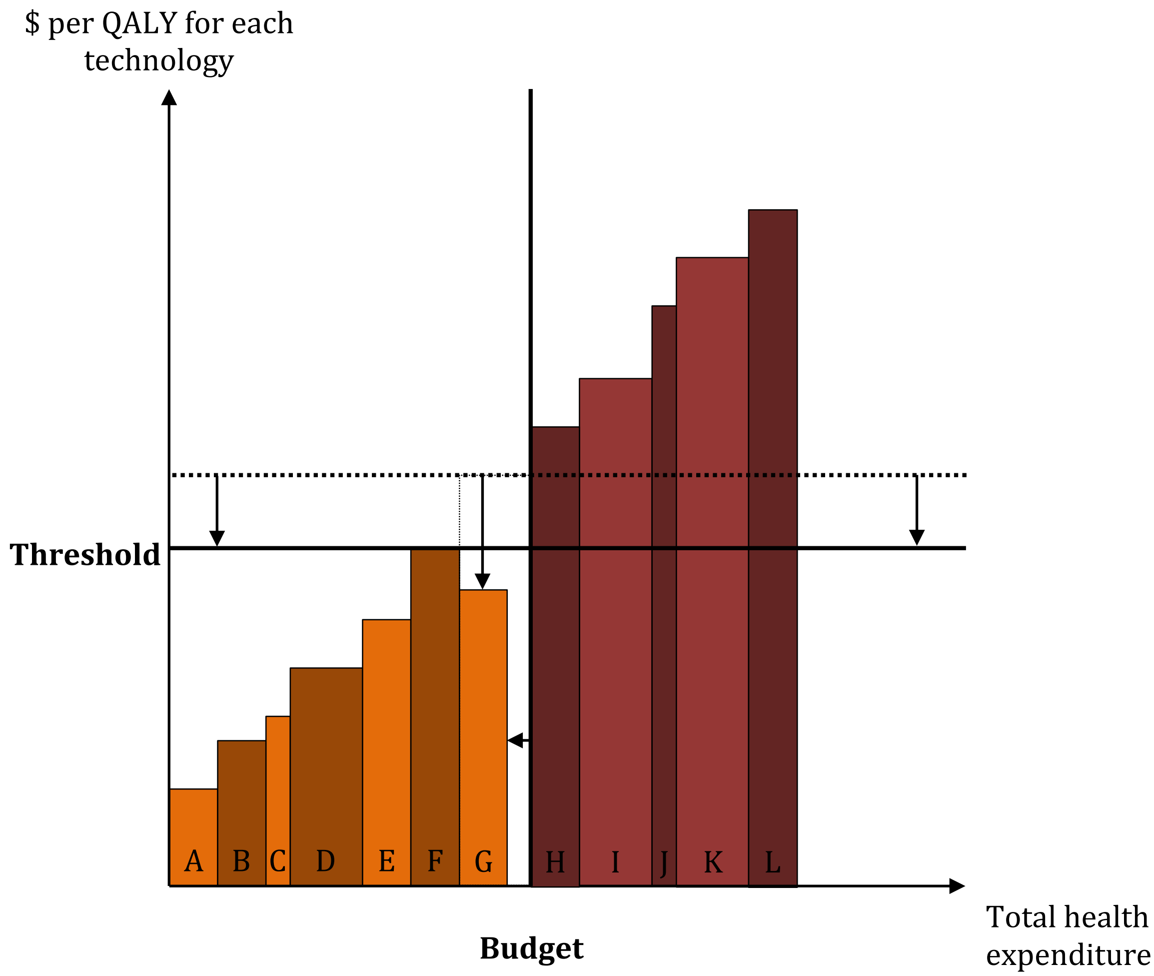

Figure 5e: A decrease in the cost of the marginal technology reduces both its ICER and its budget impact. If the reduction in budget impact is large enough to fund a new technology then the marginal technology will switch and the threshold will increase

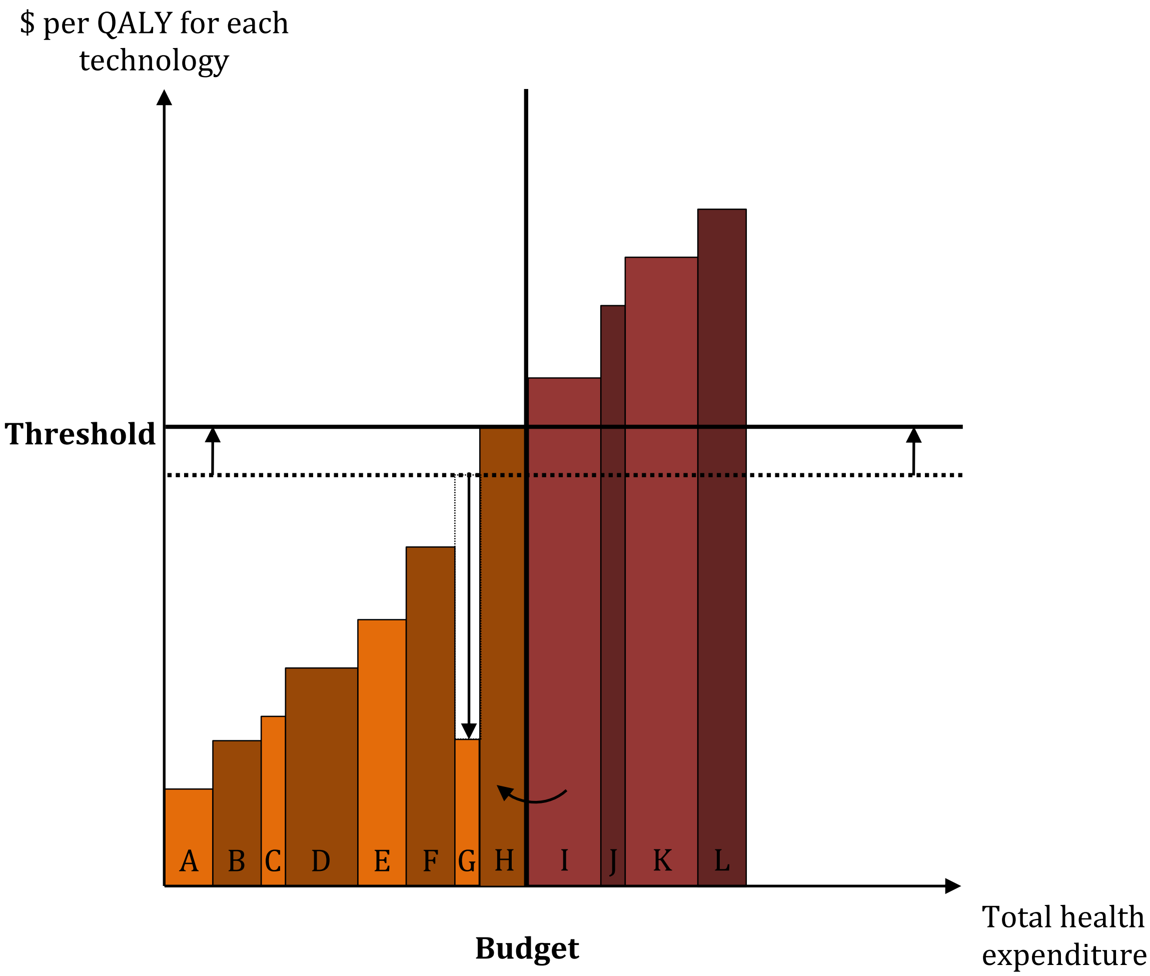

Figure 6: Funding a new technology with an ICER below the threshold reduces the threshold, with the lowest possible resulting threshold representing the ICER of technology F