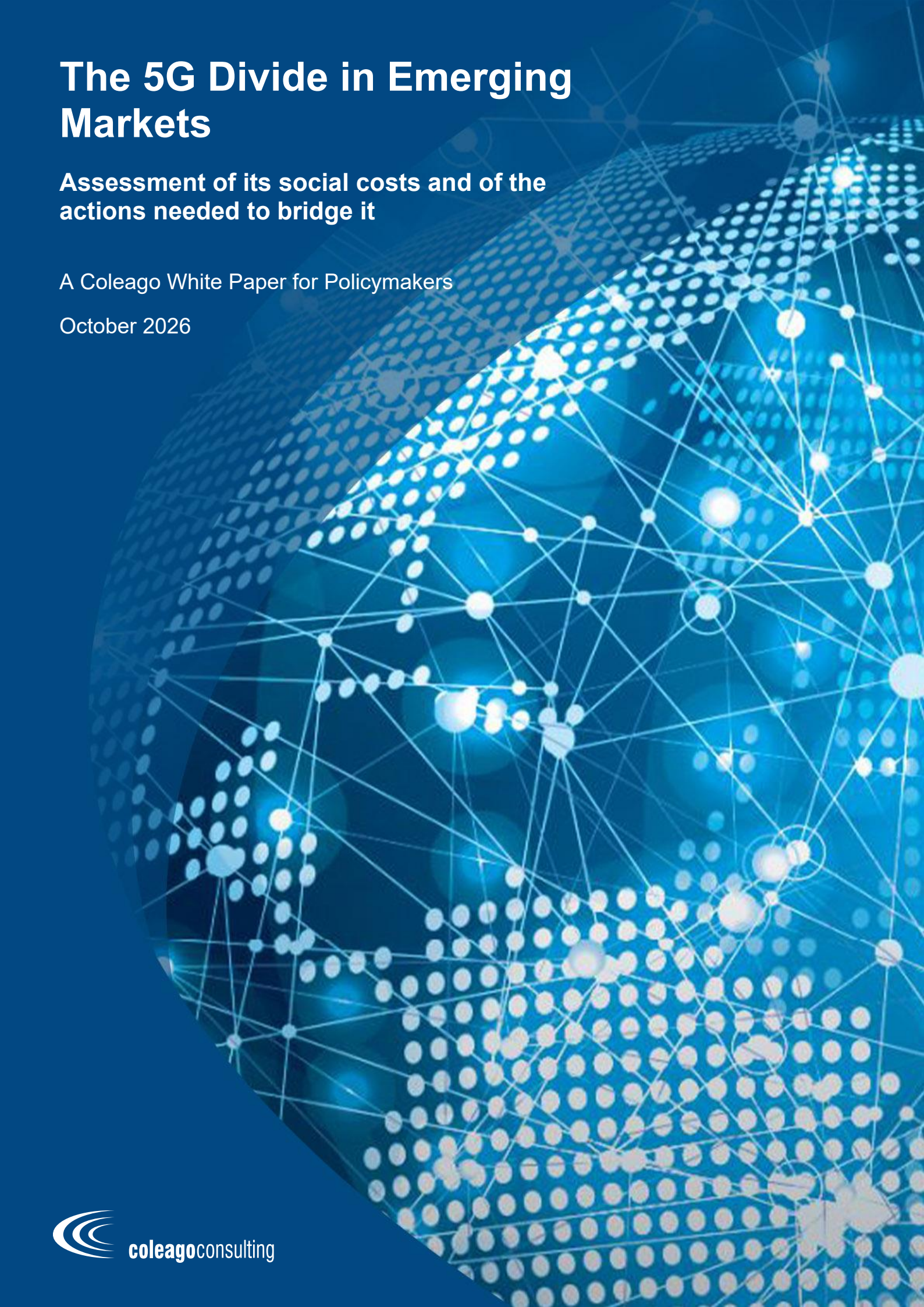
The 5G Divide in Emerging Markets

Assessment of its social costs and of the actions needed to bridge it

A Coleago White Paper for Policymakers

October 2026



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1. Executive Summary

Spectrum policy is the main determinant of 5G outcomes. These have profound implications for consumers and society.

Yet, significant lost opportunities are being risked across a range of emerging markets.

This White Paper examines the '5G Divide' between Emerging Markets (EMs), through case studies spanning Egypt, Bangladesh, Pakistan, Congo (DRC) and Vietnam. It evaluates the socio-economic costs of delayed spectrum allocation and 5G, as well as the impact of excessive spectrum prices. Finally, it seeks to identify the main steps and policies needed to bridge the 5G gap.

We focus on the impact of 'True 5G', which is taken to be wideband 5G deployment (ideally including a 100 MHz contiguous channel with for high capacity and high general performance), alongside low-band channels (for wide area coverage and improved cell-edge performance). This would maximize the likelihood of consistent user data speeds in excess of 100 Mbps.

1.1 Key findings

- Mobile is a key driver of economic development, and true 5G will play a significant part in driving incremental value in the Consumer, Home and Business verticals:
  - **Consumer**: Ultrafast Mobility and Latency-sensitive applications;
  - **Home**: Fibre-like Fixed Wireless Access (FWA);
  - **Business**: Catalyst for Industry 4.0 and AI Integration;
  - 5G will play an outsized role in enabling AI applications within EMs;
- The net incremental benefits of true 5G are in the order of **1.1% of GDP**;
- Spectrum policy is a key determinant of 5G outcomes: spectrum insufficiency, especially the lack of 3.5 GHz bandwidth, is a major barrier to true 5G and the high-performance benefits that wideband channels deliver;
  - A wideband 5G channel of 100 MHz can generate 3.5x faster data speeds than a 40 MHz channel under equivalent % cell loading (see Section 5.1.4);
- Excessive spectrum prices can "kill the Golden Goose": they either lead to unsold hence unutilized spectrum, or they choke network investment by transferring scarce capital from the industry to the state;
  - Ultimately, high spectrum fees have a disproportionate impact on consumer welfare (see Sections 6.2 and 6.3);
- Assuming equal traffic, true 5G could reduce network TCO by an amount equal to up to 11% of revenues in Egypt (see Section 5.1.3);
- In addition to high performance benefits, wideband assignments drove cost efficiency: TCO[1] per unit of capacity of a 100 MHz channel would be 45% of that for a 40 MHz channel;

Vietnam is the positive example to emulate. Pakistan, which has adopted similar policies, is likely to overtake Egypt (current #2 in our sample).

- The case studies show wide variations across Emerging Markets:
  - Vietnam is the example to emulate: it shows how a complete spectrum policy reset can transform 5G outcomes for the benefits of consumers and society;
  - Egypt is #2 within our sample, but delays in making 3.5 GHz available and excessive spectrum prices put it at high risk of falling behind Pakistan, which has recently adopted similar spectrum policies to Vietnam;
  - Significant lost opportunities are being risked across a range of emerging markets; Iraq and other Arab nations in particular would benefit from forward-looking spectrum and 5G policies, and could learn from the Egypt case study.

1 TCO: Total Cost of Ownership of an asset, calculated here as the amount expensed annually in the Profit and Loss statement.

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Exhibit 1: Case study summary

Column title	Egypt	DRC	Bangladesh	Pakistan	Vietnam
Total allocated spectrum	420 MHz	378 MHz	528 MHz	755 MHz	660 MHz
Spectrum price index (Adjusted, Egypt=100)	100	23	73	8	9
5G-enabled as % 4G+5G connections	9.3%	0.1%	2.7%	0.3%	23.5%
5G population coverage	24.5%	N/A	13.5%	5%	>90%
Coleago assessment	Currently #2 in sample; at risk due to policies	#5 in terms of 5G progress and momentum	Currently #3 in sample; Pakistan likely to overtake	Currently lagging but high 5G momentum	Undisputed 5G leader on all metrics

Source: Coleago based on multiple sources (quoted in Section 4)

1.2 Socio-economic cost of spectrum policies in Egypt

Delays in spectrum releases and excessive spectrum fees in Egypt could impose social costs of around $170 per capita.

We estimate that the GDP impact of a 5-year delay in the introduction of true 5G (beyond 2030) could exceed $13 billion. We have quantified the GDP impact of a delay in true 5G deployment in Egypt as well as the impact of excessive spectrum fees on economic Welfare.

The net welfare impact of the proposed $3.5 billion in spectrum fees in Egypt could be as high as a $7.35 billion cost. The net result of Egypt's spectrum policies could add up to a cost of **$20 billion** in GDP plus Welfare terms. This is around **$170** per capita. This assessment is intended to be illustrative for other Emerging Markets with similar policies towards spectrum.

1.3 Policy recommendations

Two things are most urgently needed to close the 5G gap:

- Forward-looking spectrum allocation policies and roadmap (see Section 7.1), including:
  - Prioritizing contiguous, wideband (100 MHz) assignments at 3.5 GHz to all operators;
  - Completing clearance and allocation of 700 MHz;
  - Filling gaps in legacy bands (between 800 MHz and 2.6 GHz);
  - Progressing towards 600 MHz clearance, with assignment in the medium term;
  - Progressing towards the assignment of the U6 band (in preparation for 6G), L-band and 4.5 GHz in the medium to longer term;
- Spectrum pricing reform (see Section 7.2):
  - Ensuring that the above assignments are priced reasonably (i.e. at sustainable levels);
  - This implies a total annual spectrum TCO certainly no higher than 7.7% of mobile revenues (the global median), and ideally less than 1.3% of revenues (to align with best international practices);
  - Where possible, regulators should seek to replace spectrum licence fees with network construction obligations (as successfully implemented in Vietnam).

Beyond this, regulators should seek to remove fiscal and other barriers to the development of the digital economy. Specifically, import duties or taxes on 5G devices, equipment and/or vendor support should be avoided, as these may impede the development of a GDP-critical and socially sensitive sector (see Section 7.3).

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2. Introduction

2.1 Background, objectives and scope

Many Emerging Markets lag both on IMT spectrum allocation and 5G deployment, which represents a dramatic lost opportunity.

There are very few parts of society and of the economy that are not touched by mobile communications. Mobile helps people stay in touch, keep informed, be entertained, and it provides a virtual bridge to safety in emergencies. It drives the wheels of the economy by facilitating the transfer of data and knowledge across and between nations. Without mobile, productivity would fall to a fraction of its current levels.

This is all the more true for Emerging Markets (EMs), where fixed networks are comparatively weaker, and where mobile is the preeminent digital access platform. For large shares of the population in EMs, it is indeed the *first and only meaningful* window into the digital world. Mobile will be more important still in the AI era.

Favourable mobile market outcomes ought therefore to be paramount public policy objectives –even more so in EMs than in advanced economies. Yet, many EMs lag both on IMT spectrum allocation and on 5G deployment, both of which are critical determinants of digital outcomes. This represents a dramatic lost opportunity.

The prime objective of this White Paper is to address the '5G Divide' in EMs:

- By assessing the cost of delayed spectrum allocations and 5G deployment both to society and to operators, to highlight the importance of the issue;
- By identifying key success factors, and by mapping out the main steps and policies needed to bridge the gap.

2.2 Study approach and evidence base

To bring the 5G Divide into focus, we have developed five national case studies using available data points and published commentary. The first three of these cases, reflecting EMs that currently lag on 5G, are Egypt, the Democratic Republic of Congo (DRC) and Bangladesh. These are contrasted with Pakistan and Vietnam.

One reason for selecting these countries is their scale: outcomes in each of these affect large populations. Another is that they span two continents. A third is that the differences across this sample are marked. They likely reflect the range of outcomes across the bulk of EMs, and they clearly illustrate poor versus better practices.

Our socio-economic impact analysis is grounded in cross-country studies that draw on empirical data. The impact of the 5G Divide on operators is assessed through technical modelling, using anonymised internal benchmarks on key mobile network parameters in EMs in conjunction with external demand forecasts.

Finally, we reference available literature, to leverage international thought-leadership on the issues at hand.

2.3 Organisation of this document

The rest of this White Paper is organized as follows:

- Section 3 describes the strategic role that 5G and associated spectrum inputs play in the Digital Economy;
- Section 4 examines the state of 5G in EMs, taking our five case studies as a broadly representative basis;
- Section 5 outlines the impact of spectrum allocation and pricing on networks and consumption, while Section 6 quantifies the socio-economic costs and gains of alternative 5G outcomes (taking Egypt in both Sections as an illustrative example);
- Our policy recommendations are provided in Section 7, and we conclude with calls to action in Section 8.

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3. The Strategic Role of Spectrum and 5G in the Digital Economy

3.1 Strategic role of mobile communications

Mobile-enabled EVA is projected to reach 8.4% of global GDP by 2030.

Mobile networks are a critical layer of the digital economy because they provide the broadest last-mile connectivity for consumers, workers, firms, and public services. In Emerging Markets (EMs), that role is especially important because mobile is often the primary or only practical way to access the internet, digital payments, platform work, commerce, health, education, and government services.

According to the GSMA[2], the global mobile sector contributed:

- $7.6 trillion in Economic Value Added (EVA) in 2025, equalling 6.4% of global GDP;
  - and this is projected to increase by three times the expected growth in global GDP, reaching $11.3 trillion (8.4% of GDP) by the end of the decade;
- $4.8 trillion of the above is attributed to mobile-enabled productivity effects (4.1% of GDP);
- $0.9 trillion in fiscal revenues in 2025 (3.5% of the global total); and
- 50 million jobs in 2025, 31 million of which were direct employment.

As a proportion of GDP, the EVA from the mobile sector appears to be significantly *higher* in many EMs than in developed economies. For example, the GSMA estimates suggest 2025 EVA contributions of:

- 8.6% of GDP in Latin America;
- 7.8% of GDP in Africa; and
- 8.1% of GDP in emerging Eurasia.

These significantly exceed the global average of 6.4% of GDP.

3.2 Incremental contribution from 5G

Mobile networks are a general-purpose platform for digital participation, but 5G raises that platform into a more capable economic infrastructure. Mobile internet became mainstream in the 4G-era. 5G matters not just because it is faster than 4G, but because it extends mobile connectivity into a foundation for data-heavy, latency-sensitive as well as machine-driven communications.

Within this report, we refer to 5G deployed over wideband channels (for optimal performance) plus low band (for wide area coverage) as ‘true 5G’ – ideally including a 100 MHz contiguous channel to maximize the likelihood of consistent user data speeds in excess of 100 Mbps. This is to contrast it with all alternatives, which do not deliver the full benefits of 5G. From a customer perspective, such alternatives are generally experienced as an extension of 4G rather than a new mobile generation.

According to the GSMA: *Countries equipped with advanced digital infrastructure, a highly skilled workforce and sustained investment in emerging technologies are positioned to benefit the most from 5G and AI*. The GSMA anticipates *more gradual but broad-based benefits as mobile technologies diffuse across their economies*, and that these will depend on *complementary policy frameworks – particularly in spectrum allocation, taxation and service-quality regulation – that support ICT capital formation and enable firms to develop new digital products and services*.

2 GSMA, The Mobile Economy 2026

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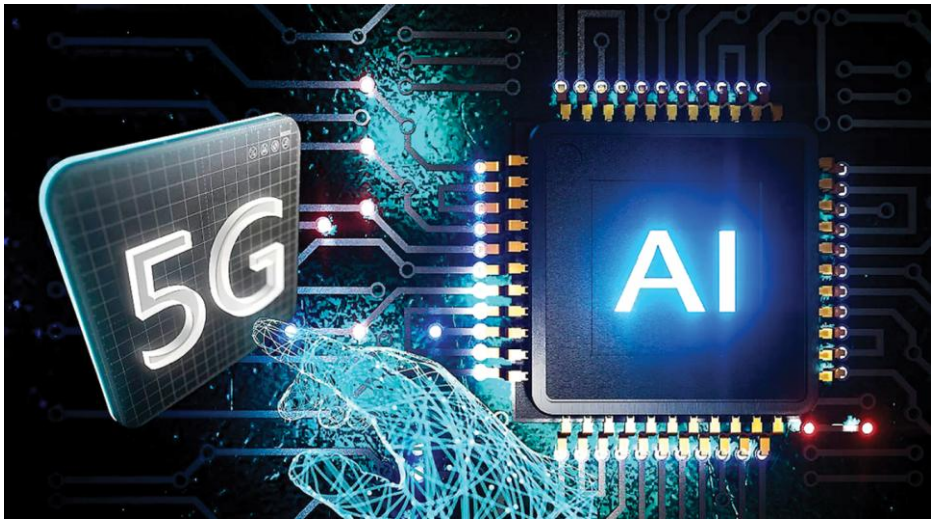


Image from vietnam.vnanet.vn

5G is likely to play an outsized role in enabling AI applications in Emerging Markets.

The outsized role that 5G is likely to play in enabling AI applications within Emerging Markets is echoed in an EM-focused IFC/World Bank publication[3]: *The interSection of artificial intelligence and 5G mobile technology has enormous potential to deliver dramatic improvements in productivity, efficiency, and cost across business sectors and broader society, delivering innovative products and services not previously possible. Though mainstream applications that combine AI and 5G have yet to emerge, key emerging markets sectors such as agribusiness, healthcare and education will be transformed by the combination of AI and 5G*.

True 5G is the main catalyst to Industry 4.0 (or the Fourth Industrial Revolution): the transition to smart, highly automated manufacturing and production systems that use real-time data, interconnectivity, and machine intelligence (AI) to operate. Within an EM context, this includes:

- **Industrial Automation & Logistics** – Ultra-low latency and high reliability enable real-time machine-to-machine (M2M) communication, which facilitates the deployment of:
  - Autonomous guided vehicles (AGVs) in logistics hubs – which is highly relevant, for example, to Egypt's position in the Mega-Ports race, and its transforming of the Suez Canal Economic Zone into a global logistics and industrial hub;
  - Remote-controlled robotics in manufacturing; and
  - Automated predictive maintenance systems;
- **Data-Driven Verticals** – In critical EM sectors like agriculture, the network can seamlessly support massive Internet of Things (IoT) sensor arrays over wide areas, using a low-band coverage layer, while utilizing the high-capacity 3.5 GHz layer to process data-heavy drone mapping and AI-driven crop analysis.

Oxford Economics[4] projects the incremental contribution from 5G technologies at $2.1 trillion by 2030 (1.7% of global GDP), assuming full 5G roll out across both mid bands and mmWaves. Assuming roll out across mid bands only (which include 3.5 GHz), Oxford Economics project a net gain from 5G of 1.1% of GDP. This is the more relevant figure for our study, and we examine it more closely in Section 6.1.

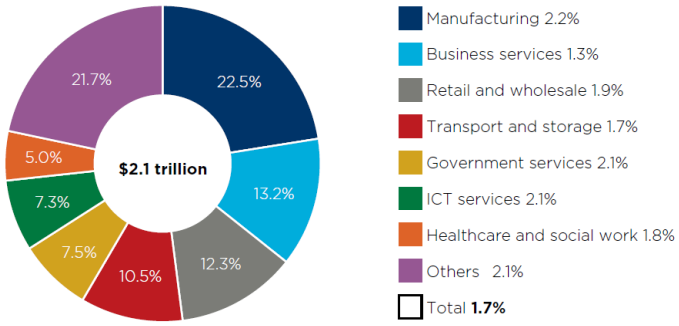
3 Mockel and Makala, 'Artificial Intelligence and 5G Mobile Technology Can Drive Investment Opportunities in Emerging Markets', EM Compass, Dec 2019
4 Oxford Economics, 'The global economic potential of 5G-enabled technology', March 2023

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Oxford Economics attributes these incremental gains to the higher data speeds and the lower latencies that true 5G would enable. They do not take other functional capabilities of 5G into account. Accordingly, they only address a portion of the total potential benefits.

The sectoral distribution of global productivity-enabled GDP gains by 2030 from full 5G rollout, projected by Oxford Economics, are shown in Exhibit 2 below. Note that while absolute GDP effects might be similar, the global sectoral distribution will likely differ in shape from that in Emerging Markets. Agriculture, for example, is bound to feature more prominently in the latter.

Exhibit 2: Global productivity-enabled GDP gains from full 5G by 2030



Figures in the legend show growth in sector economic output associated with 5G-enabled technologies.

Source: Oxford Economics

3.3 Further sources of economic value

In addition to the large impact of mobile communications on economic productivity and GDP, which are *indirect* effects, they are also a source of direct economic Welfare.

Increasing consumption at lower unit prices yields direct Consumer Welfare benefits to users themselves[5], which we explore in Section 6.2, within the context of spectrum fees. Over the past 15 years, the Consumer Surplus (CS) from mobile services has grown to a multiple of total industry revenues in many markets, as:

- Industry revenues have tended to remain broadly flat in real terms; while
- Mobile Data consumption has exploded (from 0.6 EB globally per month in 2012 to 145 EB per month in 2026 – a 220x factor increase)[6];
- Leading to a dramatic fall in prices per GB consumed.

Producer Surplus[7] is a further component of welfare, and it matters for several reasons. A healthy (but not excessive[8]) surplus is a guarantor of the financial stability and sustainability of the sector, as well as of the existing competitive rivalry within it. Moreover, a thriving IMT sector attracts foreign investment, which also contributes to economic development. While this additional effect may already be captured implicitly in the GDP multipliers, promoting investment –which requires adequate investment incentives– should remain high on the list of policy priorities.

5 Consumer Surplus (welfare) is the difference between what consumers are willing to pay for their consumption and what they actually pay for it.
6 Source: Ericsson Mobility Report, June 2026
7 Producer Surplus is the financial difference between the minimum price a seller is willing to accept for a good or service and the actual price they receive for it.
8 Excessive Producer Surplus would point to unfair rent extraction at the expense of consumers. This is unlikely to arise in most mobile communications markets, as these are inherently competitive. Indeed, many operators struggle to earn their cost of capital, suggesting producer deficits rather than surpluses.

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Producer Surplus generally rises when operator revenues expand and/or their costs contract. True 5G is likely to drive Producer Surplus gains both by driving revenue growth *and* increased cost efficiency. Specifically:

- Ericsson has shown how leading 5G markets bucked the declining revenue trend, with revenue expansion correlating well with increased 5G adoption[9];
- Deployment of 5G across wide channels with higher order MIMO antenna systems drives down total costs per Mbps of capacity (see Sections 5.3 and 5.1.3).

In practice, policy makers should be more concerned about producer deficits than excess surpluses, within the mobile industry, as surpluses tend to be competed away – leading to welfare transfers from producers to consumers.

Importantly, the impacts of mobile communications on GDP and on Welfare are largely additive:

- The GDP impact captures the extra activity that is enabled by increased adoption and usage of higher-performance mobile services – the positive 'externality'; while
- Welfare, in contrast, measures private benefits.

Any overlap between GDP and welfare effects is likely to be of a second order. Further welfare components that are mediated by mobile services include lower search costs, better matching, and convenience. The latter are hard to quantify, and some are more closely related to productivity, coordination, and new market activity – plausibly overlapping to a greater degree with the GDP effects.

On this basis, it seems reasonable to approximate a lower bound for total attributable socio-economic gains as the sum of (a) the GDP effects and (b) the welfare accruing from increased mobile consumption at lower unit prices.

Furthermore, GDP impacts also bear indirectly on the fiscal balance, since a larger economy also drives higher general tax receipts. This is an important consideration, as policy makers sometimes focus only on direct revenue extraction from the industry through licence fees.

3.4 Spectrum: the essential 5G enabler

Enabling the deployment of state-of-the-art technologies alone is not sufficient to achieve Digital Nation-building goals.

Sufficient low-band spectrum is needed to provide a robust coverage layer and to improve performance at the cell edges, while mid and higher mid-band spectrum is needed to meet capacity demand where demand is more concentrated, such as in urban centres.

Regulators should ensure that each operator can deploy 5G in at least one 100 MHz contiguous channel. In future, 200 MHz will be needed for 5G Advanced and 6G.

As discussed in further in Section 5.3, wider contiguous assignments are needed in higher bands, for the following two reasons:

- First, to obtain higher spectral efficiencies, which in turn deliver higher data rates on one hand, and higher capacity per MHz on the other;
- Secondly, to minimise network costs per Mbps of capacity delivered.

Higher capacity is essential to meet rising demand, and cost-efficiency is needed to ensure advanced mobile services can be made available at accessible retail prices.

5G allows TDD channels of up to 100 MHz wide, and these are optimal from a performance and cost per Mbps perspective. Regulators should seek to enable each operator in their market to deploy at least one such 5G channel. In future, this will need to increase to 200 MHz for 5G advanced and 6G.

9 '5G driving revenue growth in top 20 markets', Extract from the Ericsson Mobility Report, Business Review edition, February 2023.

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Making sufficient spectrum available is one prerequisite, making it available at moderate costs to operators is another. High spectrum prices often result in spectrum being unsold, hence unutilized (see the case studies in Section 4.2). High total costs of spectrum ownership also deflect capital away from deployment budgets, affecting network coverage and quality. Finally, high spectrum costs are likely to be passed on to consumers in the form of higher retail prices, affecting adoption and consumption (leading to lost productivity and GDP growth) as well as consumer welfare.

In short, spectrum insufficiency and excessive spectrum fees would ultimately impose heavy socio-economic costs. These are quantified for Egypt in Section 6.3.

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4. The State of 5G in Emerging Markets

4.1 Spectrum allocation: a first determinant of 5G outcomes

Significant spectrum allocation gaps are apparent across our sample, notably in 700 MHz and 3.5 GHz. Egypt, DRC and Bangladesh have yet to assign any 3.5 GHz to private mobile operators for 5G.

There are few factors more decisive for 5G outcomes than the quantity, timing, configuration and cost of IMT spectrum assignments. In this Section, we focus on allocation (we'll address cost in the next).

Two bands in particular play a central role in shaping digital performance:

- The **700 MHz band**, which provides wide-area, cost-effective coverage and is essential for inclusive 5G (and advanced 4G); and
- The **3.5 GHz band** (3.3–3.8 GHz), which underpins high-capacity 5G in dense urban areas and for advanced consumer and enterprise applications.

Across our sample of five Emerging Markets (EMs), policy choices around the 3.5 GHz band create a clear distinction between a more and a less favourable context for 5G.

Exhibit 3: Allocated IMT spectrum

Band	Egypt	DRC	Bangladesh	Pakistan	Vietnam
700 MHz	2x10 MHz	-	2x10 MHz	2x10 MHz	2x10 MHz
800 MHz	-	2x10 MHz	-	-	-
850 MHz	-	-	-	2x10 MHz	-
900 MHz	2x30 MHz	2x16 MHz	2x27 MHz	2x33 MHz	2x35 MHz
1800 MHz	2x45 MHz	2x43 MHz	2x72 MHz	2x65 MHz	2x75 MHz
2100 MHz	2x55 MHz	2x50 MHz	2x60 MHz	2x30 MHz	2x60 MHz
2300 MHz	-	60 MHz	70 MHz	50 MHz	-
2600 MHz	140 MHz	80 MHz	120 MHz	190 MHz	100 MHz
3.3-3.8 GHz	-	-	-	220 MHz	100 MHz
3.8-4.2 GHz	-	-	-	-	100 MHz
Total	**420 MHz**	**378 MHz**	**528 MHz**	**755 MHz**	**660 MHz**

Source: Coleago based on Spectrum-tracker.com and other sources

4.1.1 The mid-band gap: 3.5 GHz as the capacity anchor for 5G

In **Vietnam** and **Pakistan**, significant bandwidth in the 3.4-4.2 GHz range has already been made available for IMT/5G, which supports meaningful deployment.

By contrast, **Egypt**, **DRC** and **Bangladesh** have yet to assign any 3.5 GHz resources to commercial mobile operators. In Bangladesh, 60 MHz at 3.5 GHz was awarded to state-owned Teletalk in 2021, but the company failed to deploy 5G despite two project extensions and this spectrum is effectively unutilized[10]. The lack of 3.5 GHz in both markets means that:

- Operators cannot deploy true high-capacity 5G at scale, and must rely on refarmed LTE spectrum or non-ideal bands that offer lower performance;
- Network upgrades risk becoming incremental rather than transformational, with only modest gains in speed and latency relative to well-designed 4G;
- Enterprise and industrial 5G use cases, which depend on reliable mid-band capacity (e.g. smart manufacturing, logistics hubs, ports), remain largely out of reach.

10 Bonik Barta, October 2025: https://en.bonikbarta.com/technology/wXXcdCbsI4e6HI2c

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For these three markets, closing the 3.5 GHz gap is one of the single most powerful levers available to improve digital outcomes. Without timely awards of sufficiently large, contiguous mid-band blocks, 5G will remain a marginal overlay rather than a genuine step change in network capabilities.

While Vietnam and Pakistan currently stand in positive contrast relative to Egypt, DRC and Bangladesh, more progress can be made there too. With at least 400 MHz earmarked for IMT at 3.5 GHz in all ITU Regions, Vietnam and Pakistan should seek to dramatically increase total allocated bandwidth for 5G.

4.1.2 The coverage gap: under-allocation of 700 MHz

Intended as a 5G coverage layer, the 700 MHz band plays a strategic role in wide-area mobile broadband. With variations across ITU Regions, between 2×30 MHz and 2×45 MHz of spectrum in the 700 MHz range has been earmarked for IMT.

On this front, all five countries in our sample fall short, each having allocated as little as 2×10 MHz. This represents a significant lost opportunity:

- With only one third (or less) of the earmarked 700 MHz capacity available, operators cannot fully exploit the band's potential for cost-effective rural and deep-indoor coverage.
- Coverage obligations become harder and more expensive to meet, especially in sparsely populated or hard-to-reach areas.
- Inclusive digital access – one of the key promises of 5G in Emerging Markets – is weakened at the very foundation.

In Bangladesh, DRC and Egypt, this under-allocation of the "coverage anchor" band compounds the absence of the "capacity anchor" band at 3.5 GHz. Operators face a double constraint: they lack both the ideal low-band spectrum for ubiquitous coverage and the ideal mid-band spectrum for high-capacity services. Pakistan and Vietnam, by contrast, are closer to the internationally recognised IMT targets, even if implementation is not yet perfect.

4.1.3 The role of legacy bands

Other bands ranging from 800 MHz to 2600 MHz can also be used for 5G, in principle, however sufficient bandwidth needs to be maintained to serve legacy 4G demand. The pace at which 5G-enabled devices are diffused through EM customer bases will dictate the speed with which these bands can be made available for 5G (either through Dynamic Spectrum Sharing or through outright refarming to 5G).

The countries within our sample all have between 378 MHz (DRC) and 515 MHz (Pakistan) of bandwidth in these bands, and all have gaps in individual bands relative to their ITU Region IMT band-plans. Assigning these bands in full would improve outcomes for mobile users in 4G today, as well as across 4G and 5G in future.

The 2.3 and 2.6 GHz, in particular, present an important opportunity to drive up network capacity. Existing IMT band-plans provide for a total of 290 MHz across both these ranges, but all countries except Pakistan fall far short in terms of potential allocation[11].

In this regard, it is encouraging to see the progress made across the following African peer group:

- The full 190 MHz at 2.6 GHz already awarded to operators in Mozambique;
- The full 290 MHz included for IMT in Kenya's spectrum roadmap;

11 Pakistan has allocated 83% of the 290 MHz potentially available, versus 66% for Bangladesh, 48% for Egypt and DRC, and 34% for Vietnam.

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- The full 100 MHz at 2.3 GHz band being allocated on an administrative basis in Ghana[12],

Part of the progress within this group has been achieved by clearing historical assignments to Tier-2 FWA operators, which are invariably inefficient in terms of end-users per MHz compared with mobile network operators.

Efficient use of spectrum is a further imperative. First, it should be noted that TDD is more efficient than FDD, because of the flexibility it offers in setting the uplink versus downlink bandwidth ratio. On these grounds, adopting the full TDD band-plan for 2.6 GHz would be vastly preferable, where the choice may still exist.

Secondly, antenna systems with ever increasing MIMO configurations are being introduced across all legacy frequency ranges. While 4T MIMO was long considered a limit for sub-1GHz bands, 16T is now a reality. Massive MIMO deployments in lower FDD mid bands are also increasingly common, driving higher efficiencies in terms of Mbps per MHz.

Technology and spectrum availability can thus work hand-in-hand to deliver the network output required by consumers today and in the future.

4.1.4 Current spectrum roadmaps

Egypt – Recent policy signals suggest that the absence of 3.5 GHz awards will not be permanent. The National Telecommunications Regulatory Authority (NTRA) has adopted a Mobile Spectrum Roadmap for 2026–2030, which was approved by Egypt's Ministry of Communications and Information Technology (MCIT). This foresees the release of about 410 MHz of new mobile spectrum licences valid to 2039, in phases between 2026 and 2030, and includes:

- 350 MHz at 3.5 GHz;
- 40 MHz of additional spectrum in the 1800 MHz band;
- 20 MHz of additional spectrum at 2600 MHz band;
- In addition, existing 2600 MHz usage rights will be extended to 2039.

If implemented, these awards will almost double existing industry holdings. However, the main concern remains the pace with which these awards will take place.

DRC – While lagging the case-study sample group in terms of total spectrum allocated (378 MHz versus 420 MHz for next-lowest placed Egypt), the DRC has at least made a significant leap by adopting a technology-neutral, Unified Licencing framework[13]. The near-term spectrum roadmap includes the following[14]:

- The remaining 40 MHz at 2.3 GHz will be included in the next spectrum clearance plan, with a view to recover it from its current Tier-2 FWA occupant and reassign for IMT;
- A further 52 MHz of spectrum at 2.6 GHz has been cleared from FWA for mobile operators to use, and is currently pending allocation.

However, progress on 700 MHz and 3.5 GHz is wholly lacking – in sharp contrast with the Africa peer group that we invoked in Section 4.1.3:

- Mozambique: 40 MHz at 700 MHz plus 300 MHz at 3.5 GHz already allocated;
- Ethiopia: 200 MHz at 3.5 GHz already allocated;

12 Telecompaper, July 2026: https://www.telecompaper.com/news/ghana-invites-applications-for-5g-spectrum-licences--1577326
13 Ecofinagency.com, 9 December 2025.
14 Source: discussions with an international equipment vendor that is connected with relevant DRC stakeholders.

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- Ghana: 60 MHz at 700 MHz plus 150 MHz at 3.5 GHz to be awarded on an administrative basis;
- Kenya: historical 3.5 GHz assignments for FWA being cleared, with a total of 300 MHz earmarked for IMT.

Bangladesh – While recent and relevant policy documents could not be sourced, BSS News quotes the Posts, Telecommunications and Information Technology Minister, who refers to a roadmap under which "new spectrum in the 3.5 GHz band is planned to be released in 2027"[15]. In the meantime, the focus appears to be on the deployment of the 2300 and 2600 MHz bands for 5G, under technology neutral licences.

Pakistan – A major auction completed in March 2026 led to the award of 480MHz of spectrum out of nearly 600MHz on offer, including[16]:

- 700 MHz (2x15 MHz offered, 2x10MHz sold);
- 2100 MHz (2x20 MHz offered, no bids);
- 2300 MHz (50 MHz offered, fully allocated);
- 2600 MHz (190 MHz offered, fully allocated); and
- 3500 MHz (280 MHz offered, 220 MHz sold).

The failure to allocate almost 120 MHz of bandwidth is a major concern, which we discuss further in Section 4.2 below. Other than provisions to award unsold spectrum to qualified operators on a first-come first-served basis, there appear to be no published plans to allocate additional 3.5 GHz and 700 MHz spectrum in Pakistan in the foreseeable future.

Vietnam – Policymakers have already moved from planning to execution on 3.5 GHz. The Authority of Radio Frequency Management (ARFM) and the Ministry of Information and Communications ran the country's first 5G spectrum auctions in early 2024, covering both 2.6 GHz and 3.5 GHz bands. Viettel secured mid-band capacity in the 2.5–2.6 GHz range, while VNPT and MobiFone obtained licences in the 3.7–3.8 GHz and 3.8–3.9 GHz segments respectively, increasing total mid-band spectrum available for 5G and roughly doubling mobile spectrum holdings compared with the pre-5G period[17].

According to the GSMA[18], the regulator has already identified additional 3.5 GHz capacity and the full upper 6 GHz band as part of its long-term roadmap, laying the groundwork for deeper 5G coverage and an early transition to 6G.

4.2 Spectrum pricing: a second driver of 5G outcomes

Policies on spectrum pricing can have a dramatic impact on spectrum allocations. This is clearly evidenced by the cases of Pakistan and Vietnam, highlighted below. These show how high spectrum prices, historically, led to unsold –and therefore to unused spectrum, scuppering 4G ambitions at the time.

The comprehensive policy shifts in both countries demonstrate how sp5ectrum fee moderation can ensure that socially invaluable spectrum can reach the market and be made available to consumers. On this evidence, the persistently high spectrum fees in Egypt and Bangladesh are likely to perpetuate sorry digital outcomes for their citizens.

15 BSS News, June 2026: https://www.bssnews.net/special-stories/392971
16 Sources: (1) Data Darbar, March 2026: https://insights.datadarbar.io/how-pakistans-spectrum-auction-played-out/; (2) PTA Information Memorandum, January 2026.
17 Techwire Asia, February 2026, 'Vietnam's 90% spectrum discount triggered the fastest 5G rollout in Southeast Asia': https://techwireasia.com/2026/02/vietnam-90-percent-spectrum-discount-5g-rollout-southeast-asia/
18 GSMA, 'Policy leadership powering Vietnam's digital leap', March 2026: https://www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/policy-leadership-powering-vietnams-digital-leap/

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Note that our comparisons of total costs of spectrum ownership, below, are based on blended prices per MHz per capita across multiband portfolios. The mix of bands in the portfolios being considered differs, which introduces a degree of error in the comparisons. Accordingly, these should be taken as broadly indicative for pricing levels across markets. These price differentials are also normalised for GDP per capita levels and for licence durations[19].

The annual burden of spectrum ownership in Egypt and Bangladesh is equal to 15% of revenues – a massive transfer of capital to the state from a GDP-critical sector.

Egypt – Administrative awards of 2.6 GHz spectrum during 2020-2022 were priced at $1.6 billion on aggregate, for 110 MHz with 10-year licence durations (implying a price around $0.13 per MHz per capita, which is expensive for the duration in a low-income market). An additional $675 million was levied for 5G concessions[20].

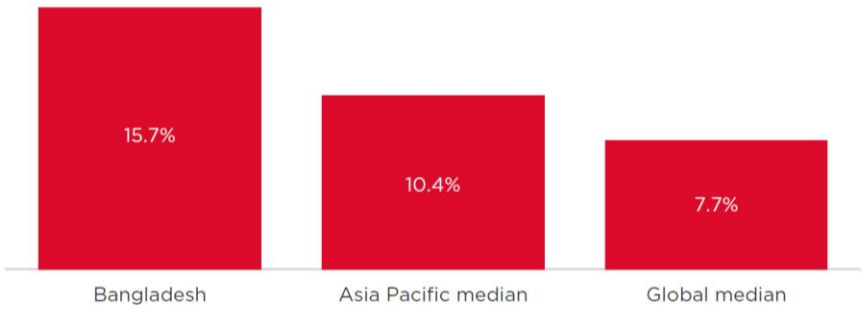
The additional 410 MHz in the 2026-2030 road map is priced at $3.5 billion (implying a blended rate of around $0.07 per MHz per capita, for licence durations of between 9 and 13 years)[21]. This is still comparable with the 2020-2022 prices for 2.6 GHz, quoted above,

We estimate that the incremental cost of spectrum ownership in Egypt will be the highest within our sample group by far (see Exhibit 8). These will be around 37% higher than the already very high blended annual cost of spectrum in Bangladesh, after adjusting for nominal wealth levels.

The high overall cost of spectrum ownership is likely to constrain 5G network rollout budgets.

Bangladesh – The burden of spectrum fees on operators is exceptionally high. According to the GSMA, the economic burden of spectrum ownership exceeds **15%** of operator revenues. This is compounded further by royalties of 5% of revenues, and USO Fund contributions of 1%, as well as by high sector-specific corporate taxes by regional standards[22].

Exhibit 4: Cost of spectrum as % recurring operator revenues



Note: The figure for Bangladesh is based on data for the three largest operators, excluding Teletalk. Asia Pacific and global medians are based on countries where data was available.
Source: GSMA Intelligence estimates based on GSMA Intelligence data

Source: GSMA

DRC – We have one data point from 2022, concerning the purchase by Airtel Africa of 58 MHz in spectrum licences across the 900, 1800, 2100 and 2600 MHz bands, with a 10-year duration, for $42 million[23]. Adjusted for GDP per capita and duration, the latest

19 For simplicity, we divide lump sum spectrum fees by licence durations to obtain an indication of the annual cost of spectrum ownership. This reflects the annual amortization expense, without adjustment for the time-value of money. GDP per capita estimates based on 2025 World Bank Open Data for GDP and population.
20 Eicon-me.com, 2022: 'NTRA Egypt assigns more spectrum, but is it enough, and at what price?'
21 Telecoms.com, February 2026: https://www.telecoms.com/spectrum/egypt-flaunts-3-5-billion-spectrum-allocation
22 GSMA, 'The impact of spectrum pricing in Bangladesh', September 2025
23 Business Insider Africa, 6 June 2022.

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blended prices in the DRC were around a quarter the incremental prices proposed in Egypt.

Pakistan – Previous auctions have been characterised by high reserve prices, both in 2014 (850 MHz, 1800 MHz) and in 2021 (1800 MHz, 2.1 GHz). The latter only attracted a single bidder, who acquired only one third of the spectrum on offer[24]. This policy resulted in slower 4G roll-out, with less bandwidth, and slower 4G adoption.

The 2026 auction represented a sea-change in policy. It raised $510 million from 480 MHz across multiple bands, implying a blended rate of $0.004 per MHz per capita, for 15-year licences. Adjusted for GDP per capita and duration, the latest blended prices in Pakistan were around a *thirteenth* of the incremental prices proposed in Egypt.

In addition, provisions were put in place for phased payment of the fees (50% in year 2, the remainder in 5 annual instalments, subject to interest), to allow operators to spread the burden more evenly.

In spite of this, almost 120 MHz was unsold during this latest auction – round 20% of the spectrum on offer. Whilst disappointing, this marks a significant improvement above previous auctions. It should also be noted that the licences came with onerous deployment and Quality of Service (QoS) obligations.

Most importantly, this highlights the economic pressures operators face in many markets, and the need to set reserve prices at a level that is broadly accessible.

Vietnam – As with Pakistan, previous auctions failed due to unduly high prices. A first auction for 2300 MHz in 2023 attracted no bids, despite 4 operators expressing interest and qualifying. Neither of these appeared willing to pay the required deposits[25]. A further 700 MHz auction planned for later in that year never took off and was finally held in 2025, after a dramatic shift in policy.

Following the 2023 fiascos, the Vietnamese regulator slashed spectrum reserve prices by up to 90%, and introduced subsidies that cover up to 15% of 5G base-station costs for operators that meet rollout targets[26]. By our estimates, price levels in Vietnam since the policy-change were just around 9% of those proposed in Egypt (i.e. 91% lower).

Effectively, the regulator swapped high spectrum fees for coverage obligations, and boosting this policy with additional deployment incentives.

The subsequent awards across the 3.5 GHz, 2.6 GHz and 700 MHz bands more than doubled industry bandwidth. Taken together, these policies drove a major spur in 5G deployment (see the next Section).

4.3 5G outcomes across our sample

Given the stark differences between our five case-study markets, highlighted above, the state of 5G in these countries may be expected to diverge markedly too.

4.3.1 State of 5G in Egypt

The first dedicated 5G licence was only granted to Telecom Egypt in early 2024, with other operators following as IMT spectrum in key bands was released.

5G is currently deployed in 2600 MHz, with operators holding between 20 and 40 MHz in this band. This yields a very ‘thin’ 5G capacity layer. A further issue is that operators

24 Sources: (1) GSMA: https://www.gsma.com/connectivity-for-good/spectrum/successful-auction-marks-a-key-milestone-for-digital-pakistan/; (2) Express Tribune, August 2024: https://tribune.com.pk/story/2485586/upcoming-auction-for-mobile-internet

25 Vietnam Net, June 2023: https://vietnamnet.vn/en/no-network-carriers-participate-in-auction-of-4g-5g-frequencies-2151667.html

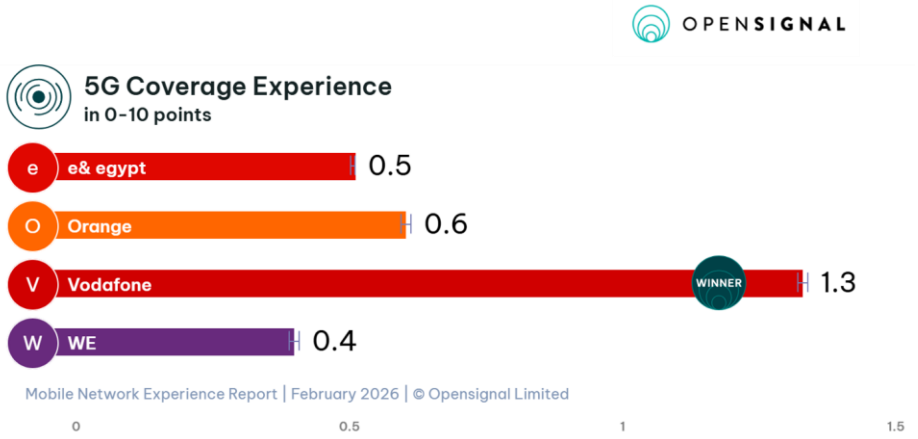
26 GSMA, ‘Policy leadership powering Vietnam’s digital leap’, *ibid*.

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need to maintain sufficient bandwidth to serve legacy 4G demand. With industry holdings of only 420 MHz, this presents a major challenge.

5G data speeds are roughly half of those in neighbouring Tunisia. On average, 5G devices camp only 5% of the time on 5G, which attests to poor 5G coverage[27]. The lack of coverage quality is further underscored by the OpenSignal's customer coverage-experience scores for 5G, averaging less than 1 out of 10.

Exhibit 5: Coverage experience in Egypt (February 2026, score out of 10)



Source: OpenSignal

GSMA Intelligence estimates that 9.3% of total 4G and 5G connections were 5G-enabled in Egypt as of Q2 2026, with 5G coverage of 24.5% of population.

4.3.2 State of 5G in the DRC

Following the transition to technology neutral licences, 5G in the DRC graduated from trials to commercial launch during Q2 2026, with very early-stage adoption. GSMA Intelligence figures suggest that 5G accounted for less than 1 per 1000 connections as of June.

5G coverage data is not available, however the 5G footprint is likely still very narrow and focused on Kinshasa and/or Lubumbashi.

4.3.3 State of 5G in Bangladesh

According to OpenSignal, Bangladesh has a long journey ahead, given limited initial rollouts to date, low 5G device penetration, and the continued development of 4G networks in the market. The 700 MHz award should support broader 5G coverage, but is unlikely to add much to the urban capacity delivered using 2300 and 2600 MHz bands. Total available 5G bandwidth is higher than in Egypt, but significantly lower than in Pakistan and Vietnam.

As of January 2026, only Robi and Grameenphone had launched 5G, with no plans announced by Banglalink and Teletalk[28].

Where 5G is available, healthy data-speeds are obtained (up to 170 Mbps download for Robi). However, this may also reflect low current 5G penetration rates –leaving much of the bandwidth uncontended, driving higher speeds for fewer users.

27 OpenSignal, January 2026: https://insights.opensignal.com/2026/01/egypt-5g-journey-readiness-launch-and-early-performance
28 OpenSignal, January 2026: https://insights.opensignal.com/reports/2026/01/bangladesh/mobile-network-experience

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Exhibit 6: 5G availability statistics in Bangladesh (January 2026)



Source: OpenSignal

OpenSignal's statistics suggest 5G availability averages below 9% of the time, which suggests poor coverage, currently focused on dense urban areas.

GSMA Intelligence estimates that just 2.7% of total 4G and 5G connections were 5G-enabled in Bangladesh as of Q2 2026, with 5G coverage of 13.5% of population.

4.3.4 State of 5G in Pakistan

As of February 2026, OpenSignal was not publishing any 5G-specific statistics for Pakistan. This suggests that operators effectively waited for the allocation of incremental spectrum (including 3.5 GHz) to support their 5G launch plans, focusing on 4G alone up to that point.

Within less than a month after the auction, however, operator Zong claimed to be the first to introduce commercial 5G in Pakistan, launching in 16 cities – which would have required significant pre-implementation spend prior to the auction[29].

In May 2026, operator Jazz announced plans to expand 5G rollout to 1,000 sites by mid-August[30]. These announcements suggest that the March auction was successful in generating momentum, enabling rapid introduction and expansion of 5G.

As of Q2 2026, however, GSMA Intelligence estimates that just 0.3% of total 4G and 5G connections were 5G-enabled in Pakistan as of Q2 2026, with 5G coverage of 5% of population.

4.3.5 State of 5G in Vietnam

Vietnam is the example to emulate, having achieved the most dramatic 5G transformation.

From the lowest spectrum costs within our sample, Vietnam has achieved the most dramatic national 5G transformation.

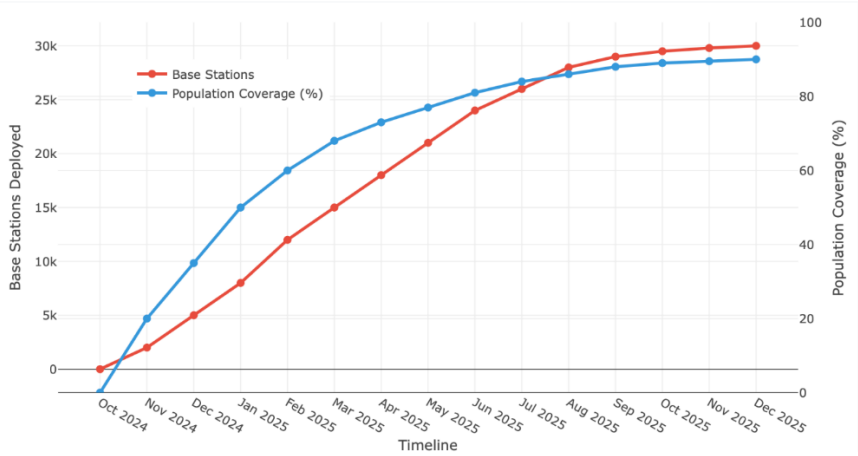
Operators in Vietnam installed 5G on 30,000 sites in just 14 months, achieving around 90% population coverage[31]. This represents over 2000 sites per month, and over 500 on average per operator.

5G adoption already stands at 23 million customers as of March 2026, implying a penetration rate of 22.5% of the population[32].

29 Arab News, March 2026: https://www.arabnews.com/node/2636907/pakistan
30 Arab News, May 2026: https://www.arabnews.com/node/2642623/pakistan
31 Techwire Asia, February 2026, *ibid*.
32 Vietnamnet Global, March 2026: https://vietnamnet.vn/en/vietnam-brings-5g-to-90-of-its-population-2500426.html

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Exhibit 7: 5G deployment timeline in Vietnam



Source: TechWire Asia (based on GSMA Intelligence and operator reports)

According to the GSMA[33]: *Targets such as nationwide fibre coverage, 5G in all provinces and mobile broadband across major transport routes are no longer long-term aspirations. They are tied to updated public-private partnership (PPP) rules, higher infrastructure investment and a Telecommunications Law that opens the market to cloud and data-centre providers while reducing licensing barriers*.

And: *Innovation is gaining momentum too. Commercial 5G services launched at the end of 2024. Open RAN pilots are giving local firms more opportunities, while the national 6G Task Force signals early preparation for technologies on the horizon*.

On account of its trailblazing policies, Vietnam was granted the GSMA Government Leadership Award at MWC 26.

GSMA Intelligence estimates that the proportion of 5G-enabled connections in Vietnam reached a total of 23.5% of combined 4G and 5G by the end of Q2 2026.

Given these striking developments, one may ask whether an impact of 5G on the wider economy is already visible. The following key figures were presented at the Vietnam Government's Steering Committee on a.o. Digital Transformation in May 2025[34], spanning to first four months of 2025:

- 22% growth in e-commerce activity, with a 19% increase in tax revenue collection from e-commerce activities;
- 38.7% increase in cashless payments;
- 16.2% increase in technology product exports;
- 44.4% increase in ICT industry revenues.

5G will undoubtedly have contributed to the growth in e-commerce and possibly also to cashless payments. It is also plausible that 5G may have played a part in driving cross industry efficiencies, contributing to the success of the technology products sector.

4.4 Summary of case studies

Exhibit 8 below summarizes the key metrics and our assessment across our case study sample. On all metrics, Vietnam stands out as the EM most should seek to emulate.

33 GSMA, 'Policy leadership powering Vietnam's digital leap', *ibid*.
34 From infographic published at: https://vietnam.vnanet.vn/english/long-form/5g-commercialisation-helps-drive-in-depth-development-of-digital-economy-433672.html

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On 5G coverage and penetration, Egypt is currently in second position within our sample. However, its relative position is at high risk, while:

- Egypt remains the most constrained market in terms of total spectrum bandwidth, resulting in the 'thinnest' 5G capacity layer;
- Narrow 5G channels result in weaker network performance and in cost inefficiencies (higher costs per MHz deployed);
- High costs of spectrum ownership reduce available capital for deployment.

Bangladesh is currently third on 5G coverage and penetration. However, it is likely to be overtaken by Pakistan, which has seized a big advantage on spectrum allocation and pricing, giving it the momentum.

Exhibit 8: Benchmark overview

Column title	Egypt	DRC	Bangladesh	Pakistan	Vietnam
Population (million)	118	113	176	255	102
GDP per capita	$3,085	$807	$2,600	$1,600	$5,066
Total allocated spectrum	420 MHz	378 MHz	528 MHz	755 MHz	660 MHz
Spectrum price index (Adjusted, Egypt=100)	100	23	73	8	9
5G-enabled as % 4G+5G connections	9.3%	0.1%	2.7%	0.3%	23.5%
5G population coverage	24.5%	N/A	13.5%	5%	>90%
Coleago assessment	Currently #2 in sample; at risk due to policies	#5 in terms of 5G progress and momentum	Currently #3 in sample; Pakistan likely to overtake	Currently lagging but high 5G momentum	Undisputed 5G leader on all metrics

Source: Coleago based on quoted sources

Unless Egypt, DRC and Bangladesh reset their spectrum policies, 5G outcomes in these markets will remain deeply sub-par –leading to dramatic lost opportunities to drive Welfare gains and mobile-enabled productivity and GDP growth.

4.5 Other barriers to 5G in Emerging Markets

As illustrated by our case studies, spectrum insufficiency and capital constraints (due for example to excessive licence fee extraction from the industry) are the two main barriers to true 5G deployment. But there are others too.

Planning and permitting is one issue that may constrain infrastructure deployment. But this tends to affect new site build rather than 5G deployment on existing sites. Moreover, planning and permitting tends to be a greater problem for operators in high-income countries than in EMs. This is because advanced economies usually have more complex, fragmented and stringently enforced zoning, aesthetic, and environmental regulations.

5G device diffusion is a more prominent issue, especially in EMs, where high initial smartphone costs restrict consumer adoption compared to high-income nations. As the 5G ecosystem matures, this affordability constraint is increasingly mitigated by the rapid growth of secondary device markets, offering accessible refurbished, as well as by the increased availability of lower-tier options.

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5. Impact of Spectrum Policy and 5G on Networks

5.1 Egypt: two distinct scenarios

The spectrum roadmap set out by the NTRA implies that the spectrum needed to deliver 'true 5G', notably the 350 MHz in the 3.5 GHz band, could be made available any time between 2026 and 2030 (see Section 4.1.4). In a worst case, under the roadmap, this critical resource might only be released at the end of 2030, which would mean consumers need to wait until at least 2031 for it to be meaningfully deployed.

This yields two distinct book-end scenarios: one in which 'true 5G' is launched in 2027 (the soonest this could occur, even if 3.5 GHz is assigned in Q4 2026), and another in which it is delayed beyond 2030.

Key outcome-determining parameters being subject to some uncertainty, we have adopted a conservative stance in our choice of inputs, with a bias towards understating rather than exaggerating the impact of true 5G in Egypt.

5.1.1 Key assumptions

Key model inputs, summarized in Exhibit 9, include the following:

- Total mobile data demand across the Egyptian market is as projected by GSMA Intelligence, implying a **2.7x** factor increase from 2025 to 2030[35];
  - We apply the same traffic across both scenarios, which likely understates the impact of true 5G: a step-change in available capacity, with the deployment of 5G at 3.5 GHz, would likely stimulate significant extra data consumption;
  - We also assume that revenues are identical across both scenarios, ignoring any increase that true 5G would likely drive (see Section 3.3, specifically Ericsson's findings on the correlation of 5G adoption and revenue expansion);
- For simplicity, we ignore 2G and 3G data traffic, which is likely to be a very small proportion of the total, and we assume that all bands are either deployed for 4G or for 5G –which is likely to understate the net impact of true 5G;
- The extra 40 MHz at 1800 MHz and 20 MHz at 2600 MHz in the roadmap are assigned immediately (implying a total of 480 MHz excluding the 3.5 GHz band);
  - Note that in the True 5G scenario, 2600 MHz is redirected towards 4G, as this would be more efficient: 3.5 GHz gives more than sufficient 5G capacity up to 2030, while more 4G capacity is needed to support legacy demand;
- Tri-band 32T massive MIMO is deployed across 1800, 2100 and 2600 MHz on all sites (likely optimistic);
- Each network operator in Egypt has 9,200 sites[36];
  - Aggregate industry output is modelled as if the sites from all operators were co-located, with all available spectrum resources deployed on these;
- We constructed a site busy-hour distribution across the network based on anonymised operator data from a range of markets, with a bias on Egypt regional peers that have less concentrated distributions[37] – yielding the profile in Exhibit 12;
- Maximum cell loading factor: **80%** PRB utilization

35 GSMA Intelligence database, accessed in August 2026.
36 This figure is an estimate of Vodafone Egypt's site count provided by Mordor Intelligence in its forecasts for the Egypt MNO market, 2026-2031. Assuming all operators have the same site count as the market leader is likely to understate the severity of spectrum insufficiency.
37 A 'flatter' distribution of peak traffic tends to understate the impact of spectrum insufficiency.

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- This is the point at which busy hour demand is deemed to equal the capacity supplied by a cell;
- Hence it is the point beyond which a site or sector is deemed to be congested, requiring a capacity upgrade[38].

Exhibit 9: Key model inputs

Category	Parameter	Model input
Traffic	Data traffic per capita in 2025	11.6 GB per month
	Growth factor 2025-2030	2.7x (28.5 GB in 2030)
Busy hour	% daily traffic in the busy hour	10%
	% traffic in the downlink	90%
	% in busiest 20% of sites	32.5% of total busy hour
	% in busiest 50% of sites	67.5% of total busy hour
	Maximum cell loading factor	80% PRB utilization
Spectrum and MIMO order	700 MHz	20 MHz, 5G, 2T MIMO
	900 MHz	60 MHz, 4G, 2T MIMO
	1800 and 2100 MHz	240 MHz, 4G, 32T MIMO
	2600 MHz in the 'True 5G' case	140 MHz, 5G, 32T MIMO
	2600 MHz if no 3.5 GHz	140 MHz, 4G, 32T MIMO
	3.5 GHz ('True 5G' case only)	350 MHz, 5G, 64T MIMO
Spectral efficiencies	4G with 2T MIMO	1.57 Mbps per MHz[39]
	5G with 2T MIMO	1.8 Mbps per MHz
	Per doubling of the MIMO order	1.27x increase
Site and other assumptions	Baseline site count	9,200 sites
	Average sectors per site	3 on average
	% Site traffic in the busiest sector	40% of site busy hour
	% TDD bandwidth for downlink	72%

Source: Coleago

For both scenarios, across 4G and 5G, we obtain the 'raw capacity' contributions per site in Mbps shown in Exhibit 10. 'Raw', here, means before any adjustment for:

- The proportion data demand that is 5G compatible, if this is lower than the 5G share of total capacity; and/or
- Capacity traded for enhanced coverage (as discussed further below).

The raw capacity contribution from the 3.5 GHz band alone is a staggering 1.7x of the combined total from all legacy bands. However, this capacity can only be accessed by 5G devices. To compare effective 4G and 5G capacity on a like-for-like basis, therefore, we need to consider the projected mix of devices and the relative data usage intensity across 4G and 5G devices.

GSMA Intelligence projects that 36% of (4G plus 5G) connections will be 5G-enabled in Egypt by 2030. But data usage per 5G connection tends to be far higher than that per 4G connection – typically in the order of 2x, irrespective of 5G market maturity:

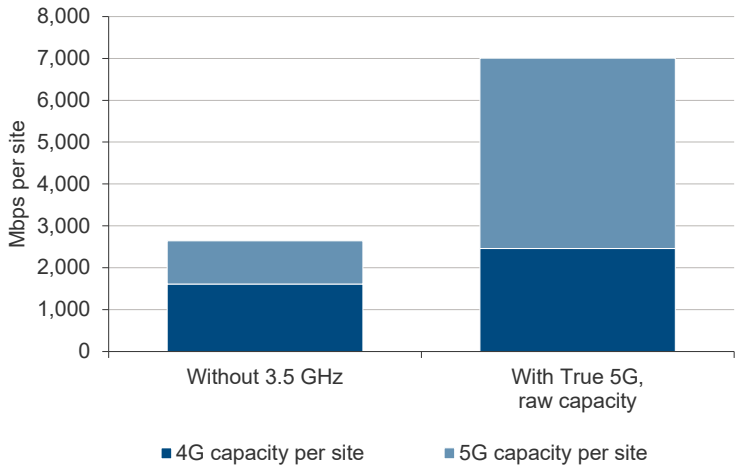
- Early in the 5G lifecycle (October 2020), OpenSignal reported that 5G users on average consume up to 2.7x more mobile data compared to 4G users[40];

38 Beyond 80% PRB (Physical Resource Block) utilization, the quality of user experience degrades significantly. Quality-focused operators may set a lower capacity threshold.
39 We assume that the spectral efficiency of 5G is 15% than that for 4G on a like-for-like band and MIMO configuration. Taking 1.8 Mbps/MHz for 5G as a baseline, this yields 1,57 for 4G.
40 Based on a study of 6 markets including South Korea (2.0x), UK (2.5x), Japan (2.6x), USA (1.9x), Australia (1.7x), Germany (2.7x).

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- Ericsson's Mobility Report (June 2026) implies that on a global basis by 2030, average 5G traffic per 5G connection will be 1.95x the 4G traffic per 4G connection.

Exhibit 10: Raw capacity per site



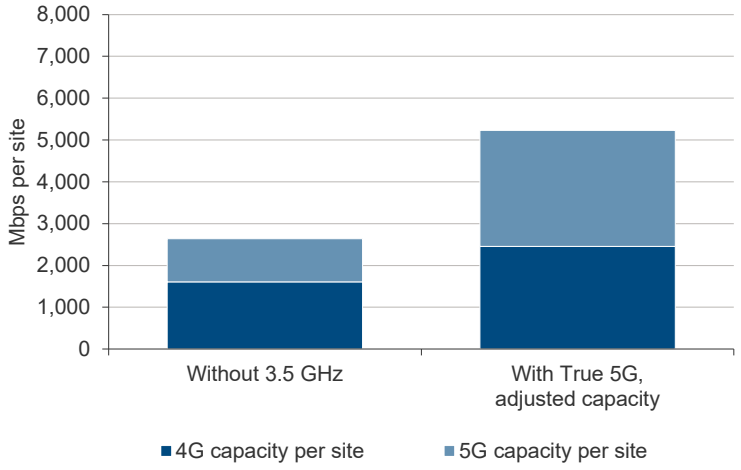
Source: Coleago

The 3.5 GHz band would double effective capacity per site in Egypt.

We assume that Ericsson's global 1.95x unit-traffic multiple for 5G is broadly representative for Egypt. If so, the 5G traffic generated by 5G-enabled connections (36%) will be **53%** of the total by 2030. Any 5G capacity beyond 53% of the total may be deemed 'surplus capacity', that is not needed to serve 5G demand within the 80% PRB utilization threshold. The net result is that only **60%** of the 3.5 GHz bandwidth is strictly needed by this criterion – albeit this will increase after 2030, as 5G penetration rises.

To calculate how many new sites are needed to meet combined 4G and 5G demand in each scenario, we use the 'effective' 5G capacity, adjusted down to 53%, as shown below:

Exhibit 11: Effective capacity per site



Source: Coleago

Effective capacity per site in the True 5G scenario is still around double that without 3.5 GHz, which is one reason for which it would be so transformative for mobile networks in Egypt. Also note that while we use this adjusted supply figure to estimate network densification requirements, it is not the case that the implied 'spare capacity' is left idle.

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On the contrary, the full band continues to be utilized. With massive MIMO systems, a portion of capacity can be traded for extra coverage, which means that the 3.5 GHz can effectively behave more like lower mid bands for users closer to the cell edge. We estimate that around **30%** of 3.5 GHz capacity would typically be traded for this.

This yields the following breakdown of 3.5 GHz capacity utilization:

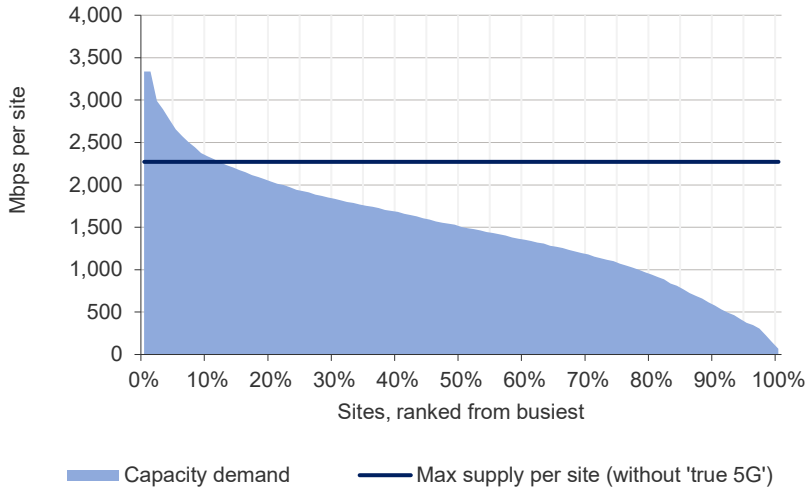
- 60% effective capacity – needed for parity with legacy resources on % cell loading;
- 30% traded for coverage and cell-edge performance;
- 10% net surplus.

The net 10% surplus ensures that the PRB utilization rate remains well below 80%, which results in higher quality of service for all the users that have 5G devices. In short, nothing is wasted.

5.1.2 Capacity demand versus supply

Our assumptions yield the following snapshot for aggregate demand versus supply of capacity in Egypt for 2025.

Exhibit 12: Capacity demand versus supply in Egypt in 2025



Source: Coleago

The solid blue line above represents the downlink capacity delivered per site, and it is the product of downlink bandwidth in each band and the spectral efficiencies assumed for each band. The light-blue area curve represents the demand for capacity per site during the busy hour. It depicts the typical 'pareto' distribution in which a minority of busy sites carry a majority of total site busy-hour traffic.

For sites where the light-blue curve is above the solid blue line, demand for capacity exceeds supply[41]. The 2025 snapshot above, which is likely optimistic for the reasons outlined earlier, would suggest that around 11% of the busiest sites would be deemed to be congested. These carry around 20% of busy hour traffic, meaning that a fifth of demand would be served with low quality during peak times.

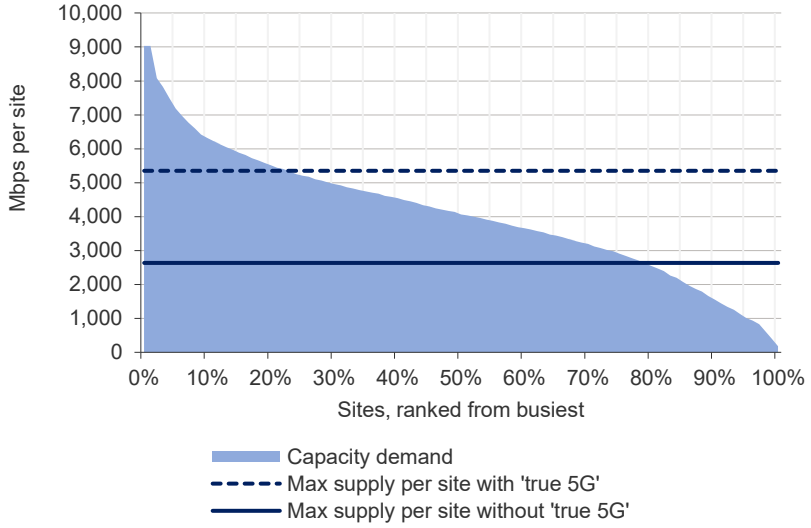
By 2030, with total traffic growing by a factor of 2.7x, the outlook for capacity demand versus supply would be far worse. This relationship per site, based on the *current* assumed site count, is shown in Exhibit 13 below.

41 Supply, based on the chosen maximum cell loading factor, which is a network quality or design criterion.

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The light-blue area curve (demand) crosses the solid blue line (supply) at the 78% mark, which means that demand for capacity would exceed supply for the busiest 78% of existing sites. In contrast, if 3.5 GHz is added to all existing sites, only 22% of sites run out of capacity by the end of 2030, based on the effective capacity supply[42].

Exhibit 13: Projected 2030 capacity demand versus supply per current site



Source: Coleago

Moreover, in the 'Without true 5G' scenario, the busiest sites would need more than 2x the capacity currently provided, implying a tripling rather than a doubling of site density in those areas. Given the demand and the supply per site, we calculate the total extra sites needed as follows:

Exhibit 14: Network deployment requirements

Deployments	Without true 5G	With true 5G
% Sites needing 3.5 GHz	Not applicable	78%
Total 3.5 GHz deployments (per MNO)	Not applicable	7,176
% Sites needing cell splits	78%	22%
% Sites needing 2-way cell splits	22%	-
Total extra sites needed to meet demand	9,200	2,024

Source: Coleago

Without true 5G therefore, operators in Egypt would effectively need to double their total existing site counts to meet projected demand by 2030.

Assuming, optimistically, that this were achieved via a tower company, with all new sites shared by each of the four MNOs, this would imply an average of 2,300 new sites per each of the 4-years spanning 2027, 2028, 2029 and 2030. While such a roll-out programme would be ambitious, precedents suggest it should remain feasible[43].

So, what exactly is the problem? Two main issues would persist with this scenario:

42 This is point below which the demand curve is above the dashed blue line (effective capacity supply in the True 5G case), and which corresponds with the 22% busiest sites.

43 IHS towers committed to building 5,800 new sites within a 3-year period, which is almost 2,000 per year. See: 'IHS Towers Signs Agreement with EDCI to Build and Lease Telecom Towers in Egypt', October 2021.

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- It would be very costly, even with 4-way sharing of passive infrastructure – these costs would likely be passed on to consumers in the form of higher prices and/or reduced investment (leading at best to partial realization of this scenario);
- The outcome would still fall far short of the promise of true 5G.

We address both of these in turn below.

5.1.3 Cost comparison

The essential point is that building a new site for capacity costs significantly more and delivers less capacity than adding 3.5 GHz to an existing site.

Exhibit 15 below shows typical, normalized unit TCO by component, for emerging markets, based on internal Coleago benchmarking. It assumes the site configurations detailed in Exhibit 9, and that, optimistically, backhaul is included in the 4-way sharing of passive infrastructure.

Exhibit 15: Unit cost breakdown per site and per operator

Component	Normalized TCO
Passive infrastructure and backhaul, shared 4-ways	37
Active equipment, all bands below 3.5 GHz	33
Total for a site without 3.5 GHz	70
Added by 3.5 GHz (5G, 64T)	30
Total TCO per site with maximum specification	100

Source: Coleago

This suggests that the cost of adding 3.5 GHz to an existing site is 43% of the cost a new, high-specification site that excludes 3.5 GHz. Meanwhile, the effective capacity of the 3.5 GHz layer is roughly equal to that of all other bands combined[44]. In other words, the 3.5 GHz network TCO is less than half that for all other resources, both in absolute terms and per unit of effective capacity.

Multiplying the number of deployments calculated in the previous Section by the above unit TCO figures yields the following totals for both scenarios:

Exhibit 16: Network TCO comparison (2030)

Normalized TCO	Without true 5G	With true 5G
3.5 GHz deployments	0	215,280
New sites without 3.5 GHz	644,000	141,680
Total capacity-expansion TCO	644,000	356,960

Source: Coleago

Under equal traffic, true 5G could reduce network TCO by an amount equal to up to 11% of revenues.

To conclude, by 2030, annual capacity-expansion TCO in the true 5G case would be just **55%** of that without 3.5 GHz – a massive cost saving.

Assuming total RAN-related TCO is up to 40% of revenues and that capacity-expansion TCO is half that amount (in the without 3.5 GHz case), this yields a cost differential between both scenarios equal to up to **11% of revenues**. If all else were equal, this would imply an 11-percentage point increase in EBIT (and pre-tax profit) margin.

44 The 43% figure is obtained from the normalized cost of 30 for 3.5 GHz divided by the 70 for a full site without 3.5 GHz. Based on our modelling, the capacity of a site without 3.5 GHz is 2,638 Mbps, whereas the 3.5 GHz layer adds 2,716 Mbps in effective capacity.

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In normal circumstances, such gains would be partly offset by extra spectrum fees in the true 5G case. Furthermore, competition would typically ensure that a significant proportion of the net savings, after extra spectrum fees, would be passed on to consumers in the form of lower retail prices (which would contradict the simplified scenario assumptions that we drew up to estimate the gross impact in the first place[45]).

But even if only a fifth of the network TCO savings were retained by operators, the 2 percentage-point increase in EBIT margin would be substantial in an industry that struggles to earn its risk-adjusted cost of capital.

In Egypt however, the extra $3.5 billion in spectrum fees would offset almost all of the gross TCO savings. The net social cost of this is discussed and quantified in Sections 6.2 and 6.3. Iraq and other Arab nations should avoid going down the same route.

5.1.4 Network performance and capabilities

The 3.5 GHz band would generate data rates that are 3.5x faster than for 5G in legacy bands.

In addition to increased cost efficiency, the True 5G scenario also delivers substantially increased network performance and capabilities.

Deployment of a wideband 5G channel already provides a first, step change in performance. Even under saturated conditions, a user on a 100 MHz 5G cell will experience in the order of **2.5x** faster data speeds than a user on an equally saturated 40 MHz 5G cell.

Moreover, in our scenario, the 3.5 GHz channel never even gets near saturation, because there is still a net 10% of surplus capacity in this band. Under equal radio conditions, when legacy bands on a site reach saturation, at 80% PRB utilization, the 3.5 GHz band would reach 72%. This would drive a further increase in experienced data rates of **1.4x** under saturated conditions.

Taken together, 5G users may expect data rates that are around **3.5x** faster under peak traffic conditions, through the introduction of 3.5 GHz[46].

This 3.5 GHz-driven performance boost transforms the quality of experience and operational capability across Consumer, Home and Business verticals.

The combined value of True 5G with SA to each of these may be summarized as follows.

- **Consumer**: Ultrafast Mobility and Latency-sensitive applications;
- **Home**: Fibre-like Fixed Wireless Access (FWA);
- **Business**: Catalyst for Industry 4.0 and AI Integration (as discussed in Section 3.2).

The net socio-economic impact of the delay in True 5G deployment in Egypt is addressed in Section 6.3.

5.2 Impact of high spectrum costs on operators

High spectrum fees cannibalize direct network investment, leading to poor outcomes for consumers and for economic development.

High spectrum fees crowd out capex, impeding network deployment, which ultimately harms consumers.

To put things into perspective, consider the annual burden of spectrum ownership in Bangladesh. It currently exceeds 15% of recurring revenues, as discussed in Section 4.2. This is in the same order as typical *network* capex budgets. It is simply not feasible

45 In spectrum valuation, under the 'avoided cost' method, it is common to assume a fixed demand forecast across alternative spectrum scenarios. The value of avoided costs calculated this way is taken as a reasonable (if imperfect) approximation of spectrum value – while recognizing that in practice, actual revenue and traffic levels are likely to vary with spectrum supply.

46 This is obtained from the product of 2.5x (speed boost under equal cell loading) and 1.4x (impact of lower cell loading).

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to maintain the same level of network roll-out while shouldering such high spectrum costs.

Adjusted for GDP per capita and licence duration, the proposed prices in Egypt will be even higher than in Bangladesh (37% by our estimates), adding to the high economic burden of existing spectrum holdings. Based on available figures in the public domain, we estimate that the burden of 2600 MHz licences plus that of the additional 410 MHz in the 2026-2030 road map will amount to 14.5% of annual revenues.

Relative to revenues, these figures suggest spectrum fees in Egypt are equally high as those in Bangladesh. However, our calculation excludes the cost of other legacy bands (over which we were unable to find reliable data), so this may be taken as a lower bound estimate.

5.3 The importance of wide-band assignments

Wide band 5G channels of 100 MHz TDD in higher-mid bands are optimal both from a channel performance perspective, and from a cost-efficiency perspective.

New band deployments on a site involve the installation of radio units, antenna systems (high order MIMO in the case of mid and higher bands), as well as the associated passive infrastructure. Ongoing costs include power consumption and maintenance.

The cost per Mbps of a 100 MHz channel may be as low as 12% of that of a 10 MHz channel.

Most of the total costs of ownership (TCO) are similar, whether one deploys a radio with a 10 MHz channel or with 100 MHz. The wider the channel that is deployed in a single radio and antenna system, therefore, the lower the cost per MHz deployed – hence the lower the cost per incremental unit of capacity (the "cost per bit").

We apply the following rules of thumb for a 3.5 GHz (5G) site:

- Around 20% of capex (RAN Software Capacity Licenses) scales with bandwidth;
- Power accounts for around 40% of opex in emerging markets, and around half of that cost scales with channel size[47] – implying that around 20% of network opex scales with bandwidth.

These figures would suggest that 80% of relevant TCO is fixed, while only 20% scales with channel bandwidth, from which we obtain the relations illustrated in Exhibit 17 below.

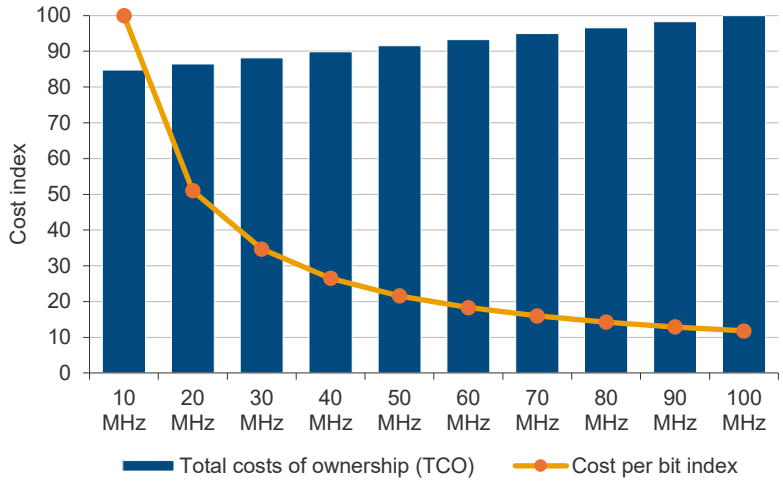
In this case, the TCO *per* MHz (or indeed per Mbps) for a 100 MHz channel would be just 12% of those for a 10 MHz channel – a massive reduction in costs per unit of capacity.

More directly relevant to Egypt, the cost per Mbps for a 100 MHz channel at 3.5 GHz would be 45% of that for a 40 MHz channel at 2.6 GHz, if both were deployed using the same MIMO order.

47 The GSMA 'State of the Industry on Climate Action 2023' suggests power accounts for 20-40% of network opex. In emerging markets, Diesel consumption often plays a larger part in the mix, likely pushing operators closer to the top of our range. We assume that around half of power consumption is needed for cooling, digital processing and for power amplifiers in massive MIMO systems, with the remainder scaling with emitted bandwidth.

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Exhibit 17: Cost per MHz deployed as function of channel bandwidth



Source: Coleago

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6. Socio-Economic Impact

6.1 Impact of 5G on GDP

True 5G could deliver an uplift to emerging market productivity in excess of 1% of GDP.

In this Section, we explore the extra gains that true 5G can deliver to economic growth in Emerging Markets (EMs).

By 'true 5G', as mentioned in Sections 3.2 and 5.1, we mean deployment with wide channels in upper mid band for high performance, as well as low band for wide-area coverage. Narrowband 5G deployments such as those in Bangladesh and Egypt, to date, may be viewed as modest enhancements or complements to 4G –and we do treat these here effectively as members of the 4G family.

6.1.1 Recent literature on the influence of digital connectivity

Much of the existing literature on mobile-driven GDP multipliers draws on regression analysis of historical data from multiple markets. This is also the case with the Oxford Economics study[48] cited in Section 3.2.

Being inherently backward looking, regression analyses may uncover quantitative relationships that are no longer valid: if these relations are prone to change over time, then the predictive accuracy of the resulting models may be brought into question. Furthermore, these approaches are open to the entirely reasonable criticism that it may indicate correlations, at best, but not causal relationships. For example, it could be argued that an increase in affluence within a country drives higher use of mobile services, rather than the other way around.

However, this last criticism does not hold for the recent studies that we invoke below: these *do* establish positive causal relationships between broader, more advanced digital access and economic activity. They support the powerful intuition that successive mobile generations (from 2G to 5G and beyond) add to cross-sectoral efficiencies through the incremental capabilities that each brings.

The following examples were compiled by Jonas Hjort and Lin Tian (2025)[49]:

- Simione & Li (2021) and Goldbeck & Lindlacher (2024) use variation in submarine cable arrival timing to show evidence of large effects of internet penetration on economic growth and productivity in sub-Saharan Africa;
  - Goldbeck & Lindlacher: in towns that were incidentally connected to early internet backbones, night-time light intensity increased by about 10%, suggesting a large increase in local economic activity[50]
- Hjort and Poulsen (2019) find similar effects from the later arrival of fast internet – notably that employment increased by roughly 4.2% to 10% in connected areas after fast internet became available;
- Agarwal et al. (2024)[51] find that 4G availability in India increased agricultural households' incomes by 7.9%;
  - According to the paper: *survey evidence indicates that 4G reduces information frictions primarily by delivering agronomic information in cognitively accessible, trusted, and timely audio-visual formats, often mediated by social networks*;

48 The authors rely on surveys of consumers and business executives in 13 markets, as well as on the outputs of an econometric model that uses data from the 2G, 3G and 4G eras.
49 'The economic impact of internet connectivity in developing countries', Annual Review of Economics, 17(1), 99 - 124
50 Across many countries and years, changes in night-time light intensity are strongly correlated with changes in GDP, industrial output, and employment measured in traditional surveys and national accounts.
51 'Bridging the Information Gap: Sowing the Seeds of Productivity with High-Speed 4G Internet', available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4805486

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- Masaki et al. (2020): gradual 3G coverage expansion is associated with a 14% increase in total consumption and a 10% decline in extreme poverty in Senegal;
- Bahia et al. (2024) find that the gradual rollout of mobile broadband in Nigeria between 2010 and 2016 increased labour force participation, employment, and household consumption by around 6%;
- Blumenstock et al. (2024) studied randomized locations of new mobile towers in the Philippines, and found a 17% increase in household incomes, with gains stemming from both local self-employment and employment outside the village;
- Roessler et al. (2021) present results from an experiment in Tanzania that gifted randomly chosen women either a basic phone, a cash grant, or a smartphone:
  - Smartphones increased household per capita consumption by 20%, an effect three times greater than that of basic phones and 3.6 times that of cash grants;
  - This highlights the role of internet access, with smartphone use and occupational changes being key drivers of increased consumption;
- Gunsilius and Van Dijcke (2023) approach the question from the opposite direction, by assessing the economic costs of internet shutdowns: they estimate that a shutdown in India reduced economic activity by 25–35%.

While none of the above results translate directly into GDP multipliers for 5G, they do suggest a high economic impact of improved connectivity in emerging markets (EMs). They also provide some helpful insights and pointers.

These studies span different situations. Some show the impact of a first, basic layer of internet access, such as via 3G, while others effectively highlight the incremental benefits of faster broadband (such as 4G) over basic access. The incremental impact of 5G over 4G will be different still.

Furthermore, the above effects on employment, consumption, household income and economic activity will depend on available opportunities that can be mediated by digital communications. These are bound to vary in different settings. Nevertheless, as discussed below, we may attempt to use some of these results to construct a rough, indicative factor that approaches the incremental impact of 5G in a typical EM.

6.1.2 Extrapolating the empirical results to 5G

Consider, first, the impact of 4G availability (from Agarwal et al., 2024). We take this to be an effect of moving from basic internet (3G, with some users on still on 2G) to basic mobile broadband (4G). Here is what we can distil from that study:

- Agriculture accounts for around 16% of India GDP, with agriculture supporting just over half of the population;
- If the 7.9% uplift from 4G (that the study infers) were to apply uniformly to this 16% agricultural value added, it would yield around 1.3% in extra GDP[52];
- This would be the net impact from increased incomes across around half the population –but there would likely also be an added impact across the other, more affluent half;
- The uplift in household incomes across that wealthier half is bound to be lower in % terms, but suppose (not unreasonably) that it were at least the same in *absolute* terms:
  - If so, the total increase in national income would be 2x the increase from the agricultural segment alone;

52 A 7.9% uplift × 16% of GDP = 1.3% of GDP, from the impact of 4G on the agricultural sector alone.

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- Hence a **2.6%** total uplift in GDP, against a baseline of $2,700 per capita (which is close to the median of our earlier case study sample).

The question, now, is how this might be translated into an impact of 5G relative to 4G. We might expect declining marginal socio-economic gains from successive generations, with the leap from no-G to 2G having the greatest impact, and the step-up from 4G to 5G the least.

However, this marginal curve does not appear to be so steep. According to Bahia et al (GSMA, 2020), a 10% increase in overall mobile adoption drives a 0.4-0.8% increase in GDP per capita, while a 10% increase in mobile broadband adoption drives further gains of 0.1-0.7%[53].

This suggests that the added gains from mobile broadband are up to 87.5%[54] of the original socio-economic benefits delivered by plain (2G) mobile. It stands to reason that each successive mobile generation brings its unique capabilities to bear. 5G brings its own too, as outlined in Section 3.2 – with AI enablement a key theme, in which 5G will likely play an essential role.

If, nevertheless, we err on the side of caution and assume that socio-economic gains halve with each successive generation – then, per the above analysis, 'true 5G' would still drive an extra 1.3% in GDP in a typical EM (over and above the *direct* contribution from mobile communications to the economy).

This aligns closely with the 1.1% of global GDP figure that Oxford Economics estimated for 5G with full mid-band deployment (i.e. including the 3.5 GHz band), as quoted in Section 3.2. GDP effects from advanced mobile communications may be more pronounced in EMs than advanced economies, where incremental efficiency gains may be harder to find. In any case, reaching similar results via different routes provides extra comfort in the validity of both figures. Going forward, we take the lower of the two – thus assuming that 'true 5G' will deliver a **1.1% GDP uplift** in EMs.

It's worth placing spectrum fees within this context. In Egypt, the cost of spectrum to operators is likely in the order of 15% industry revenues (see Section 4.2). Such large transfers of capital from a critical industry to the state are bound to have severe consequences for ICT investment, with unfavourable knock-on effects for economic development. Yet within a broader economic context, the amounts raised by the state through direct licence fees are small: 15% of mobile revenues is around 0.2% of GDP.

In other words, to generate a one-off 0.2% of GDP in direct income for the state, the Egyptian government is effectively risking 1.1% in extra *recurring annual* GDP that a successful introduction of 'true 5G' could deliver.

6.2 Welfare impact

While mobile communications and 5G produce powerful and positive externalities (the *indirect* effects on GDP discussed above), they also yield substantial direct Welfare benefits (as discussed in Section 3.3).

Consumer and Producer Welfare is (or ought to be) an important public policy consideration, and it can be significantly enhanced by favourable mobile market outcomes. Conversely, it can be harmed by:

- Reduced consumption due to a lack of coverage or capacity supply for specific mobile services;
- Poor quality of experience, due to network congestion or to poor radio-channel performance caused by a lack of bandwidth; and/or

53 Based on 2000-2017 data from 160 countries.
54 0.7%, the maximum uplift from (a 10% rise in) mobile broadband is 87.5% of 0.8%, the maximum uplift from (a 10% rise) in mobile adoption.

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- Higher retail prices.

Spectrum policy has a heavy influence on all these aspects, which also bear on the GDP multipliers discussed in the preceding Section. Specifically:

- A failure to allocate sufficient spectrum in a timely manner to operators may drive supply scarcity, leading to higher retail prices per GB reduced overall consumption;
- Excessive spectrum fees may cannibalize direct network investment and/or result in higher retail prices if these costs are passed on to consumers;
  - And whichever proportion of unduly high spectrum fees are absorbed by operators reduces Producer Surplus (equally a policy concern if this affects the financial health and sustainability of the sector).

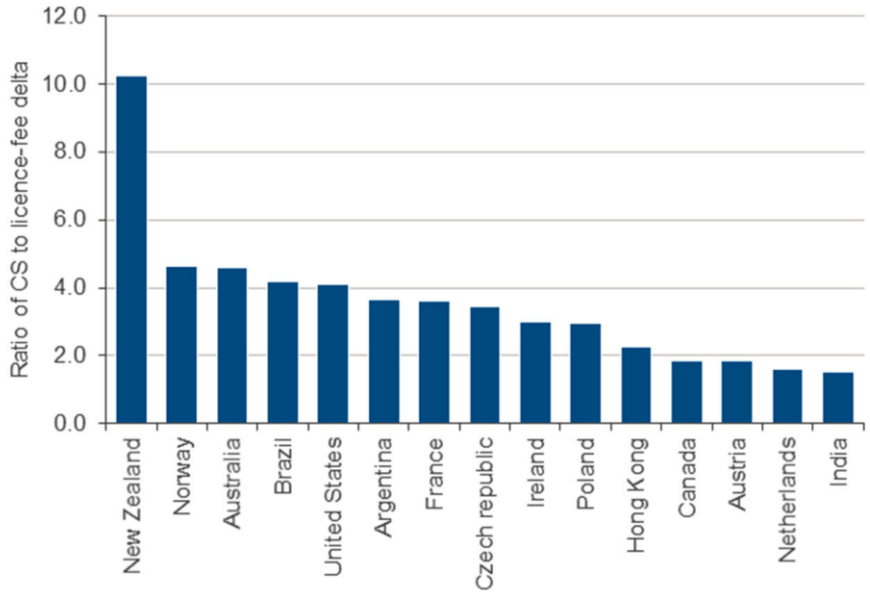
This second aspect has been quantified empirically. Based on econometric demand modelling, NERA shows that reductions in licence fees would be more than offset by increases in consumer welfare[55]. The ratio of increases in welfare to decreases in licence fees for 15 markets in their dataset is shown in Exhibit 18 below.

Increases in welfare exceed foregone mobile licence fee receipts by an average of 2.5-to-1.

On aggregate, NERA find that the governments in these markets could have generated incremental value for society with a purchasing power of US$250 billion, had they surrendered as little US$98 billion in direct licence-fee receipts (on a PPP-adjusted basis)[56].

While the weighted average ratio of gains to foregone licence fees in this sample was 2.5-to-1, the median was 3.4-to-1 and the lowest (India) was 1.5-to-1, implying gains at least 50% higher than the foregone direct fee income for the State.

Exhibit 18: Increases in welfare as function of reductions in licence fees



Source: NERA, 2017

While this study is almost a decade old, we believe that its overall conclusions retain their validity. In particular, we have observed steep increases in consumption across all markets during this interval, while total industry revenues have tended to remain flat or 2027

55 NERA, 2017: 'Effective Spectrum Pricing: Supporting better quality and more affordable mobile services', R.Marsden, B.Soria and H-M.Ihle.
56 The average ratio of gains to foregone licence fees is 2.6x. The US$250 billion gain quoted by NERA thus corresponds with a reduction of 250/2.6 =US$98 billion.

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to decline in real terms. This points towards a very large increase in Consumer Surplus (CS).

If all other things remained equal, the proportional impact of licence fees on CS should therefore be even greater than those depicted in Exhibit 18 above.

6.3 Egypt: net socio-economic impact of alternative 5G scenarios

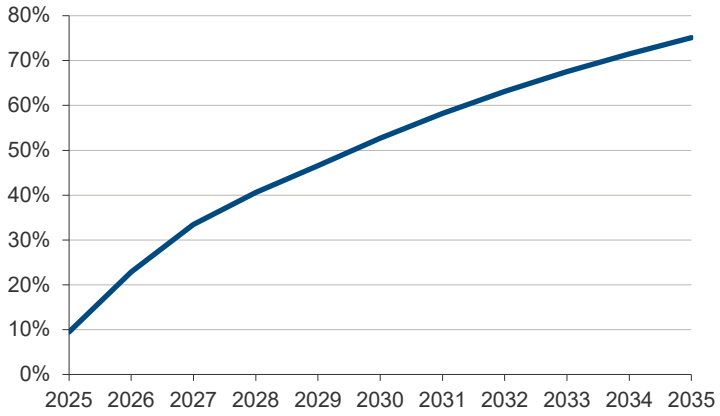
6.3.1 GDP cost of delays in the launch of true 5G in Egypt

The net socio-economic cost of spectrum policies in Egypt could exceed $20 billion.

Any delay in the deployment of True 5G deployment postpones its benefits to the economy. Our analysis in Section 6.1.2 suggests an annual value equivalent to 1.1% in GDP, or around **$4.0 billion** per year in the case of Egypt.

However, it takes time to roll-out 3.5 GHz across the network, and thus for the potential economic uplift to materialize. Furthermore, the potential uplift will be related to the proportion of demand that is 5G enabled. We project this proportion as follows for Egypt[57]:

Exhibit 19: 5G-compatible traffic as % total MBB traffic in Egypt



Source: Coleago based on GSMAi and Ericsson projections

Let us assume, conservatively, that the $4 billion GDP uplift from 5G is only realized in 10 years' time (2035). 5G traffic, at that point is projected to be 75% of total MBB traffic. Suppose, further, that the actual GDP uplift is based on how close the actual % 5G traffic is relative to this 75% figure.

A launch in 2026 based on a 4-year deployment would yield the following GDP uplift by year (taking GDP to be constant for simplicity):

Exhibit 20: GDP uplift in Egypt if true 5G were launched in 2026

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
% 5G-enabled demand	23%	33%	41%	47%	53%	58%	63%	68%	72%	75%
% 5G network roll-out	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%
% 5G traffic	6%	17%	30%	47%	53%	58%	63%	68%	72%	75%
% of max 5G uplift realized[58]	8%	22%	41%	62%	70%	77%	84%	90%	95%	100%
GDP uplift ($ billion)	0.3	0.9	1.6	2.5	2.8	3.1	3.4	3.6	3.8	4.0

57 These projections are based on the device diffusion forecast by GSMA Intelligence to 2030, extrapolated by us to 2035, in conjunction with the assumed 5G unit-traffic multiple described in Section 5.1.1.

58 Calculated as actual % 5G traffic in the relevant year divided by the figure in 2035.

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Source: Coleago

The above scenario would have generated a cumulative true 5G uplift to GDP worth $26 billion by 2035, but it would have required an award of 3.5 GHz spectrum by early 2026. An immediate assignment of 3.5 GHz in Egypt would already entail a 1-year delay relative to this. Over the same period, we would obtain the following:

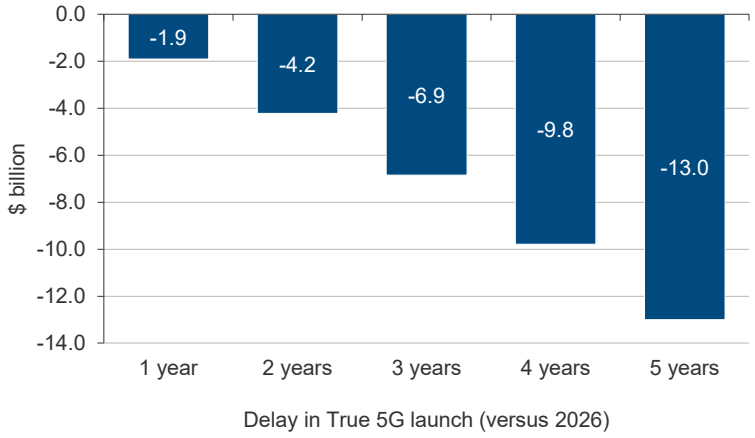
Exhibit 21: GDP uplift in Egypt with a true 5G launched in 2027

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
% 5G-enabled demand	23%	33%	41%	47%	53%	58%	63%	68%	72%	75%
% 5G network roll-out	0%	25%	50%	75%	100%	100%	100%	100%	100%	100%
% 5G traffic	0%	8%	20%	35%	53%	58%	63%	68%	72%	75%
% of max 5G uplift realized[59]	0%	11%	27%	46%	70%	77%	84%	90%	95%	100%
GDP uplift ($ billion)	0.0	0.4	1.1	1.9	2.8	3.1	3.4	3.6	3.8	4.0

Source: Coleago

On a cumulative basis, this scenario would generate $24.1 billion in extra GDP from true 5G, which is $1.9 billion less than with a 2026 launch. In other words, the 1-year delay would entail a **-$1.9 billion** cost in foregone GDP. Applying the same logic, we obtain the following for delays between 1 and 5 years, relative to a 2026 launch of True 5G:

Exhibit 22: Extra GDP cost of delays in True 5G



Source: Coleago

A 5-year shift in the overall deployment and adoption curves would thus put the net extra cost of the delay to the economy at a staggering **$13 billion**.

Added to this is the direct welfare impact. Estimating the loss of Consumer Surplus due to the delay in True 5G in Egypt is a difficult task. However, we can estimate the social cost of the proposed spectrum fees in Egypt, by using the results from the NERA study cited in Section 6.2, as shown below.

59 Calculated as actual % 5G traffic in the relevant year divided by the figure in 2035.

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6.3.2 Social cost of proposed spectrum fees in Egypt

The extra 410 MHz that Egypt proposes to award by 2030 are priced at $3.5 billion. Taking the average ratio of 2.5-to-1 suggested by NERA, we obtain a social cost of $8.75 billion.

This would only partly be offset by the social gains from the spectrum fees, which are given by the avoided deadweight losses that alternative modes of taxation would incur. Assuming efficiency savings of 40%, the receipts of $3.5 billion would generate social savings of $1.4 billion – yielding a net expected social cost of **$7.35 billion**[60].

6.3.3 Combined cost of spectrum policies in Egypt

Taken together, the combined socio-economic costs of spectrum policies in Egypt could add up to over **$20 billion**, if these delay the introduction of true 5G by 5 years and if the ultimate price paid for the spectrum remains as per current proposals.

For each year in which the award of 3.5GHz is delayed, we obtain the following net social losses:

Exhibit 23: Combined cost of delays and excessive spectrum fees in Egypt

Delay in true 5G	1 year	2 years	3 years	4 years	5 years
GDP impact of delay	$1.9 bn	$4.2 bn	$6.9 bn	$9.8 bn	$13.0 bn
Net social cost of fees	$7.4 bn	$7.4 bn	$7.4 bn	$7.4 bn	$7.4 bn
Combined costs	$9.3 bn	$11.6 bn	$14.2 bn	$17.1 bn	$20.4 bn

Source: Coleago

60 Gross social costs of $8.87 billion minus gross savings of $1.4 billion yield a net social cost of $7.35 billion. The 40% deadweight savings figure is based on a Marginal Cost of Public Funds (MCPF) of 1.4, which is close to the top of the range of typical values obtained for Africa by Auriol and Walters in 'The Marginal Cost of Public Funds and Tax Reform in Africa', Toulouse School of Economics, November 2009.

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7. Policy Recommendations to Bridge the 5G Divide

7.1 Spectrum allocation policy and roadmap

Accelerated spectrum allocation and spectrum pricing reform should be top policy priorities.

The top two priorities for regulators should be:

1. To ensure that all operators have access to frequency resources with large amounts of contiguous bandwidth – ideally, this would include individual channels 100 MHz wide for each operator, which the IMT band-plans provide for in **3.5 GHz** band;
   - Operators need to play their part too, here, by actively pursuing wider allocations and deploying wideband channels where possible
2. To ensure that the **700 MHz** band is allocated in full, to support 5G wide-area coverage layers.

The next priority for regulators should be to fill any allocation gaps in legacy bands between 800 MHz and 2.6 GHz. For operators, extending their assignments in existing bands is typically inexpensive, and this provides additional bandwidth that can support near-term legacy 4G demand. This extra bandwidth can also be made available for 5G in the future, and in some cases immediately.

In many instances, assignment gaps occur due to high spectrum fees, leaving spectrum unsold. This can be remedied through spectrum-fee moderation.

In others, assignment gaps within the IMT band-plan arise because the spectrum is occupied by inefficient spectrum users. In these instances, regulators should use every available means to recover the spectrum and reassign it to operators. To this end, the government should actively specialized teams to organize and coordinate frequency clearance.In the medium term, regulators should prioritise the award of the **600 MHz** IMT band to operators. This would provide additional capacity for the wide-area 5G coverage layer, improving cell-edge performance in particular. Traction for this critical band is growing, and strong device support for this band may be anticipated in the medium term.

In **Egypt**, specifically, the NTRA should consider accelerated 600 MHz clearance with a view to concurrent allocation with 700 MHz to operations. The reasons for this are twofold:

- The 600 MHz band has already been identified for IMT in Egypt; and
- There are four well-established operators in Egypt, which means that joint clearance would be needed to ensure that these four can each secure at least 2x10 MHz of contiguous bandwidth across both bands (with an average of 2x15 MHz per operator).

Beyond the above, policy makers should reasonably plan the overall pace of spectrum awards. This should take account of IMT sector needs, spectrum clearance timelines, and the global ecosystem in each band (including device support for those bands).

To support 5G Advanced and future 6G, regulators should seek to ensure that each operator will have access to contiguous channels that are 200 MHz wide. This will be possible in the medium to long term in the Upper 6 GHz (**U6**) band, subject to IMT identification (which should be supported), as well as band **n79** (4.5 GHz).

The L-Band, finally, can provide a valuable spectrum complement. The Supplementary Downlink (SDL) model helps address the strong downlink bias in mobile communications, and the 1.5 GHz band also benefits from favourable propagation characteristics. However, we see this as a medium to longer term priority, as device support for this band may take longer to reach critical mass in emerging markets.

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Exhibit 24: High-level spectrum roadmap

Priorities	Bands	Rationale
Near term:	Full 3.5 GHz, 700 MHz Gaps in legacy bands	Wide 3.5 GHz channels needed for effective 5G, full 700 MHz for coverage Legacy bands: cheap to deploy if extending existing assignments
Medium term:	600 MHz	Growing traction and device ecosystem in medium term; enhance capacity in wide-area coverage layer
Medium to long term:	U6, n79 (4.5 GHz), L-Band	U6: emerging band, will allow 200 MHz assignments per operator for 6G L-band: valuable spectrum complement as global device support improves (SDL)

Source: Coleago

7.2 Spectrum pricing reform

Spectrum pricing reform is urgently needed in many EMs including, notably, Egypt and Bangladesh within our case study group. Together with spectrum allocation policy, spectrum fees are the most important determinants of mobile market and 5G outcomes. These outcomes, in turn, have a large impact on overall economic development as well as welfare.

7.2.1 Socio-economic impact of excessive spectrum fees

Excessive spectrum fees destroy the aggregate value of spectrum to society. This may happen in one or more of the following ways:

- Excessive costs often lead to unsold or unutilised spectrum, which is highly inefficient (see Section 4.2);
  - This affects consumers, operators, and ultimately also the state through reduced total public revenue generation (i.e. due to a lower sum of direct licence fee income plus indirect tax collection[61])
- If fees are too high, it may not be economically feasible for an operator to acquire the spectrum assets it needs, leading to spectrum insufficiency;
- High spectrum fees crowd out capex, impeding network deployment, which ultimately harms consumers;
  - This may lead to delayed coverage expansion and to reduced network capacity, severely affecting the quality of mobile experience;
- Spectrum costs may be passed on to consumers in the form of higher retail prices and/or reduced investment, which harms consumers;
  - As evidenced in Section 6.2, the social costs often dwarf the social gains from direct spectrum fee receipts for the state;
- Spectrum licence fees are a fixed cost, and operators with a lower market share are impacted disproportionally when these fees are unduly high;
  - This may lead to a reduction in competition through mergers or market exits, as have been observed in Mexico, Ghana, and Indonesia.

Reduced quality and coverage of advanced mobile services, distorted competition, and/or higher retail prices affect consumers directly and economic development

61 Foregone taxes collected may be linked to reduced equipment imports, lower sales taxes due to lower consumption (due to lower network capacity), and a weaker economy generating fewer taxes (see impact on GDP, Section 6.1).

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indirectly. This also affects the net fiscal balance, which is sensitive to the evolution of GDP.

7.2.2 Spectrum as a fiscal tool versus economic enabler

As argued in preceding Sections, spectrum is a key enabler of economic development and welfare generation. Yet, all too often, regulators see spectrum policy as an instrument to finance the state.

A focus on direct licence fee generation at the expense of wider societal benefits tends to be counterproductive, and all the more so if the net aggregate impact on the fiscal balance is negative.

Nevertheless, fiscal extraction in low-tax-base EMs does pose a dilemma. There is an apparent trade-off between short-term direct revenue for the state and long-term growth –with long-term growth and welfare dominating, as evidenced a.o. in Section 6. Accordingly, one may *wish* to focus policy on the wider benefits –but if the state cannot raise capital through direct licence receipts, then where will the money come from to fund essential public expenditures?

If the state really cannot avoid taxing the mobile industry, we firmly believe that it is more efficient to tax the outputs than spectrum inputs. Of course, a tax on mobile consumption also comes at a social cost, and it may also hinder the use of certain mobile services that would otherwise drive extra productivity. However:

- It is likely that (high) spectrum fees would in any case be passed on to consumers, in the form of reduced total network investment and/or higher retail prices;
- A tax on consumption is at least broad based: it affects all operators indirectly, and in equal proportion;
  - Unlike spectrum costs that are fixed, and that affect smaller operators disproportionately (distorting competition, and possibly forcing consolidation).

7.2.3 Optimal spectrum pricing policies

Given all the above, spectrum fees need to be set at reasonable levels, within the context of the economic realities of operating a mobile business.

The overall burden of spectrum fees should certainly not be higher than the global median (7.7%, as shown in Exhibit 4). Ideally, it would be far lower still. Our analysis in Section 4.2 suggests the following:

- Spectrum fees in Egypt and Bangladesh are in the order of 15% of revenues;
- Incremental spectrum fees (per MHz) in Pakistan and Vietnam are between 5.5% and 9% of those in Egypt and Bangladesh, adjusted for duration and GDP per capita;
- Taking Pakistan and Vietnam as examples to emulate on this policy, this would suggest spectrum total spectrum fees in the order of 0.8% to 1.3% of revenues.

Where possible, regulators should seek to replace spectrum licence fees with network construction obligations (as successfully implemented in Vietnam). The resulting large-scale 5G deployment will promote the development of the digital economy.

7.3 Further policy measures

Where there are fiscal or other barriers to the development of the digital economy, these should be removed to promote the development of the domestic digital economy, and to enhance the country's competitiveness in the digital economy.

Specifically, we would advocate against import duties or taxes on 5G equipment and vendor support, for the same reasons as we advocate against high spectrum fees. Equipment inputs are fixed costs that fall more heavily on operators with a lower

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market share. Taxes on all critical industry inputs are highly undesirable because they are not broad based.

Regulators should also seek to minimise taxes and import duties on mobile devices and components. It is especially important that 5G devices be available in the market at affordable levels to promote their diffusion across mobile customer bases. In this regard, policy makers may consider subsidy or financing support for entry-level 5G devices and applications.

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8. Conclusion: Closing the 5G Gap

Emulating the Vietnam policy turn-around is the quickest and most effective way of closing the 5G gap and to drive major societal and economic transformation.

5G is a foundational platform for national resilience and competitiveness, not just a telecom upgrade. It is the connectivity glue for the digital transformation of a country. Emerging Markets (EMs) cannot realistically achieve their digital nation-building goals without true 5G mobile coverage and capacity.

As we have shown, however, some EMs severely lag on 5G – Egypt and Bangladesh are two examples that we have analysed, and there will be many more across multiple continents.

In particular, we estimate the net socio-economic costs of the 5G lag plus of the proposed spectrum prices in Egypt at $17 billion (see Section 6.3). The high costs of the delayed true 5G opportunity in Egypt are borne by society as a whole (loss of GDP), with forgone benefits in the To Consumers vertical (data speeds), To the Home (fibre-like broadband), and To Business (notably the successful transition to Industry 4.0).

We have also shown how a policy reset can promote mobile and 5G development in a market. Both Pakistan and Vietnam have taken radical steps to make spectrum available to operators at accessible prices. While Pakistan has only just brought this into effect, we have already witnessed transformative outcomes in Vietnam, within a very short span of time.

Two things are most urgently needed to close the 5G gap:

- Forward-looking spectrum allocation policies and roadmap (see Section 7.1), including:
  - Prioritizing contiguous, wideband (100 MHz) assignments at 3.5 GHz to all operators;
  - Completing clearance and allocation of 700 MHz;
  - Filling gaps in legacy bands (between 800 MHz and 2.6 GHz);
  - Progressing towards 600 MHz clearance, with assignment in medium term;
  - Progressing towards the assignment of the U6 band (in preparation for 6G), L-band and 4.5 GHz in the medium to longer term;
- Spectrum pricing reform (see Section 7.2):
  - Ensuring that the above assignments are priced reasonably (i.e. at sustainable levels);
  - This implies a total annual spectrum TCO certainly no higher than 7.7% of mobile revenues (the global median), and ideally less than 1.3% of revenues (to align with best international practice);
  - Where possible, regulators should seek to replace spectrum licence fees with network construction obligations (as successfully implemented in Vietnam).

Beyond this, regulators should seek to remove fiscal and other barriers to the development of the digital economy. Specifically, import duties or taxes on 5G devices, equipment and/or vendor support should be avoided, as these may impede the development of a GDP-critical and socially sensitive sector.

Finally, we would urge policy makers across EMs to take Vietnam as a positive example to emulate. The social and economic stakes are high, and delays in true 5G deployment come at a high cost. For this reason, we advocate firmly for urgent action.

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Glossary

AGV	Autonomous Guided Vehicle
AI	Artificial Intelligence
ARFM	Authority of Radio Frequency Management (Vietnam)
BSS	Bangladesh Sangbad Sangstha (Bangladesh's state-run news agency)
CS	Consumer Surplus
DRC	Democratic Republic of Congo
EB	Exabyte
EBIT	Earnings Before Interest and Tax
EM	Emerging Market
EVA	Economic Value Added
FDD	Frequency Division Duplex
FWA	Fixed Wireless Access
GB	Gigabyte
GDP	Gross Domestic Product
GHz	Gigahertz
GSMA	GSM Association
ICT	Information and Communication Technology
IFC	International Finance Corporation
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITU	International Telecommunication Union
LTE	Long-Term Evolution (4G)
M2M	Machine-to-Machine
MCIT	Ministry of Communications and Information Technology (Egypt)
MCPF	Marginal Cost of Public Funds
Mbps	Megabits per second
MHz	Megahertz
MIMO	Multiple Input, Multiple Output
MNO	Mobile Network Operator
MWC	Mobile World Congress
NTRA	National Telecommunications Regulatory Authority (Egypt)
PPP	Public-Private Partnership / Purchasing Power Parity
PRB	Physical Resource Block
QoS	Quality of Service
RAN	Radio Access Network
SDL	Supplementary Downlink
TCO	Total Cost of Ownership of an asset, calculated here as the amount expensed annually in the Profit and Loss statement

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TDD	Time Division Duplex
USO	Universal Service Obligation

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