



Spectrum pricing in developing countries

Evidence to support better and more
affordable mobile services

July 2018



The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

For more information, please visit the GSMA corporate website at www.gsma.com.

Follow the GSMA on Twitter: [@GSMA](https://twitter.com/GSMA).

GSMA Intelligence

GSMA Intelligence is the definitive source of global mobile operator data, analysis and forecasts, and publisher of authoritative industry reports and research. Our data covers every operator group, network and MVNO in every country worldwide – from Afghanistan to Zimbabwe. It is the most accurate and complete set of industry metrics available, comprising tens of millions of individual data points, updated daily. GSMA Intelligence is relied on by leading operators, vendors, regulators, financial institutions and third-party industry players, to support strategic decision-making and long-term investment planning. The data is used as an industry reference point and is frequently cited by the media and by the industry itself. Our team of analysts and experts produce regular thought-leading research reports across a range of industry topics.

Follow GSMA Intelligence on Twitter: [@GSMai](https://twitter.com/GSMai).

www.gsmaintelligence.com

info@gsmaintelligence.com

Authors:

Chiara Garbellini, Economist

Kalvin Bahia, Principal Economist

Pau Castells, Director of Economic Analysis

Contributors:

Robert Wyrzykowski, Mobile Spectrum Analyst

Dennisa Nichiforov-Chuang, Lead Spectrum Analyst

Contents

1.	Executive Summary	2
2.	Key Considerations For Spectrum Policy	4
3.	How Rising Spectrum Prices Are Affecting Consumers In Developing Countries	8
4.	Spectrum Pricing Policy Case Studies	24
5.	Conclusions	38
6.	Appendix: Methodology	40

1. Executive Summary

To deliver affordable, widespread and high-quality mobile broadband services, mobile operators require affordable and predictable access to sufficient radio spectrum. Well-designed spectrum policy is therefore a critical input for a thriving digital economy. The right spectrum pricing policies can help enhance consumer and social welfare in developing countries. Policies that seek to maximise state revenues, however, can have a negative influence on consumer outcomes, including more expensive mobile services and reduced network investment.

This report highlights that high spectrum prices are a significant issue in developing countries. On average, between 2010 and 2017, final spectrum prices in developing markets were more than three times those of developed countries once income levels are taken into account. Governments and regulators play a role in increasing spectrum prices through policy decisions. This includes directly setting high final prices, setting high auction reserve prices, constricting the supply of spectrum and using poor award rules.¹ For example, this study found average reserve prices in developing countries were more than five times those of developed countries over the period considered, once income levels are taken into account.

Although high proceeds from spectrum assignments increase public funds to help ease short-term public sector fiscal pressures, there can be significant adverse effects for the mobile

market, with slower deployment of LTE networks and more expensive, lower quality mobile broadband services. This cripples the development of the mobile market and prevents societies from fully using mobile technology to accelerate social and economic development.

Mobile technology has grown exponentially in developing countries, with average mobile internet adoption increasing from 13% in 2010 to 37% at the end of 2017. This has driven transformative social and economic impacts in these countries – for example, greater financial inclusion from mobile money services, higher economic growth and greater access to quality healthcare and education.

1. For example, auction formats that limit price discovery

Despite this progress, at the end of 2017, 2.3 billion people in developing countries were not using mobile services and 3.9 billion were not accessing the mobile internet. A large proportion of consumers in developing countries are also using legacy 2G services, so they are unable to realise the full range of benefits that the mobile internet can enable. 4G networks have yet to launch in some developing countries, or have low market penetration – 28.6% on average at the end of 2017, which is less than half that for the developed world (67.5%).

Connecting everyone and closing the digital divide is a key policy objective for most governments in developing countries. Radio spectrum is the first building block. However, if mobile operators do not have affordable and predictable access to sufficient spectrum, it will not be possible to achieve universal access, particularly in countries with a high proportion of the population residing in rural and remote areas.

This report follows previous publications by the GSMA on the impact of spectrum prices.² It investigates trends in spectrum pricing in developing countries³, their drivers and potential impact on consumers. Bringing together a unique and rich dataset on spectrum pricing, consumer outcomes and relevant macroeconomic indicators, we find the following:

- **Between 2010 and 2017, final spectrum prices in developing countries were on average more than three times those in developed countries once differences in income are taken into account.**
- **These high final prices are driven in part by government spectrum policy decisions. These include directly setting high final prices, artificially limiting the amount of licenced spectrum available, lack of a clear spectrum roadmap, and the design of spectrum auctions. Reserve prices in spectrum auctions are also set aggressively high in many developing countries, often driven by short-term public revenue maximisation objectives, especially in countries with high levels of sovereign debt and limited access to financial markets. These dynamics are not observed to the same extent in developed countries.**
- **Reserve prices in developing countries were found to be more than five times those in developed countries, once differences in income per capita are taken into account.**
- **The link between high spectrum prices and high levels of national debt adds weight to the argument that high spectrum prices are in part caused by government policies and not just by operators' market-based decisions.**

■ **High spectrum prices in developing countries are linked to more expensive, lower quality mobile broadband services. This highlights the trade-off in spectrum policy when trying to raise revenues for the public sector while also delivering greater consumer welfare and achieving digital inclusion objectives.**

In some developing markets, spectrum prices have been influenced by government policies that seek to maximise revenues. Operators in such countries have often paid similar prices for spectrum as those in developed countries, even though consumer incomes and expected mobile service profits are substantially lower. This directly affects return on investment and may also impose financial constraints on operators, which likely lead to reduced investment and higher consumer prices.

In Chapter 4, we analyse some countries with low average revenue per user (ARPU) levels and high spectrum prices – a result that seems only possible if government intervention is indeed having an impact on spectrum prices, beyond the voluntary market-driven bidding activity by operators.

In the case of Jamaica, for example, delays in the assignment of 4G bands, as well as higher than average final spectrum prices, are associated with significantly lower 4G market penetration compared to the Caribbean average. By contrast, Costa Rica ranks among the top performers in Central America in terms of 4G coverage and mobile internet penetration. Here, the regulator has made sufficient amounts of spectrum available at more affordable prices; the country's mobile market has reaped the rewards.

With advanced 4G technologies requiring increasing amounts of spectrum, it is crucial that spectrum policies in developing countries support fast and sustainable development of the mobile sector. This helps realise maximum benefit for citizens, particularly the digitally excluded.

2. The global report, Effective Spectrum Pricing, was published in February 2017

3. "Developing countries" includes low, lower-middle and upper-middle income based on the World Bank 2017 classifications (countries with a GNI per capita below \$12,235). This is also in line with the UN classification of developing countries.

2. Key Considerations for Spectrum Policy



Mobile technology has become the most popular and widespread form of personal technology on the planet, with 3.8 billion unique subscribers in developing countries at the end of 2017. It has also become a powerful force for social and economic development, providing a platform for reducing poverty, improving healthcare and education, and driving economic growth. However, as of 2017, 2.3 billion people in developing countries do not use mobile services and 3.9 billion do not have access to the mobile internet.

Providing connectivity to the unconnected population and closing the digital divide are key policy objectives for most developing countries. It is important that governments prioritise efficient spectrum awards that increase the profound socioeconomic benefits mobile services provide.

2.1 Why mobile technology matters

Mobile access is having a profound impact on society, redefining the way individuals and businesses function and interact. With more than 5 billion unique subscribers worldwide, mobile is the most widespread form of personal technology and in many developing markets has become the dominant platform for access to the internet.

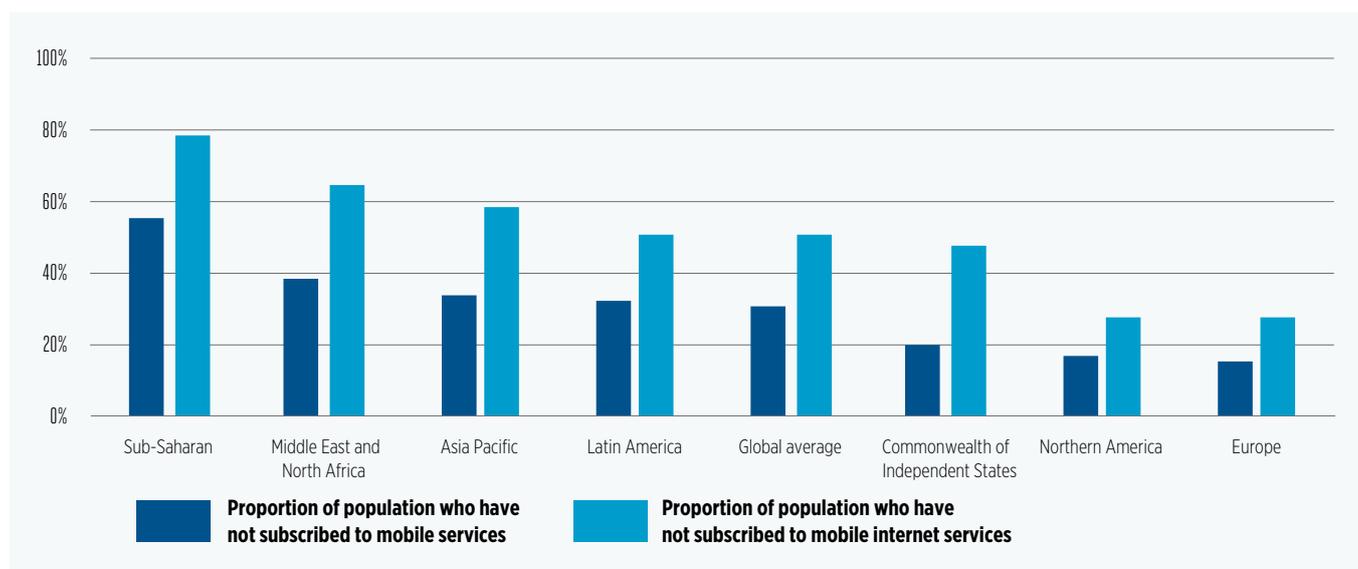
In 2017, mobile technologies and services generated 4.5% of GDP globally, a contribution that amounted to \$3.6 trillion of economic value added. By 2022, this contribution will reach \$4.6 trillion, or 5% of GDP, as countries around the globe increasingly benefit from the improvements in productivity and efficiency brought about by the increased take-up of mobile services and IoT solutions. In 2017, the wider mobile ecosystem supported a total of 29 million jobs around the world.⁴

Mobile connectivity also brings a range of social and economic benefits by helping to promote digital inclusion and supporting the delivery of essential services and key public policy objectives. Poverty eradication, healthcare, education, financial services and gender equality are all impacted. For these reasons, the mobile sector has become central to the international development agenda. Wider mobile reach and better networks are proving to be key enablers to achieve the UN's Sustainable Development Goals (SDGs), an ambitious 17-point plan introduced in September 2015 to end poverty, combat climate change and fight injustice and inequality by 2030.⁵

2.2 Digital divide in developing countries

While the growing adoption of mobile-based solutions in developing countries is supporting easier access to healthcare and providing increased productivity and information, there is more work to be done. The number of people not using mobile services or mobile internet services in some regions, such as Sub-Saharan Africa and parts of Asia Pacific and MENA, is still high. See Figure 1.

FIGURE 1: PROPORTION OF POPULATION NOT SUBSCRIBED TO MOBILE SERVICES OR MOBILE INTERNET SERVICES, 2017



Source: GSMA Intelligence

Access to radio spectrum is an essential component to delivering mobile services in developing countries and closing the digital divide. Efficient spectrum assignments increase the

socioeconomic benefits mobile services deliver – both directly and indirectly. These can significantly exceed the shorter-term benefits of higher spectrum revenues for the state.

4. The Mobile Economy 2018, GSMA Intelligence, 2018

5. 2017 Mobile Industry Impact Report: Sustainable Development Goals, GSMA Intelligence, 2017

2.3 Different types of mobile spectrum costs

In most cases, an upfront price is paid for mobile spectrum licences, usually at auction but occasionally through a direct administrative award from a government or regulator to a mobile operator. Licensees also usually pay an annual fee to cover the costs of managing the spectrum. In some cases, the annual fee can be higher where licences have been renewed without an upfront cost, or where lower upfront charges were applied. There can also be other types of spectrum licence cost. For example, operators might need to pay a percentage of their annual revenues. Some licences also contain coverage obligations or social obligations, which can also be costly to fulfil.

This report only includes in its analysis upfront spectrum fees, as it is usually the most significant cost and most commonly applied. Crucially, there is also the greatest amount of publicly available data on upfront spectrum costs, so a wide sample of countries could be studied. Annual fees and other financial obligations are not incorporated into this analysis. As such, the amount actually paid by operators is often higher than the values shown here and in some cases could be considerably higher.⁶

2.4 Spectrum policy objectives

Radio spectrum is used to carry communications wirelessly and a critical input in the provision of mobile connectivity. When awarding spectrum for mobile services, governments generally make three considerations:

- **Efficient assignment.** Assign spectrum to those who value it most and so will use it most efficiently.
- **Maximisation of consumer welfare.** Assign spectrum to support a well-functioning competitive mobile market, which can introduce new services effectively, ensure sufficient capacity for existing services and keep prices low for customers.⁷
- **Raise revenue for the state.** Governments often view spectrum assignments as a way to raise public revenues.

In many cases, these objectives can be broadly aligned, with the highest value bidders also the best candidates to realise the highest welfare in society through the use of spectrum. This in turn generates revenue for the public sector as a by-product. However, there are a number of competing factors when designing a spectrum award. While very few governments prioritise the revenue maximisation objective with no other considerations, some countries have historically placed more focus on raising revenues than pursuing market efficiency and consumers' interests.⁸ In fact, spectrum assignments are often seen as a simpler way to raise additional revenues than introducing or raising taxes.

Pursuing revenue maximisation when awarding spectrum, however, can be detrimental to consumer interests. As highlighted in economic literature⁹, efficient spectrum assignments increase the socioeconomic benefits delivered by mobile services, which in turn are greater than the short-term gains from higher licence payments.

6. These countries include Bangladesh, Pakistan and Mexico, among others

7. This objective may not always align with the first because assigning spectrum to the highest value bidder does not always maximise or enhance consumer welfare. This is because the value of bidders in an auction for spectrum depends on their expected profit. There can be a divergence between activities that are the most profitable and those that generate the greatest social benefit.

8. For example, Article 72 of the 1341 Law in Colombia emphasises the objective of maximising revenues from spectrum.

9. A welfare analysis of spectrum allocation policies, RAND Journal of Economics, 2009

2.5 How spectrum prices affect investment and consumer pricing

There are contrasting arguments in academic literature around the potential impacts of spectrum prices on mobile market outcomes. These are summarised below. The following section of the report highlights evidence that supports the view that spectrum prices can impact mobile market outcomes, such as the cost of services and network investment levels.

Why spectrum prices may affect mobile market outcomes

1. **Actual inputs in investment and pricing decisions:** With increased costs for firms through higher spectrum prices, the mobile market can become less profitable compared to other industries. This can make investing relatively less attractive, leading to underinvestment by domestic and foreign investors in the country's mobile industry and inefficient allocation of capital across the economy, especially once the wider benefits generated by mobile connectivity are taken into account. Alternatively, firms may try to recover these high costs through higher mobile tariffs.
2. **Creating uncertainty around long-term investment horizons for the mobile market:**
 - a. The high upfront investment required for mobile infrastructure and long repayment cycles present a number of risks to operators. In particular, once they have made an investment, any unexpected changes in regulatory charges may affect a company's profitability, lowering returns.
 - b. Short licence duration and lack of transparent spectrum awards can create additional uncertainty and an unfavourable long-term investment environment.

3. **Creating financing constraints:** High spectrum prices may require debt financing, which has a direct impact on the competitive behaviour of a firm and its pricing strategies. In addition, when financed through debt, the cost of spectrum can be annualised in line with the debt repayments, and considered an additional investment, affecting the company P&L and cash available for network investment.

Why spectrum prices may not affect mobile market outcomes

According to the sunk cost argument, spectrum licence fees are sunk costs, and as such should not be taken into account by companies in future decisions (e.g. pricing and investments). In addition, even if spectrum prices and consumer outcomes show a relationship, it may not be the case that spectrum prices are passed onto consumers, but rather that firms are deciding what to pay for the licence based on the expected future growth and profitability of the market.

3. How Rising Spectrum Prices are Affecting Consumers in Developing Countries

Between 2010 and 2017, final spectrum prices in developing countries were on average more than three times those in developed countries once income per capita is taken into account. In addition to genuine market dynamics and other spectrum management policies, this is in part the result of aggressive reserve prices and high administrative fees, which are often driven by short-term public revenue maximisation objectives. These dynamics are not in evidence to the same extent in developed countries.

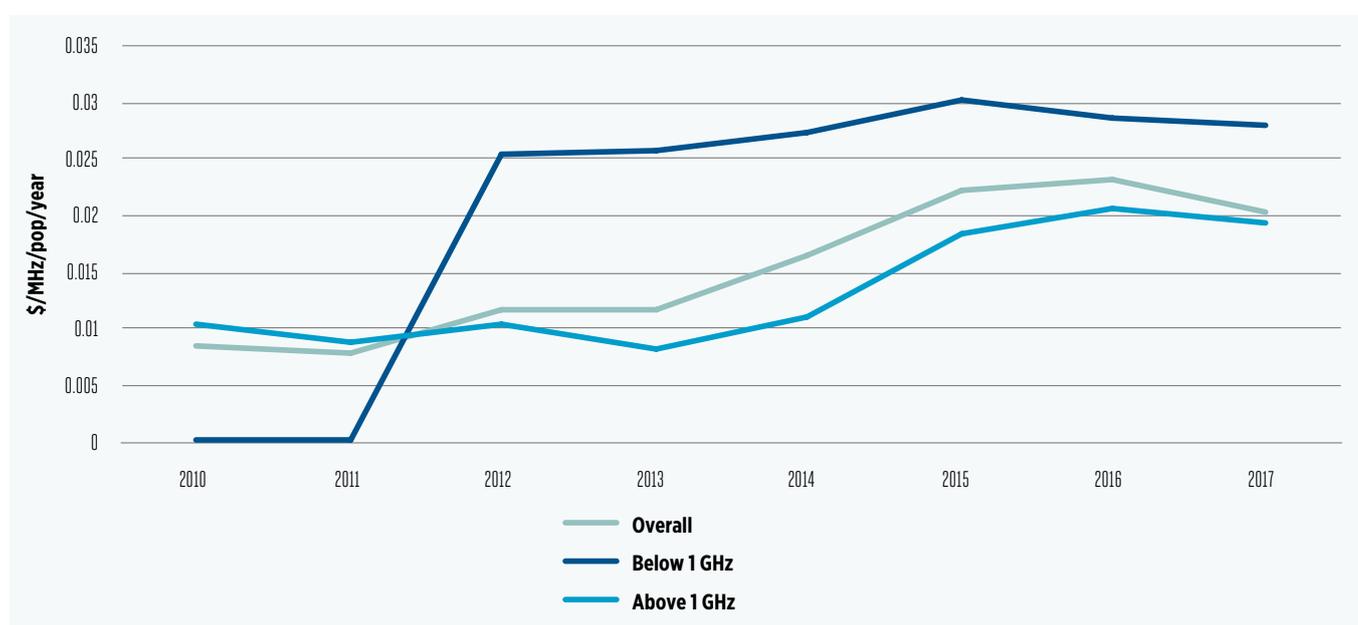
The results also suggest that higher spectrum prices can lead to more expensive, lower quality mobile broadband services, highlighting the trade-off that exists in spectrum policy when trying to achieve both public financing and consumer welfare objectives.

3.1 Rising spectrum prices

To understand the trends and potential impacts of spectrum prices¹⁰, we examined more than 1,000 spectrum assignments across 102 countries (including 60 developing and 42 developed countries¹¹) between 2010 and 2017. The analysis for developing countries draws on a subset of these awards, covering almost 400 spectrum assignments across 60 markets. Figure 2 shows that average 4G spectrum prices in developing countries more than doubled between 2010 and 2017.

We start by analysing 4G spectrum prices, as 4G is the latest technology rolled out in developing countries over the period studied. There is also considerable interest in supporting widespread 4G services to help developing countries bridge the digital divide.

FIGURE 2: 4G FINAL SPECTRUM PRICES ON THE RISE IN DEVELOPING COUNTRIES



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted for inflation, PPP (2016 prices), and licence duration, and aggregated by country, band, generation and assignment. The 4G classification is based on actual use of spectrum assigned, based on GSMA Intelligence data. All spectrum bands for which relevant data was available are included. Outliers have been removed from the analysis.¹² The analysis is based on 3-period moving averages. 3-period moving average represents a series of averages of different three-year subsets of the full dataset over time.

10. All spectrum prices in the report include upfront payments only. Annual fees and other financial obligations are not incorporated into the analysis. As such, the amount actually paid by operators is often higher than the values shown here. See the Appendix for more details on the spectrum prices data and metrics.

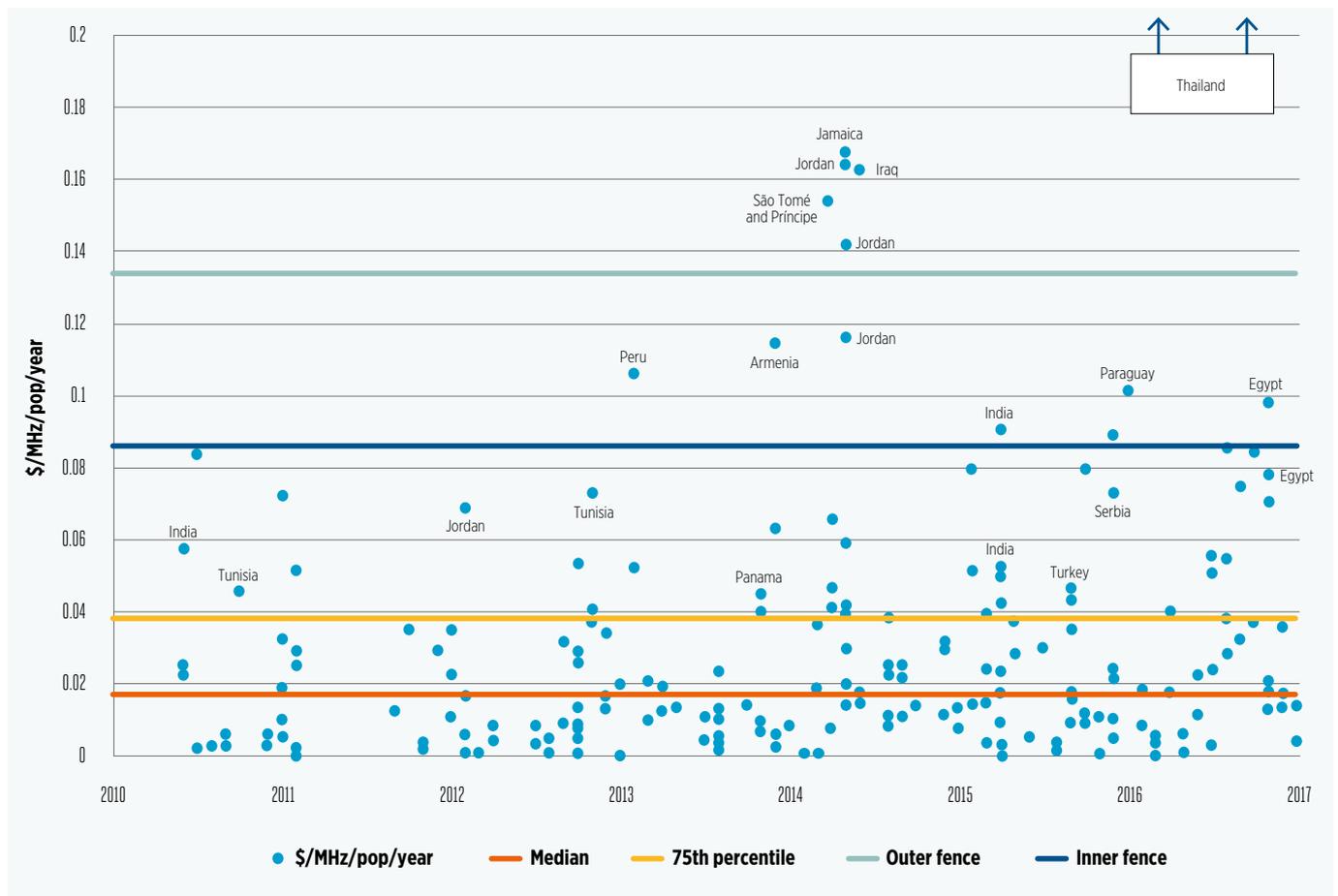
11. The list of countries is provided in the Appendix.

12. In order to identify and exclude outliers, we used a standard statistical technique. The Inter Quartile Range (IQR) is defined as the observations between the 1st and the 3rd quartile (25th and 75th percentiles respectively). Outliers are classified as being above an "inner fence", i.e. above 3rd quartile + 1.5 IQR. These observations were removed because they have a disproportionate effect on the overall trends and increase volatility.

By analysing the full sample of spectrum awards in developing countries, a number of high prices have been identified over recent years, particularly between 2013 and 2016, as shown in Figure 3. This would not be a concern if it were the result of strong and direct competition between bidders in auctions; however, in some cases higher prices have been driven by government policy rather than market forces. This includes setting high reserve prices or high final prices in administrative awards; features of the auction design; artificial scarcity of spectrum; and the lack of a spectrum roadmap.

According to our analysis, the biggest outliers coincide either with cases of expensive administrative assignments or auctions with high reserve prices.¹³ Some of these expensive assignments also occurred in markets where revenues per user are relatively low, which further highlights that market forces are not always the key drivers of spectrum prices. In other cases, assignments were conducted in markets that had already experienced substantial delays in the award of key 4G bands – Jamaica being a notable example.

FIGURE 3: WIDE RANGE OF FINAL PRICES IN DEVELOPING COUNTRIES INCLUDING EXTREME OUTLIERS (2010–2017)



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted by inflation, PPP (2016 prices) and licence duration, and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included. The IQR is defined as the observations between the 1st and the 3rd quartile. Outliers are classified as being above an “inner fence”, i.e. above 3rd quartile + 1.5 IQR. Extreme outliers are classified as being above an “outer fence”, i.e. above 3rd quartile + 3 IQR.

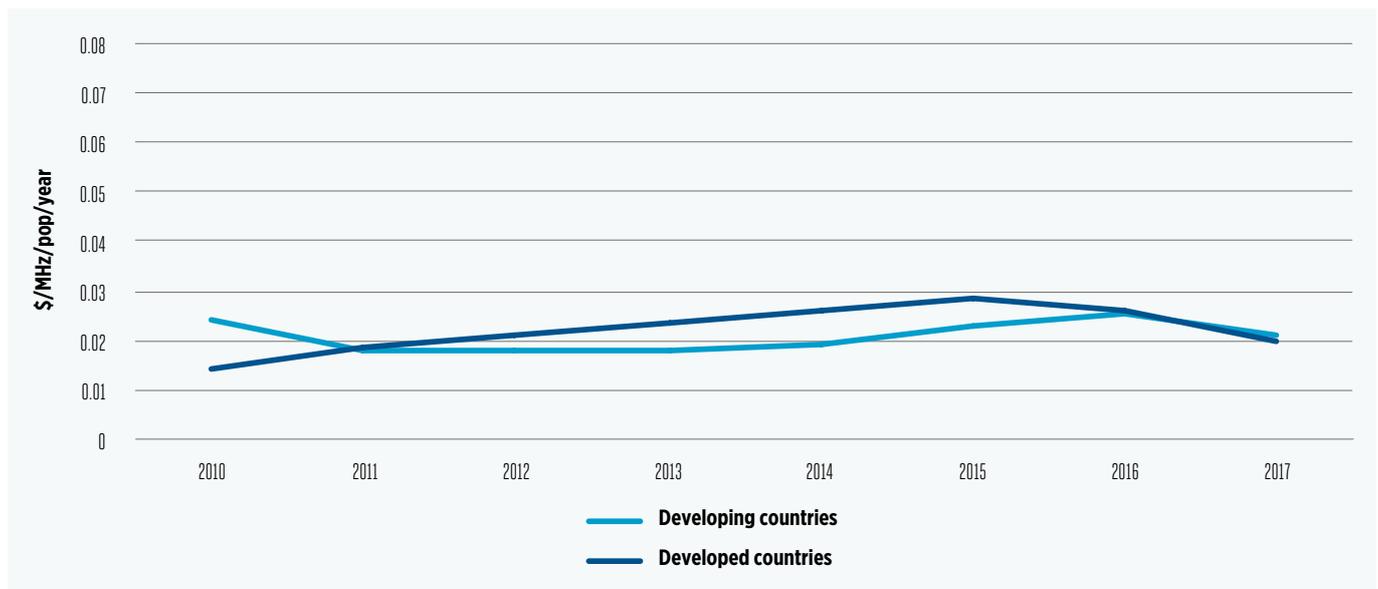
13. Reserve prices for the biggest outliers – above the inner fence – where applicable, are either higher than the average reserve prices observed during the period 2010–2017 or in some cases abnormally expensive (on average 5.6 times the global average).

Spectrum prices have been fairly similar in developing and developed countries over the 2010–2017 period, as shown in Figure 4. The prices have been adjusted by purchasing power parity, so the cost of purchasing a unit of spectrum – 1 MHz of spectrum per inhabitant and year of licence – is the same in developing as in developed countries.

Purchasing power parity adjustments, however, do not take into account income levels. Figure 5 shows that once overall spectrum prices are adjusted for GDP per capita, spectrum prices in developing countries have been consistently and significantly higher than in developed markets.¹⁴ The cost of spectrum as a proportion of average income per capita in developing countries is on average more than three times that of developed markets over the period studied. This may imply comparatively lower investment returns and, as a consequence, underinvestment in mobile markets in developing versus developed countries.

The cost of spectrum as a proportion of income was around 2.5 times higher in developing than in developed countries between 2010 and 2013, then increased to around four times higher between 2014 and 2016, before returning to 2.5 times higher in 2017. The spike in the developing countries' prices between 2014 and 2016 is mostly due to a number of expensive assignments in India, Iraq, Pakistan, Niger and Afghanistan. In 2017, prices fell back in line with the levels observed between 2010 and 2013, with spectrum costs twice as expensive in developing than in developed countries, once income levels are taken into account. A similar trend can be observed for reserve prices. (Figures 6 and 7).

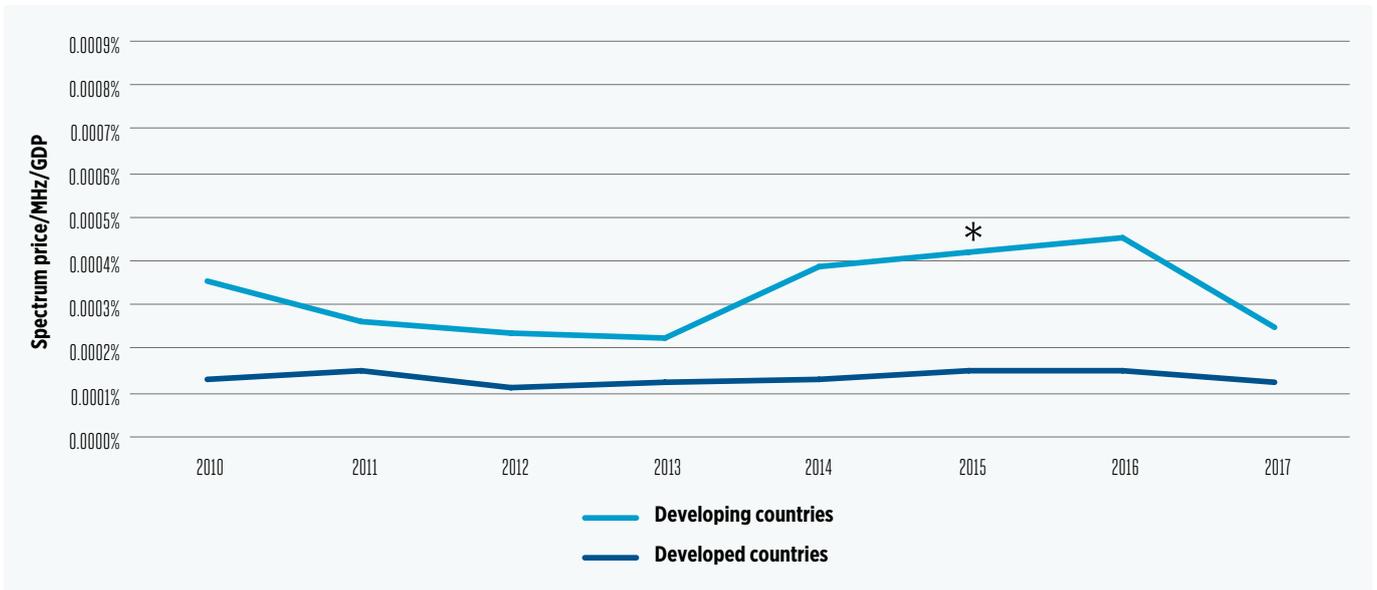
FIGURE 4: FINAL PRICES ARE COMPARABLE IN DEVELOPED AND DEVELOPING MARKETS WHEN ADJUSTED FOR PURCHASING POWER



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted by inflation, PPP (2016 prices), and licence duration and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included. Outliers have been excluded from the analysis. The analysis is based on 3-period moving averages.

14. An argument could be made that consumers in developing countries are willing to pay more for mobile as a proportion of income but this seems unlikely and there is currently no evidence to support such a hypothesis.

FIGURE 5: FINAL SPECTRUM PRICES IN DEVELOPING COUNTRIES ARE ON AVERAGE MORE THAN 3 TIMES THOSE OF DEVELOPED COUNTRIES WHEN INCOME IS FACTORED IN



Source: GSMA Intelligence. Notes: spectrum prices in local currency (by MHz/pop/year) have been adjusted by inflation, GDP per capita, and licence duration, and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included in this chart. Outliers have been excluded from the analysis. The analysis is based on 3-period moving averages.

* The spike between 2014 and 2016 is mostly due to a number of expensive assignments in India, Iraq, Pakistan, Niger and Afghanistan, among others. In 2017, prices fell back in line with the levels between 2010 and 2013.

Compared to developed countries, mobile spectrum in developing countries is also much more scarce, as regulators have on average chosen to make less available. As of 2017, total spectrum holdings in the developing countries considered in

our sample were on average around 340 MHz, compared to around 550 MHz for developed countries. This reduced supply of spectrum contributes to the higher average prices in developing markets.



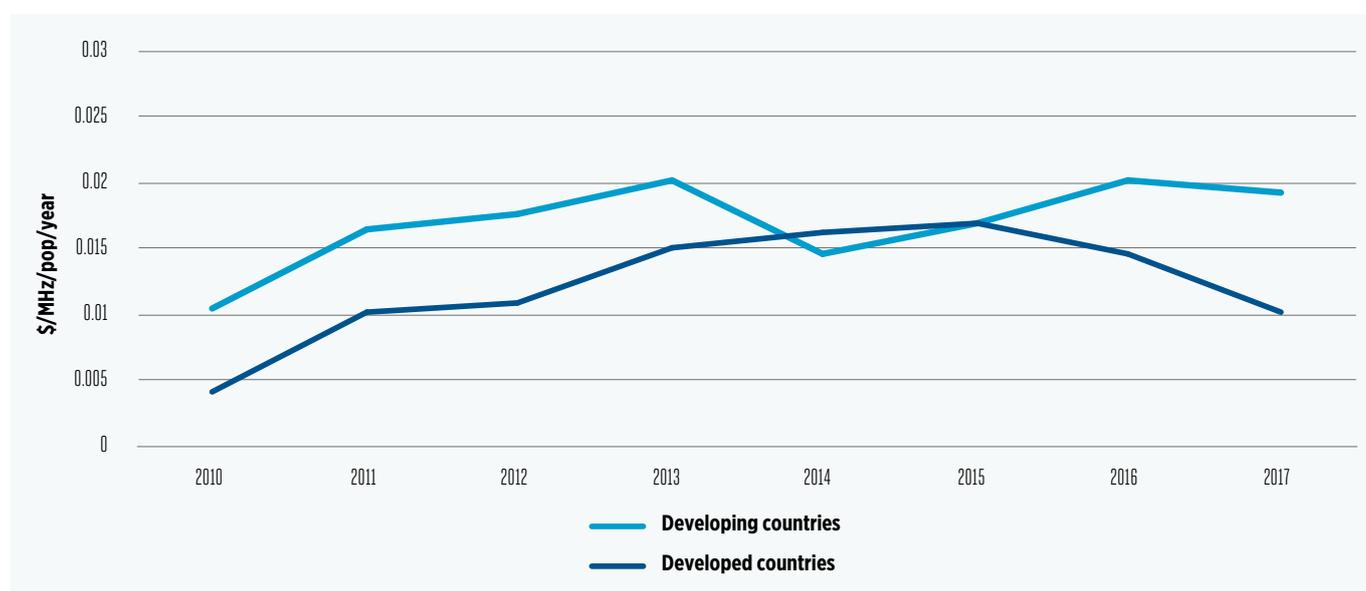
3.2 Government and regulatory intervention

3.2.1 Reserve Prices

High upfront spectrum prices can be the result of several different factors. Competition among bidders will drive prices up, but governments can also influence the final spectrum assignment and price. They can do this by directly setting high final prices, setting high auction reserve prices, constricting the supply of spectrum, not publicising a long-term spectrum roadmap, or using poor award rules. If governments are primarily focused on maximising public revenues, reserve prices are often a key mechanism used.

In developing countries, average reserve prices across all spectrum bands almost doubled between 2010 and 2017. When comparing reserve prices between developing and developed countries, we detect relatively similar trends, but significantly higher prices in developing countries across all frequencies, as shown in Figure 6. When adjusted for income per capita, reserve prices in developing countries were on average more than five times those in developed countries between 2010 and 2017 (see Figure 7).

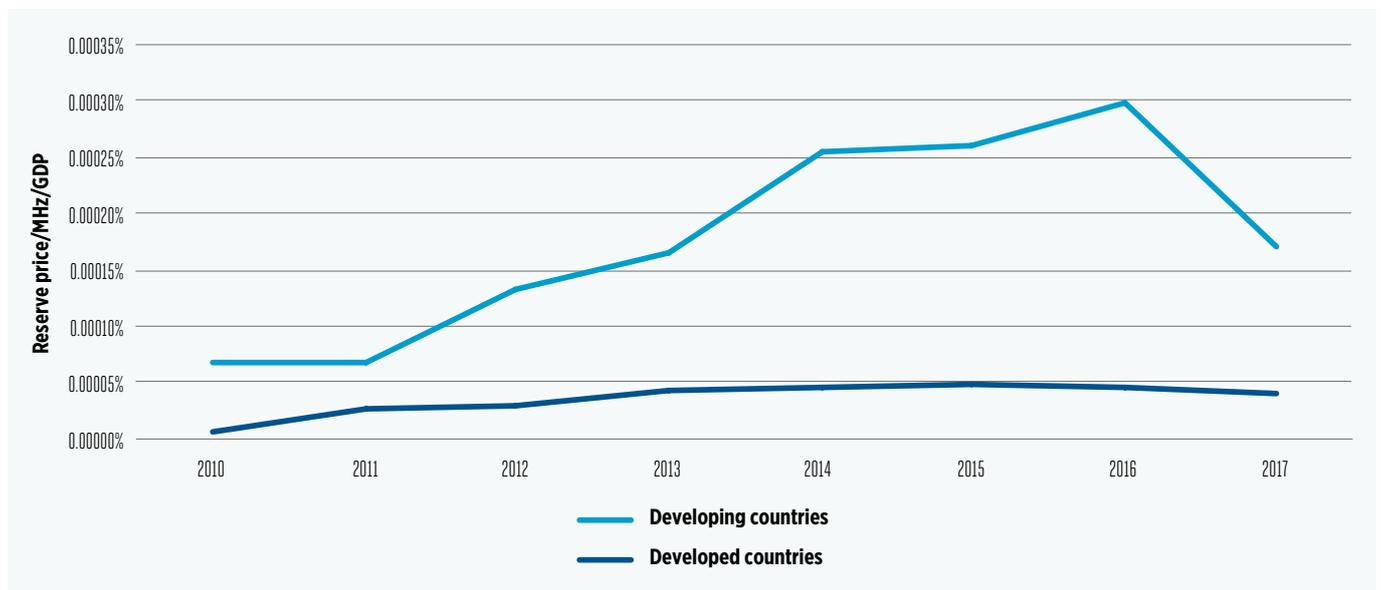
FIGURE 6: RESERVE PRICES IN DEVELOPING MARKETS CONSISTENTLY HIGHER THAN DEVELOPED



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted for inflation, PPP (2016 prices), and licence duration, and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included in this chart. Outliers have been excluded from this analysis. The analysis is based on 3-period moving averages.



FIGURE 7: RESERVE PRICES IN DEVELOPING COUNTRIES ARE ON AVERAGE MORE THAN FIVE TIMES THOSE IN DEVELOPED COUNTRIES WHEN FACTORING IN INCOME

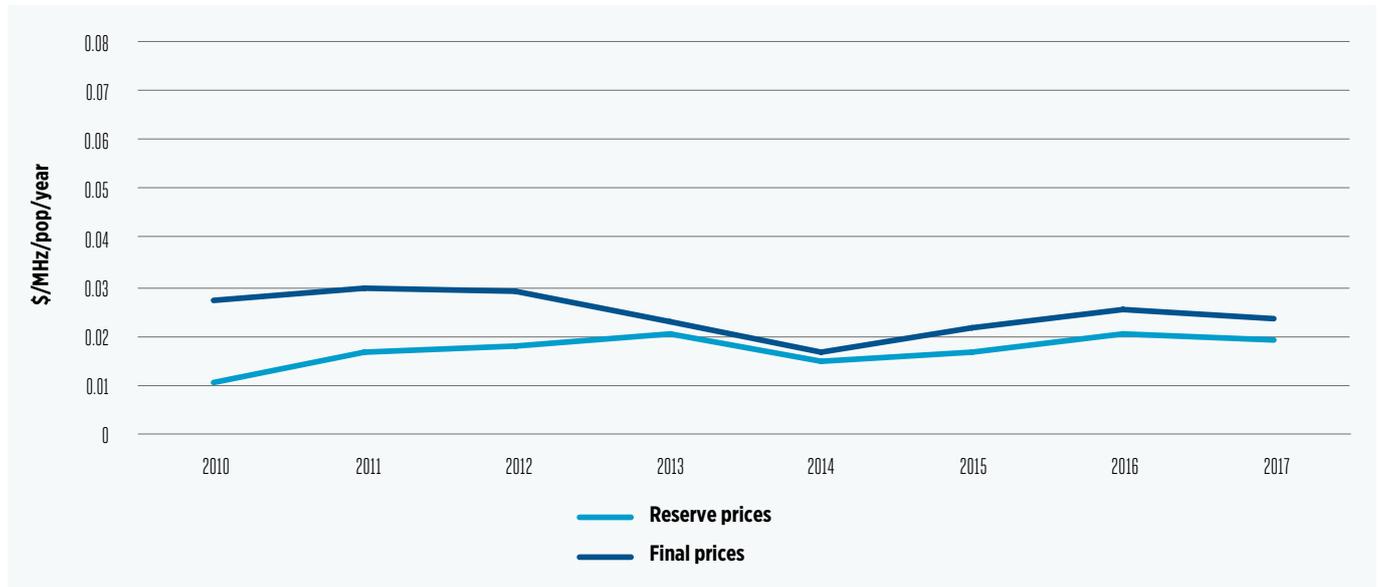


Source: GSMA Intelligence. Notes: spectrum prices in local currency (MHz/pop/year) have been adjusted for inflation, GDP per capita, and licence duration, and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included. Outliers have been excluded from the analysis. The analysis is based on 3-period moving averages.

Figure 8 shows how operators in developing countries have been paying final prices that are close to reserve prices, particularly in recent years. As a result, the fundamental aim of the auction, which is to let the market determine prices, can be compromised.

Reserve prices already capture most, if not all, of the operator’s willingness to pay, leaving little room for manoeuvre in setting market-led prices.

FIGURE 8: FINAL PRICES CLOSE TO RESERVE PRICES IN DEVELOPING COUNTRIES

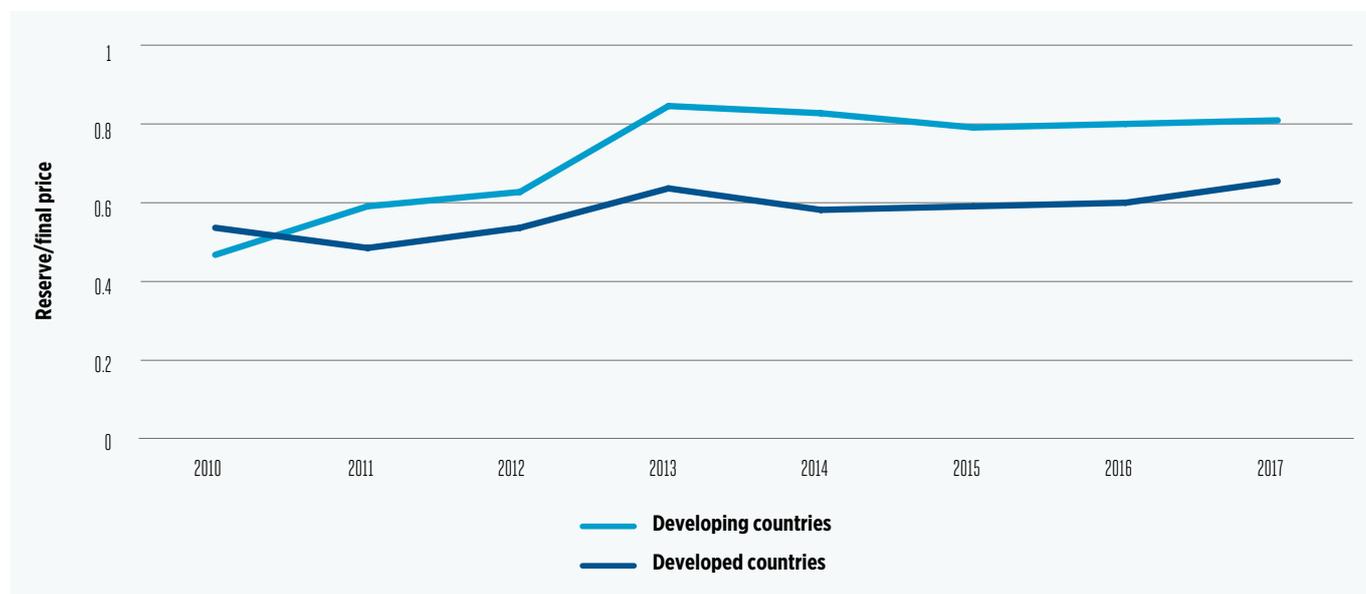


Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted for inflation, PPP (2016 prices), and licence duration, and aggregated by country, band, generation and assignment. All spectrum bands for which relevant data was available are included. Outliers have been excluded from this analysis. The analysis is based on 3-period moving averages.

As final prices in developing countries are typically similar to developed countries, and actually higher when income is taken into account, it is clear that this does not reflect a lower financial burden for operators or a lower level of competitiveness in the auctions. In fact, a much higher proportion of operator investment is being squeezed out by reserve prices in developing countries. This again points to reserve prices being set more aggressively in developing countries. As shown in Figure 9, the ratio of reserve to final prices has increased from approximately 50% to 80% between 2010 and 2017 in developing countries, while remaining at lower levels in developed countries.

Reserve prices should discourage speculators and frivolous bidding, recover the administrative costs of the award process and limit collusion incentives between bidders, while leaving enough room for market price discovery. Where reserve prices are set with these principles in mind rather than public financing objectives, we would expect them to be lower than they appear in the current analysis.

FIGURE 9: RESERVE/FINAL PRICE RATIOS SHOW RESERVE PRICES SET MORE AGGRESSIVELY IN DEVELOPING COUNTRIES



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been adjusted for inflation, PPP (2016 prices), and licence duration, and aggregated by country, band, generation and assignment. For assignments where both a final and a reserve price were available, ratios of these variables have been calculated. All spectrum bands for which relevant data was available are included. Outliers have been excluded from this analysis. The analysis is based on 3-period moving averages.

Some countries do not need to set reserve prices as they directly set the final price through an administrative award. These prices are sometimes set at high levels that can significantly exceed the average developed country final spectrum price, after PPP adjustment. Examples include spectrum awards in Malaysia (900 and 1800 MHz) and Myanmar (1800 MHz) in 2016 and 2017 respectively.

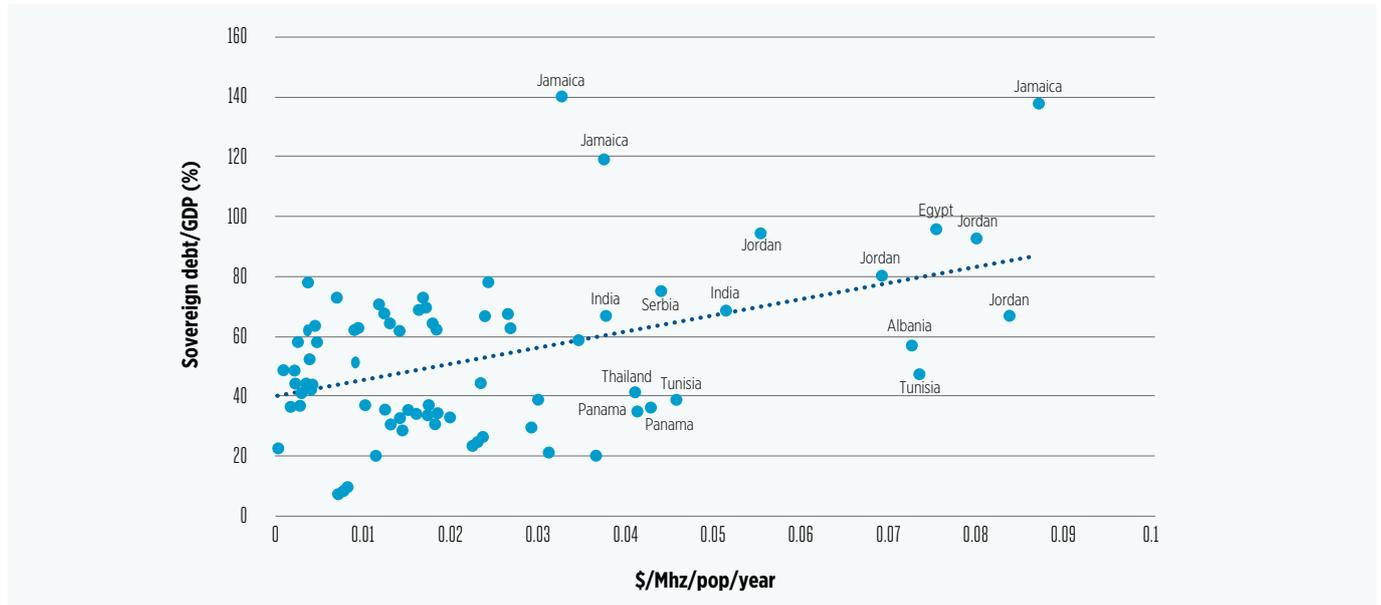
3.2.2 Spectrum Prices and the Wider Macroeconomic Environment

Reserve pricing policies that price aggressively high are sometimes linked to the need to raise public funds. Although revenue maximisation is rarely the only objective considered when assigning spectrum from a government perspective, it is sometimes prioritised over the efficient development of the market and the long-term welfare of consumers.

Developing countries where the public sector is highly indebted (calculated as sovereign debt as a proportion of GDP or average tax revenues¹⁵) tend to have higher spectrum prices (see Figures 10 and 11). The relationship does not hold to the same extent in developed countries. Given that spectrum prices are unlikely to determine government debt, the more plausible interpretation is that governments in developing countries experiencing financial challenges are using spectrum assignments to increase public sector revenues.

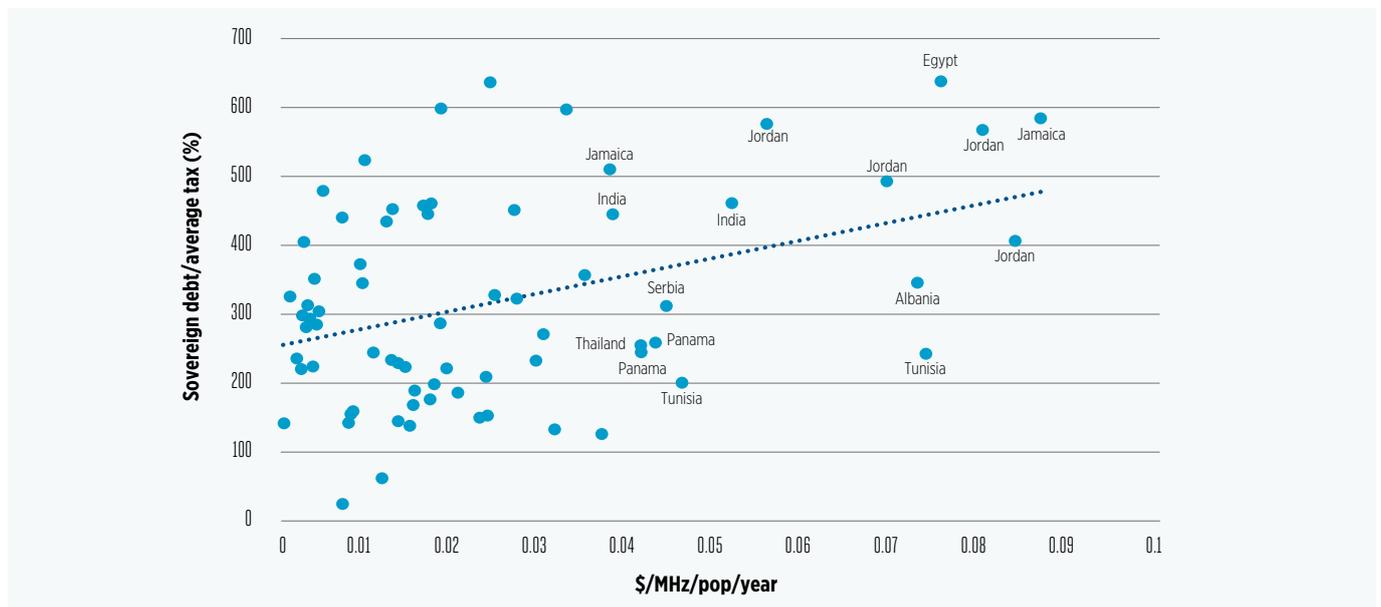
15. Measuring debt as a percentage of average tax, rather than GDP, provides a more direct measure of debt sustainability in the country, as it assesses debt as a proportion of public sector financing.

FIGURE 10: SPECTRUM PRICES AND SOVEREIGN DEBT/GDP RATIO



Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed.

FIGURE 11: SPECTRUM PRICES AND SOVEREIGN DEBT/AVERAGE TAX RATIO



Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed.

This link is particularly strong where governments need to repay a large amount of debt in the short term and where access to financial markets is foreclosed or difficult.¹⁶ Figure 12 shows that high spectrum prices are more common in countries with higher percentages of sovereign debt due in 12 months (or less). Figure

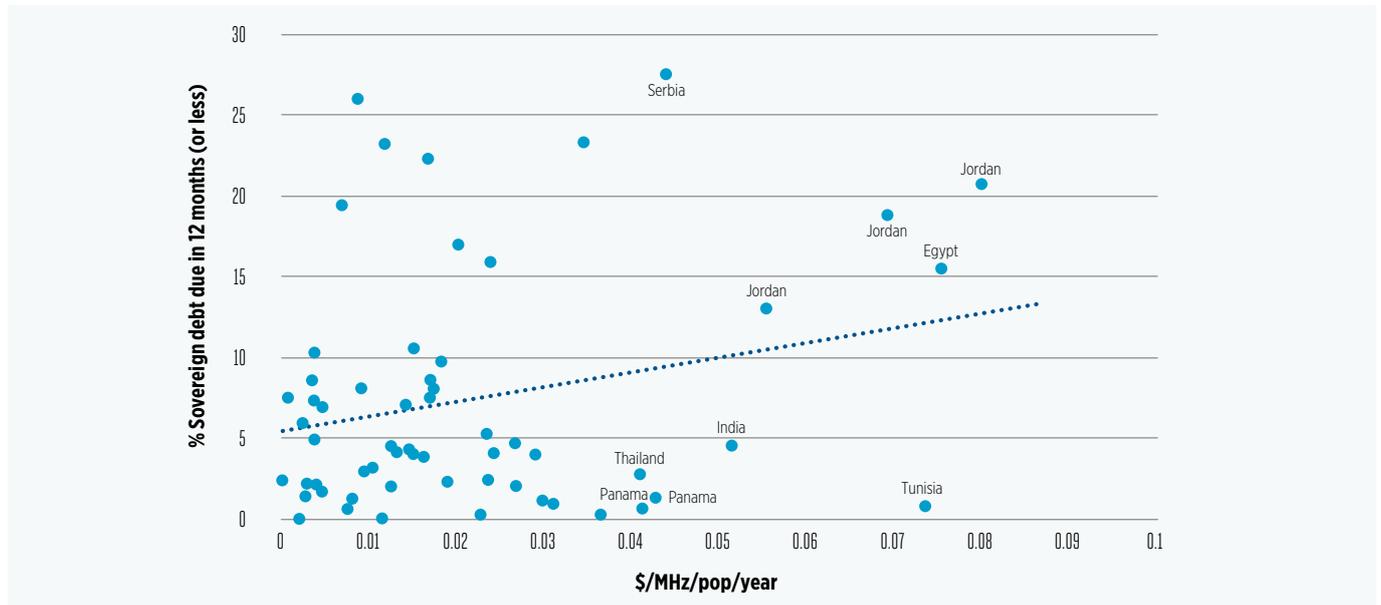
13 shows that lower average maturities¹⁷ are also linked to higher spectrum prices. Figure 14 shows how higher spectrum prices are associated with larger sovereign CDS spreads¹⁸, indicating that access to financial markets may be difficult.

16. High risk of default on sovereign debt can make borrowing on the financial markets more expensive and therefore challenging.

17. Average amount of time until the maturity of the different sovereign debt instruments, where maturity represents the final payment date of loan or other financial instrument.

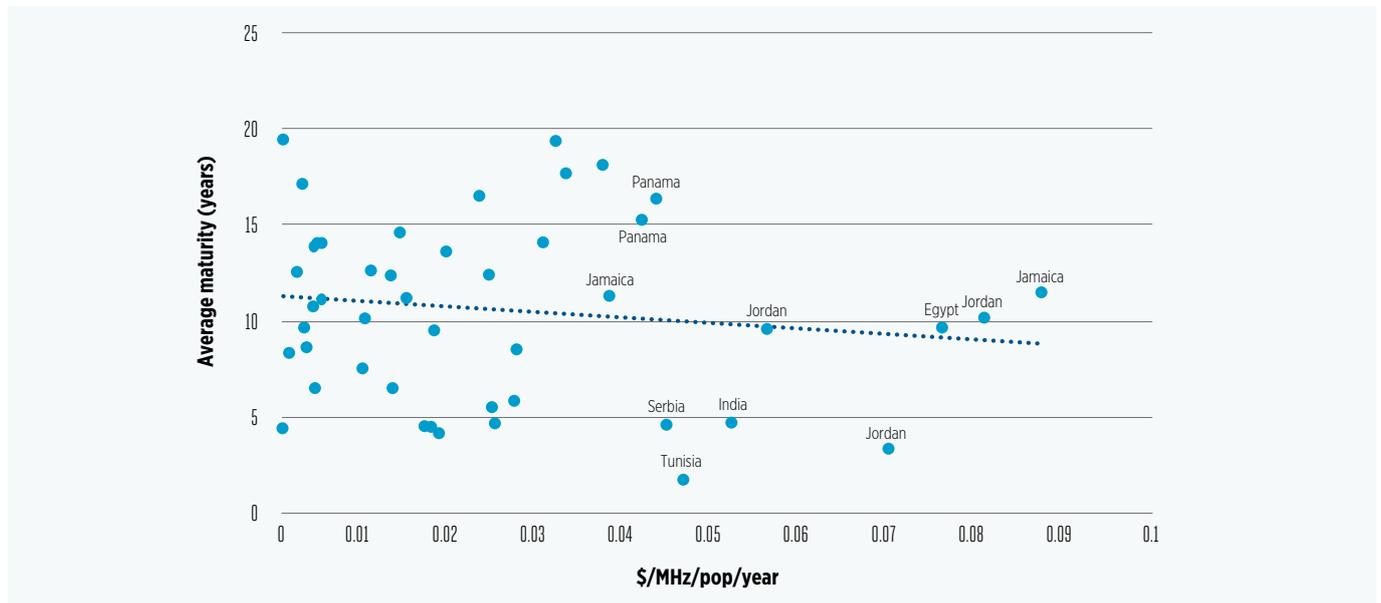
18. Credit Default Swap spreads associated with sovereign debt. The higher CDS spreads are, the higher the risk of default on the sovereign debt, and the harder it is to access financial markets for further financing.

FIGURE 12: SPECTRUM PRICES AND PERCENTAGE OF SOVEREIGN DEBT DUE IN 12 MONTHS (OR LESS)



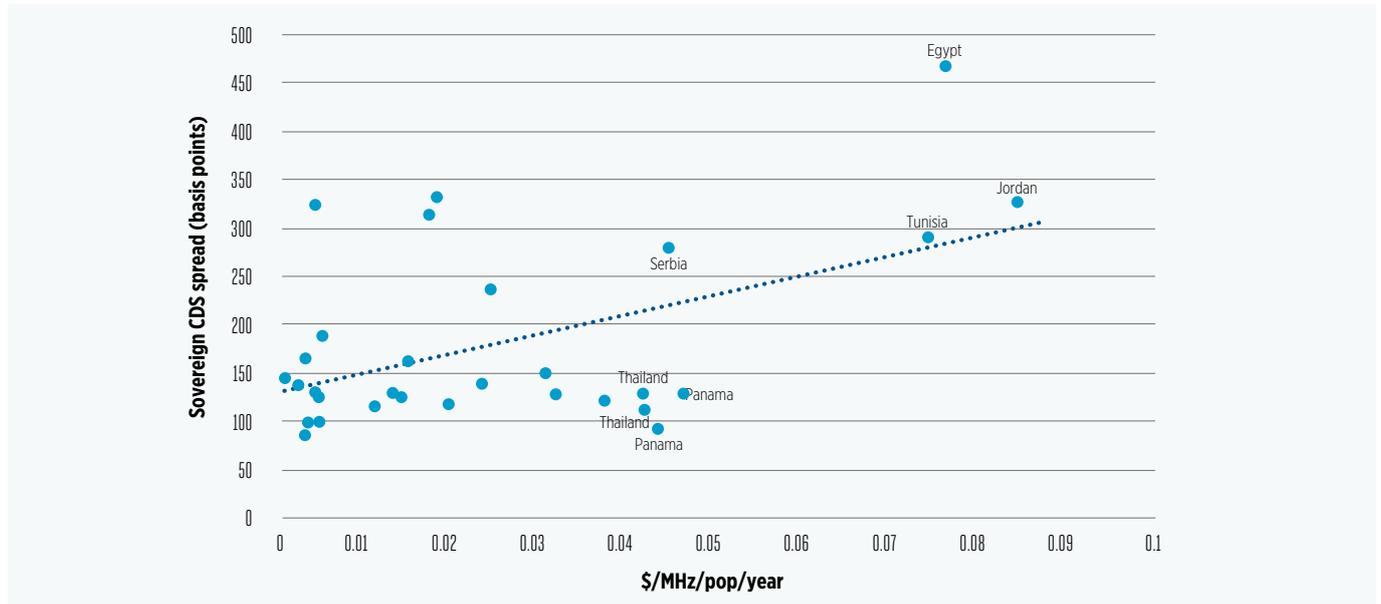
Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed from this analysis.

FIGURE 13: SPECTRUM PRICES AND AVERAGE DEBT MATURITY



Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed from this analysis.

FIGURE 14: SPECTRUM PRICES AND FIVE-YEAR SOVEREIGN CDS SPREAD

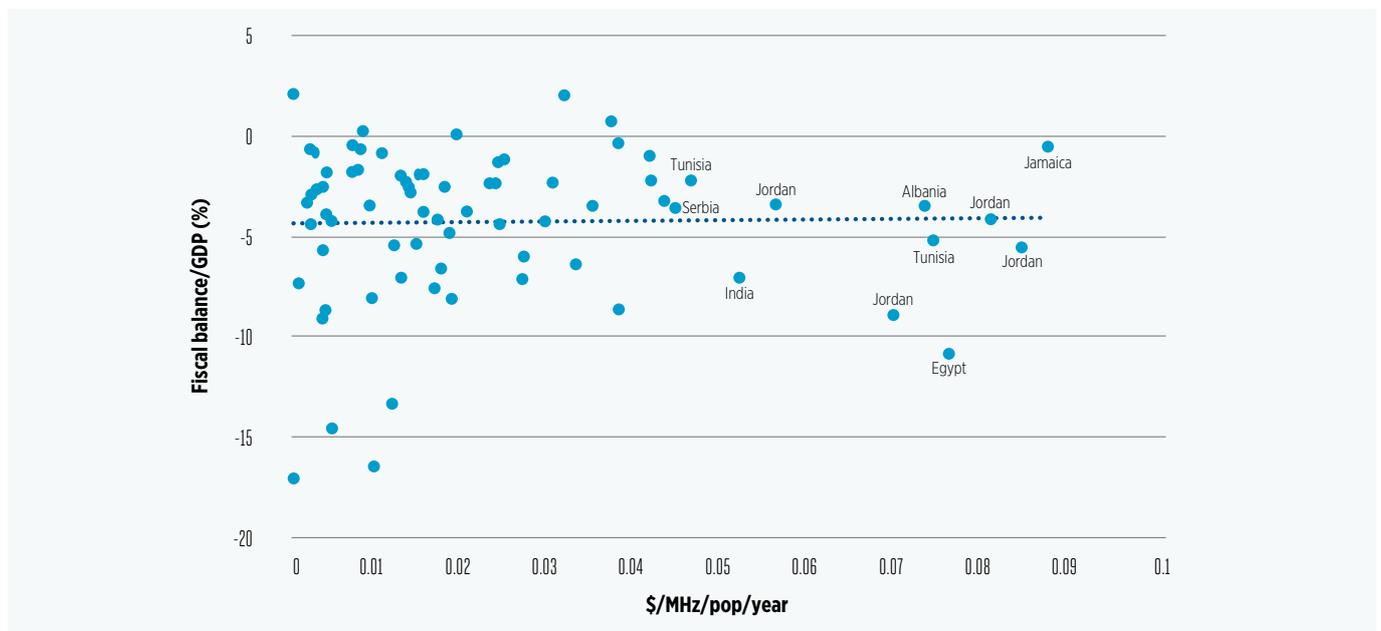


Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed from this analysis.

By contrast, the correlation between spectrum prices and measures of long-term debt (e.g. foreign currency long-term sovereign debt rating) is generally weaker. When considering

even more structural measures of debt sustainability, such as the fiscal balance of a country¹⁹, the link with spectrum prices disappears, as shown in Figure 15.

FIGURE 15: SPECTRUM PRICES AND FISCAL BALANCE AS A PROPORTION OF GDP



Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country and year over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. Outliers have been removed from this analysis.

19. The fiscal balance is the difference between government revenues and spending.

This is to be expected, as structurally balancing the public sector budget requires broader and longer term measures than raising greater revenues from spectrum awards. However, spectrum awards can serve as a short-term aid for developing countries facing high levels of overall debt, impending debt payments and/or challenging access to financial markets.

While using spectrum revenues to ease short-term levels of sovereign debt could be a legitimate public policy objective, this may be detrimental to the efficient and growth-promoting assignment of spectrum and, as a consequence, the maximisation of social welfare.

3.3 Spectrum prices and mobile market outcomes

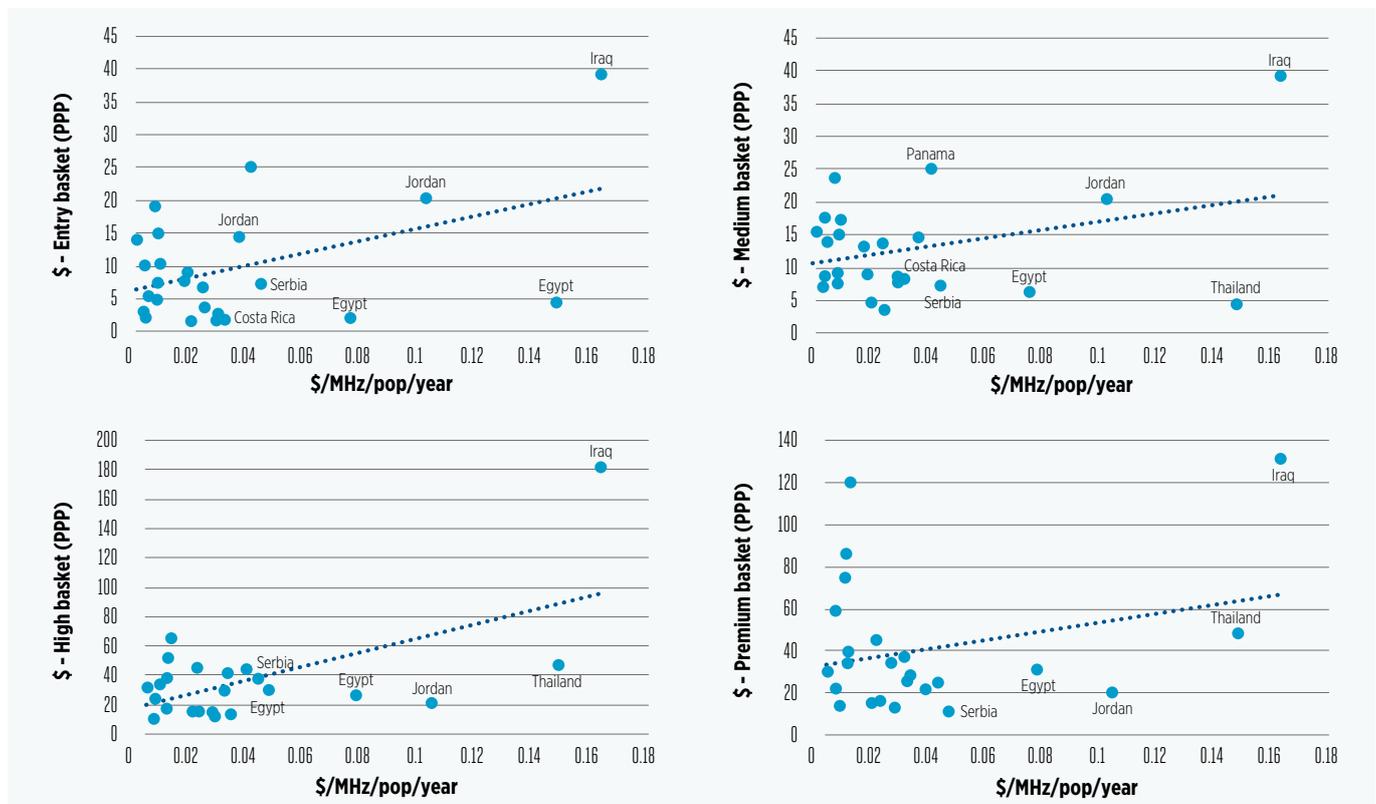
3.3.1 Spectrum Prices And Mobile Tariffs

Affordable mobile broadband access is a primary focus for all telecoms regulators, especially those in developing countries, as it is a crucial enabler of widespread mobile internet adoption.

There are theoretical arguments that explain why high spectrum prices may in part be passed onto consumers through high mobile tariffs. Operators experiencing lower returns on investment, or financial constraints as a consequence of higher

spectrum costs, may try to recover part of the costs through higher tariffs. Our analysis indeed shows a positive relationship between spectrum prices and consumer tariffs for mobile services. Figure 16 shows the correlation between total spend on spectrum over the period 2010–2016 and retail mobile tariffs as of the first quarter of 2017. To identify potential impacts across different consumer segments, four baskets with different levels of usage allowance, type of contract and technology are considered.²⁰

FIGURE 16: HIGH SPECTRUM PRICES ARE LINKED TO HIGHER MOBILE TARIFFS



Source: GSMA Intelligence and Tarifica. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 are included in this analysis.

20. See Appendix for more detail on the mobile tariff data and different baskets.

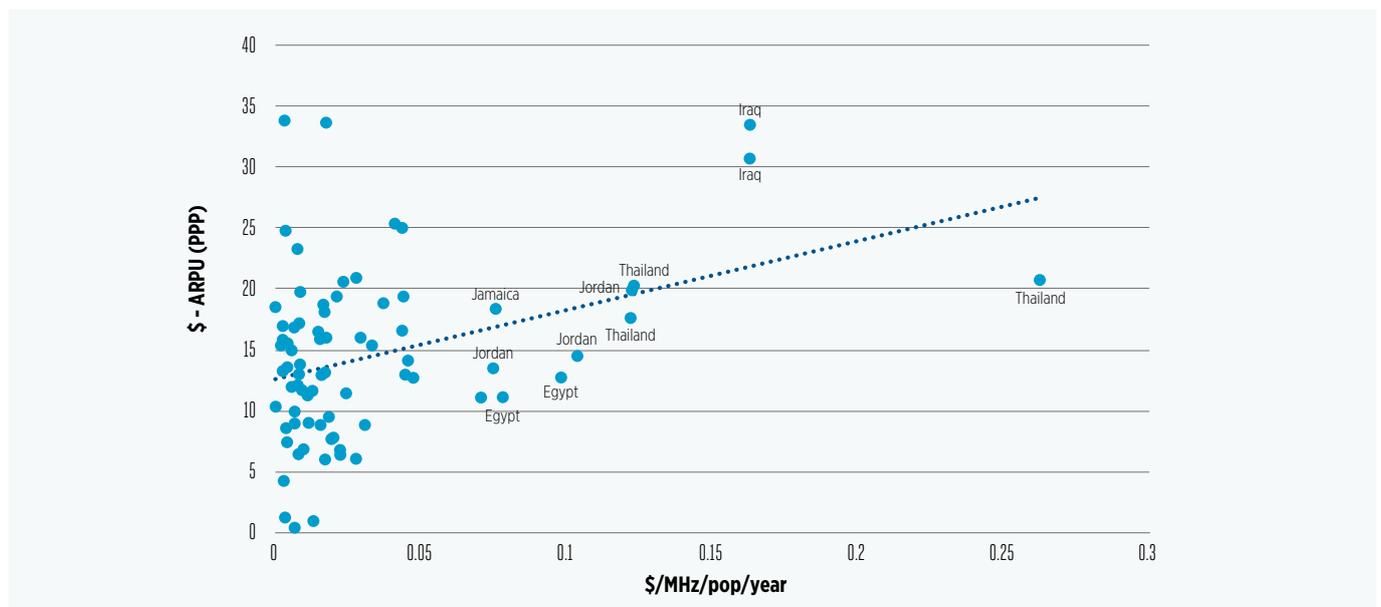


The relationship holds across all consumer segments, though it appears stronger for lower usage baskets, which are likely to be more representative of usage in many developing markets.²¹ This suggests that high spectrum prices may induce higher retail prices, especially for lower consumption segments of the population. These are also the segments of the population with more affordability challenges and therefore the target of digital inclusion policies to lower barriers to connectivity.

These results are consistent with the relationship we also observe between operators' average revenue per user (ARPU²²) and spectrum prices, where ARPU is used here as a proxy for consumer prices. The relationship between spectrum prices

and consumer prices and ARPU can, however, work in both directions. On the one hand, operators will typically be prepared to pay more for spectrum in markets where revenues are higher. On the other hand, high spectrum prices can lower returns on investment, which can put upward pressure on consumer prices. As we have seen, government policies can drive spectrum prices up significantly. Several expensive assignments have also occurred in markets where revenues per user are relatively low, which further highlights that market forces are not always the key drivers of high spectrum prices. In developing markets both factors (market drivers and government policies) appear to be playing a role in driving spectrum prices.

FIGURE 17: SPECTRUM PRICES AND ARPU



Source: GSMA Intelligence and World Bank. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by operator over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. Only countries with a comprehensive set of pricing data between 2010 and 2016 were included in this analysis. ARPU has been adjusted for inflation and PPP (2016 prices).

21. In the majority of African countries, average mobile data usage is in the 60–120 MB range and in some cases less than 60 MB per person per month (source: State of the Mobile Web Africa 2016, Opera, 2016). In Latin America, high and premium baskets are also substantially less affordable than in more developed markets. According to GSMA Intelligence analysis, for the lowest 20% of earners, the high basket represents 29% of income, compared to between 3% and 4% for the lowest 20% of earners in North America and Europe respectively.

22. ARPU represents the average total recurring (service) revenue generated per connection per month over the period.



3.3.2 Spectrum Prices, Network Innovation and Quality

High spectrum prices can also introduce significant financial constraints on operators, hindering their ability to invest in the market. With higher costs for firms, the mobile market becomes less profitable, which can lead to underinvestment. In addition, if fees are unexpectedly high, the additional uncertainty can impact an operator's business case for long-term investment. A riskier investment climate will have adverse effects on consumers, by slowing down sector development. This can affect network innovation and quality, and ultimately the quality of mobile services that consumers enjoy.

Measuring innovation in mobile markets can be challenging, because it is a broad concept encompassing processes that drive cost reductions and the introduction of new products and services. In this study, we consider the impact on innovation by looking at 4G coverage, with 4G the latest technology rolled out during the period 2010–2016, in most developing countries. 3G coverage is excluded from the analysis as most countries had already fully or almost fully rolled out 3G networks before the period of analysis, making it challenging to assess the impact of spectrum prices on that metric.

In terms of network quality, a number of parameters are regularly used to establish the quality of voice and data services, including the following:

- download speeds²³ (higher speeds allow consumers to download content more quickly and use data-intensive applications and content, such as video)

- upload speeds²⁴ (higher speeds enable consumers to share more content and experience better performance of services such as online gaming)
- latency²⁵ (relevant for services that require minimal delays such as video calls, VoIP or online gaming)
- signal strength²⁶ (which affects the overall quality of voice, SMS and data)
- call reliability (dropped or blocked calls²⁷).

For this study, we focus on average download speeds, upload speeds and latency in the countries, considering a summary measure across all technologies.²⁸ These measures are also more effective indicators of network innovation and quality than traditional investment metrics such as capex, especially when assessing the impact on consumers. High levels of capex and investment are only meaningful for consumers to the extent that they improve the performance of the mobile service provided through some of the outcomes analysed.

In order to test the link between high spectrum pricing and network innovation and quality, we correlate total spectrum spend over the period 2010–2016 with coverage and network quality metrics in 2016.

Coverage

There is a correlation between high spectrum prices and reduced 4G population coverage in developing markets, as shown in Figure 18.

23. Download speed is the rate of data transmission to a user's device. It is usually measured in Megabits per second (Mbps) or kilobits per second (kbps).

24. Upload speed is the rate of data transmission from a user's device.

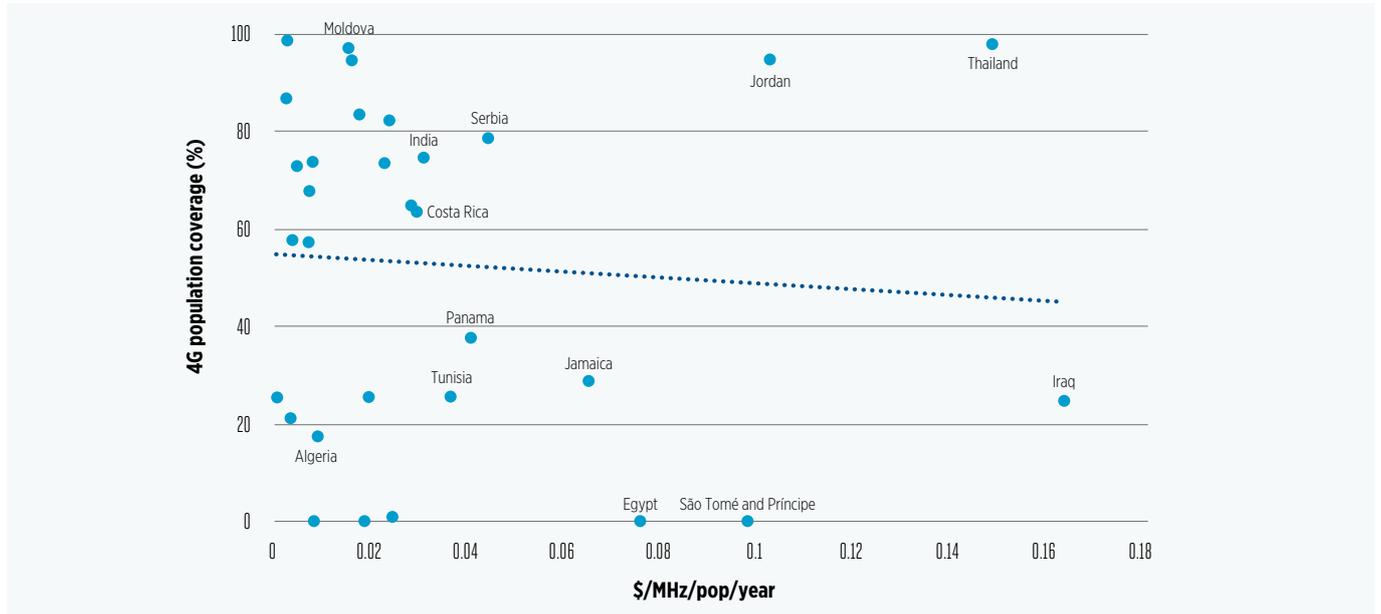
25. Latency measures the delay that occurs in data communications over mobile networks (e.g. the total time it takes a data packet to travel from one node to another).

26. Signal strength is the power level of mobile signals – received at a particular location – from a mobile network operator. It is usually measured in decibels.

27. Blocked calls happen when the user is in an area of coverage but cannot make a call; this can be because of heavy demand on the mobile network. Dropped calls occur when a call is connected but then terminates unexpectedly; this can happen when a user moves into an area with poor or no mobile signal.

28. See Appendix for more details regarding the methodology and data sources for these metrics.

FIGURE 18: SPECTRUM PRICES AND 4G COVERAGE



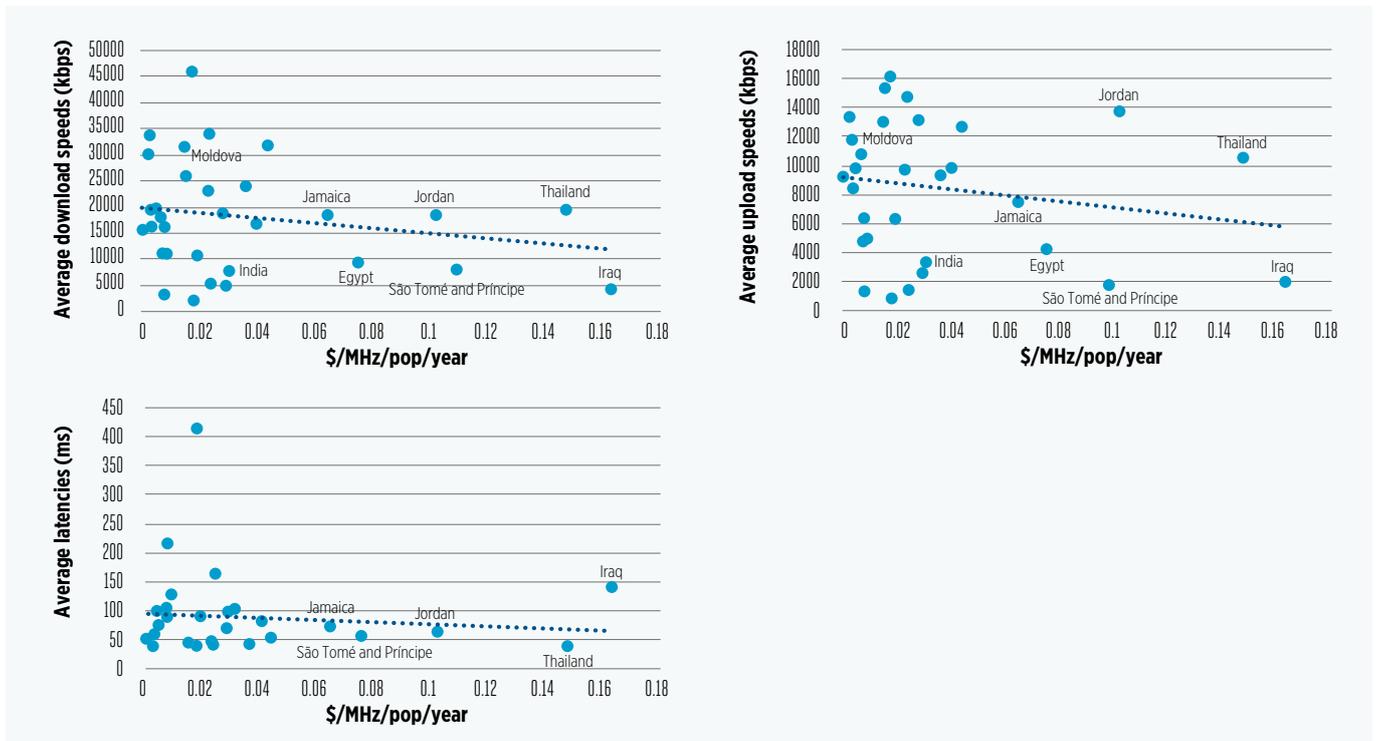
Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration. 4G population coverage represents 4G mobile coverage at the end of the period (2016) as a percentage of total market population.

Network Quality

High spectrum prices are also linked to lower upload and download speeds, but no link is identified with latency (see

Figure 19).²⁹ The results support the hypothesis that high spectrum costs may suppress investment in mobile markets and result in lower quality of mobile services.

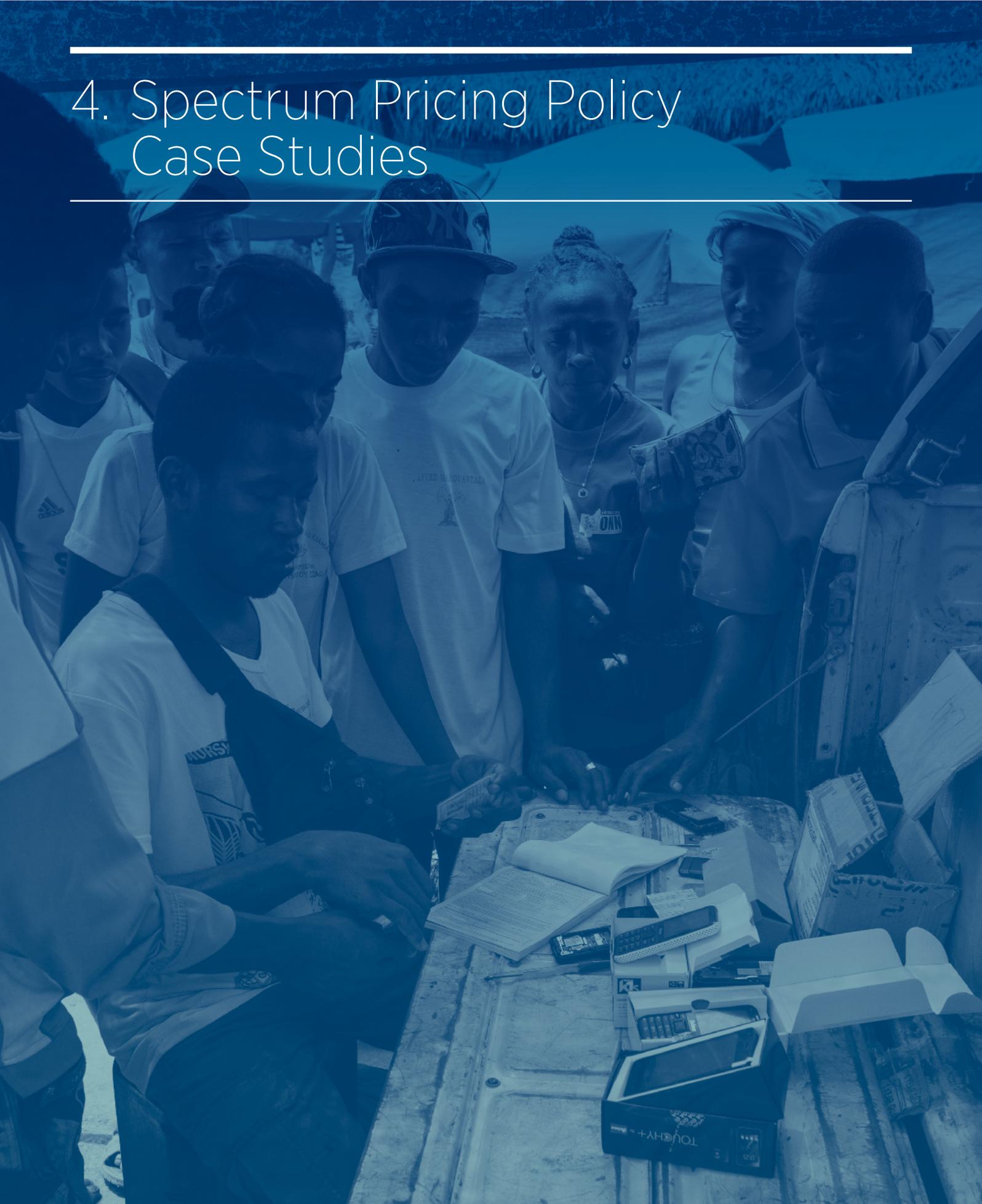
FIGURE 19: SPECTRUM PRICES AND NETWORK QUALITY



Source: GSMA Intelligence. Notes: spectrum prices (\$/MHz/pop/year) have been aggregated by country over the period 2010–2016, and adjusted for inflation, PPP (2016 prices) and licence duration.

29. LTE network investment is expected to focus on coverage and capacity (e.g. speed) as this allows the network to support more paying customers and address rising data traffic. Latency would be considered a secondary investment goal and tends to improve most significantly by jumping to a new technology generation.

4. Spectrum Pricing Policy Case Studies



Clearly, spectrum assignments in developing countries have often been expensive. In some cases, this may be the result of natural competition between operators. However, in other cases, high spectrum prices in developing countries are linked to governments needing to maximise public sector revenues.

High spectrum prices (which in some cases result in spectrum remaining unsold) and a lack of transparency in assigning spectrum can discourage LTE rollouts, constrain consumer welfare and delay the closing of the digital divide. In contrast, making substantial amounts of spectrum available at prices that lead to an efficient and growth-promoting allocation of spectrum can help realise vital digital development goals through affordable, high-quality and widespread broadband services.

In this section we present a selection of case studies relating to spectrum pricing practices and market outcomes following assignments. They contextualise the trade-off between revenue maximisation from spectrum awards and the wider socioeconomic benefits that can be driven by the mobile sector. In line with the previous chapters, we focus the analysis on reserve prices and direct administrative prices.

Approaches to setting reserve prices in developing countries have varied significantly, from lows close to \$0/MHz/pop in PPP terms (e.g. Romania in 2015) to highs of almost \$4.5/MHz/pop (e.g. Thailand in 2016). A number of developing countries

have set reserve prices so high that assignments have resulted in substantial amounts of spectrum remaining unsold. This has led to delays in awarding key 4G bands, ultimately affecting consumers in mobile markets and hindering the closing of the digital divide. A similar argument holds in the case of administrative assignments priced highly.

In addition, high spectrum prices sometimes occur in relatively low ARPU markets, providing further evidence that market conditions and local demand are not the only drivers when it comes to spectrum prices.

4.1 Administrative Assignments

Iraq

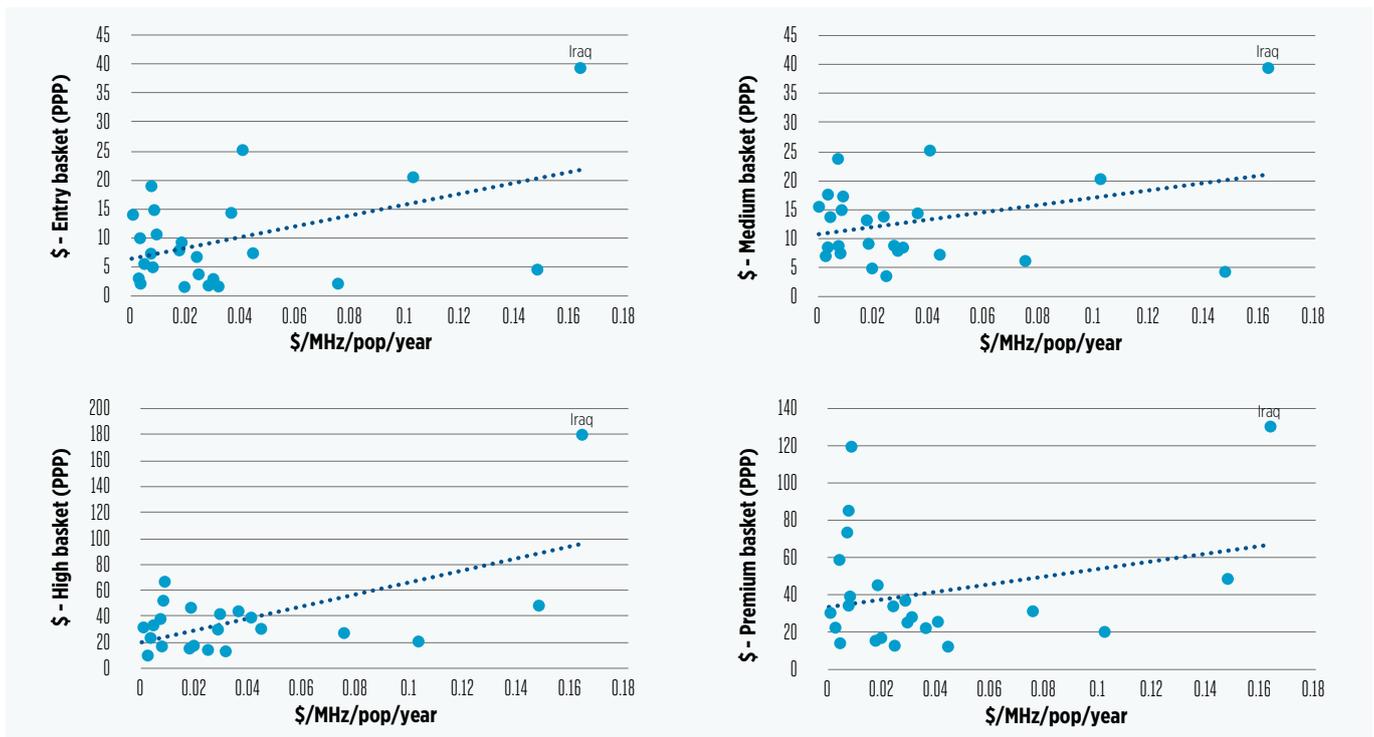
Iraq has presented challenges to the provision of mobile services in recent years, including damaged and inaccessible networks. A supportive spectrum policy environment would have helped safeguard sector development and consumer welfare including greater digital inclusion. However, in Iraq, spectrum has consistently been awarded at high prices – on average, almost 15 times the global median over the period 2000–2017.

In 2007, the three mobile operators in Iraq (Asiacell, Korek and Zain) paid \$1.25 billion each for 2G spectrum licences in the 900 and 1800 MHz bands – a substantial investment, given that total mobile service revenues in Iraq reached \$1.6 billion in that year. These assignments were among the top 5% of the most expensive assignments globally over the period 2000–2017. 3G licences were subsequently assigned to the three operators in 2014, at an abnormally high average price (\$1.14/MHz/pop versus the global median of \$0.27/MHz/pop).

In early 2017, mobile tariffs in Iraq were among the highest across all baskets considered in our sample (see Figure 20). As well as factors not considered in this analysis, this is a likely consequence of overly aggressive spectrum pricing.



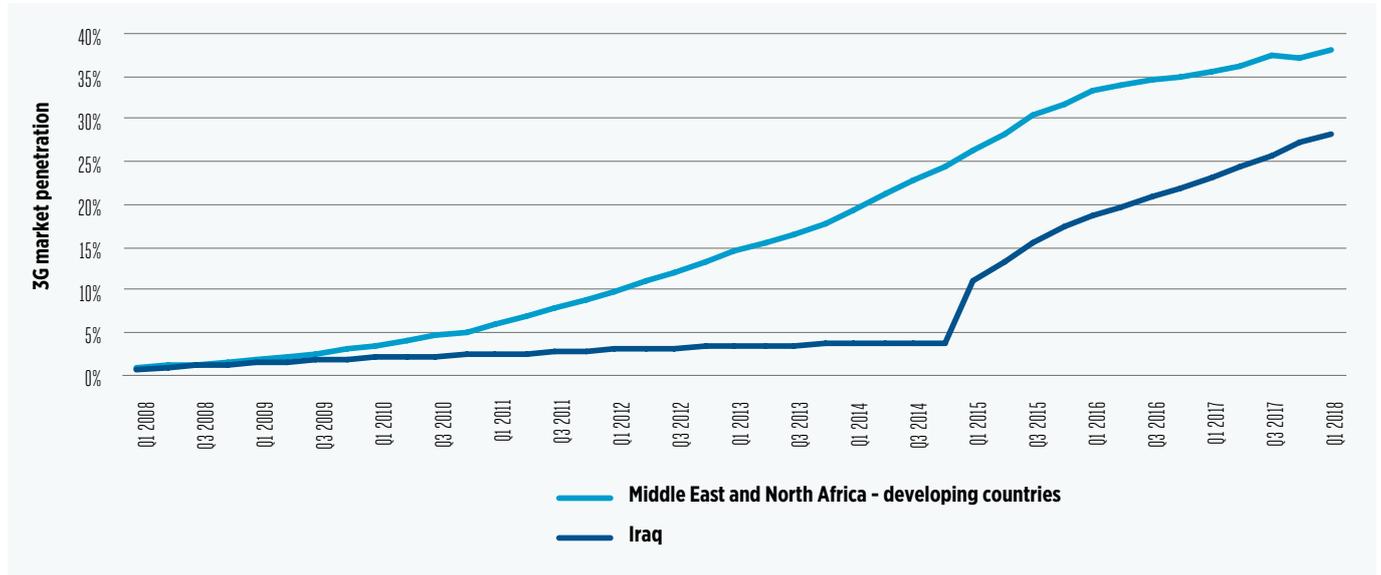
FIGURE 20: IRAQ'S MOBILE TARIFFS COMPARED TO DEVELOPING COUNTRIES SAMPLE



Source: GSMA Intelligence

In addition, as shown in Figure 21, Iraq has lower 3G market penetration than the average for developing countries in the MENA region.

FIGURE 21: 3G MARKET PENETRATION IN IRAQ VERSUS DEVELOPING COUNTRIES IN THE MENA REGION



Source: GSMA Intelligence. Notes: 3G market penetration represents the number of 3G connections at the end of the period as a percentage of total market population.



Moldova

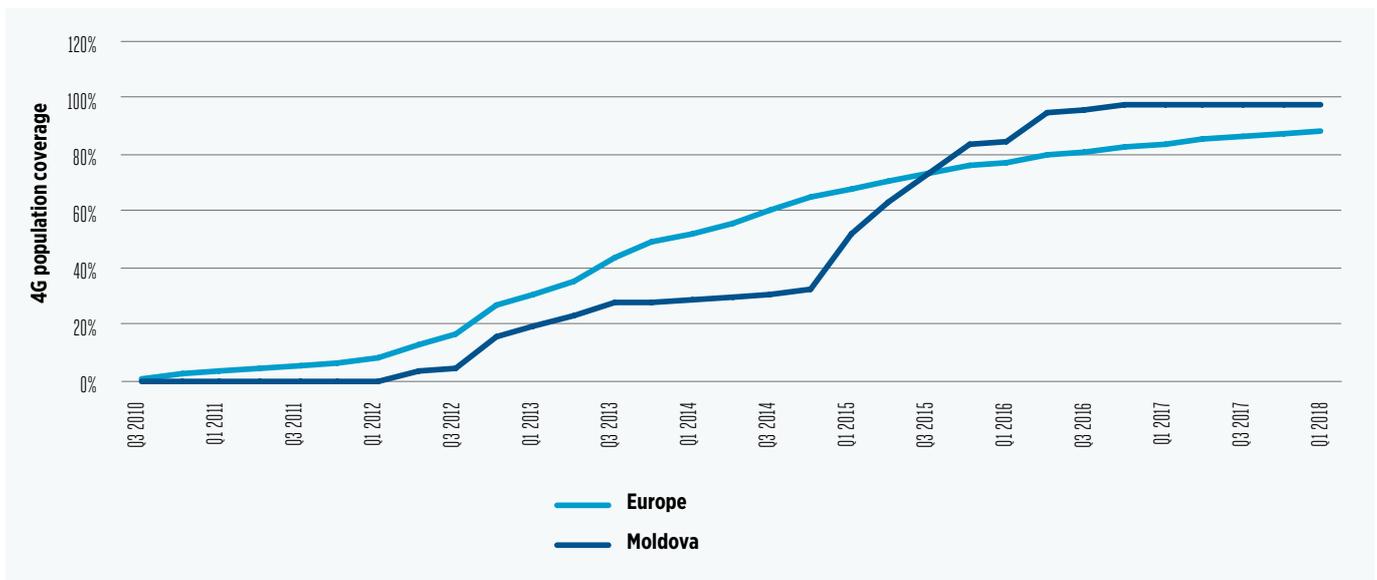
At the end of 2012, Moldova had one of the lowest levels of 4G coverage in Europe, at 16% – much lower than the European average of 26.5%. That was before the Radio Spectrum Management Programme for 2013–2020 was introduced by the Ministry of Information, Technology and Communications. The programme promotes efficient spectrum management to ensure broadband development.

The National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI) issued 15-year technology-neutral spectrum licences in the 800, 900 and 1800 MHz bands to three incumbent operators in 2014: Orange Moldova, Moldcell and Moldtelecom. Together, all three operators paid €62.5 million for 240 MHz of spectrum. That meant a doubling of the amount of spectrum holdings for mobile services in the country, at a price that was in line with the global median for 2000–2017. Access to this spectrum enabled operators to deploy 3G and 4G networks quickly and improve 4G mobile

coverage, which reached 98% of the population at the beginning of 2018, surpassing the European average (see Figure 22). Average download speeds, upload speeds and latency across all networks were generally in line with the European average in 2017.



FIGURE 22: 4G COVERAGE IN MOLDOVA VERSUS EUROPEAN AVERAGE



Source: GSMA Intelligence. Notes: 4G population coverage represents 4G mobile coverage at the end of the period as a percentage of total market population.

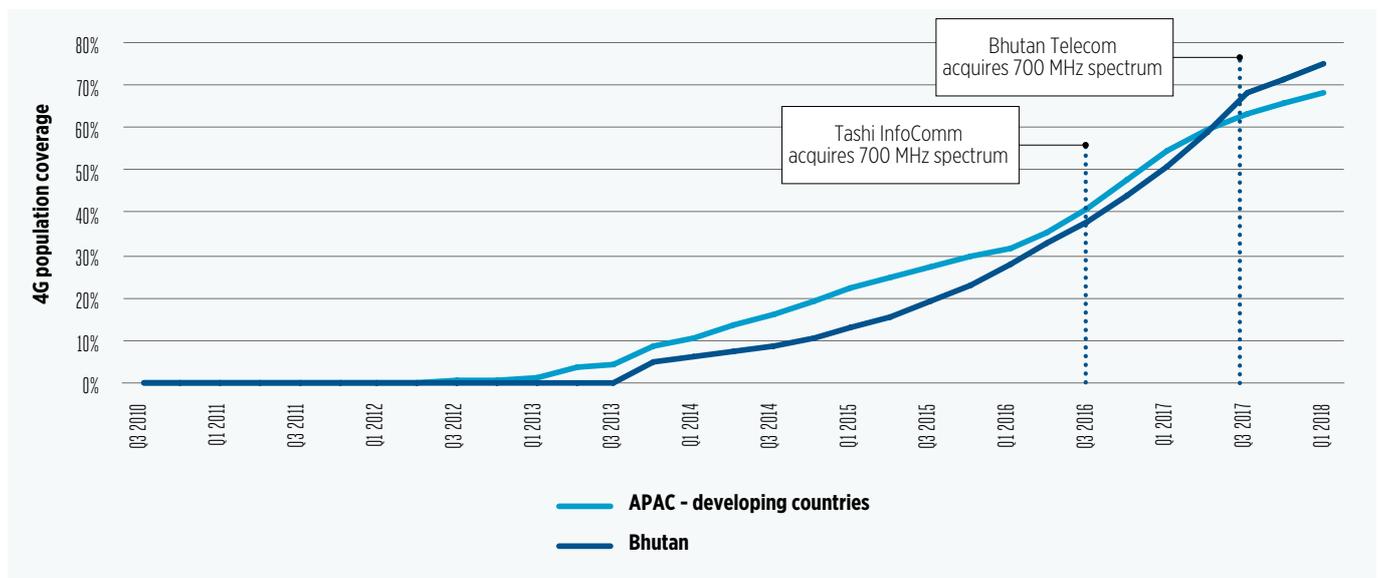


Bhutan

The Bhutan Infocomm & Media Authority (BICMA) does not set upfront assignment fees, and only charges annual fees. BICMA assigned two 2x20 MHz lots in the 700 MHz band to incumbent service providers Tashi InfoComm and Bhutan Telecom in 2016 and 2017 respectively, with the condition that they surrender 2x5 MHz to a third operator. The annual spectrum fee of BTN1.31 million (\$20,000) for the 700 MHz band only constituted 0.2% of their annual service revenues.³⁰ With access to 700 MHz spectrum at a reasonable price, operators were able to deploy LTE. As shown in Figure 23, 4G coverage increased rapidly after the 2016 assignment and surpassed the average 4G coverage level for developing countries in Asia Pacific shortly after the 2017 assignment.



FIGURE 23: 4G COVERAGE IN BHUTAN VERSUS ASIA PACIFIC DEVELOPING COUNTRIES



Source: GSMA Intelligence. Notes: 4G population coverage represents 4G mobile coverage at the end of the period as a percentage of total market population.

30. When these annual fees are consolidated into the spectrum pricing metric (\$/MHz/pop), it is around a tenth of the global median price over the period 2000–2017.

4.2 Reserve Prices

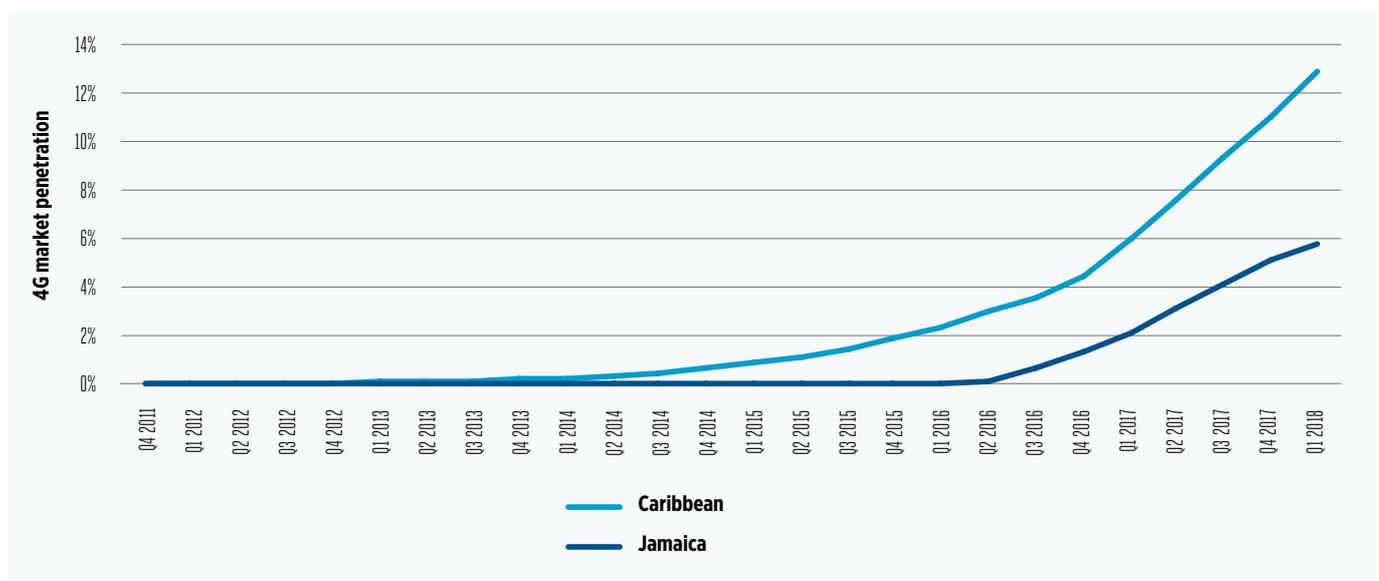
Jamaica

High reserve prices imposed by the regulator in Jamaica delayed the assignment of 4G spectrum to operators and consequently 4G deployment. With a reserve price of \$40–45 million set in 2013 for 700 MHz, the auction attracted no interest from operators, and the band was assigned only a year later to Digicel, at a price of \$0.62/MHz/pop. 4G networks were finally launched in Jamaica in 2016, following the assignment of additional AWS spectrum to Flow in 2015 for JMD2.6 billion, and the renewal of 850 and 900 MHz licences for Digicel and Flow at nearly JMD7 billion (and a resulting \$1.32/MHz/pop on average³¹).

The delays caused by initially high reserve prices, as well as the above-average final spectrum prices, had a negative impact on 4G penetration in the country, which has fallen behind its regional peers (see Figure 24).



FIGURE 24: 4G MARKET PENETRATION VERSUS CARIBBEAN AVERAGE



Source: GSMA Intelligence. Notes: 4G market penetration represents the number of 4G connections at the end of the period as a percentage of total market population.

Jamaica also experienced high levels of sovereign debt over the period considered, with an average sovereign debt/GDP ratio of 134% between 2010 and 2016. This is much higher than the Latin America and Caribbean average of nearly 51% over the same timeframe. Average ARPU levels in Jamaica over the period

2010–2016 were also much lower (\$17.2) than in Latin America and the Caribbean (\$30.6), once adjusted for inflation and PPP. This again underlines that expectations around future revenues and ARPU are not the only factor driving high spectrum prices and that government policies can also have negative repercussions.

31. The average \$/MHz/pop price in Latin American developing countries over the period 2000–2017 is \$0.38/MHz/pop.

	Sovereign Debt to GDP (average 2010–2016)	ARPU (average 2010–2016)
Jamaica	130%	\$17.2
Latin America & the Caribbean	51%	\$30.6

Source: GSMA Intelligence and World Bank. ARPU has been adjusted for inflation and PPP (2016 prices).

Spectrum pricing policy in Jamaica and its associated impacts on consumers do not align well with the Jamaican National Development Plan, and in particular the Information and Communications Technology Sector Plan (under Vision 2030).

The plans highlight key links between the adoption and application of ICT and the growth of other sectors as a means to ensure that Jamaica reaches its goal of developed country status by 2030.³²

Nigeria

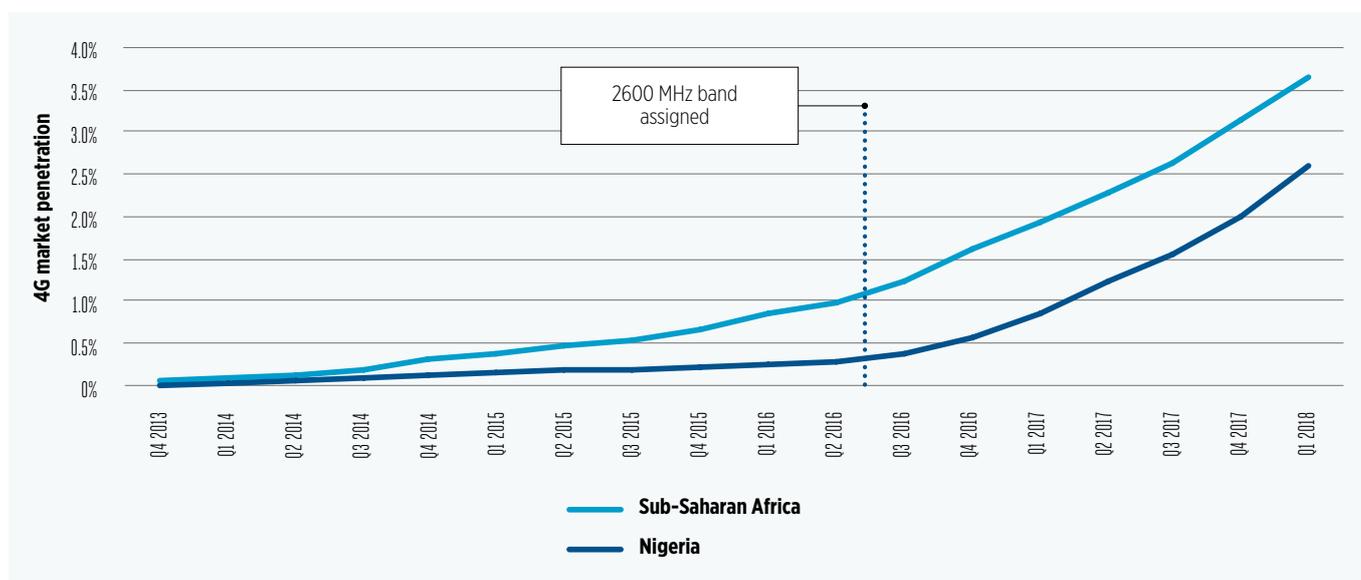
In May 2016, the Nigerian Communications Commission (NCC) auctioned 2×70 MHz of spectrum in the 2.6 GHz band. The spectrum was split into 14 lots of 2×5 MHz with a reserve price of \$16 million per lot. Although the price was not particularly high when benchmarked, the price denomination in US dollars made the potential investment riskier given the instability of the local currency exchange rate against the US dollar over that period. The Nigerian Naira depreciated by more than 20% in the two years preceding the auction and experienced an even more severe drop (42%) over the two years after, making it more expensive for operators to finance their spectrum payments.

Eventually, one bidder (MTN) secured six of the lots available (equivalent to 2×30 MHz of spectrum) at the reserve price, while the rest of the spectrum remained unsold. Leaving a large amount of capacity spectrum unsold will likely hinder the development



of the mobile market in Nigeria, which is one of the world's most populated countries. As highlighted in Figure 25, Nigeria's 4G market penetration trails the average for Sub-Saharan Africa.

FIGURE 25: 4G MARKET PENETRATION IN NIGERIA VERSUS SUB-SAHARAN AFRICA AVERAGE



Source: GSMA Intelligence. Notes: 4G market penetration represents the number of 4G connections at the end of the period as a percentage of total market population.

32. See <http://mset.gov.jm/policies-glance-0>

Bangladesh

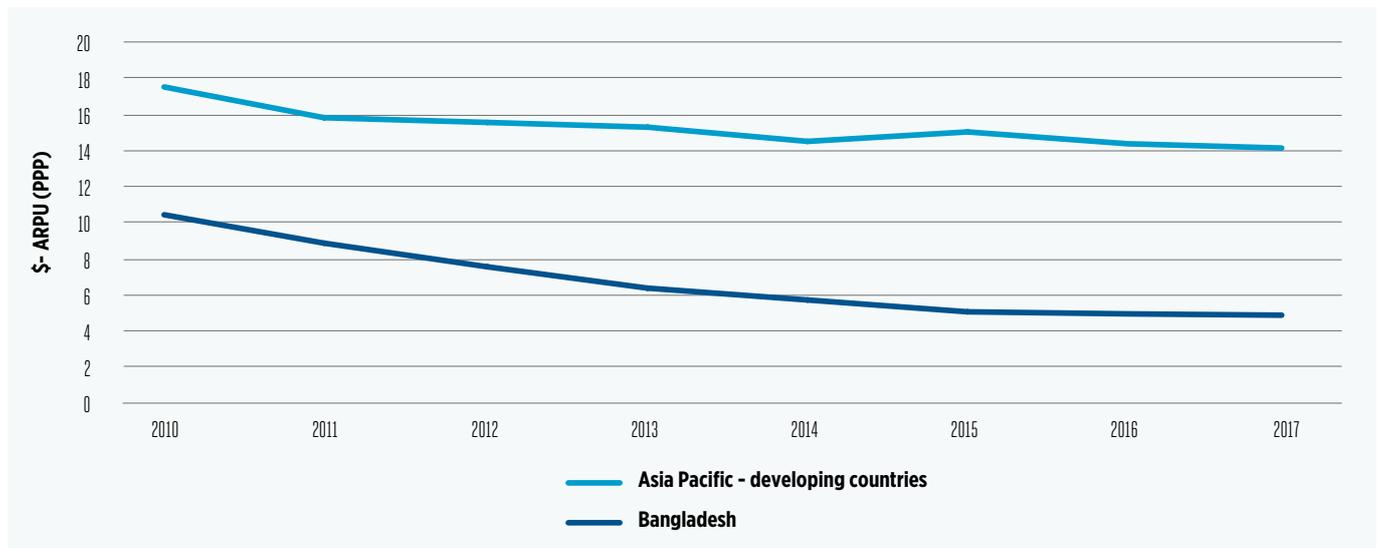
Bangladesh faces a significant digital divide. Legacy 2G services account for 71% of total connections and only one in five Bangladeshis subscribed to mobile internet services in 2017 (one of the lowest penetration levels in the South Asia/Asia Pacific region). This is despite 3G networks covering in excess of 90% of the population. The government is trying to address this through its Digital Bangladesh programme, which aims to drive socioeconomic transformation through information and communications technology.

In February 2018, policymakers made an important step towards introducing 4G/LTE services in the country by auctioning 2x25 MHz in the 2100 MHz band, 2x18 MHz in the 1900 MHz band and 2x3.4 MHz in the 900 MHz band. However, reserve prices of \$30 million per MHz in the 900 and 1800 MHz bands, and \$27 million per MHz in the 2100 MHz band, were extremely high. When adjusted for GDP per capita in Bangladesh, these prices were almost three times the Asia Pacific average final price over the period 2000–2017. This also needs to be considered in



the context of the Bangladesh mobile market, which has some of the lowest ARPU levels in the world. Even when compared to the average for developing countries in the region, ARPU in Bangladesh was on average 56% lower than average over the period studied (see Figure 26).

FIGURE 26: ARPU IN BANGLADESH VERSUS ASIA PACIFIC DEVELOPING COUNTRIES



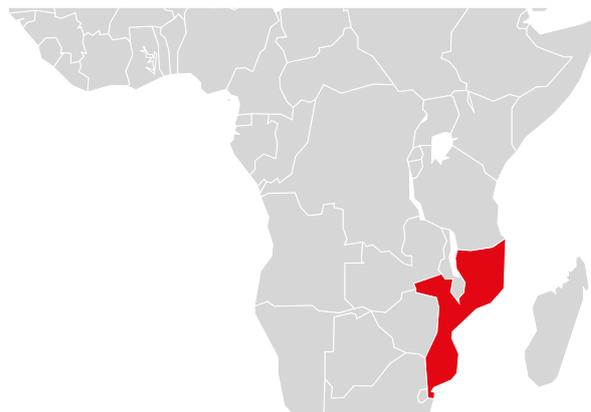
Source: GSMA Intelligence. Notes: ARPU has been adjusted for inflation (2016 prices) and PPP.

As a result, only 33% of the spectrum available in the auction was sold. This is a good example of the outcome being driven by the high reserve prices. Failure to sell spectrum prevents the use of a scarce resource to provide valuable services for consumers. This could also mean lower revenues for the government, as the regulator could have raised more money overall by selling the entire band at a lower price.

Although it is still too early to assess the impacts of this spectrum assignment on consumers, in April 2018, 4G coverage in Bangladesh was still less than a fifth of the developing country average in Asia Pacific. Considering also that Bangladesh was one of the last countries in South Asia to award 4G spectrum licences, it seems likely that achieving Digital Bangladesh's objectives will be challenging.

Mozambique

In April 2013, the National Communications Institute of Mozambique (INCM) offered a total of 50 MHz in the 800 MHz band for the reserve price of \$150 million. The price was regarded as excessive – mobile operators would have to invest at least a third of their annual mobile service revenues, equivalent to \$448 million in 2013, to meet the starting bid, which was 50% higher than the average final prices in Sub-Saharan Africa over the period 2000–2017, once adjusted for income per capita. No bidders participated in the spectrum auction, which was eventually cancelled by the regulator. 800 MHz spectrum has not been made available to operators since then – only in May 2018 did INCM announce potential plans for the second attempt to award spectrum in this band to bidders. The delay in assigning valuable digital dividend spectrum has adversely affected technological development in Mozambique: as of June 2018,



no LTE services had been launched, which leaves the country lagging behind other countries in the region.



India

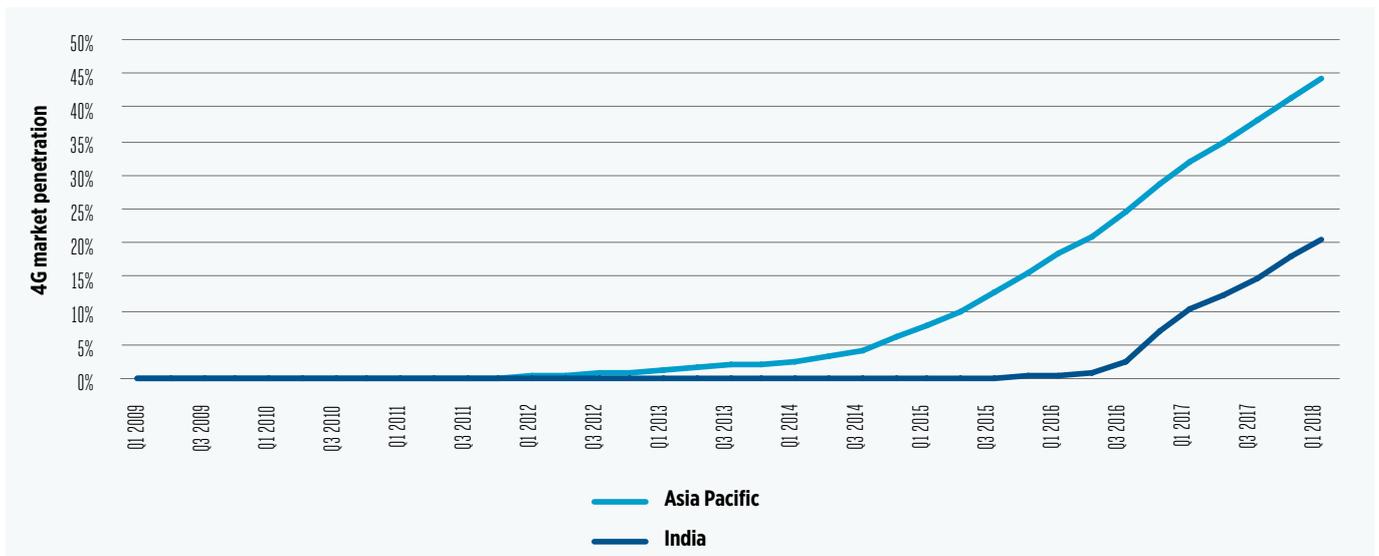
Between 2010 and 2016, India held six auctions for mobile spectrum, more than any other country over this time. Since the 3G auction in 2010, the government approach to spectrum management has resulted in inflated spectrum prices and unsold spectrum. ARPU levels in India are also on average almost 35% lower than developing countries in Asia Pacific overall (over the period 2010–2017). This suggests policy making by the government and regulator has played a role in the high spectrum prices.

The October 2016 auction featured a much greater quantity of spectrum than previous awards and included seven bands. However, the auction was not a success; only 41% of the spectrum was sold. The average price was \$0.33/MHz/pop (across 850, 1800, 2100, 2300 and 2600 MHz), which was almost 50% higher than the median price in developing countries between 2000 and 2017. The 700 MHz – important for widening access to affordable mobile broadband services – received no bids, reportedly due to the high reserve prices. However, the recent draft publication of the National Digital Communications Policy (NDCP) acknowledged that optimal pricing of spectrum needs to be ensured for sustainable and



affordable access to digital communication. If this leads to a policy change in practice, then it would be an important step in the right direction to help India increase its 4G market penetration, which is currently behind the average in Asia Pacific (as shown in Figure 27). This study also found that the networks perform notably worse on average than developing countries in the region overall, with slower upload and download speeds and higher latency.

FIGURE 27: 4G MARKET PENETRATION IN INDIA VERSUS ASIA PACIFIC



Source: GSMA Intelligence. Notes: 4G market penetration represents the number of 4G connections at the end of the period as a percentage of total market population.

Costa Rica

Costa Rican mobile operators have historically benefited from timely and fair access to sufficient spectrum at affordable prices compared to other developing countries in the region. In 2017, the national regulator Superintendencia de Telecomunicaciones (SUTEL) auctioned 70 MHz of spectrum in the 1800 and 2100 MHz bands (ICE, the State owned operator, has 550 MHz of total spectrum due to historic reasons, so was excluded from the auction). Following unsold spectrum in 2011, the regulator decided to re-auction the unsold concession in 2017 at a much lower reserve price (\$70 million in 2011 versus \$43 million in 2017). Movistar and Claro were able to secure the spectrum in 2017 (40 and 30 MHz respectively) for \$43 million, which, in \$/MHz/pop terms, was over 55% cheaper than the average for developing countries in Latin America.

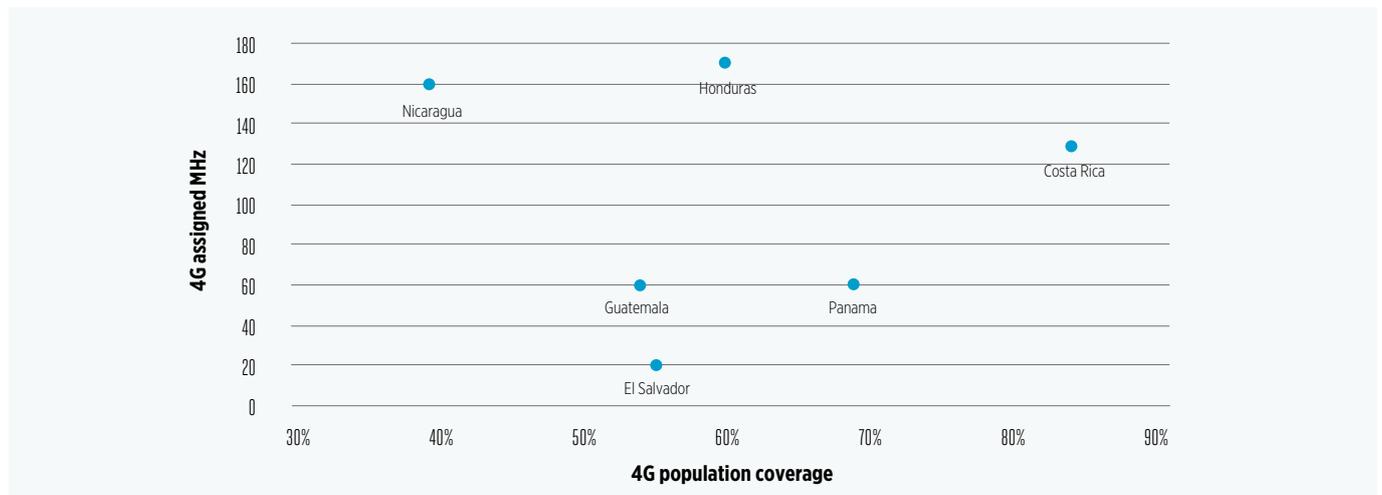
Maximising revenues was not the main goal of the Costa Rican regulator. As Gilbert Camacho, Chairman of the Board of SUTEL, declared, *“this auction will enable mobile telecommunications operators to strengthen and expand the capacity of existing mobile networks, so that the user can have greater access to new generation networks, which provide greater speeds and better coverage in the mobile phone service”*. Fostering competition between operators and assigning spectrum at lower prices has had a positive impact on consumer prices.



Costa Rica's mobile tariffs are among the lowest in our sample for the lower usage baskets. When compared to other countries in Central America, Costa Rica has the highest 4G coverage, and ranks among the top three countries for the amount of 4G spectrum assigned as of 2017 (see Figure 28). Costa Rica also ranks among the top performing countries in Central America for mobile internet penetration, second only to Panama by a few percentage points, as of 2017 (see Figure 29).

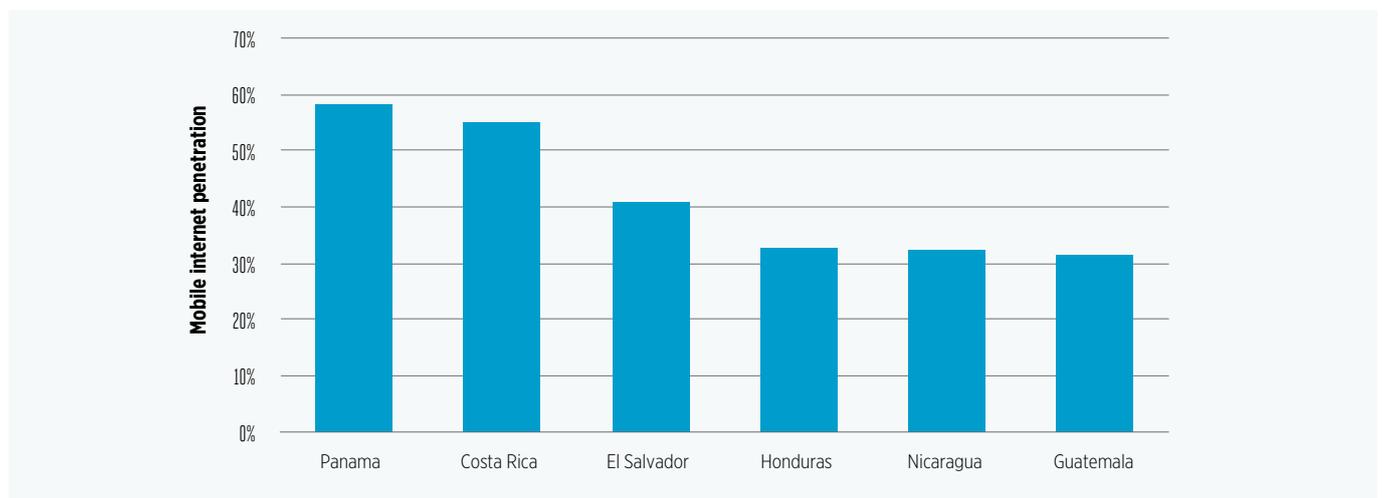


FIGURE 28: 4G COVERAGE AND AMOUNT OF SPECTRUM ASSIGNED IN CENTRAL AMERICA, AS OF 2017



Source: GSMA Intelligence. Notes: 4G population coverage represents 4G mobile coverage at the end of the period as a percentage of total market population.

FIGURE 29: MOBILE INTERNET PENETRATION IN CENTRAL AMERICA BY COUNTRY, 2017



Source: GSMA Intelligence. Notes: mobile internet penetration represents the number of total mobile internet subscribers at the end of the period as a percentage share of total market population



5. Conclusions



Effective spectrum pricing policy must balance a number of competing objectives. While few governments solely prioritise revenue maximisation, some countries do still place excessive focus on this goal, which can have a significant negative impact for users of mobile services.

This report highlights the following key findings:

- Final spectrum prices are higher in developing markets than developed markets (when income levels are taken into account).
- Governments appear to be driving these higher prices to maximise state revenues, especially when they are highly indebted or face challenges in accessing financial markets.
- High spectrum prices are often linked with more expensive, lower quality consumer mobile services – and our analysis suggests that these negative consumer outcomes may be policy-driven.

High spectrum prices are influenced by different factors.

Competition among bidders will drive prices up – but governments also exert a significant influence on the final price through their choice of reserve price and assignment mechanism. How much spectrum they make available and what indications they give about future assignments through a spectrum roadmap are also important.

The focus on revenue raising is most prominent when governments need to repay large amounts of debt in the short term and when access to financial markets is challenging. This partially explains why operators in developing countries are paying similar prices for spectrum to those in developed countries, even though consumer incomes and expected revenues are lower. This directly impacts expected operator returns on investments, distorting investment decisions, and may also impose financial constraints on operators. This can reduce network investment and lead to higher consumer prices.

The relationship between spectrum prices and consumer prices (measured through tariffs and ARPU) can work in both directions. On the one hand, operators will typically be prepared to pay more for spectrum in markets where revenues are higher. On the other hand, high spectrum prices can lower returns on investment, which can put upward pressure on consumer prices. As we have seen, government policies can drive spectrum prices up significantly. In our case studies, some countries show both low ARPU levels and high spectrum prices – a result that seems only possible if government intervention is indeed having an impact on spectrum prices, beyond the voluntary market-driven bidding activity by operators.

High spectrum prices not only hinder the development of the mobile market but also prevent societies from fully leveraging the potential of mobile technology to accelerate social and economic development. Nowhere is this a greater concern than in developing countries. In addition to contributing to economic growth, mobile connectivity brings a wide range of social and economic benefits. These include promoting digital inclusion and supporting the delivery of essential services and key development objectives such as poverty eradication, healthcare, education, financial services and gender equality. Governments should prioritise these objectives over short-term targets related to maximising spectrum revenues.

Appendix: Methodology

Data sources

For the purposes of the study we collected data on spectrum prices, macroeconomic indicators and mobile market outcomes. Table A1.1 summarises the specific variables used.

Table A1.1. Summary of variables and sources

Area	Variable	Time	Source
Spectrum prices	\$/MHz/pop/year	2000–2017	GSMA Intelligence
Macroeconomic	PPP	2000–2017	IMF World Economic Outlook ³³ and World Bank ³⁴
	Inflation	2000–2017	IMF World Economic Outlook ³⁵
	Nominal GDP	2000–2017	World Bank ³⁶
	Sovereign debt/GDP	2010–2016	World Bank ³⁷
	Sovereign debt/average tax	2010–2016	World Bank ³⁸
	Average sovereign debt maturity	2010–2016	World Bank ³⁹
	Fiscal balance	2010–2016	World Bank ⁴⁰
	Exchange rates	2000–2016	World Bank ⁴¹ and GSMA Intelligence
Mobile market outcomes	Tariff price for Basic basket	Q1 2017	Tarifica
	Tariff price for Medium basket	Q1 2017	Tarifica
	Tariff price for High basket	Q1 2017	Tarifica
	Tariff price for Premium basket	Q1 2017	Tarifica
	ARPU	2010–2016	GSMA Intelligence
	4G and 3G coverage	2016	GSMA Intelligence and ITU
	Download and upload speeds	2016	Ookla

33. See IMF WOE Database imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx

34. See World Bank data data.worldbank.org/indicator/PA.NUS.PPP

35. See IMF WOE Database imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx

36. See World Bank data data.worldbank.org/indicator/NY.GDP.PCAP.KN

37. See World Bank worldbank.org/en/research/brief/fiscal-space

38. See World Bank worldbank.org/en/research/brief/fiscal-space

39. See World Bank worldbank.org/en/research/brief/fiscal-space

40. See World Bank worldbank.org/en/research/brief/fiscal-space

41. See World Bank worldbank.org/indicator/PA.NUS.FCRF

Spectrum prices

Spectrum pricing data was sourced from the GSMA Intelligence spectrum database. This collects data on spectrum assignments across the world, including relevant information such as band, amount of MHz assigned, licence duration and price.

In order to compare spectrum prices across assignments and countries, spectrum prices were adjusted for inflation (in 2016 prices) and converted using purchasing power parity exchange rates (\$ PPP). Where relevant, prices were also adjusted by GDP per capita. Prices were then aggregated:

- by country, band, generation and assignment over the period 2010–2017 for the trend analysis
- by country and year over the period 2010–2016 for the correlation analysis with macroeconomic data
- by country or operator over the period 2010–2016 for the correlation analysis with mobile market outcomes analysis.

Following aggregation, prices were then divided, by the number of MHz allocated, country population and duration of spectrum licence. Where data on the licence duration was missing, imputation was performed based on country benchmarks.

Spectrum annual fees are not incorporated into the calculation of the spectrum pricing metric, with the exception of China, where, absent any upfront fees, the annual fees are used to calculate the spectrum pricing metric instead. Licence obligations are also not considered for the purpose of this analysis.

As part of the analysis, we also developed three other pricing metrics in addition to the one used in the report:

- **price per MHz per population – this is the more standardised approach to normalising spectrum prices but does not account for differences in licence duration**
- **an annual annuitised value of spectrum price per MHz per population, based on country-level estimates of the cost of capital**
- **the present value of the operator's or country's outstanding spectrum fee liabilities.**

The results of the trend and correlation analyses presented in this report all hold when using these alternative metrics (i.e. there are no significant differences depending on which pricing metric is used).

Mobile tariffs

Pricing data for mobile tariffs was provided by Tarifica. Retail prices were captured as of the first quarter of 2017, including all relevant taxes. Based on GSMA Intelligence analysis, four baskets were considered, based on different levels of usage allowance, type of contract and technology:

- **Entry:** 100 MB data, prepaid, 2G, 3G or 4G
- **Medium:** 500 MB data, prepaid or post-paid, 3G or 4G
- **High:** 250 voice minutes, 100 SMS, 1000 MB data, prepaid or post-paid, 3G or 4G
- **Premium:** 5000 MB data, prepaid or post-paid, 3G or 4G.

Mobile tariffs for each country were measured by the cheapest available plan for each basket across all mobile operators in the market. The plans and prices available in each market were obtained from the websites of mobile operators.

Download speeds, upload speeds and latency

To measure download and upload speeds, and latency we use data provided by Ookla®, a global leader in fixed broadband and mobile network testing applications, data and analysis. The company's flagship enterprise product, Speedtest® Intelligence⁴², provides the results of thousands of consumer-initiated tests taken using Speedtest. Over 10 million tests are actively initiated by consumers each day across all Speedtest platforms, with nearly 20 billion completed to date.⁴³ As a result, Ookla has the most comprehensive analytics on worldwide internet performance and accessibility.

In this analysis, we used the average (mean) network quality metric across all users in 2016 at the country level. We calculated these metrics as a weighted average of the 2G, 3G and 4G network quality metrics, weighted by the number of tests performed.

42. <http://www.speedtest.net/mobile/>

43. Further details can be found in Ookla's methodology document. Available at <http://www.ookla.com/methodology/pdf>

Countries included in the study

This analysis is based on spectrum prices in 60 developing countries (see Table A2.1). We also analysed spectrum prices in 42 developed countries for benchmarking and comparison (see Table A2.2). The countries studied include all those for which the GSMA

Intelligence spectrum database provides at least one price point after 2010 (see Figure 30). Additional pricing data from countries not part of the list was used for comparison purposes in Chapter 4.

FIGURE 30: COUNTRIES INCLUDED IN THE STUDY

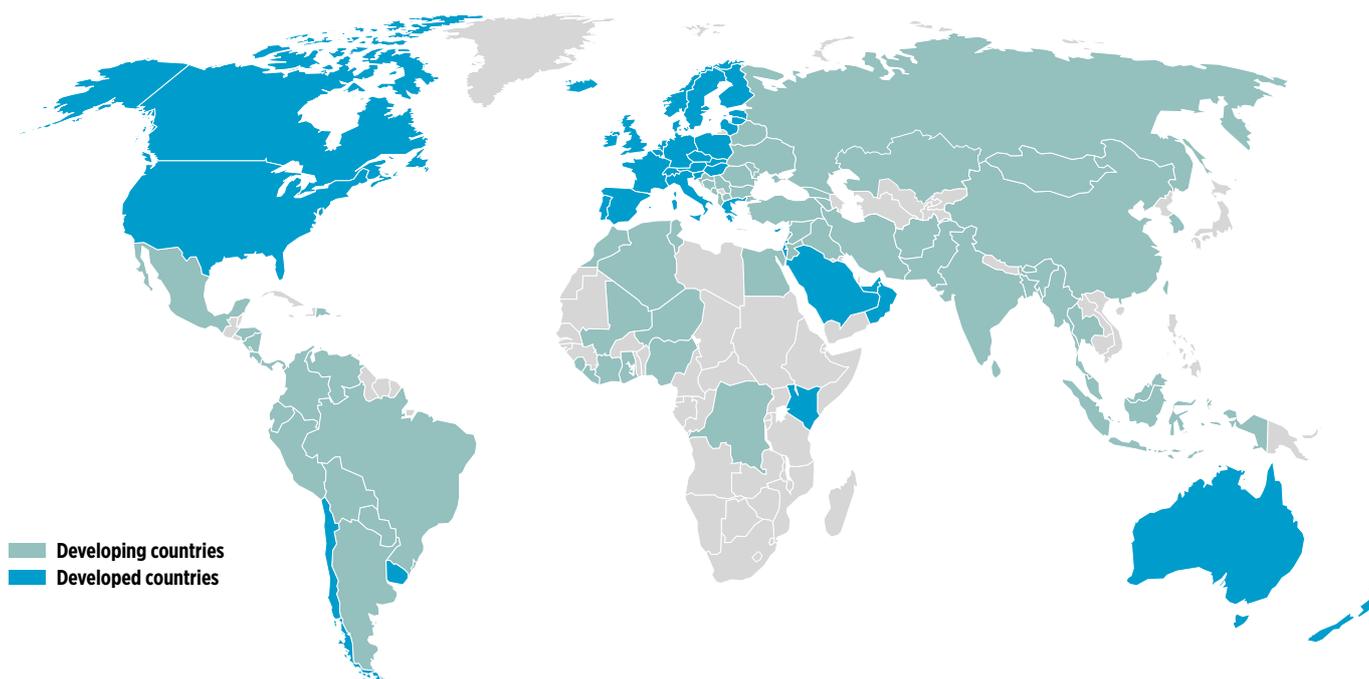


Table A2.1. Developing countries

Afghanistan	Burkina Faso	Egypt	Kazakhstan	Morocco	Russian Federation
Albania	Cameroon	Fiji	Kenya	Myanmar	São Tomé and Príncipe
Algeria	China	Georgia	Macedonia	Nicaragua	Serbia
Argentina	Colombia	Ghana	Malaysia	Niger	Sierra Leone
Armenia	DRC	Honduras	Mali	Nigeria	Sri Lanka
Bangladesh	Costa Rica	India	Mauritius	Pakistan	Thailand
Belarus	Cote d'Ivoire	Indonesia	Mexico	Panama	Tunisia
Bolivia	Croatia	Iraq	Moldova	Paraguay	Turkey
Brazil	Dominican Republic	Jamaica	Mongolia	Peru	Ukraine
Bulgaria	Ecuador	Jordan	Montenegro	Romania	Venezuela

Table A2.2 Developed countries

Australia	Cyprus	Greece	South Korea	Oman	Spain
Austria	Czech Republic	Hong Kong	Kuwait	Poland	Sweden
Bahamas	Denmark	Hungary	Latvia	Portugal	Switzerland
Bahrain	Estonia	Iceland	Lithuania	Saudi Arabia	Taiwan
Belgium	Finland	Ireland	Netherlands	Singapore	UK
Canada	France	Israel	New Zealand	Slovakia	US
Chile	Germany	Italy	Norway	Slovenia	Uruguay

For the purpose of the correlation analysis with macroeconomic data and market outcomes, only countries with a comprehensive set of spectrum pricing data during the period 2010–2016 were considered (see Tables A2.3 and A2.4). This allowed us to detect

the relationship between the full spectrum spend in a given period and the different metrics considered. In a few instances where a minor proportion of pricing data was missing, imputation was performed based on benchmarks.

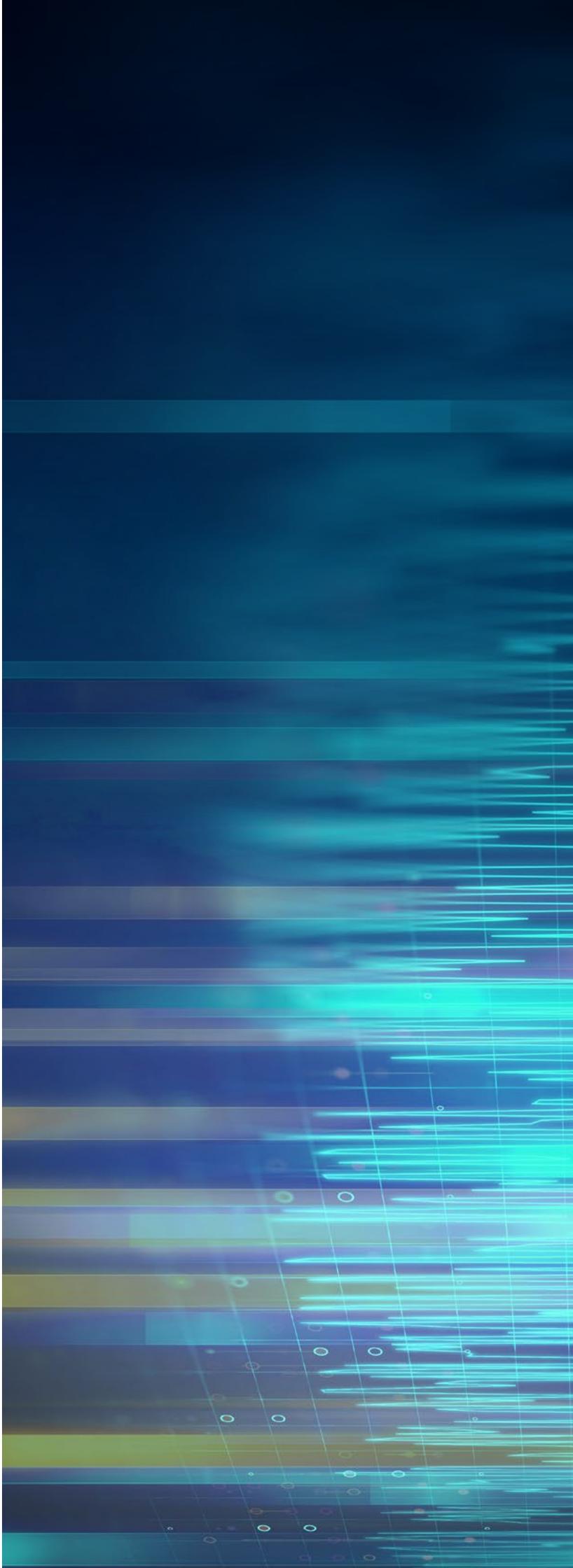
Table A2.3 Developing countries with comprehensive spectrum pricing data, 2010 - 2016

Afghanistan	Costa Rica	Jordan	Morocco	São Tomé and Príncipe	Venezuela
Albania	Egypt	Kenya	Niger	Serbia	
Algeria	Fiji	Macedonia	Pakistan	Thailand	
Brazil	India	Mexico	Panama	Tunisia	
China	Iraq	Moldova	Peru	Turkey	
Colombia	Jamaica	Mongolia	Romania	Ukraine	

Table A2.4 Developed countries with comprehensive spectrum pricing data, 2010 - 2016

Australia	Chile	Germany	Israel	Norway	Spain
Austria	Cyprus	Greece	Italy	Poland	Switzerland
Bahamas	Czech Republic	Hong Kong	Latvia	Portugal	Taiwan
Bahrain	Denmark	Hungary	Lithuania	Singapore	UK
Belgium	Finland	Iceland	Netherlands	Slovakia	US
Canada	France	Ireland	New Zealand	Slovenia	Uruguay





Floor 2, The Walbrook Building
25 Walbrook, London EC4N 8AF UK
Tel: +44 (0)207 356 0600

spectrum@gsma.com
www.gsma.com

© GSMA July 2018