

SPECTRUM RENEWAL PRICING: RETHINKING THE SUNK-COST PROPOSITION

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INTRODUCTION

The proposition that sunk costs should not influence forward-looking decisions is a longstanding principle of neoclassical economics. With the introduction of large-scale spectrum auctions from the mid-1990s, economists applied this principle to license payments. Kwerel (2000) provided one of the clearest formulations: Once an upfront spectrum auction payment has been made and is irrecoverable, it should not directly affect subsequent marginal pricing or output decisions by mobile network operators (MNOs).

This proposition is best understood as a benchmark for how economists think firms should behave once an irreversible payment has been made. It is less convincing as a description of how firms actually behave. A substantial body of theory and empirical evidence suggests that prior expenditures can continue to affect financing, capital allocation, investment, and market conduct. This is because firms face real financial constraints or their behavior departs from the textbook frictionless model.

The distinction between textbook and real-world behavior by MNOs matters because sunk-cost reasoning is often invoked when setting prices to renew mobile spectrum licenses. Once a large upfront renewal fee has been paid, the argument runs, it becomes sunk and should have no effect on subsequent economic decisions. Such reasoning makes it easier for regulators to price spectrum robustly. Even when a regulator has no revenue goal, it may still have a general preference for higher prices over lower ones, provided it does not perceive efficient allocation to be at risk. Regulators may also be sensitive to general government needs for revenues and aware that high price events can make for a “better” news story. But if firms do not behave as the sunk cost proposition predicts, such reassurance is weakened.

There is also a more fundamental question: Should a regulator whose objective is dynamic efficiency in spectrum allocation actually want to encourage firms to treat frequency holding decisions as sunk costs for a lengthy licensing period? Unlike network equipment, spectrum does not depreciate and can be reallocated repeatedly over time. For primary awards involving new network investment to deploy in a new frequency band, there is a strong case for long, secure rights. But this logic does not carry forward cleanly to renewals, in which investment cycles remain long but vary across bands and operators have increasing flexibility over when to upgrade equipment, how much spectrum to deploy, and which bands to prioritize. What operators really need is sufficient forward-looking certainty to earn a return on network investment, and they need this certainty to be regularly renewed for as long as it is relevant. A lengthy license of, say, 20 years can provide this certainty for about 15 years, but there will always be an end period when investment incentives are undermined.

This short paper promotes two complementary approaches to spectrum license renewals. First, in support of dynamic efficiency in allocation, it makes the case that regulators should price below rather than at benchmark estimates of market price. Second, it identifies rolling renewals and annual fees as a better option than fixed durations and upfront fees for facilitating efficient change in spectrum holdings over time. Regulators may fail to fully explore the advantages of these approaches because they are obscured by undue faith in the sunk-cost proposition.

THE SUNK COST PROPOSITION IS NOT AN ADEQUATE STORY OF HOW MOBILE OPERATORS RESPOND TO SPECTRUM FEES

The sunk cost proposition itself is unobjectionable. The problem begins when this normative principle is turned into a positive assumption that firms behave as though large license payments disappear from subsequent decisions and then into a regulatory conclusion that high renewal charges are harmless.

This concern is not new. “Effective Spectrum Pricing” (GSMA/NERA, 2017) challenges the proposition that spectrum expenditure can have no economic effect because the payment subsequently becomes sunk. It identifies several channels through which high upfront spectrum payments could affect later outcomes, including regulatory hold-up, internal financing constraints, and behavioral or strategic responses. The report argues that large payments can absorb relatively low-cost internal funds and alter subsequent investment where external finance is more expensive. Spectrum payments are often large enough to add material debt to company balance sheets and contribute to lower financial ratings and higher costs of capital. This mechanism is particularly relevant to mobile, in which operators manage network investment against capex-to-revenue targets and parent groups allocate finite capital budgets across countries. A spectrum payment that absorbs part of that financial envelope can reduce or defer otherwise viable network investment.

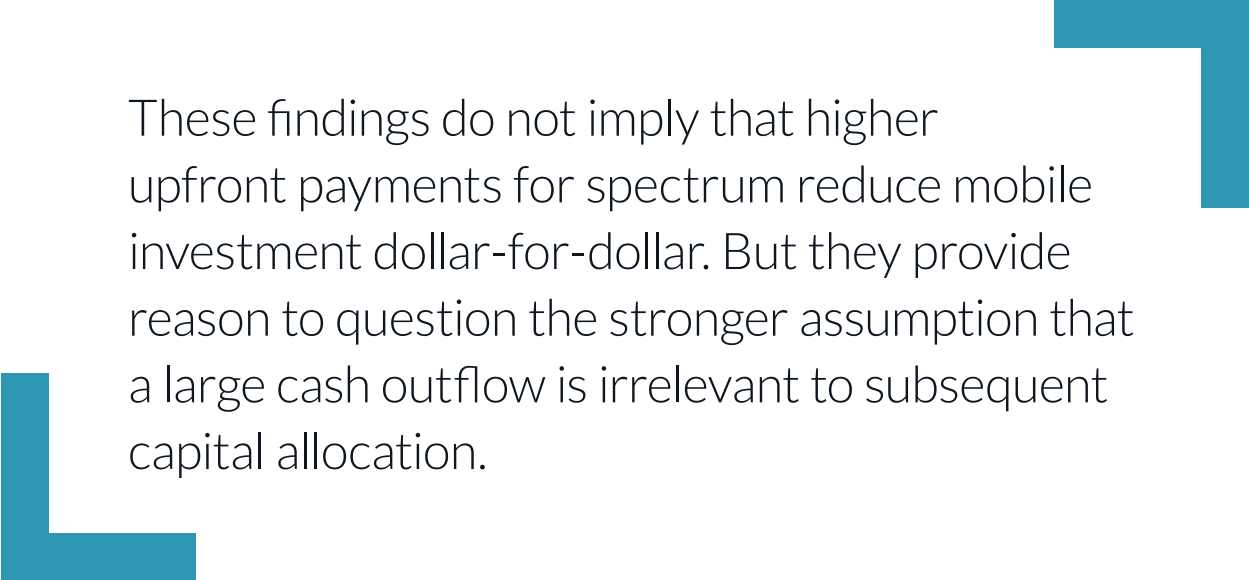
Recent literature strengthens the basis for taking these mechanisms seriously. Kamphorst et al. (2020) show that sunk fixed costs can rationally affect pricing where firms face liquidity constraints and current sales help generate future profits—for example, by building a customer base that persists over time. Negrini et al. (2022) find a reverse sunk-cost effect in investment decisions, with larger initial commitments reducing subsequent investment. Meanwhile, Bahia and Castells (2022), using 64 countries, find that higher spectrum costs are associated with lower network coverage and quality, consistent with the findings of GSMA/NERA (2017). The authors similarly point to capital constraints and centrally managed budgets as explanations for why network investment is crowded out.

Corporate-finance research provides a separate mechanism that requires no departure from economically rational behaviour. Dai et al. (2024) model multi-division firms in which internal liquidity and costly external finance affect the allocation of investment across businesses. Santioni et al. (2020) and Buchuk et al. (2020) provide empirical evidence that internal capital markets can materially reallocate funds within corporate groups when financing conditions matter. These findings do not imply that higher upfront payments for spectrum reduce mobile investment dollar-for-dollar. But they provide reason to question the stronger assumption that a large cash outflow is irrelevant to subsequent capital allocation.

The same caution applies to pass-through. No serious argument for conservative renewal pricing requires every dollar of lower spectrum fees to be spent on network investment or competed away through lower retail prices. Some may be. Some may support other expenditure or financial resilience. Some may accrue to shareholders.

The relevant welfare question is whether some of the differences affect real economic outcomes. Additional mobile investment can generate wider benefits not fully captured by operators, while lower access prices increase consumer surplus and may support greater mobile adoption and use. Partial pass-through can therefore matter materially even if it is significantly below 100%.

Repeated interaction between operators and regulators introduces another problem. As Ihle and Khatri (2026) describe, MNOs in most countries invest today knowing that licenses will be renewed and repriced in the future. If successful investment raises the ex-post value of spectrum that a regulator subsequently seeks to capture at renewal, operators can rationally anticipate that part of the return to current investment will later be extracted. If operators expect the regulator to extract full market value of the spectrum at renewal, they have an incentive to reduce their ex-ante investment in infrastructure.



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SUNK COST REASONING ENCOURAGES AGGRESSIVE SPECTRUM PRICING

Most leading spectrum managers worldwide use auctions for primary awards and many also use them to re-award expiring licenses. Over time, the results of these awards have developed into a rich database of prices for mobile spectrum that can be used to benchmark a “market price” for future awards. Naturally, such benchmarks have become a focal point in regulatory debates over administrative pricing of spectrum, including reserve prices for auctions and spectrum fees for direct renewals.

With respect to renewal pricing, there is considerable common ground among stakeholders. Three propositions command broad agreement. First, administratively valuing spectrum is difficult: Unlike an auction, a renewal does not reveal a market-clearing price. Second, international benchmarking is useful—often the best empirical evidence available—but necessarily imprecise because awards differ across countries, bands, license conditions, and time. Third, the consequences of valuation error are not symmetric: Setting a renewal price too high can prevent efficient use, while the consequences of setting it somewhat too low are different and potentially less severe.

Views diverge over how regulators should respond to that uncertainty. Under a strong sunk-cost interpretation, a regulator may simply define their task as estimating market value as accurately as possible and then charging close to that estimate. In this view, asymmetric risk matters but mainly around the boundary at which the regulator might accidentally price spectrum out of use. Regulators should certainly avoid an estimate that is too high, but neither should they set the price too low. In support of this approach, a recent paper by DotEcon (2026a) argues that opportunity cost pricing maximizes incentives for efficient reorganization of spectrum holdings and that setting fees below a reasonable estimate of market value forgoes government receipts.

This perspective also helps explain the attraction of central estimators in benchmark analysis. Spectrum-price distributions are often “right skewed” (owing to a modest number of high price observations), so a median or geometric mean will generally produce a lower estimate than the arithmetic mean. In its advice to ACMA on setting renewal prices for expiring spectrum licenses, DotEcon (2026b) describes the median, geometric mean, and its preferred geometric Hodges-Lehmann estimator as “conservative” approaches and concludes that this approach already places greater weight on avoiding over-estimation than under-estimation. Accordingly, it sees no reasonable case for a further downward adjustment in pricing to address asymmetric risk.

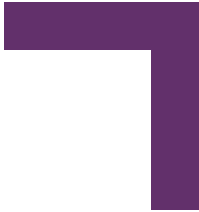
In contrast, once the limitations of sunk-cost reasoning are recognized, estimating market value becomes only an intermediate step toward selecting a renewal price. A prudent regulator should also consider whether a high spectrum bill affects financing capacity, investment, competition, and future spectrum-holding decisions after a license is renewed. And it must assess the possibility that some of the benefits of lower fees are competed away through increased investment and improved consumer outcomes, even though pass-through will be less than 100%. A benchmark central estimator provides a useful reference, but it does not answer the subsequent policy question of where the administered price should sit relative to that uncertain estimate. In a paper NERA and Aetha prepared for submission to the ACMA (NERA/Aetha, 2024) on behalf of Telstra, we made this distinction explicit: A benchmark methodology first produces estimates of full market value, after which a separate conservative-pricing adjustment is required to reach the renewal fee.

From this view, “underpricing” looks less troubling. Some economic rent undoubtedly remains with operators, but this is not a deadweight loss. This rent may support additional investment, some may be competed away in downstream markets, and leaving a margin between the administrative charge and spectrum value can facilitate future trades and other adjustments in holdings. Where network investment has wider social benefits, those effects may offset the fiscal value forgone.

This difference in perspective becomes especially important when renewal prices are considered across an operator’s spectrum portfolio rather than band-by-band. Even if each individual benchmark appears reasonably conservative, the aggregate renewal bill can be large. MNOs typically operate within constrained capital budgets, often managed in relation to revenues, and multinational groups allocate investment across competing markets and projects. Even in the common case in which operators retain high-price spectrum, a large payment can absorb internal funds, raise financing requirements, and crowd out or delay network capex. The fact that the spectrum payment is sunk after it is made does not imply that the financial capacity it consumed was unlimited.



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CONSERVATIVE PRICING MATTERS IN PRACTICE

For most spectrum regulators, there is no statutory objective to price spectrum renewals based on a central estimate of market value. The standard policy objective is to promote efficient use of spectrum and wider public interest, not to maximize license revenue. The debate over sunk costs therefore matters for policy.

A number of regulators are currently contemplating substantial payments by MNOs to renew their expiring spectrum licenses. In Australia, the ACMA has proposed a A\$7.32 billion price tag to renew licenses expiring between 2028 and 2032; prices reflect the regulator's central estimate of market value based on an international benchmarking process. Switzerland is preparing to reassign the 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, and 2600 MHz licenses acquired in its 2012 auction and expiring at the end of 2028 using a new award process with a proposed reserve price of 854.7 million Swiss francs. Portugal is likewise consulting on the renewal of expiring licenses in several core frequency bands and has estimated a private value to incumbent MNOs of 550.3 million euro for licenses expiring in 2027 and 2033.

NERA is advising incumbent operators responding to the regulatory processes in each of these countries. Operators plainly have a commercial interest in retaining spectrum on favorable terms. Our advice has therefore focused on identifying price levels compatible with the regulators' objectives and, in particular, whether proposed pricing arrangements promote dynamic spectrum efficiency, investment, and downstream competition. We have argued for more conservative pricing while accepting that regulators have a legitimate interest in ensuring scarce public spectrum is not retained at trivial prices.

In our opinion, there are particular reasons for caution in setting spectrum renewal fees at the present point in the spectrum cycle:

1. We are currently in a period of declining mobile spectrum prices. Marsden (2024) identifies a strong downward trend starting around 2016. The NERA Spectrum Report (2026) finds that international spectrum prices declined substantially through most of the 5G era: Between 2017 and 2024, the three-year moving average fell by around 57% for low-band spectrum and 47% for lower-mid-band spectrum. There are indications of stabilization in 2025, so this is not a claim that prices must continue to fall. It is evidence that benchmarks drawn from earlier years may belong to a materially different valuation environment.

2. The upward trend in general inflation increases the risk of benchmark error. Over much of the same period in which spectrum prices were falling, general price levels were rising. Mechanically inflating older auction observations can therefore push historical spectrum prices upward precisely when the spectrum-specific evidence points in the opposite direction. NERA/Aetha (2024) highlights this tension and argues that the traditional practice of simply adjusting historical awards for inflation was inappropriate in a period of declining spectrum values.
3. Weak industry profitability increases the potential burden of high renewal fees. DotEcon (2026a) characterizes spectrum value as “the additional rent that an operator will enjoy under oligopolistic competition downstream.” That framing makes high renewal charges look principally like the extraction of excess profits. This is how spectrum license acquisition was perceived in the early 3G era (2000–2001), when mobile revenues were growing rapidly and 3G licenses were viewed as market entry tickets. But it is not a good description of how an MNO typically values additional MHz to augment a modern network, in which value is primarily derived from the network costs it allows them to avoid. In an industry in which profitability has been weak through much of the 5G investment cycle, this distinction matters: Willingness to retain incremental spectrum does not imply that a large aggregate renewal bill is financially innocuous.

In Australia and Switzerland, such arguments have so far had limited traction. Regulator deference to the sunk-cost proposition has arguably narrowed the debate. Regulators are naturally alert to the incentive of incumbent operators to argue for lower spectrum prices, but sunk cost theory tends to obscure their own institutional anchors. One is a reluctance to set a materially lower price than peer regulators have previously obtained for apparently similar spectrum. Another is an instinct to preserve the real value of historic benchmarks through inflation adjustment. Both intuitions are understandable. But in the context of declining spectrum values, a regulator should expect to receive lower revenues (on a per MHz basis) than in an earlier, higher-value period. Treating a decline in receipts as evidence that the methodology is too generous risks building an upward bias into the exercise.



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SHOULD MATURE SPECTRUM BE SUNK AT ALL?

The economic case for license security is not the same for a primary award and for the renewal of a mature mobile band. When a new band is introduced, substantial complementary investment may be needed in network equipment, antennas, devices, and supporting technology. Long, secure spectrum rights can protect those irreversible investments and allow a new frequency ecosystem to develop. There is a powerful case for giving operators confidence that access to the spectrum will endure long enough to justify those sunk network investments.

At renewal, circumstances are often different. The band is established, equipment and devices already exist, and operators may have greater scope to substitute between bands or alter the quantities of spectrum they deploy. The efficient holder of spectrum—and the efficient quantity held—can change as technology, demand, and spectrum supply evolve.

In such circumstances, why should a regulator deliberately make the holding decision sunk for another 15 or 20 years? A large upfront renewal fee pushes the pricing signal in that direction. Before payment, the charge may influence whether an operator retains the spectrum. Once paid, however, the fee itself disappears from the forward-looking holding decision under conventional sunk-cost reasoning. There is an awkward tension here with the usual justification for opportunity-cost pricing, which is that users should remain conscious of the value of the spectrum they occupy. And licenses of any fixed duration, long or short, will eventually produce a cliff edge that can paralyze forward investment and trading.

For mature mobile spectrum, a different architecture may therefore be preferable: secure or indefinite rights combined with prospective annual charges that can be reviewed periodically. Ofcom's regime for several mature mobile bands illustrates the principle. After the initial license period, the UK model combines indefinite license tenure with annual fees and a five-year notice period for revocation on spectrum-management grounds. Future fees remain relevant to the decision to retain spectrum, rather than disappearing into an irreversible payment on the first day of a new 20-year term. Ofcom's 2025 review also illustrates the flexibility of this approach: When its assessment of market evidence changed, Ofcom reduced annual fees for 900 MHz and 1800 MHz spectrum by 26%.

Annual charging potentially creates better forward-looking discipline but only if the price is designed appropriately. In the UK, Ofcom was directed by the government to set certain mobile annual license fees to reflect "full market value." That creates a separate tension with secondary trading. Suppose a regulator sets a recurring fee close to the entire estimated value of the spectrum. Even where an alternative user values the spectrum more highly than the incumbent, the administrative charge can absorb all or most of the surplus that would otherwise make a trade worthwhile. A full-market-value holding charge can therefore make the secondary market less liquid, deterring acquirers and thereby undermining the regulatory case that fees should discipline firms to sell spectrum when they are not the most efficient user.

Ofcom attempts to mitigate this problem by adopting “conservative” assumptions when estimating market value and by periodically reviewing fees. Relative to other regulators, its approach also puts more weight on quality assessment of individual benchmarks and somewhat less on statistical averages from large samples. Arguably, this approach may reduce risk of overstatement. But if the regulator’s objective is efficient spectrum use rather than revenue extraction, a better approach may simply be to set recurring charges somewhat below estimated market value. Such a fee can maintain a meaningful scarcity signal while leaving room for gains from trade and providing insurance against estimation error and downward shifts in spectrum value.

There is also a risk-sharing advantage with annual fee regimes for renewals. A large upfront renewal payment fixes the allocation of valuation risk at the start of the license term. If spectrum values subsequently fall, the operator bears the loss: The payment is sunk and cannot adjust to the new market reality. If values rise, by contrast, the operator retains the upside for the remainder of the term. A recurring annual charge that is set conservatively and is reviewed periodically allows valuation risk to be shared more flexibly over time. Fees can fall if market values decline and rise if sustained evidence points to higher values, while the operator retains enough headroom to justify investment and facilitate trade. This need not mean continuous repricing or regulatory uncertainty: Reviews can be infrequent, rules-based, and subject to clear notice periods. The objective should not be to track market value perfectly each year but to avoid locking either party into a 15- or 20-year valuation made under considerable uncertainty.



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REGULATORS SHOULD LOOK BEYOND THE SUNK-COST PROPOSITION

The sunk-cost proposition remains a useful economic discipline, but it is too narrow to provide a blueprint for spectrum-renewal policy. Large upfront spectrum payments can affect subsequent financing, investment, and market behavior; benchmark valuations are uncertain, and the welfare costs of overpricing and underpricing are asymmetric; and mature spectrum requires licensing structures that allow efficient reallocation over time. These considerations point away from mechanically translating benchmark estimates into long-term upfront fees. Regulators should be willing to price below central estimates where the consequences of error or financial burden justify doing so and should consider secure rolling renewal rights combined with conservative annual charges and periodic review. The objective should not be to extract the maximum defensible value from spectrum today but to design a regime that promotes efficient investment, holding, and reallocation over time.

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