



Review

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Technological Aspect of Digital Terrestrial Television Implementation: Network Architecture, Signal Processing and the Development Prospects

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Abstract. This article examines the recent transformation of digital terrestrial television (DTT) in Italy through the analytical lens of costs, benefits and strategic implications for broadcasters. Unlike earlier studies focused mainly on analogue switch-off, the paper updates the discussion to the 2015–2026 period, when the Italian broadcasting system was reshaped by 700 MHz spectrum refarming, DVB-T2/HEVC migration, MPEG-4 transition, hybrid broadcast-broadband services and growing competition from satellite, IPTV and over-the-top platforms. The aim is to explain how regulatory change and technological modernization redistributed economic burdens and strategic opportunities among national public-service broadcasters, commercial groups, local television operators and pay-TV competitors. The methodology combines literature review, qualitative web content analysis and a comparative case-study approach based on regulatory documents, industry reports, corporate communications and recent policy materials. The findings show that DTT modernization generated important public and technical benefits, including spectrum efficiency, platform continuity, improved quality potential and universal access. However, the same process created asymmetric costs related to infrastructure renewal, receiver compatibility, content expansion, advertising fragmentation and regulatory adaptation. The article argues that the success of DTT modernization depends not only on transmission standards but also on interoperability, platform governance, sustainable local broadcasting and integration with broadband-based media ecosystems.

Keywords: digital terrestrial television, Italy, DVB-T2, spectrum refarming, media economics, hybrid television, broadcasters.

Introduction

The transition from analogue terrestrial television to digital terrestrial television (DTT) represented one of the most significant transformations in European media policy. In Italy, this process was particularly important because terrestrial television has historically occupied a central position in national media consumption, advertising markets and public communication. While the earlier phases of the switch-off established the foundations of the digital platform, the period from 2015 to 2026 has become equally significant, representing a second phase of modernization characterised by spectrum refarming, receiver migration, codec renewal and increasing platform convergence.

This article, therefore, reinterprets the Italian DTT experience through the lens of recent broadcasting modernization rather than viewing it solely as a historical analogue-to-digital switch-off. Since 2015, the Italian television environment has been shaped by several overlapping developments, including the European decision to allocate the 700 MHz band to wireless broadband services, the migration of DTT broadcasting to the sub-700 MHz UHF spectrum, the gradual transition from MPEG-2 to MPEG-4 and subsequently towards DVB-T2/HEVC standards, the expansion of connected television and the growing relevance of RaiPlay, Mediaset Infinity, satellite distribution, IPTV and over-the-top (OTT) platforms [1].

The central research problem addressed in this article is the following: how has the recent phase of DTT modernization affected the costs, benefits and strategic positioning of broadcasters in Italy? Three research questions guide the analysis. First, which categories of cost became most significant for broadcasters during the 2015–2026 period? Second, what benefits and emerging opportunities did the evolving DTT environment create for national, local and pay-TV operators? Third, why were some actors more successful than others in adapting to DTT modernization?

The article contributes to the existing literature by integrating media economics, spectrum policy and platform strategy within a unified analytical framework. It argues that digital broadcasting modernization constitutes more than a technical upgrade; rather, it represents a socio-technical restructuring process that redistributes costs and opportunities among broadcasters, audiences, governments, device manufacturers and network operators. The Italian case is analytically valuable because it combines a strong terrestrial broadcasting tradition, a major public-service broadcaster, influential commercial media groups, local television pluralism and intense competition from satellite and broadband-based platforms.

Literature review

The academic discussion surrounding digital terrestrial television (DTT) has generally evolved around four principal themes: spectrum management, public policy, market competition and social access. Foundational studies emphasised that digital switchover should be understood as a coordinated policy process rather than a single technological event. More recent scholarship has shifted attention towards platform convergence, connected television, regulatory prominence and the long-term role of DTT within an increasingly broadband-oriented media environment.

The first relevant strand of literature concerns spectrum policy. The European UHF framework and the reallocation of the 700 MHz band demonstrate that broadcasting policy has become increasingly intertwined with the development of mobile broadband services. European policy documents relating to the sub-700 MHz spectrum indicate that the 470–694 MHz band remains essential for DTT and programme-making services at least until 2030, while the 700 MHz band has been reassigned to mobile communications and 5G deployment [2]. This development creates a structural tension whereby broadcasters must maintain universal free-to-air services within

reduced spectrum capacity, while mobile operators continue to demand additional low-frequency resources.

Table 1. Updated research focus and contribution of recent sources (2015–2026)

Research area	Recent relevance for the Italian case	Contribution to this article
Spectrum policy and 700 MHz refarming	EU and Italian policy shifted DTT into a reduced UHF environment while supporting 5G deployment.	Explains why DTT modernization created new infrastructure and coordination costs.
DVB-T2/HEVC and receiver migration	More efficient standards improve capacity and quality but require compatible devices and public communication.	Shows that technological efficiency can create short-term social and economic burdens.
Hybrid TV, HbbTV and DVB-I	Broadcast and broadband services increasingly operate in a common user environment.	Links DTT strategy to connected television and platform governance.
Local broadcasting sustainability	Local broadcasters face weaker advertising markets, SFN constraints and higher relative transition costs.	Highlights the asymmetry between national and local operators.
Platform prominence and access	AGCOM's 2024 measures on DTT access icons reflect the importance of visibility on smart devices.	Extends the analysis from transmission coverage to interface-level accessibility.

The second strand addresses the economics of television platforms. Digital compression expands transmission capacity and enables the launch of additional channels, thematic services and high-definition broadcasting. At the same time, however, it contributes to audience fragmentation and the dispersal of advertising revenues. For large broadcasting groups, such fragmentation may be managed through portfolio-based strategies; for local operators, by contrast, the same process can weaken traditional advertising models while simultaneously increasing technical and operational costs. The third strand of literature focuses on public-service broadcasting and questions of access. Rai's responsibilities extend beyond the mere transmission of content and encompass broader principles of universality, visibility, accessibility and technological neutrality. Within a hybrid media environment, these obligations increasingly reach beyond terrestrial coverage to include satellite complements, electronic programme guides, connected television interfaces and issues of platform prominence. Recent AGCOM regulations concerning access to DTT channels further demonstrate that visibility within device interfaces has become not only a matter of market design but also a significant regulatory concern [3].

Finally, the literature on hybrid broadcast-broadband television suggests that the future of

DTT is likely to be characterised by integration rather than isolation. Standards such as HbbTV, DVB-I and connected television technologies point towards a transition from channel-based distribution to service-based discovery across terrestrial, satellite and broadband networks. For broadcasters, this implies that DTT continues to play an important role in ensuring reach and system resilience, while broadband platforms increasingly provide personalization, interactivity, audience measurement and on-demand viewing capabilities.

The methodology

This study applies a qualitative case-study design supported by a literature review and web content analysis. The empirical focus is Italy during the period 2015–2026, with historical references to the earlier analogue switch-off where necessary. This updated timeframe was selected because it captures the second phase of digital terrestrial modernization, including 700 MHz spectrum refarming, MPEG-4 migration, DVB-T2/HEVC planning, the development of connected television and the growing convergence of terrestrial, satellite and broadband platforms.

Table 2. Methodological design of the study

Element	Description
Research design	Qualitative case study with literature review and web content analysis.
Time frame	2015–2026, with historical context from the initial Italian DTT switch-off.
Units of analysis	Regulatory documents, industry reports, corporate communications and scholarly publications.
Core variables	Costs, benefits, strategic positioning, market consequences and policy milestones.
Analytical logic	Comparison of national broadcasters, local broadcasters, pay-TV operators and hybrid/OTT platforms.
Limitations	The study does not provide a full econometric cost-benefit estimate because detailed firm-level costs are not publicly available.

The empirical material includes academic publications, European policy documents, AGCOM reports and resolutions, industry materials produced by broadcasting and standards organizations, and corporate communications issued by major Italian broadcasters. The analysis is qualitative rather than econometric, as detailed cost attribution for individual broadcasters is not always available within public sources. Nevertheless, public reports and regulatory documents make it possible to identify recurring cost categories, strategic decisions and broader market consequences [4].

The analytical framework is structured around five coding categories. The first category, policy and timeline, captures regulatory milestones, spectrum decisions and stages of implementation. The second category, costs, includes infrastructure investment, simulcasting, receiver

compatibility, content expansion, workforce skills and regulatory compliance. The third category, benefits, encompasses spectrum efficiency, channel multiplication, improvements in transmission quality, platform continuity and digital dividend outcomes. The fourth category, strategic positioning, examines the responses of Rai, Mediaset, local broadcasters, Sky, IPTV providers and OTT platforms. The fifth category, market consequences, captures advertising fragmentation, platform rivalry, audience behaviour and the growing role of hybrid services.

The analysis proceeded in three stages. First, the source material was organized chronologically in order to reconstruct the sequence of broadcasting modernization. Second, the material was coded thematically according to the five analytical categories described above [5]. Third, the findings were compared across different groups of actors to identify structural asymmetries. This comparative logic is particularly important because the same technological transformation may produce different outcomes depending on the scale of the actor, capital resources, content portfolio and regulatory obligations.

Findings/Discussion

1. DTT modernization after 2015: from switch-off to platform restructuring. The Italian DTT story did not conclude with the completion of analogue switch-off. After 2015, the central challenge shifted towards maintaining a strong terrestrial broadcasting platform while simultaneously releasing valuable spectrum for mobile broadband services and adapting television delivery to increasingly connected devices [6]. The 700 MHz refarming process altered the strategic environment, as broadcasters were required to operate within a narrower portion of the UHF spectrum while preserving coverage, service continuity and audience expectations regarding transmission quality.

This phase transformed DTT from a conventional transmission platform into a component of a broader audiovisual ecosystem. Broadcasters could no longer focus solely on terrestrial coverage; instead, they were required to manage the evolving relationship between DTT, satellite complementarity, IPTV, smart television applications, OTT services and regulatory requirements relating to platform visibility and accessibility [7]. This explains why the strategic value of DTT after 2015 differs from its role during the initial switch-off period. Increasingly, its significance lies in ensuring universal reach, system resilience, free-to-air accessibility and complementarity with broadband-based services.

2. Main cost categories for broadcasters. The first major cost category concerns infrastructure renewal. Broadcasters and network operators were required to reorganize frequency allocations, adjust transmitters, filters and multiplexing equipment, and ensure compatibility with evolving technical standards [8]. These expenditures are substantial in absolute terms for national operators and proportionally burdensome for smaller local broadcasters.

The second category relates to receiver and consumer migration. More efficient standards such as DVB-T2 and HEVC offer improvements in capacity and transmission quality; however, they also require compatible television sets or decoding devices. If migration occurs too rapidly, part of the audience may lose access to television services; if it proceeds too slowly, gains in spectrum efficiency are delayed. This creates both a regulatory and commercial dilemma, as broadcasters depend upon audience reach while regulators pursue more efficient spectrum utilization.

The third category involves content and portfolio management. Expanded transmission capacity can support additional channels, high-definition services and thematic segmentation, yet these opportunities require investment in programming, content rights, scheduling and marketing.

DTT capacity becomes economically valuable only when it is linked to content capable of attracting audiences and generating advertising or subscription revenues.

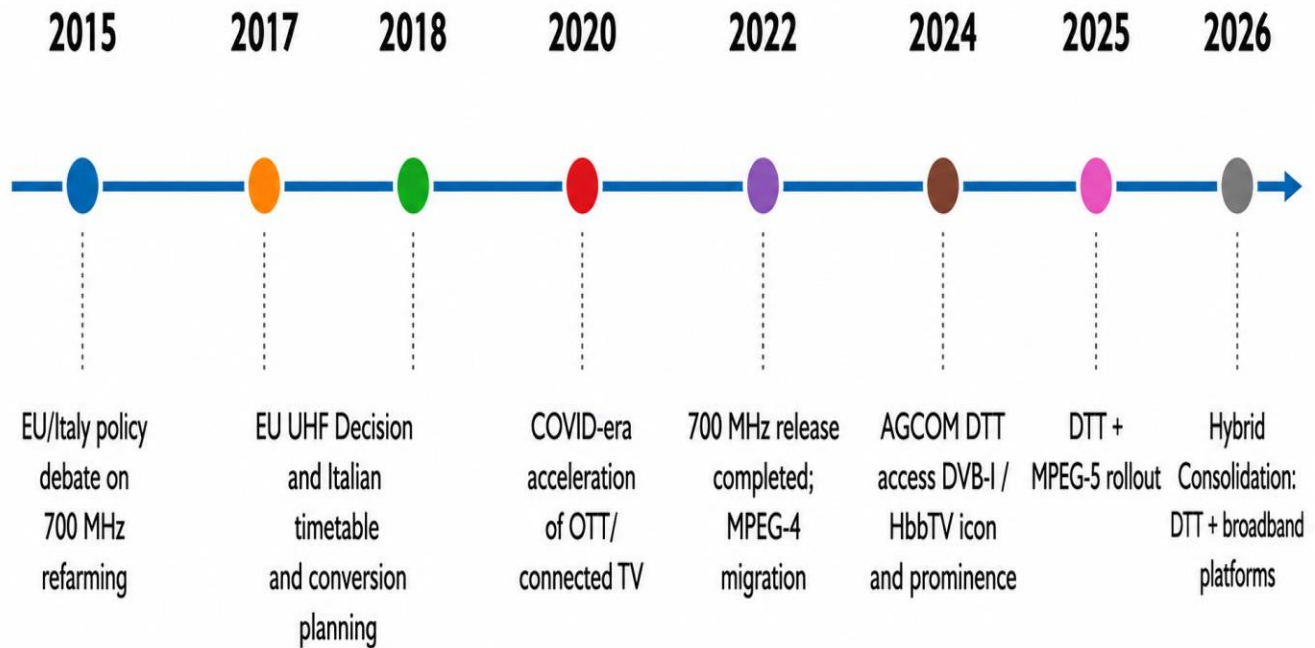


Figure 1 - Recent evolution of Italy's DTT ecosystem, 2015-2026

Source: compiled by the author based on regulatory and industry materials, 2015–2026.

The fourth category concerns organizational capability. Contemporary digital broadcasting increasingly requires expertise in encoding technologies, data analytics, connected television applications, rights management, user-interface design and multi-platform marketing. Broadcasters historically structured around linear generalist channels must now manage increasingly complex digital portfolios operating across both terrestrial and broadband environments [9].

3. Uneven impact on national and local broadcasters. The effects of DTT modernization are inherently asymmetric. Large national broadcasters are generally better positioned because they are able to combine technical capacity with established brands, extensive content libraries, sophisticated advertising systems and integrated online services [10]. Rai can align DTT with its public-service mission and RaiPlay, while Mediaset is able to integrate free-to-air television, advertising, Mediaset Infinity and broader commercial portfolio management. Local broadcasters, by contrast, face a more fragile environment. Their revenue bases are smaller, advertising markets are geographically more limited and their capacity to finance technological transition is comparatively weaker. During the analogue era, some local broadcasters were able to differentiate advertising across provinces or sub-regional markets. Although digital single-frequency network (SFN) planning improves spectrum efficiency, it may simultaneously reduce this operational flexibility. The result is a classic policy trade-off: the technical system becomes more efficient, while the business model of certain local operators becomes increasingly vulnerable

This asymmetry is central to the Italian case. DTT modernization may represent a strategic

opportunity for broadcasters possessing scale, capital and content resources, yet it may become a financial burden for operators lacking sufficient investment capacity, premium content or multi-platform capabilities. Consequently, policy success should be evaluated not solely in terms of cleared frequencies or technical compliance, but also with regard to the long-term sustainability of the broadcasting ecosystem.

Table 3. Costs and benefits of DTT modernization for broadcasters

Cost categories	Benefit categories
Infrastructure renewal: transmitters, filters, multiplexing, monitoring and frequency coordination.	Spectrum efficiency: more services within less spectrum and better long-term use of the UHF band.
Receiver migration: compatibility problems related to MPEG-4, DVB-T2 and HEVC.	Quality improvement: potential for HD, Full HD, 4K and more efficient compression.
Content expansion: additional slots require programming, rights and brand development.	Portfolio strategy: thematic channels, public-service channels and targeted audience segmentation.
Regulatory adaptation: compliance with spectrum, prominence, access and consumer-information rules.	Platform continuity: DTT remains a mass free-to-air platform even in the broadband era.
Local broadcaster burden: weaker capital base and reduced flexibility in advertising geography.	Hybrid integration: terrestrial reach combined with broadband interactivity and on-demand services.

4. Hybrid television and the new meaning of access. During the initial phase of DTT development, access was primarily determined by signal coverage and decoder availability. In the contemporary environment, however, access increasingly depends upon platform prominence, smart television interfaces, applications, electronic programme guides and the integration of broadcast and broadband services. The 2024 AGCOM regulation concerning a DTT access icon illustrates this changing landscape: viewers must be able to locate terrestrial services easily on connected devices; otherwise, the visibility of free-to-air broadcasting may decline even where transmission coverage remains available [11].

Hybrid television is also reshaping the economics of DTT. Broadcast distribution remains highly efficient for simultaneous mass audiences, emergency communication and universal access. Broadband distribution, by contrast, is more effective in providing personalization, interactivity, data-driven services and on-demand catalogues. Consequently, the strategic direction for Italian broadcasters is not to replace DTT with broadband distribution, but rather to integrate DTT within a coherent and complementary multi-platform environment.

5. Strategic outcomes of selected actors. The strategic consequences of the Italian DTT transition differed substantially across market actors. While digital broadcasting created new opportunities for audience expansion, platform diversification and revenue generation, it also exposed broadcasters and media operators to uneven technological, regulatory and commercial

constraints [12]. Table 4 summarizes the main opportunities, limitations and strategic implications experienced by selected actors within the Italian DTT ecosystem.

6. Synthesis: who benefits and who pays? The distribution of benefits and costs depends largely on the relevant time horizon. In the short term, broadcasters and viewers bear the costs of transition through infrastructure renewal, receiver replacement, information campaigns and service reorganization [13]. In the medium term, national broadcasters and network operators benefit from more efficient spectrum utilization and improved portfolio management. In the long term, society benefits from the digital dividend and from a more integrated media infrastructure, provided that accessibility and media pluralism are effectively preserved [14].

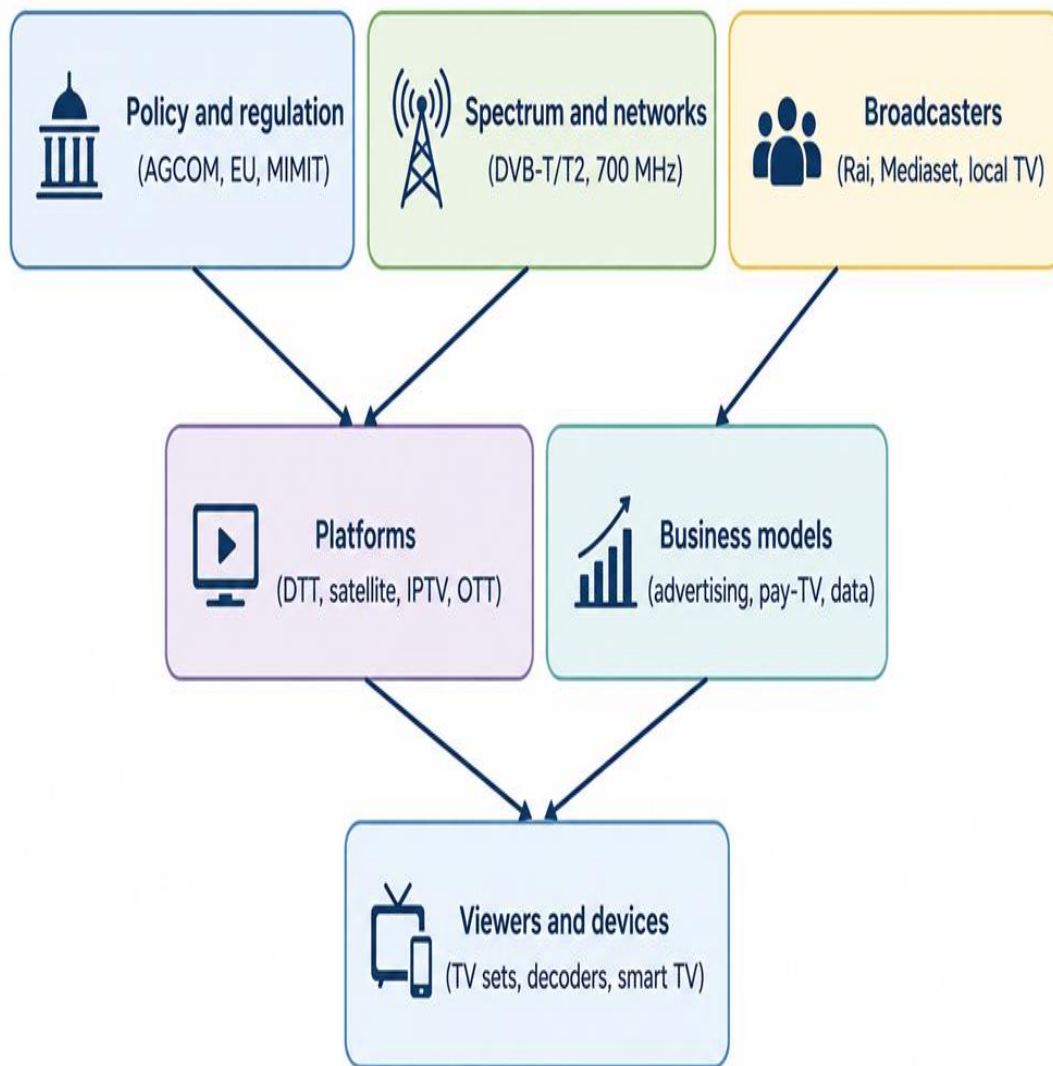


Figure 2. Analytical model of DTT transformation as a socio-technical ecosystem

Source: compiled by the author.

The Italian case demonstrates that technological efficiency does not automatically translate into economic efficiency for all actors involved. More efficient codecs and transmission standards

may increase capacity, yet they can also generate additional costs for both households and broadcasters. A greater number of channels may expand consumer choice, but it may simultaneously fragment audiences and weaken advertising value. Similarly, enhanced platform integration can improve the user experience while also raising important questions concerning prominence, technological neutrality and control over platform interfaces [15].

Table 4. Strategic outcomes of selected actors in the Italian DTT transition

Actor	Main opportunity	Main constraint	Strategic implication
Rai	Universal public-service reach through DTT, Tivùsat and RaiPlay.	Platform neutrality, rights management and accessibility obligations.	DTT remains essential for public-service universality but must be integrated with connected services.
Mediaset / MFE	Commercial portfolio strategy across free TV, advertising and Mediaset Infinity.	Competition from OTT platforms and high cost of premium rights.	DTT supports mass reach, while online platforms support additional monetization.
Local broadcasters	Regional visibility and local identity.	High relative transition costs, weaker advertising and SFN constraints.	Require targeted support and flexible regulation to preserve local pluralism.
Sky and satellite platforms	Premium bundles, HD/UHD capacity and national coverage.	Higher subscription model and regulatory limits in terrestrial markets.	Satellite remains a benchmark for quality and premium content.
IPTV/OTT operators	Personalization, on-demand catalogues and data-driven marketing.	Dependence on broadband quality and subscription fatigue.	They intensify competition and push broadcasters toward hybrid strategies.

Conclusion

The Italian experience with digital terrestrial television demonstrates that broadcasting modernization constitutes a socio-technical transformation rather than a purely engineering undertaking. The period from 2015 to 2026 confirms that the central challenges of contemporary broadcasting extend far beyond the original analogue switch-off. They increasingly involve spectrum refarming, DVB-T2/HEVC migration, receiver compatibility, hybrid television development, platform visibility and intensifying competition from OTT and broadband-based services.

The findings of this study indicate that DTT continues to provide significant public and strategic value. It supports spectrum efficiency, universal free-to-air reach, public-service accessibility, network resilience and the potential for enhanced transmission quality. At the same

time, modernization imposes considerable burdens on broadcasters, including infrastructure investment, regulatory compliance, content expansion, organizational adaptation and the growing risks associated with audience fragmentation. These costs and opportunities are distributed unevenly. National broadcasters and vertically integrated media groups are generally better positioned to convert DTT modernization into a strategic advantage, whereas local television operators remain comparatively more vulnerable to technological and economic pressures.

The study further demonstrates that technological efficiency does not automatically translate into economic sustainability for all actors within the broadcasting ecosystem. Digital capacity acquires strategic value only when supported by compelling content, platform interoperability, stable audience relationships and sustainable business models. Consequently, the long-term success of digital broadcasting cannot be assessed solely through technical indicators or spectrum efficiency outcomes.

The principal policy implication is that future broadcasting reforms should pursue a balanced approach that combines technological modernization with media pluralism, local broadcasting sustainability and the practical accessibility of public-interest content. For Italy, and for other countries undergoing similar transitions, the future of DTT is unlikely to consist of isolated terrestrial broadcasting alone. Rather, it is increasingly likely to evolve towards a hybrid and integrated media environment in which the efficiency and reliability of broadcast networks are combined with the flexibility, interactivity and personalization offered by broadband-based services.

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