**Real Option Value and Path Dependence in Oncology Innovation**

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**Abstract**

New oncology drug innovation relies on cumulative, path-dependent, incremental research and development (R&D). Yet few have studied how path-dependence impacts the decisions of oncology pharmaceutical producers, consumers, and insurers/payers. This study illustrates how real options can be used to value the effects of path-dependence, that is, the additional value that incremental innovation adds when that innovation is an intermediate step to a major innovation or cure. We show how rational pharmaceutical producers and consumers recognize the additional real option value. However, many payers, particularly European government payers, use Comparative Effectiveness Research (CER), which ignores this option value. Many expect the U.S. government to follow Europe and use CER in the future given that the American Recovery and Reinvestment Act of 2009 authorizes $1.1 billion to study CER. Because CER ignores real option value, widespread use of CER is likely to reduce oncology R&D, particularly for intermediate innovations that are more likely to lead to breakthrough innovations, but that cost relatively more to develop than me-too drugs. When firms and consumers agree that a particular drug has option value but payers who set the terms of exchange do not, the resulting mix of R&D spending will be suboptimal from a social economic welfare perspective.

**Introduction**

New oncology drug innovation relies on cumulative, path-dependent, incremental research and development (R&D), as is the case in many other therapeutic classes of drugs. However, the mortality rate in oncology is particularly high, which we show can add substantial value to non-cure incremental innovations. To date, many national payers, policy-makers, insurers, and firms have not considered or recognized a very significant economic value to incremental innovations in cancer therapy: an option to extend the innovation technology to a cure (or another incremental innovation).

Some pharmaceutical firms may rationally ignore option value if they cannot capture enough of it to cover their substantial R&D costs, creating a market failure. This happens when they think that their patents on the incremental drug won’t last long enough to protect their development of a follow on cure. In addition, firms could undervalue the option if they face particularly high costs to develop the cure, but expect limited pricing flexibility from payers. From a welfare economics perspective, ignoring the option value leads to reduced R&D incentives, inefficiently low R&D, and a loss in economic/social value.

A simple diagram and example will illustrate how misaligned R&D incentives and path dependence lead to inefficiency.

**Figure 1: Path Dependence for the Discovery of Cancer Drug A**

**PATH 1:** Drug A ­­ ----------🡪 Drug B ---------🡪 Drug C

**PATH 2:** Drug A -------------------------------------------------------------------🡪 Drug C

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0 Years 5 Years 10 Years

Figure 1 considers two hypothetical paths to a cure, during which, the stock of information and research findings grows at different rates until a cure is discovered for a particular type of cancer. In Path 1, research and development of innovative Drug B provides a bridge to a more expeditious discovery and development of a cure, Drug C. Here for simplicity we assume that Drug B is the only intermediate drug but we could have included more steps in the path. The important point is that Path 1 with an intermediate drug gets us to a cure quicker.

In the absence of the development of Drug B, the stock of clinical and scientific knowledge grows slower than it otherwise would, and if incremental drug discovery and development is proportional to the existing knowledge stock, successful discovery and development of a cure will take longer. The hypothetical example in Figure 1 shows that Path 2 takes 10 years to discover Drug C from the advent of Drug A, instead of 5 years if appropriate economic incentives were in place to lead to the development and marketing of Drug B. Of course, the delay in Path 2 could be longer, especially if the technology behind Drug C is more complex and expensive to develop.

We show below that the social economic value of discovering and developing Drug B could be very significant, even if its efficacy does not represent a very significant improvement over Drug A. The total value is not just the additional profits earned by the developer of Drug B and the immediate benefits to the consumer. The value should also include the value of the chance that the consumer of Drug B will survive to consume a cure. That is, Drug B not only extends the patient’s life, but provides an option to consume Drug C.

The value of incremental oncology drugs could be substantial. For example, Murphy and Topel (2004) estimate that a 10% reduction in mortality due to medical and pharmaceutical innovation would be worth $5 trillion in real U.S. GDP, almost half of total real GDP. Lichtenberg (2010) finds that between 1996 and 2006, only seven percent of the decline in cancer mortality was due to a decline in cancer incidence, while about twenty five percent was due to drug innovation. According to CMR International (2010), cancer R&D in 2009 represented 17.9 percent of total global pharmaceutical R&D, more than any other therapeutic group. Firms must be allocating the most R&D investment to cancer for a reason, i.e., at least some markets recognize the large potential value of cancer cures. What we plan to do below is illustrate the impact of this additional value using a real options approach.

We also explain how to use real options to improve pharmaceutical technology assessment. We are not aware of any government technology assessment methods that recognize this option value. They may ignore it partly because option value relies on a yet undiscovered cure. Some pharmaceutical firms recognize the option value but some do not. The value of the option to the firm will depend upon whether its incremental innovation is covered by a patent when the cure is discovered, and whether it will be allowed by large government purchasers to charge the proper (perhaps high) price for the cure.

A precedent for correcting this type of quasi-market failure does exist: namely, the designation of some drugs as Orphan Drugs (drugs with small treatment populations). The enactment of the Orphan Drug Act provided additional years of patent protection, giving incentives to firms to spend more to develop highly innovative drugs that offer limited profit potential because of small market size. Longer patents imply greater option values.

Under proper conditions, both producers and consumers should recognize option value. The consumer of Drug B should be willing to pay more for it than just his valuation of the years of life during which he takes Drug B. Clearly, a patient should place less value on a dead-end drug, that is, one that offers no chance of living to eventually consume a cure.

On the producer side, all else equal, firms should value more highly and invest more R&D dollars in, a drug whose technology could be an incremental step to a cure. Even if the firm does not itself discover the cure, it can license its technology to others, assuming it believes it will still have patent protection when the cure is discovered. Indicators of this additional value frequently appear in new drug patents that refer to previous drugs.

Sometimes the science that leads to an intermediate drug like Drug B, is used to develop a drug to treat a totally different disease. These knowledge network effects are common and also valuable options. Henkel and Maurer (2010) describe the network effects in biotechnology R&D as positive externalities where positive spillover effects reduce costs and boost R&D productivity.

Combination therapies are an example of positive spillovers. Therapies developed in different subspecialties are combined to produce a safer, more effective drug. Combination therapies are becoming increasingly important treatments for a variety of conditions including tuberculosis, malaria, cancer, rheumatoid arthritis, and HIV/AIDS. Reece et al. (2007) show that combination drug therapies have become standards of care for a number of non-urological conditions including cancers, asthma, and type 2 diabetes mellitus. Combination drugs have long been used for AIDS patients and may reduce the risk of HIV patients contracting tuberculosis. And Girardi et al. (2000) show that combination drug therapy is becoming the norm to improve effective treatment and reduce the spread of resistance for infectious diseases like malaria. Combination drugs represent off-line path dependence. Although these examples focus on in-line network effects solely within oncology, the option effects in-line and off-line can be valued similarly.

The paper is organized as follows. First, we illustrate the real option value from the firm's perspective, characterizing its R&D investment decision as an option. Second, we illustrate the option value from the consumer's perspective. Third, we discuss some numbers one could use for the option model parameters to get dollar value estimates for the option. Last, we consider the effect of real options on policy using Comparative Effectiveness Research (CER), the most common technology assessment method used by many governments and healthcare insurers to decide whether to pay for a new drug or include it in their formulary.

**I. Real Options Value in the Firm's Investment Decisions**

Figure 2 illustrates the real options modeling framework for a firm's valuation of a developmental oncology product. For continuity, we carry over some of the notation from Figure 1 by referring to the incremental innovation as Drug B and the cure as Drug C. The incumbent Drug A already exists so it does not enter into the firm's decision about whether to invest in Drug B. To simplify the discussion, we consider a single representative firm and single representative consumer.

The standard capital budgeting approach takes the discounted present value of the positive net cash flows that the firm expects to receive from the consumer of Drug B during his life extension, and subtracts the present value of the R&D investment costs incurred in the years leading up to the discovery of Drug B. If the difference between the two, the net present value (NPV), is positive, then the firm should make the investment. The decision rule is to fund the R&D for Drug B if:

NPV = Present Value of Drug B Cash Flows - Present Value of Drug B R&D > 0

The decision rule changes when the development of Drug B provides a pathway to discover Drug C. The firm can benefit from its R&D investment in Drug B in two ways. Figure 2 shows that the firm earns cash flows while the patient extends his life by purchasing and consuming Drug B, but might also earn much more on the cure, if such a cure is discovered.

**Figure 2. The firm's investment decision including real options**

Extends Life - Firm Earns P

Cure Discovered - Firm Earns uP

No Cure Discovered - Firm Earns 0

Drug B

Drug C

The firm's new rule for deciding whether to invest in Drug B's R&D is:

{Present Value of Drug B Cash Flows - Present Value of Drug B R&D} + Option Value > 0

This standard NPV approach ignores the fact that the firm's discovery of Drug B could generate new technology that leads it to discover Drug C. This option value of its new technology makes the research and development of Drug B more attractive to the firm. Indeed, the simple NPV for Drug B could be negative, but if the value of the real option on Drug C is relatively large and positive, it should develop Drug B even though it knows it will lose money on the sale of Drug B. The reason is path dependence. It will not get the chance (the option) to develop and sell Drug C if it does not first develop Drug B.

A simple way to value the option to invest in Drug C is to use a binomial option pricing model. Investing in the R&D for Drug B gives the firm an option to make a subsequent investment in the R&D for Drug C. In options terminology, this is a "call" option that is exercised if the firm successfully develops Drug B, and the technology of Drug B provides a path to discover Drug C.

Consider the following stylized presentation of the binomial model. Remember that we are assuming just one firm and one consumer for simplicity. Also for simplicity, assume that the life extending Drug B is taken at the beginning of year one, it extends the consumer's life for one year, and then, if the cure is discovered, Drug C is taken at the beginning of year two.

We define the terms in the model as follows.

C = call option value

P = the price charged for Drug B

R = cost of R&D to develop Drug C

r = risk-free interest rate

u = the multiplicative increase in price above P to be charged for Drug C (u > 1 + r)

d = the multiplicative decrease in price below P to be charged for Drug C (0 ≤ d < 1)

Cu = uP - R = call value if a cure is discovered

Cd = 0 = call value if a cure is not discovered

The call option value will be a function of the price that the firm can charge for Drug C. We assume that Drug A (the incumbent drug) is currently priced at P and that Drug B will be at least as effective as Drug A so that the firm knows it can charge P when it markets Drug B. In options terminology, P is the underlying asset value.

Besides the fact that Drug B is at least as effective as Drug A, Drug B's technology could lead to the discovery of Drug C. The firm knows that after developing and marketing Drug B, it will have the option to make a subsequent investment of R to develop Drug C. In option terminology, R is the exercise (or strike) price of the option. Assuming that the firm develops Drug B and that Drug B's technology can be extended to develop Drug C, the firm can "exercise" its option to develop Drug C, but at a cost of R.

When the firm is deciding whether to develop Drug B, it knows that Drug B's technology could lead to a cure (Drug C), but it might not. If it does not develop Drug B, there is no chance it can develop a cure. But after developing Drug B, the firm learns that the new technology can be extended to a cure, in which case it spends R to extend the technology, or it learns that the technology cannot be extended, in which case it will not spend R.

The firm also knows that it can charge a price higher than P for a cure, which we define as uP where u > 1 + r, and r is the risk free interest rate. For this successful outcome, the firm will earn Cu = uP - R, which we assume is positive. Of course, in reality, if u is relatively small, perhaps because of government price controls, or R is relatively large, then Cu could be small or even negative. If it is negative, the firm will not exercise its option to develop Drug C.

If the technology cannot be extended, its option on Drug C is worthless, d = 0, and Cd = 0. The firm will not exercise its option. This set of parameters is assumed for simplicity. We could have assumed that Drug C is either a cure or an incremental improvement on Drug B. Now in both cases, the firm might exercise its option to develop Drug C. That would increase the option value but does not affect the conclusions in a significant way. Nevertheless, one can see that the simple binomial model can be used to consider many more complex cases by changing the parameters to fit the situation.

Given the terms defined above, the general binomial model call value is:



For the simplified case with d = 0, and Cd = 0, then:

C = Cu/u = (uP - R)/u.

The final result is relatively simple but intuitively appealing. The call option to develop Drug C based upon Drug B's technology, depends on the R&D cost to extend the technology and the price that the firm can charge for Drug C relative to the price of Drug B.

A key assumption underlying the analysis is that the firm owns Drug B's technology when the option to invest in Drug C's R&D comes to fruition. In this simple example, the patent rights to Drug B must last into a second year. If patent rights expire before then, the firm's option is worth less, and perhaps zero, because any competitor firm could use Drug B's technology to develop Drug C.

The firm may still develop Drug B, but it is less likely. The firm will use the simple NPV decision rule to decide whether to develop Drug B. Now the most innovative drugs are less likely to be developed because those drugs probably cost more in R&D to develop, leading to negative NPVs.

**II. Real Options from a Consumer's Perspective**

Section I considered the option value from the supply side; the firm's perspective. We also explore the option value from the consumer perspective, the demand side. At least in a free market, the drug price is set through the interaction between supply and demand, i.e., between consumers and firms. Consumers translate the utility value of the drug into money value, and then decide whether to purchase the drug given its price and their budget constraints. For simplicity we again refer to one representative consumer and one representative firm, and we reuse some of the terms in section I where appropriate.

**Figure 3. The consumer's drug consumption decision including real options**

No Cure Discovered - Death - Immediate Consumption Utility

Extends Life - One Year Utility

Cure Discovered - Life Utility

Drug B

Drug C

Death - Immediate Consumption Utility

Figure 3 illustrates the consumer's decision. Assume that the consumer in endowed with an amount of money M and that M > (P + uP). At the start of the first period, the consumer can choose to consume Drug B at a cost of P and extend his life one year, or accept imminent death after immediate consumption of M (this immediate consumption could be a bequest to his family).

It is clear that the consumer will not necessarily pay P for Drug B because he has an alternative to consume M immediately. The decision depends upon the consumer’s utility function. The smaller the consumer's utility from living an extra year relative to the utility of immediate consumption, the less likely he is to choose to pay for Drug B.

This is the standard utility maximization problem which considers allocation of the consumer's budget over the current set of commodities. But it ignores the option value provided by the life extension derived from consuming Drug B. The full value of Drug B includes the option to survive until time 2 and perhaps consume a cure that is not yet available, and indeed may never be available to him. Nevertheless, it is rational for the consumer to take into consideration the possibility that Drug B could lead to a cure.

In a more complete utility maximization problem, the consumer's decision to pay P for Drug B depends upon the immediate value of a one-year life extension plus the option to consume Drug C at time two and live for perhaps many more years. The additional life utility could be worth a great deal, depending upon the consumer’s utility function, current age, available resources M, etc.

The utility maximization problem can provide the consumer's utility value of the option. The option value in dollar terms, assuming that the consumer decides to purchase Drug B and Drug C (if it is a cure), must be at least what we derived for the firm, C = Cu/u = (uP - R)/u. A more precise value estimate for the consumer is complicated by the fact that after consuming Drug B, he can derive utility from consuming Drug C if it turns out to be a cure, or immediately consuming the rest of his endowment M - P if Drug C is not a cure. Knowing that the consumer values the option at least as much as the firm is enough for our purposes.

**III. Placing a Dollar Value on Pharmaceutical Real Options**

Computing a value for a pharmaceutical real option depends on many unknowns, hence, confidence in a particular dollar value estimate will be low. Nevertheless, Sections I and II show that the option value exists from both the consumer's and firm's perspective. In this section, we offer empirical evidence from earlier studies that can be used to infer that the value is likely to be substantial. We also offer some ballpark estimates.

One important piece of empirical evidence is that, at least in the U.S. where prices are set more freely, the market offers higher prices for more innovative drugs. Lu and Comanor (1998) find that new therapeutic advances are priced between two and three times higher than incumbents. Me-too medicines or generics are priced at the level of incumbents. Part of the price premium for new advances could reflect patient’s willingness to pay for life extension (the option) to live to see a cure or another life-extending drug.

Lu and Comanor's (1998) results can be used to support an estimate of between 2 or 3 for the parameter u in the binomial option model, C = Cu/u = (uP - R)/u = (P – R/u). Recall that P is the price of the incremental innovation Drug B, u is a number greater than one and R is the cost of R&D for the cure, Drug C. Suppose that R&D for a cure is twice as expensive as the R&D for the incremental drug, then we know that the simple NPV value for Drug B is NPV = (P – ½R). This is the value of Drug B, ignoring the real option it provides on Drug C. If we use 2 as the low estimate for u then C = (P – R/u) = (P – ½R) = NPV. In this case, the option value is equal to the stand alone NPV value of Drug B. At the high end, u = 3 and C = (P – ⅓R) > NPV.

These results show that the option value for on a cure can be greater than or equal to the stand alone NPV of an R&D investment in an incremental drug. Of course, not every incremental drug has technology that leads to a cure, but the relative size of the option value is instructive. Indeed, many of the innovative drugs in Lu and Comanor's (1998) study were not cures but just significant advances above the incumbent drug. Clearly, the value of parameter u for cures alone could be larger, increasing the relative value of the real option.

Given an estimate of the relative size of the real option value, we suspect that it is a major driver of pharmaceutical R&D in general, and oncology R&D in particular. As mentioned earlier, oncology R&D has grown to represent the largest single therapeutic area of global pharmaceutical R&D. But Vernon, Golec, and DiMasi (2010) show that only 2 out of every 10 new medicines generate present value, after-tax net revenues in excess of average, after-tax drug development costs. That is NPV < 0 for 8 of 10 drugs. Assuming firms are rational, we infer from these results that pharmaceutical R&D depends critically on options value. Those 8 of 10 drugs likely provide substantial option value. Of course, many of those options end up worthless, but the few that lead to breakthroughs or cures are highly priced and highly profitable. Indeed, Vernon, Golec, and DiMasi (2010) show that the returns to breakthrough are very high.

Other evidence that pharmaceutical options value could be substantial appears in Golec, Hegde, and Vernon (2010). They show that drug firms that have more R&D projects with greater option values tend to have stock prices that react more negatively to drug pricing constraints than drug firms with R&D projects with less option values. Price constraints affect options values in the model more than NPV values because constraints reduce the parameter u.

The simple model normalizes time to two periods for tractability, however, options values are greatly affected by time. The longer the time period covered by the option, the greater its value. We alluded to this indirectly when we noted that patent length is crucial to option values. An option created by technology developed for Drug B on the cure Drug C, is worthless unless the firm believes that its patents on Drug B technology will extend long enough to be in force when Drug C is marketed. The longer the patent, the more confidence the firm has that if it discovers a cure, it will be the one to benefit from it sale.

The consumer’s perspective is slightly different but still depends significantly on time. The longer that drug that Drug B extends his life, the more valuable is the option value of Drug C to the consumer. Of course the consumer values the additional years as a direct benefit, but an indirect benefit is that a longer life extension increases the probability that a cure will be developed and that the consumer will get to use it. Essentially, speeding up the development of a cure through multiple incremental drugs or a longer life extension from any of the incremental drugs increases the consumer’s valuation of the option.

Perhaps surprisingly, options are worth more when there is greater expected volatility in the R&D results. When there are many new and innovative strands of R&D for a particular therapeutic group, such as for oncology, the likelihood of a cure increases. If an area has already been well researched and there is little innovative R&D going on for one reason or another, then the option will be less valued. One reason, firms might limit their allocation of R&D to a particular therapeutic group is that payers ignore of undervalue the option values attached to drugs in the group. We consider this issue next.

**IV. The Effects of Real Options on Comparative Effectiveness Research (CER)**

We consider the most common technology assessment method used by many governments and healthcare insurers to decide whether to pay for a new drug or to include it in their formulary. Although the U.S. government does not require the use of Comparative Effectiveness Research (CER), the American Recovery and Reinvestment Act of 2009 authorizes $1.1 billion to study CER, and many expect it to be used more widely in the future. Indeed, most of Western Europe, Canada, Australia, and New Zealand use explicit or implicit forms of CER (Jommi 2001; Gosling 2000). The U.S. may follow suit.

In this section, we explain CER in more detail and illustrate where real options analysis fits in. Many European governments use CER to negotiate lower average prices or exclude some drugs from formularies. While they assume that CER still provides good innovation incentives, we argue that adding real options to CER is likely to provide improved incentives and better drug value assessments. Although adding real options to CER probably gets us closer to what free market prices can do, we do not claim that CER plus real options is an improvement on market pricing.

To outperform the market, those implementing CER need to have the resources and incentives to gather the proper information and the technical skills required to interpret the information. Perhaps some would argue that they have done this and the inputs to their CER model are accurate. Even if this is true, we argue that CER models undervalue many drugs because focus on the direct benefits of a drug and ignore the indirect option values many drugs provide. Surprisingly, many who support CER over market forces believe that consumers and providers are too ignorant of new medicines’ values to allow them to make the choice (Sloan 1995).

CER requires someone to assign a monetary value to health benefits. In the market, values are set through the interaction between firms and consumers. Assigning health benefit value was a contentious issue in the decisions to restrict access to various drugs in the United Kingdom. For example, the National Institute for Clinical Excellence (NICE) in January 2001 decided to restrict Alzheimer’s disease (AD) drugs under the UK’s National Health Service to patients with the most severe stages of the disease.NICE determined that none of four AD drugs it considered met a threshold it had set for health value at their price levels. Below, we briefly review the CER method.

Using some of our terms, CER involves comparing the ratio of the difference in marginal costs and benefits between a new drug (Drug B) and an incumbent (Drug A).



Costs are relatively easy to measure using various prices. Benefits are measured in standardized units of health such as life years or quality-adjusted life years (QALYs). NICE guidelines, for example, recommend the use of QALYs. QALYs are “weighted” life years. If a drug prolongs life by 1 year but the patient is in poor health during those years, CER could set the benefit at 0.5 life years instead of 1.

Consider the following example of a payer using CER to evaluate Drug B which provides an additional life year at a cost that exceeds Drug A’s cost by $80,000. If the payer assumes that an extra year of life is worth $100,000. Then:



A threshold ratio less than 1 (ΔC/ΔB < 1) implies that the costs are less than the benefits and the medicine would seem to be acceptable. But some users add what they consider refinements to their application of CER that make it more precise. In order to be more confident that the benefits will exceed the costs, some payers use a smaller threshold ratio say, 0.50. Research by Murphy and Topel (2003) on the economic value of a life year suggests national payers are setting their thresholds too low[[1]](#footnote-1). Many also use QALYs, so that an impaired patient’s life year saved is only worth, say, 0.50 QALYs. This might particularly impact cancer patients whose intermediate treatments like Drug B extends their lives but can make them weak or fragile.

Assuming that the administrator’s CER threshold or QALY is correct, then Drug B is not acceptable. But CER completely ignores the option value of Drug B. Indeed, a fragile consumer likely increases his life utility by taking the cure Drug C more than a relatively healthy patient taking the same drug. The option value of the cure is greater for the low QALY patient.

CER completely ignores the possibility of Drug C and the implied option value. The previous section showed that the option value associated with Drug B could be greater than or equal to its direct life extension value. This option value may not be large for all therapeutic groups, particularly for those with low mortality and morbidity rates. But we suggest that CER should be modified to include an option benefit for therapeutic areas like oncology, particularly for drugs that involve innovative technology.

Using CER unadjusted for options values will unfairly penalize innovative technology drugs in high mortality therapeutic groups, leading to the socially undesirable effect of reducing innovation incentives to levels below their socially optimal level. In the example above, the patient did not meet the threshold set by the CER administrator. But if real options value were included, the benefit could double or triple, producing a CER cost-benefit ratio that exceeds the threshold. When option value is ignored and a patient is unfairly rejected for a treatment, the utility value of the option is lost to the patient and society.

CER helps payers to place an explicit value on a new technology. This method can be attractive to payers even if it is imperfect, because it can help convince patients that their health coverage is defined by objective criteria. But it also formally defines a payer’s maximum willingness to pay for different pharmaceuticals. Firms can reverse-engineer a maximum price for a medicine when they know how a payer determines its QALYs and its threshold. Doing so essentially forces risk averse firms to also ignore options values because they see that they will not be compensated for taking the risks inherent in new potential breakthrough technologies.

Vernon, Hughen, and Johnson (2005) show that firms are already making R&D product development and in-licensing decisions based upon the CER signals being sent by foreign governments via their reimbursement and coverage decisions. They describe how firm managers use this approach in the earliest stages of drug development, leading to socially suboptimal results.

**V. Conclusion**

This paper shows how the path-dependent R&D for new oncology drug innovations involves real options. We study how path-dependence impacts the decisions of producers, consumers, and insurers/payers. We show that the value of real options bound up with incremental oncology drug development can be greater than the direct life-extending value of the incremental drug itself.

We show how rational pharmaceutical producers and consumers recognize the additional real option value. However, foreign government payers using Comparative Effectiveness Research (CER) ignore this option value. And the U.S. may follow suit as the American Recovery and Reinvestment Act of 2009 authorizes $1.1 billion to study the use of CER in the U.S. Because CER ignores real option value, it penalizes intermediate innovations that are more likely to lead to breakthrough innovations compared to less costly, no option incremental innovations.

When firms and consumers agree that a particular drug has option value but payers who set the terms of exchange do not, the resulting mix of R&D spending will be suboptimal from a social economic welfare perspective. We suggest that markets are more likely to get the optimal mix of R&D spending right. However, if the CER method must be used due to political circumstances, then it should be adjusted for an estimate of option value, particularly for highly innovative drugs for high mortality diseases.

Finally, there are many more example of option effects that CER does not value. Combination therapies are becoming more common, as are cases where a drug used for one clinical indication is also used for another. These cases have off-line path dependence, that is, they come from outside a particular therapy group. They represent positive network effects that are difficult for a CER administrator to grasp, even if the administrator accounts for more easily seen in-line path-dependent options. Hence, markets are likely to assess technology value much more efficiently and completely. If the pharmaceutical producer sees the R&D path, either on-line or offline, develops the incremental drug, and the consumer experiences the benefits of life extension to a cure, then both the firm and the consumer gain. If the connection is short-circuited by a CER administrator unable or unwilling to attach value to increment link, then technology growth slows or stops.

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1. For example, the UK’s NICE uses approximately $50,000 per QALY to measure benefits. Research by Hirth, Chernow, and Orzol (2000) and Murphy and Topel (2003), however, suggests the value of a life year in the United States is much higher, closer to $175,000 in current dollars. These studies estimate QALY values using market data on how much people are willing to pay to avoid hazardous work (and increase their expected life span). Even with a cutoff set at 1, when the UK measures benefits at less than a third of what they may be, fewer pharmaceuticals will pass this criterion. [↑](#footnote-ref-1)