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El impacto de los precios del espectro en México

DATE
Julio 2022

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1. Precio del espectro y consumidores – un estudio global

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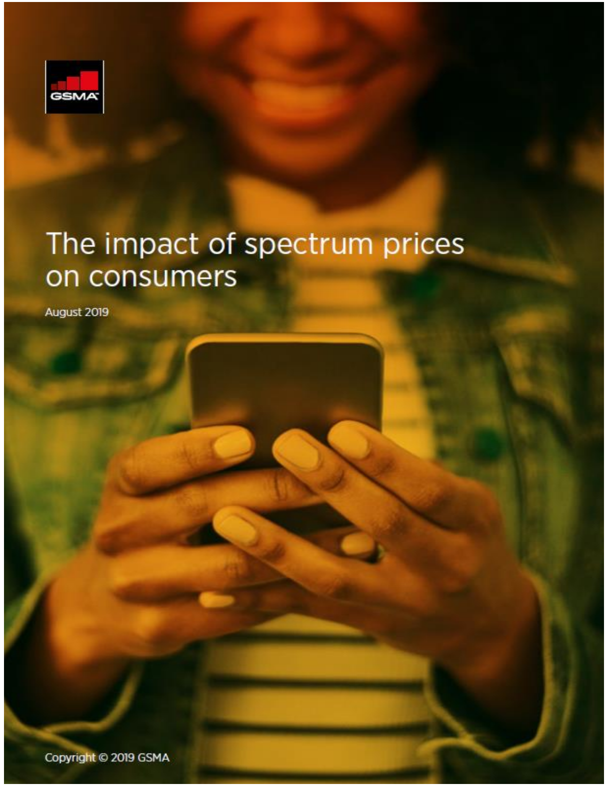
Estudio económico desarrollado por GSMA Intelligence



- El estudio evalúa el impacto de los precios del espectro en tres aspectos fundamentales para los consumidores:
    1. Cobertura de red
    2. Calidad de red
    3. Precios finales
- Analizamos 229 operadores en 64 países (34 renta alta y 30 de renta media y baja) entre 2010-2017
- Es el estudio más exhaustivo realizado hasta la fecha sobre el impacto que tiene la política de espectro en los consumidores. Estudios previos tienen limitaciones metodológicas, de datos y se han centrado principalmente en algunos países de renta alta
- Modelo econométrico que evalúa el impacto del costo del espectro sobre la cobertura, calidad de red y precios finales para los usarios
- Métodos estadísticos robustos que aíslan el efecto y su dirección respecto a otros factores

Resultados principales – impacto negativo cuando los precios del espectro son más elevados

	Países de renta media/baja	**Países de renta alta**
Cobertura de red	**Despliegue más lento de redes 3G y 4G**	**Despliegue más lento de redes 4G**
Calidad de red	**Peor calidad de red (en todas las redes)**	**Menor velocidad de descarga en redes 4G**
Precios finales	Indicios de que los precios son más altos, pero resultados inconcluyentes	Resultados inconcluyentes – se necesitan mejores datos

Resultados principales – impacto de otras políticas públicas de espectro

	Todos los países
Cobertura de red	• **Mayor cantidad de espectro licenciado conlleva mayor cobertura poblacional** • 20 MHz adicionales de espectro incrementan cobertura poblacional 4G entre 2-4 puntos porcentuales • **Licenciar el espectro rápidamente conlleva mayor cobertura poblacional** • Asignación de espectro dos años antes incrementa la cobertura 4G en 11-16pp y la cobertura 3G en 20pp
Calidad de red	• **Mayor cantidad de espectro licenciado conlleva mayor calidad de red** • 20 MHz adicionales de espectro 4G incrementan las velocidades de descarga entre 1-2.5 Mbps

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Conclusiones sobre los precios del espectro

- No se explican sólamente por motivos de oferta y demanda
- Algunos gobiernos dan prioridad a otros objetivos, por ejemplo una mayor recaudación
- Esto tiene repercusiones para los consumidores y las empresas

Menor cobertura | Menores velocidades | ¿Servicios más caros?

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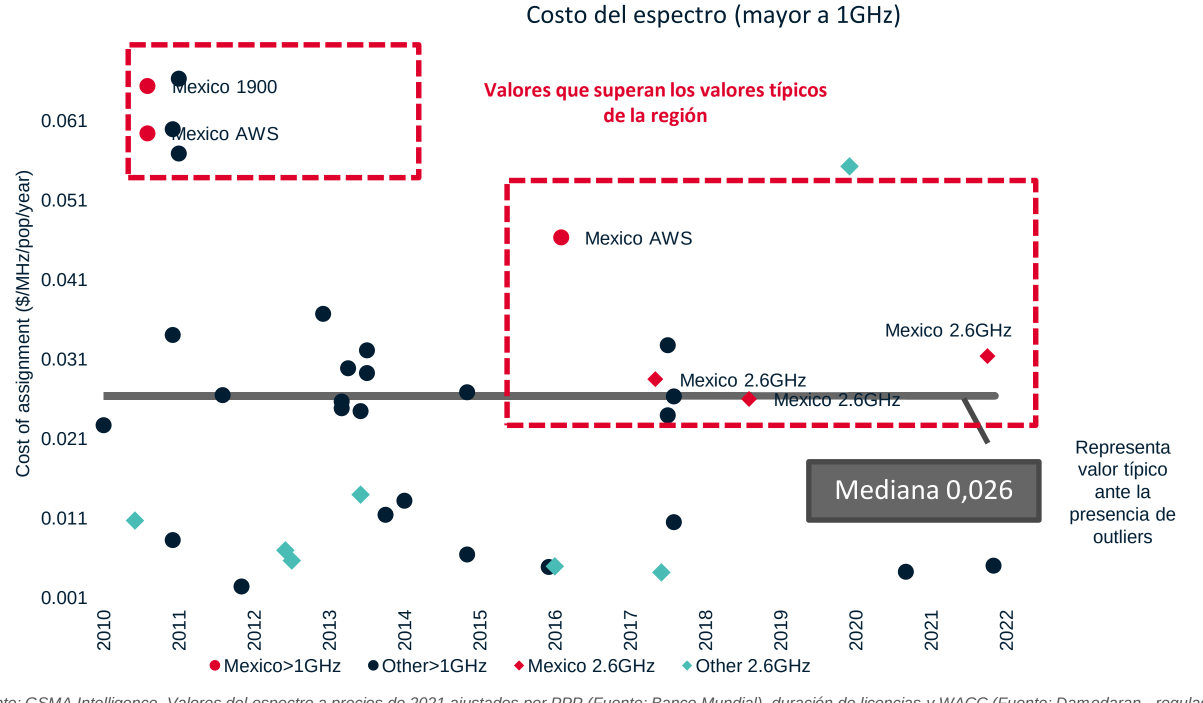
2. Precio del espectro en México

El costo total del espectro en México es elevado

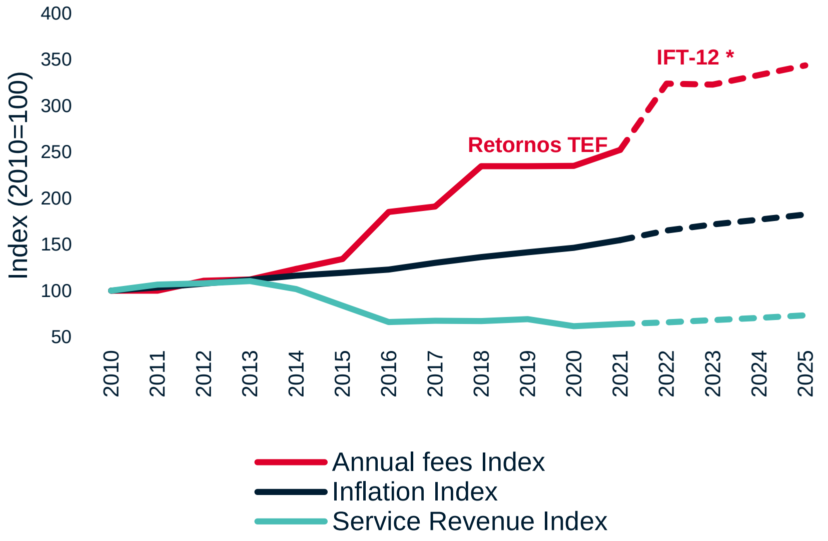


- Las últimas licencias otorgadas en México (2.6GHz) presentaron valores por encima de los valores típicos de la región.
- También las asignaciones de las bandas PCS y AWS en 2010 y 2016 se encontraron entre las más caras en la región.

Fuente: GSMA Intelligence. Valores del espectro a precios de 2021 ajustados por PPP (Fuente: Banco Mundial), duración de licencias y WACC (Fuente: Damodaran - reguladores). Incluye pagos iniciales y anuales. Pagos iniciales agregados por país, banda y asignación.

No está alineado con la evolución del mercado

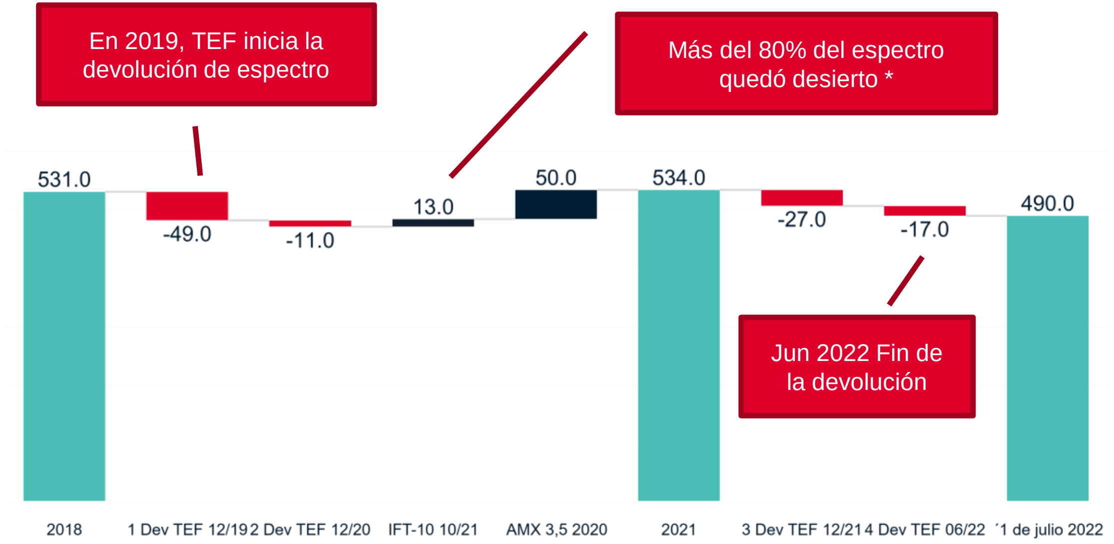
Derechos anuales, inflación y desarrollo del mercado



- Los derechos anuales aumentan y no siempre en relación a la inflación.
- Los ingresos del sector han disminuido, creciendo por debajo de la inflación y del incremento de los derechos anuales en los últimos 5 años.
- El costo total del espectro seguirá creciendo si no hay reformas, limitando la capacidad e incentivos de los operadores para invertir en el despliegue de nuevas tecnologías.

Fuente: GSMA Intelligence / Ley Federal de Derechos / IFT / Banco Mundial
** Supone una asignación completa de los bloques a subastar y que las tarifas anuales mantienen los valores actuales*

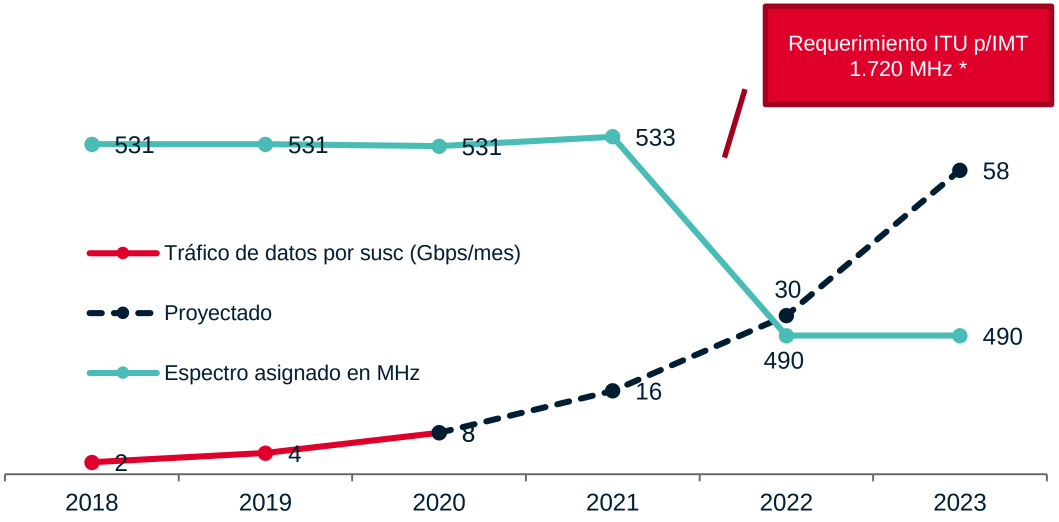
Disminución en la cantidad asignada y subastas con bloques desiertos



- **En 2019 TEF inició el retorno de sus licencias,** que ya finalizó en junio de 2022.
- En octubre de 2021 se llevó a cabo **la licitación IFT-10, donde 38 bloques de 41 ofrecidos quedaron desiertos**
  - Participaron AT&T y Telcel.
  - Se asignaron un bloque en la banda de 2,5 GHz, el bloque de 800 MHz para las regiones celulares 1 a 4 y otro para la Zona Metropolitana del Valle de México.
  - Quedaron desiertos bloques completos en AWS y 1900 MHz.

Fuente: GSMA Intelligence / Telconomía.com: Resultados de la Licitación IFT-10 en México (diciembre 2021)
** Según la zona, se llegaron a ofrecer hasta 100 MHz de ancho de banda, de los cuales solamente se asignaron 13 MHz*

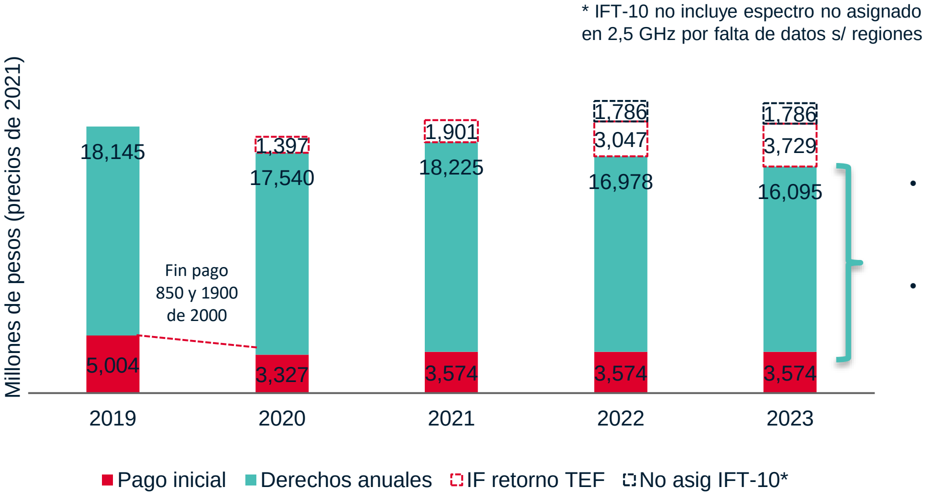
Desafío al abastecimiento para hacer frente a la demanda de tráfico



- La **demanda de datos** por usuario en México **crece exponencialmente.**
- Sin embargo, México es el único país de la región donde **la cantidad de espectro asignado para IMT disminuye.**
- Las **tenencias actuales están por debajo de los requerimientos de espectro de la UIT para IMT** y el promedio de los países de la OECD (1.276 MHz).

Fuente: GSMA Intelligence / Estimaciones propias basadas en datos de GSMA intelligence
** Report ITU-R M.2290-0 para mercados de alto desarrollo*

La tormenta perfecta donde todos pierden



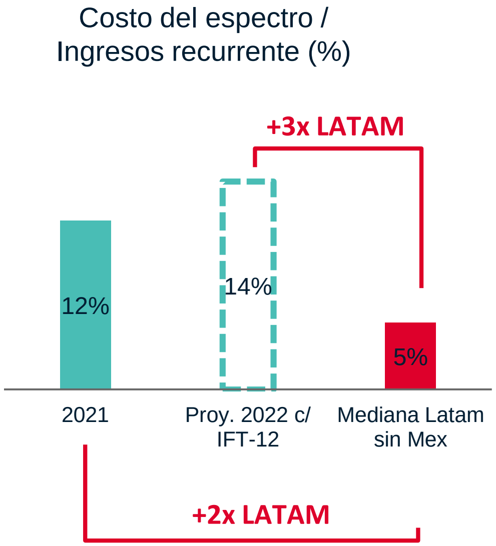
- Los derechos anuales representan el **85% del costo total (+4x Latam**)
- Se **renuevan anualmente generando un alto grado de incertidumbre**

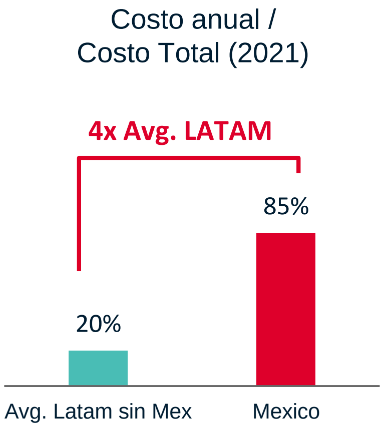
Menor recaudaciòn
MXN 13.645 millones (~USD 635 millones)

- El gobierno recauda menos.
- Los operadores no tienen la posibilidad de ofrecer más y mejores servicios.
- Los consumidores tienen una peor experiencia de consumo y navegación.

Fuente: GSMA Intelligence. / Ley Federal de Derechos / Costos ajustados por inflación a precios del 2021. (Fuente: FMI)
Pagos iniciales anualizados a un costo anual equivalente, basado en la duración de la licencia y en el WACC (Fuente: IFT).

El costo del espectro es más del doble de la mediana en Latam y podría triplicarse

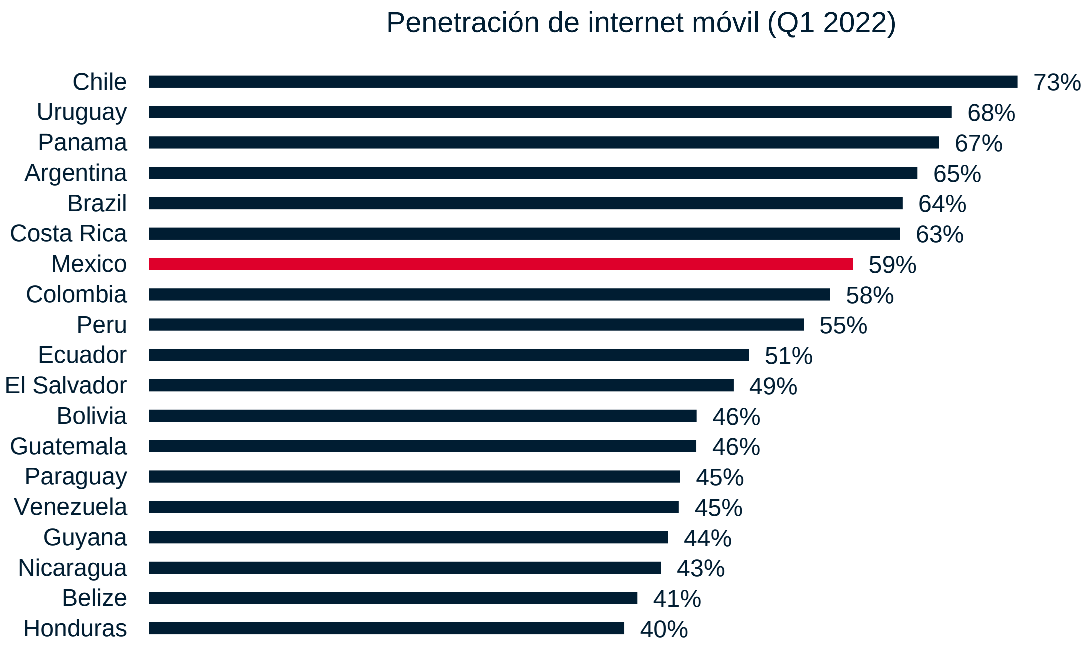




- El alto impacto de los derechos anuales **minimiza el impacto de la puja del mercado** sobre el nivel de precios.
- **El mecanismo de ajuste anual** de derechos a través de la LFD **genera incertidumbres sobre los pagos futuros.**
- Si mantienen la tendencia al alza, impactará sobre los consumidores: **menor calidad de servicio, menos servicios innovadores.**
- Reducir y fijarlas, **podría dotar de predictibilidad a los modelos de inversión** de la industria, y asegurar el éxito de los procesos futuros.

Fuente: GSMA Intelligence. Costos de espectro nominales divididos por los ingresos recurrentes nominales. El costo total incluye pagos anuales e iniciales. Los costos iniciales se anualizan en función de la duración de la licencia y la tasa de descuento (Fuente: IFT)

Disminuir el precio del espectro podría ayudar a reimpulsar la conectividad móvil del país



- ~40% de la población de México no está conectada al internet móvil.
- Un porcentaje significativo de la población no es capaz de beneficiarse de los impactos económicos y sociales de la digitalización.

Fuente: GSMA Intelligence. Calculado como el número de suscriptores únicos de internet móvil dividido por la población

3. El impacto de los altos precios del espectro en el desarrollo económico y social de México

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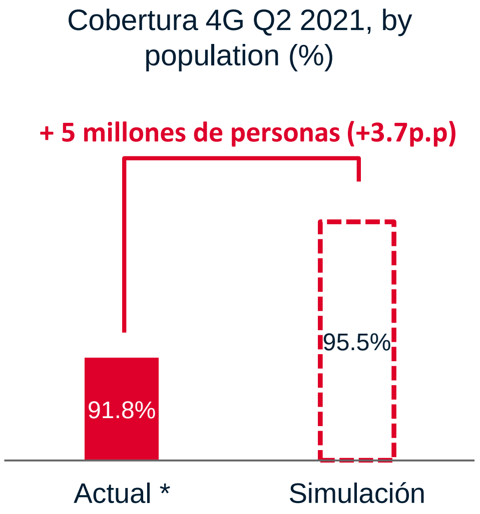
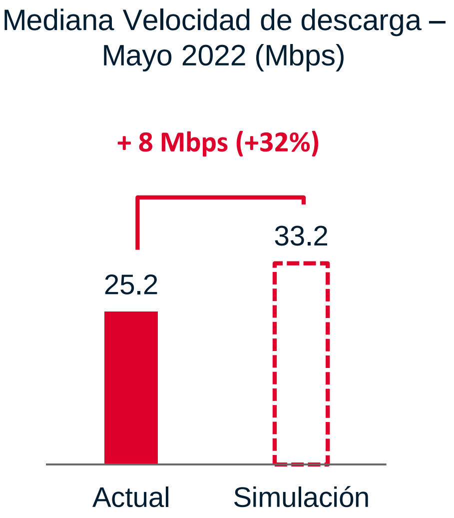
Simulaciones aplicadas al mercado mexicano

- Hemos analizado cómo políticas alternativas en política de precio del espectro hubieran impactado el desarrollo del mercado móvil en México entre 2010-2022.
- Nos centramos en el impacto sobre cobertura 4G y la mediana de la velocidad de descarga.
- No consideramos el efecto sobre los precios finales ya que los resultados globales no son completamente concluyentes.
- Para simular los efectos sobre el desarollo del mercado, consideramos un **escenario donde el precio del espectro en México está en línea con los niveles de precio promedio a nivel global.**
- **Esto es equivalente a una reducción en los derechos anuales de alrededor del 50%.**

La reducción generaría +3.7 pp de cobertura y un servicio 8 Mbps más veloz





- Reducir el costo del espectro ayudaría cerrar la brecha digital, **extendiendo la cobertura en zonas suburbanas y rurales**, que aún no cuentan con el servicio.
- Los países desarrollados tienen velocidades superiores a los 60 Mbps, por lo que **México cuenta con margen para continuar desarrollando la velocidad.**

*Fuente: GSMA Intelligence – Quién es quién en cobertura móvil en México (IFT- 2Q2021) - * la cobertura actual toma el valor de cobertura 4G máximo informado por los operadores / Speedtest intelligence - Ookla*

El alcance de los impactos va más allá del sector móvil

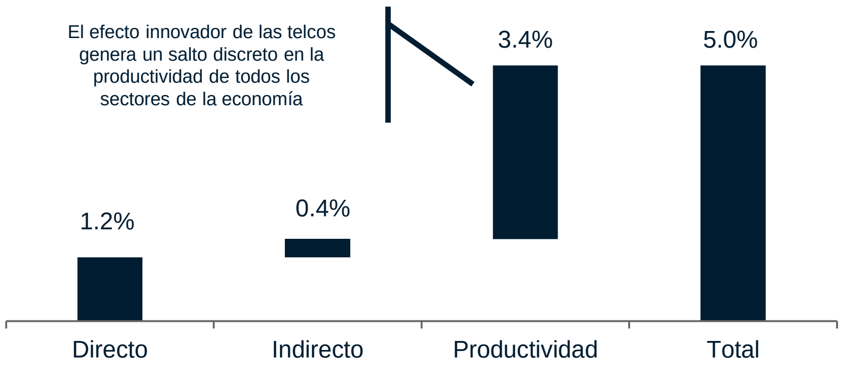
- En México, los pagos por espectro han sido más elevados que en la mayoría de países.

- Esto ha supuesto unos niveles de cobertura poblacional y de calidad de red menores de los que se habrían alcanzado con menores precios.

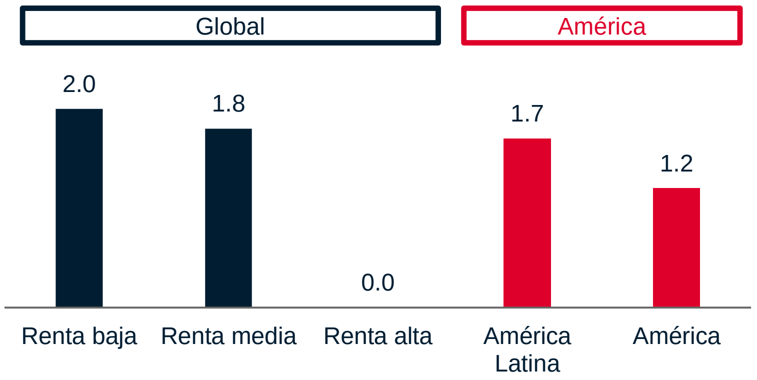
- Tiene implicaciones más amplias para el desarrollo económico y social del país – existe un cuerpo sólido y amplio de estudios económicos (ver apéndice) que ha encontrado un efecto positivo y estadísticamente significativo de las tecnologías TIC (incluyendo tecnología fija y móvil) en el crecimiento del PIB y la productividad.

Las telecomunicaciones móvil son una tecnología de uso general

Impacto económico del móvil en América Latina (% PIB)



Impacto económico de la adopción de banda ancha móvil (puntos porcentuales)



La tecnología móvil contribuye alrededor del 5% del valor añadido total generado en América Latina, equivalente a USD 280 Bn . Como tecnología de uso general, su impacto económico se extiende más allá de su aporte directo.

Fuente: GSMA Intelligence (2018)

En América Latina, un incremento de 10 puntos porcentual en la penetración de la banda ancha móvil resulta en un incremento de 1.7 pp en el PBI.

Fuente: ITU/Katz and Callorda (2019)

Estudio reciente de GSMA corrobora efectos sobre desarrollo económico

- GSMA Intelligence ha evaluado el impacto de la tecnologia móvil entre 2000 y 2017.
- Las oleadas más recientes (3G y 4G) generaron crecimiento económico adicional al ya generado con tecnologías 2G.
- El efecto adicional de la tecnología móvil respecto a la tecnología fija es también significativo – sugiere efectos de eficiencia y productividad que complementan (no sustituyen) la banda ancha fija.
- El efecto y magnitud del impacto de la tecnología móvil depende de las características del stock de capital y trabajo en el país:
    - Impacto mayor con educación secundaria (no tanto con primaria),
    - Impacto mayor en economias basades en industria y servicios,
    - Retornos crecientes con la adopción (efectos de red).

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Impactos más amplios que son clave para un desarrollo sostenible

Reducción de pobreza – la tecnologia móvil puede reducir la pobreza en zonas rurales, ej. la tecnología móvil redujo la incidencia de la pobreza en zonas Rurales de Perú en 8 puntos porcentuales (Banco Mundial, 2012).

Bienestar – uso de tecnología e internet móvil está asociado con una mejora en la calidad de vida y bienestar de las personas (GSMA y Gallup, 2018).

Salud – servicios móviles aplicados al ámbito de la salud y nutrición han mejorado las conductas y la salud de usuarios (GSMA, 2018 and Lee et al, 2018).

Educación – móvil mejora la calidad de la ensenanza y facilita y mejora el aprendizaje (UNESCO, 2014 and Sung et al, 2016).

Inclusión financiera – el dinero móvil ha reducido la exclusion financiera e impulsa el desarollo de innovación financiera y el acceso a servicios financieros a amplios segmentos de la población (Banco Mundial, 2018).

Asistencia humanitaria – el uso de tecnología móvil para comunicarse y acceder a información en situaciones de emergencia es reconocido ampliamente como una forma esencial de asistencia humanitarian (GSMA, 2019 and 2018).

4. Conclusiones y alternativas de políticas públicas

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Estudio global muestra que los precios del espectro:

- No se explican solamente por motivos de oferta y demanda
- Algunos gobiernos dan prioridad a otros objetivos, por ejemplo una mayor recaudación
- Esto tiene repercusiones para los consumidores y las empresas

Menor cobertura | Menores velocidades | Servicios mas caros?

Conclusiones (I)

1	El costo del espectro en México se encuentra entre los más elevados de la región y es más alto que en la mayoría de los países del mundo. Esto se debe a la evolución que han experimentado los derechos anuales en los últimos años.
2	El nivel actual de los derechos anuales por uso del espectro está impactando negativamente en la inversión y el crecimiento del mercado móvil, afectando la expansión de la cobertura, el aumento de la capacidad para enfrentar incrementos de la demanda de tráfico y el futuro desarrollo del 5G.
3	México está por debajo del requerimiento de espectro para IMT de la UIT, contando con recorrido para continuar con la asignación de espectro necesario para acomodar la oferta a una mayor demanda de datos móviles y lanzar en el futuro servicios 5G

Conclusiones (II)

4	Un costo del espectro alineado con otros países supondría una mejora para los consumidores en el mercado móvil, impulsaría un mayor crecimiento económico en México y a la vez ayudaría al país a alcanzar sus objetivos de conectividad y de desarrollo sostenible.
5	El bienestar del consumidor habría mejorado ostensiblemente si el costo del espectro hubiera estado alineado con la media global. 5 millones más de mexicanos tendrían cobertura 4G, y las descargas de datos serían un 30% más rápidas.
6	Los resultados tienen implicaciones más allá del mercado de las telecomunicaciones. El móvil es una tecnología de uso general que tiene efectos positivos sobre el crecimiento económico y la productividad de otros sectores de actividad económica en México.

Alternativas de políticas públicas

1	Reducir los derechos de espectro en todas las bandas.
2	Mantener el total de derechos anuales constantes en el tiempo o ajustados al crecimiento de la industria.
3	Considerar mecanismos que permitan a los operadores intercambiar pagos de derechos anuales por obligaciones de cobertura viables.

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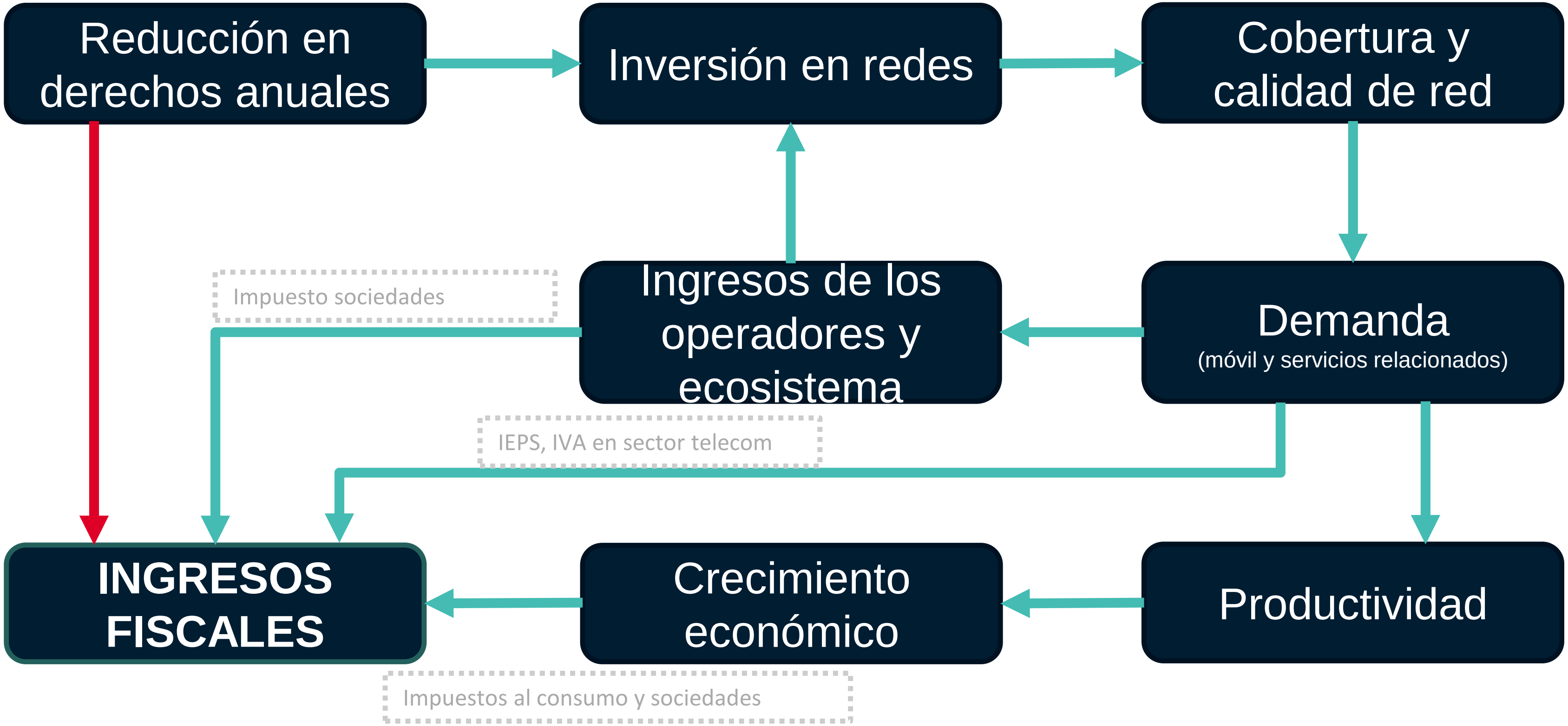
Implicaciones para los ingresos del gobierno



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Apéndice I: Precio del espectro y consumidores

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Objetivos de política pública del espectro

BIENESTAR DEL CONSUMIDOR

Asignar el espectro a quien vaya a generar mayor valor para la sociedad

RECAUDACIóN

Financiar gasto público sin generar distorsiones

- Muchos gobiernos dan prioridad a obtener el máximo de ingresos
- Pero ello puede tener un impacto negativo sobre los usuarios y la economia si con ello se entorpece el desarrollo del sector móvil

Qué determina los precios del espectro?

Demanda y disposición a pagar (factores de mercado)

Pero también las políticas públicas de espectro…

Precios de reserva muy altos

El formato de algunas subastas

Oferta limitada de espectro

No publicar un plan de espectro (roadmap)

Realmente importa que los precios del espectro sean altos?

Son los pagos por espectro un costo hundido?

Afectan a las decisiones de inversión y los precios del usuario final

Crean mayor incertidumbre para ciclos de inversion con horizontes largos

Imponen restricciones de capital y financieras

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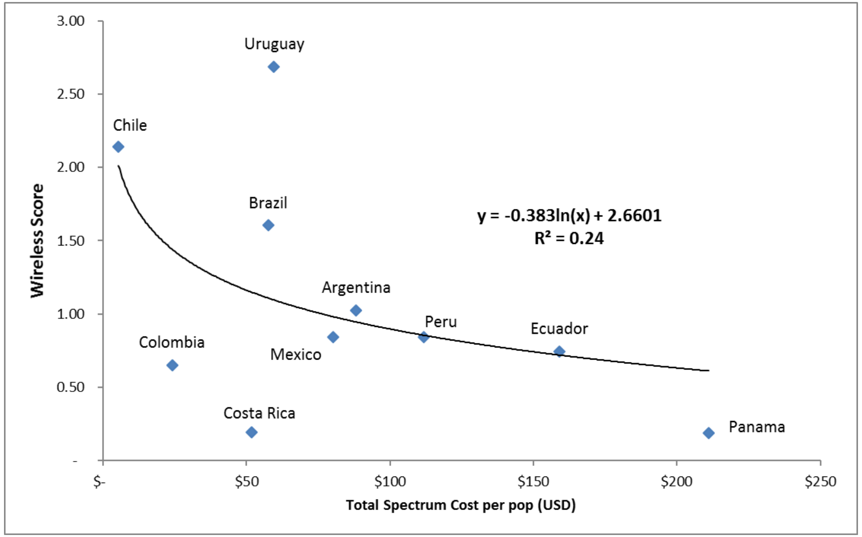
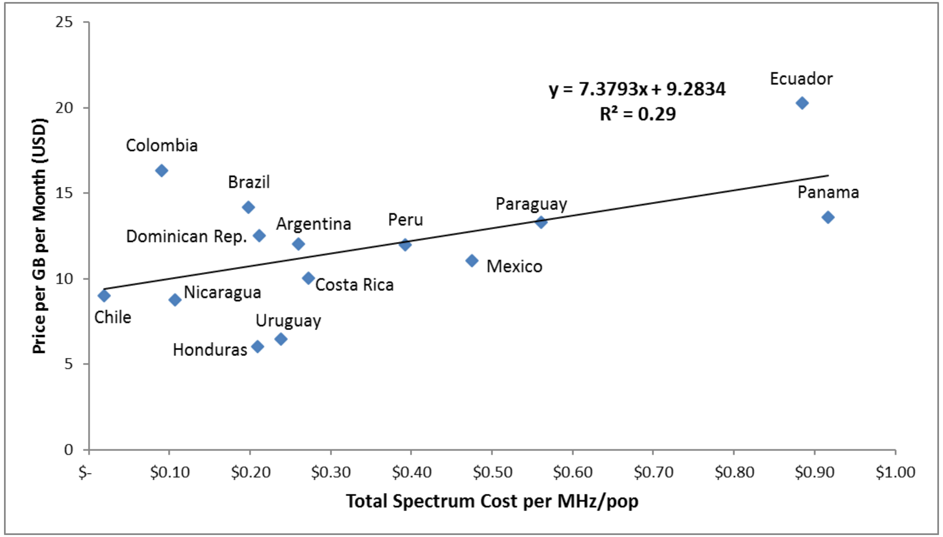
Qué nos dicen los estudios empiricos hasta ahora?

- Algunos estudios encuentran correlaciones negativas entre mayor precio del espectro y menor cobertura, calidad de red o mayores precios



Source: NERA Economic Consulting with data from OpenSignal, Ookla, GSMAi and Telegeography.. Prices are adjusted for PPP exchange rates, inflation and a 15-year licence duration, and include annual fees.



Source: NERA Economic Consulting. Spectrum prices are adjusted for PPP exchange rates, inflation and a 15-year licence duration, and include annual fees. Price per GB is calculated from a representative 5 GB plan.

Pero la mayoria de estudios empíricos no son concluyentes

Paper	Finding	Scope
Cambini and Garelli (2017)	Spectrum availability and spectrum fees are not significantly correlated with mobile industry revenues.	24 countries (mostly developed), 2005-2014
GSMA (2017, 2018)	Link between high spectrum prices and negative outcomes for consumers (higher prices and lower network coverage and quality).	*Global* - 60 countries, 2000-2016; *Europe* -30 countries, 2007-2016; *Latin America* - 15 countries, 2010-2017; *Developing* - 102 countries, 2010-2017
Kuroda and Baquero (2017)	Spectrum auctions reduce 3G diffusion rates (take-up is 2-9% lower). When used to raise public revenues, auctions sacrifice consumer surplus.	47 OECD countries, 2000-2008
Madden et al (2014)	Probability of new entry in a market is enhanced by using auction assignments and excess licenses.	49 assignments, 1999-2008
Zaber et al (2012)	Spectrum management policies have a significant impact on 3G take-up	126 countries, 2000-2009
Park et al (2011)	No effect of auction or spectrum fees on prices, competition (HHI) or investment.	21 OECD countries, cross-section
Hazlett, Munoz (2009)	The amount of spectrum and degree of market competitiveness are key drivers of retail market outcomes. Auction rules that focus on revenue extraction may conflict with the goal of maximizing social welfare.	28 countries, 1999-2003
Gruber (2007)	3G diffusion primarily impacted by market structure and not spectrum assignment method (auctions are not superior to other methods)	17 European countries, cross-section
Bauer (2003)	No relationship between spectrum fees and price of voice	18 countries, cross-section

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Methodology

- General functional form for empirical analysis:

$$y_{i,c,t} = \alpha + \gamma_c C_c + \lambda_t T_t + \sum_{i,c,t=1}^{I,C,T} \mu_{ict} X_{ict} + \rho_{ict} P_{ict} + \varepsilon_{i,c,t}$$

where

- $y_{i,c,t}$ is an outcome for customers of an operator *i* in country *c* in quarter *t*, i.e. coverage, download speeds, upload speeds, latencies, ARPUs.
- C_c and T_t are a country and time fixed effects
- X_{ict} is a set of control variables that predict changes in consumer outcomes. These vary for each consumer outcome.
- P_{ict} is the spectrum price for operator i in country c and quarter t. To generate a spectrum price over time, whenever an operator acquires spectrum, the upfront free is amortised over the length of the license.
- use a cluster-robust estimator for standard errors (clustering at country level)

Control variables

Econometric analysis considers how spectrum prices impact consumer outcomes *after isolating other confounding factors* (from correlation to a causal link).

Country fixed-effects	Controls for country-specific factors such as geography
Time fixed-effects	Controls for time-specific factors such as new technologies and handsets
GDP per capita	Proxy for average income (affects prices & adoption of new technologies)
Population distribution	Population density and % rural population (affects network costs & quality)
Market concentration	HHI used as proxy for market structure and the extent of competition
Smartphone adoption	Smartphone users likely to adopt new technologies and have digital skills
Operator scale	Market share used as a proxy for the scale of an operator
Spectrum holdings	The amount of spectrum impacts network quality and investments
Spectrum timings	Indicator to capturing the time that operators have had relevant spectrum
License obligations	Indicator to capture if operator has coverage or QoS obligations

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We also explore three other specifications

Impacts by income	The impact of spectrum prices may differ depending on for developed and developing countries. We therefore run the analysis for each group separately.
Timing of impacts	The effect of spectrum prices on consumer outcomes may change over time. They may take time to materialise or they may have a bigger impact in the short-term.
'High' or 'excessive' prices	The most material impacts on mobile operators' ability to invest may occur when spectrum prices are very high or 'excessive' – not small variations around average values

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Dynamic impacts and excessive prices

In order to assess whether the impact of spectrum price changes over time, we adjust our specification as follows:

$$y_{i,c,t} = \alpha + \gamma_c C_c + \lambda_t T_t + \sum_{i,c,t=1}^{I,C,T} \mu_{ict} X_{ict} + \rho^{Y1}(P_{ict} * D_{ict}^{Y1}) + \rho^{Y2}(P_{ict} * D_{ict}^{Y2}) + \rho^{Y3+}(P_{ict} * D_{ict}^{Y3+}) + \varepsilon_{i,c,t}$$

where

- D_{ict}^{Y1}, D_{ict}^{Y2} and D_{ict}^{Y3+} are dummy variables that take values of 1 for operator i in country c in quarter t if an operator has incurred a spectrum license payment within the previous 1, 2 and 3+ years respectively (0 otherwise)

In order to assess whether spectrum prices primarily have an impact when they are 'excessive', we adjust our specification as follows:

$$y_{i,c,t} = \alpha + \gamma_c C_c + \lambda_t T_t + \sum_{i,c,t=1}^{I,C,T} \mu_{ict} X_{ict} + \rho_{ict} P_{ict} * E_{ict} + \varepsilon_{i,c,t}$$

where

- E_{ict} is a dummy variable that takes a value 1 when the spectrum price for operator i in country c in quarter t is above the threshold used to define excessive prices (and 0 otherwise)
- We define three separate thresholds to capture very high spectrum prices. These are: (i) prices that are above the 75th percentile; (ii) prices above the inner fence (75th percentile + 1.5*IQR) and; (iii) prices above the outer fence (75th percentile + 3*IQR). These are defined for both spectrum pricing metrics and also for different income groups.

Robustness checks for CPR regressions

1. Cluster standard errors at the operator level
2. Apply operator fixed-effects model
3. Non-linear functional forms (log and logit models)
4. Use future revenues to calculate CPR

Instrumental variable regressions

- Apply 2SLS estimator (GMM was checked as sensitivity)
- Several diagnostics checks for each model

Diagnostic/test statistic	Interpretation
Under-identification p-value (P-value of the Kleibergen-Paap rk LM statistic)	Null hypothesis is that the model is underidentified. Rejecting the null at the 5% level (i.e. p<0.05) indicates that instruments are not underidentified and are therefore correlated with the spectrum price.
Weak identification p-value (P-value of the Sanderson-Windmeijer statistic)	Null hypothesis is that instruments are weakly correlated with spectrum price. Rejecting the null at the 5% level (i.e. p<0.05) indicates that instruments are not weakly correlated with spectrum price.
Weak identification F-Statistic (Kleibergen-Paap Wald rk F-statistic for weak identification)	An additional check for weak identification compares this F-Statistic with the critical Stock-Yogo values. • Developed countries – 13.91 for 5% maximal IV relative bias and 9.08 for 10% maximum IV relative bias • All countries – 16.85 for 5% maximal IV relative bias and 10.27 for a 10% maximum IV relative bias • Developing countries – 16.38 for 10% maximal IV relative bias and 8.96 for 15% maximum IV relative bias
Over-identification p-value (P-value of the Hansen's J statistic where more than one instrument is used)	Null hypothesis is that instruments are uncorrelated with the error term. Rejecting the null at the 5% level (i.e. p<0.05) indicates that instruments are not valid. Can only be estimated if there are more instruments than endogenous regressors.
Endogeneity p-value of the endogeneity test (C statistic)	Null hypothesis is that the specified endogenous regressors can actually be treated as exogenous. Rejecting the null at the 5% level (i.e. p<0.05) indicates that instruments are endogenous, though this interpretation is conditional on the instruments being valid.

Identifying robust findings

Finding	Criteria
Compelling and robust (strong evidence)	Results are significant in the majority of CPR regressions ***and*** the IV regressions for the $PPP metric
Some evidence but not definitive	Results are significant in either some of the CPR regressions ***or*** the IV regressions for the $PPP metric
No evidence of impact	Insignificant results in the majority of CPR regressions and the IV regressions for the $PPP metric
Inconclusive finding	Results are inconsistent across different models

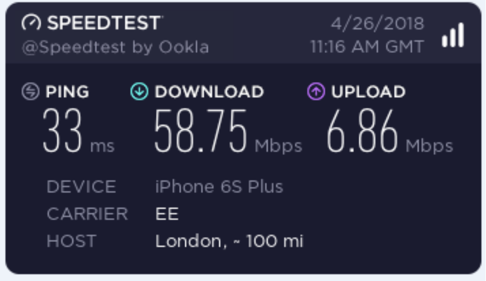
Data – Network Coverage

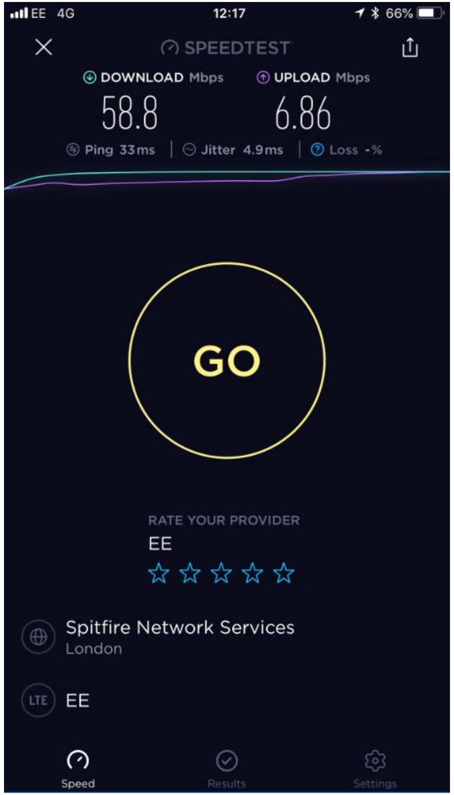
- This analysis considers innovation in technology by looking at **3G and 4G Coverage**.
- In the case of 3G, there is limited variability in most developed/high income countries in the period of analysis, so the focus is on developing countries.
- In the case of 4G coverage, both developed and developing countries experienced significant launches and improvement in 4G coverage during the period.
- Data is sourced from GSMA Intelligence and measures the proportion of the population that is resident in an area where 4G networks are available (i.e. coverage by population rather than by geographic area).
- Data is gathered directly from operators and regulators whenever 4G coverage KPIs are publicly reported. Primarily based on outdoor coverage.
- Coverage data is not reported every quarter so in certain periods the data has to be estimated (carried out by GSMA Intelligence).
- Going forward, analysis of network coverage would benefit from further data from operators as well as the use of crowd-sourcing platforms to estimate geographical coverage.

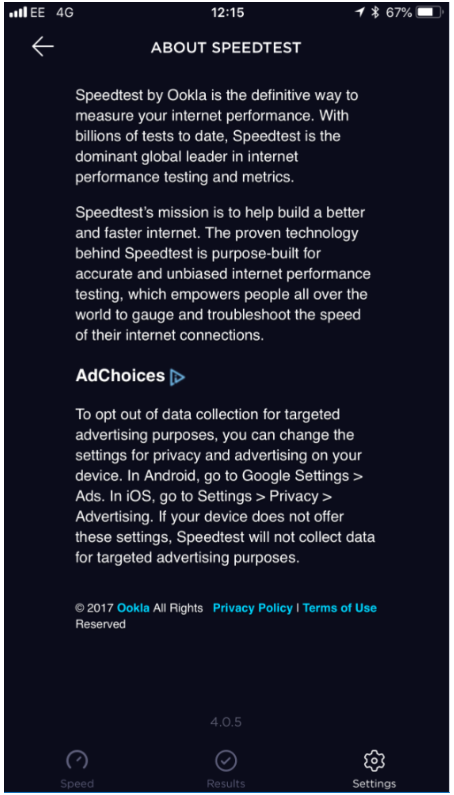
GSMA Intelligence

Data – Network Quality

- Data is sourced from Ookla, which runs the Speedtest® consumer-initiated testing platform
- Allows mobile users to initiatate a ‘speed test’ to measure network performance at any given time.
- Speedtest is used by 500 million unique users globally, and an average of 10 million consumer-initiated performance tests are run per day.
- In our dataset, the average number of tests is greater than 10,000 for each operator for most of the period







GSMA Intelligence

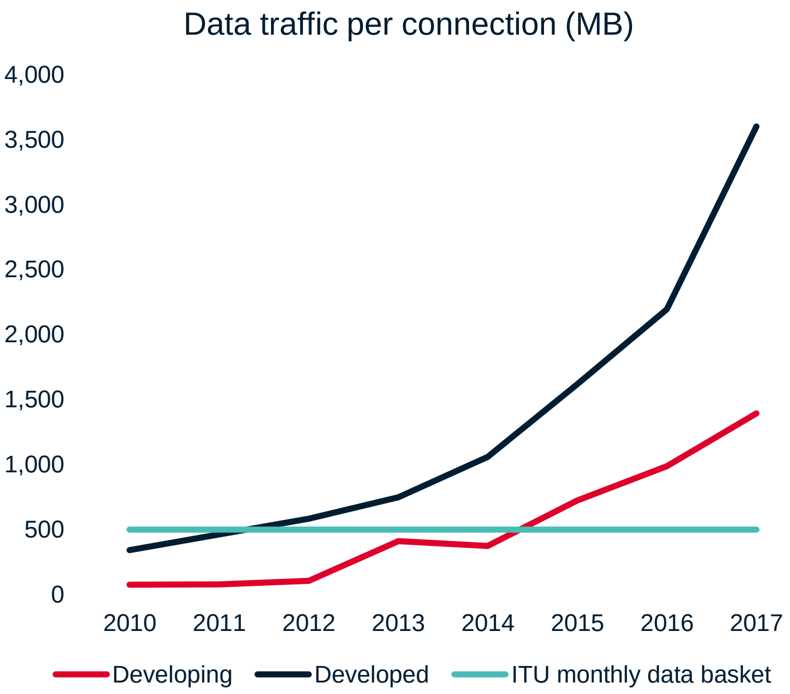
Data – Consumer Prices

There are three ways in which prices can be measured for mobile services

Price metric	Description	Pros	Cons
Revenue per unit	Divide operator revenues by subscribers (or voice revenues by call minutes of data revenues by data traffic)	- Relatively easy to implement - Data is widely available compared to other metrics	- Metric is affected by prices and usage - Does not measure prices actually paid by consumers (incorporates revenues across older tariffs as well as other sources of operator revenues)
Basket approach	Define one or more baskets that are representative of consumer usage and calculate the cost of consumption	- Gives a better indication of what consumers actually pay for mobile services - Can fix baskets to ensure only price changes are taken into account	- Difficult to identify baskets that are representative of consumers - Fixed baskets are unlikely to be representative - Changing baskets over time means price changes are affected by volumes
Unit Prices	Estimate the price paid for voice, SMS and data respectively for a given tariff and divide by usage	- Controls for changes in quantity consumed	- Very difficult to estimate accurately as voice, SMS and data are bundled together

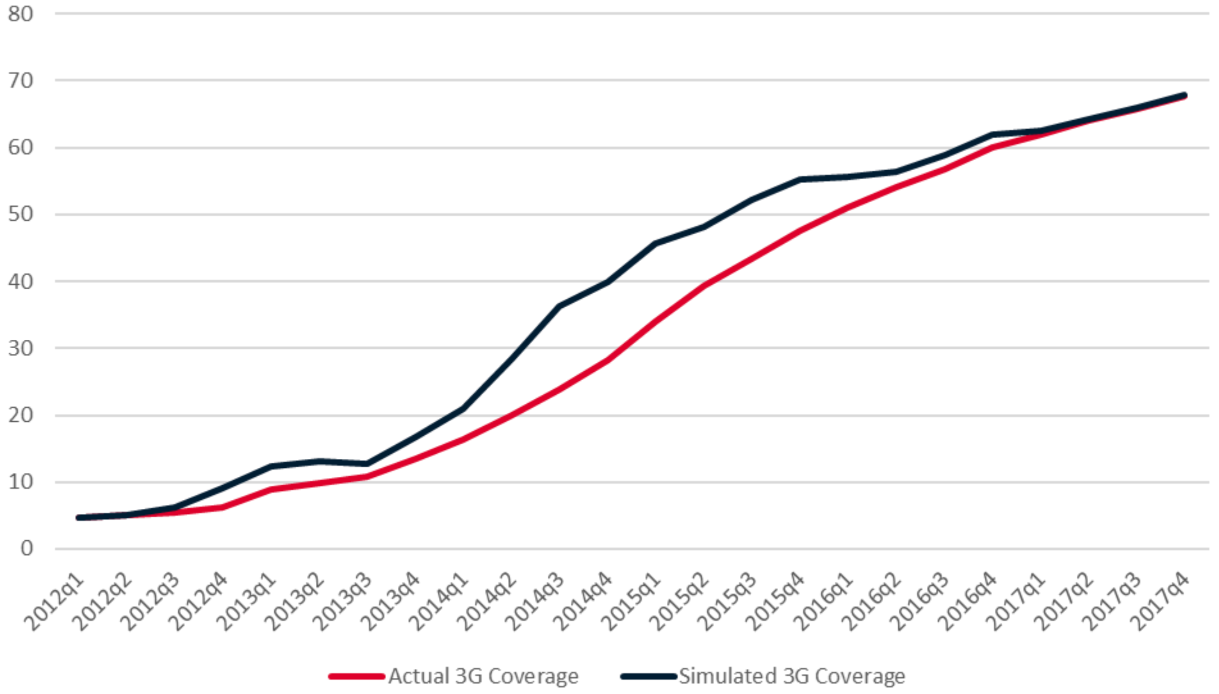
Consumer price data

- For the period 2010-2017, the only metric available to perform the analysis at the operator level are ARPUs (sourced from GSMA Intelligence)
- We perform alternative regressions with ITU pricing data based on two baskets: a basket that includes 30 calls per month and 100 SMS messages; and another basket that includes the cost of 500 MB of data (pre-paid).
- ITU baskets may be a reasonable approximation for consumption patters in developing countries but not for developed (see chart).
- ITU data also only available at the country level (not operator level)
- Results of our analysis of impacts on consumer prices are therefore treated with a degree of caution.



Source: GSMA Intelligence. Where operators report total data traffic, we divide this by the number of connections they have. Estimates in the chart represent the median values of average monthly data traffic for operators in our study that reported data traffic volumes..

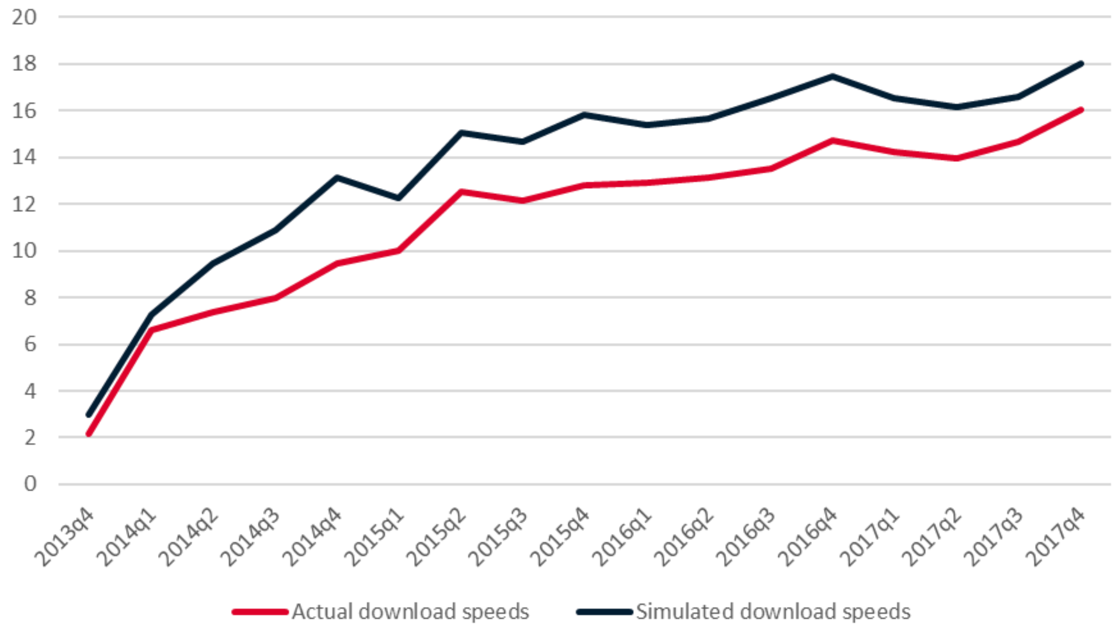
Una asignación más temprana de espectro habría acelerado la cobertura 3G en 12pp



- Este gráfico presenta la cobertura poblacional 3G en una selección de países de renta media y baja donde las primeras asignaciones de espectro se produjeron con retraso

- Los niveles de cobertura 3G alcanzados son comparados con los niveles que se hubieran alcanzado si el espectro hubiera sido licenciado antes

Mayor cantidad de espectro habría mejorado las velocidades de descarga en un 15%



- Este gráfico presenta las velocidades de descarga en una selección de países donde las cantidades de espectro asignadas fueron limitadas (definido como cantidades de espectro 3G y 4G 20 MHz por debajo de la media)
- Las velocidades de descarga alcanzadas son comparadas con los niveles que se hubieran alcanzado si las cantidades de espectro hubieran estado a niveles medios

Apéndice II: TIC y crecimiento económico

Literatura económica: TIC y crecimiento económico

Author	Data	Key variable	Outcome	Results	Methodology
Koutroumpis (2009)	22 OECD countries, 2002 to 2007	Broadband penetration (number of broadband subscribers per 100) and broadband investment. Sourced from OECD and ITU.	GDP growth	Using a SEM approach that allows endogenizing penetration: - A one percent increase in broadband adoption generates a 0.023 percent increase in GDP growth in the Instrumental Variable, fixed effects approach. - Improvements in broadband infrastructure were responsible for nearly 10 percent of the annual growth rates of the studied OECD countries. - A critical mass is found at a broadband adoption rate of 30 percent, after which the growth returns to broadband infrastructure investment are considerable larger than at lower adoption levels.	Simultaneous Equations Model with Instrumental Variable and three-stage GMM estimator with fixed effects
Czernich et al. (2011)	25 OECD countries, 1996 to 2007	Broadband penetration (number of broadband subscribers per 100). Sourced from OECD and ITU.	GDP per capita growth	- Broadband introduction increases growth per capita significantly. The introduction of broadband increases growth per capita between 2.7 to 3.9 percent. A 10 percentage point increase in broadband penetration increases annual growth per capita between 0.9 to 1.5 percentage points. - A critical mass is found at a broadband adoption rate of 10 percent.	Instrumental Variable; Difference-In-Difference fixed effects
Thompson and Garbacz (2011)	43 low to high income countries, 2005 to 2009	**Mobile broadband** penetration (number of mobile broadband lines per household). Sourced from ITU	GDP per household	Mobile broadband has a significant impact on GDP per household, with the magnitude of this impact being larger in low income countries. Fixed broadband is found to play a negative role but only marginally significant in low income countries.	Instrumental Variable fixed effects
Arvin and Pradhan (2014)	19 of G20 countries, developed and developing, 1998 to 2011	Broadband penetration (number of broadband subscribers per 100). Sourced from OECD and ITU.	GDP growth	- Causality tests suggest that, in the short run, there is a bidirectional relationship between GDP and broadband penetration for developed countries. In developing countries, only economic growth causally impacts broadband penetration. - No causal relationship is found in the long run.	Granger causality test
Gruber et al. (2014)	27 EU countries, 2005 to 2011	Broadband penetration (number of broadband subscribers per 100). Sourced from OECD and ITU.	GDP growth	Using a SEM approach that allows endogenizing penetration finds that broadband adoption rates had a significant positive effect on GDP, with this being significantly larger for a broadband adoption rate greater than 15 percent.	Simultaneous Equations Model

GSMA Intelligence

Literatura económica: TIC y crecimiento económico

Author	Data	Key variable	Outcome	Methodology
Cronin et al. (1991)	USA, 1958-1988, country level	Wireline investment	Telecommunications investment and economic growth have a bidirectional causal relationship.	Granger causality tests
Madden and Savage (1998)	Central and Eastern Europe, 27 countries, 1990 to 1995, country level	Wireline investment	Higher share of telecommunications investment in GDP significantly increases GDP growth per capita. This effect is found to be unidirectional when investment is accounted in real terms, while this is not the case in nominal terms.	Static OLS and Granger causality tests
Madden and Savage (2000)	43 countries, 1975 to 1990, country level	Wireline investment and mainline penetration (number of mainlines)	Telecommunications investment measured as proportion of GDP and the number of mainlines per working age population both have a significant impact on GDP growth	OLS and Instrumental Variable
Dutta (2001)	15 developing and 15 industrialized countries, 1960 to 1993, country level	Mainline penetration (number of telephones)	Telecommunications usage drives economic growth in half of the developing countries, while the effect is found to be significant in less countries in the industrialized markets sample. The causal impact of economic growth on telecommunications is found in significantly fewer countries, so the authors conclude that a unidirectional causal effect of telecommunications on economic growth is more likely than a bidirectional relationship.	Granger causality tests by country
Roller and Waverman (2001)	21 OECD countries, 1970 to 1990, country level	Mainline penetration (number of mainlines)	Using a SEM approach that allows endogenizing mainline penetration: - An increase in the number of mainlines per capita positively impacts economic growth. Telecommunications infrastructure accounts for approximately one third of annual GDP growth between 1970 and 1990. - Impact is found to be nonlinear, so that countries with penetration rates above 40% (i.e., approximately universal service) experience higher growth as compared to markets below this level. Findings confirm critical mass phenomenon as well as network externalities.	Simultaneous Equations Model and GMM estimator
Callorda and Katz (2019)	34 countries in Latin America	Fixed and mobile broadband	The report suggests that an increase of 10 per cent in fixed broadband penetration would yield an increase in 1.9 per cent in GDP per capita. In addition, it suggests that pricing remains a key enabler for adoption of broadband and a 10 per cent drop in prices will boost adoption by more than 3.0 per cent.	Structural model

Literatura económica: TIC y crecimiento económico

Author	Data	Key variable	Outcome	Results	Methodology
Yilmaz et al. (2002)		US State level data, 1970 to 1997	Wireline capital stock	- State telecommunications capital stock has a significant positive impact on output growth. - Telecommunications investment also produces a significant negative spillover effects for other states, so that geographical proximity to a state increasing its telecommunications investment adds to these negative spillover effects	GLS with first differences, Static classical production function
Datta and Agarwal (2004)		22 OECD countries, 1980 to 1992, country level	Mainline penetration (number of access lines)	- Higher number of access lines per 100 inhabitants is found to significantly increase real GDP per capita. - Returns to telecommunications infrastructure are found to be decreasing, so that countries with few access lines experience stronger impacts	Dynamic panel data with fixed effects
Shiu and Lam (2008)		22 Chinese provinces, 1978 to 2004, province level	Mainline penetration	A causal impact of telecommunications on real GDP is found for high-income provinces, in the Eastern region, but not in the low-income central and western provinces. Telecommunications has a causal effect on economic growth in provinces with high adoption rates, while no effect is found is provinces with low penetration rates.	Dynamic panel data with first differences, Granger causality test
Lam and Shiu (2010)		105 countries, 1980 to 2006, country-level	Mainline penetration	- A bidirectional relationship is found between fixed line telecommunications adoption and growth in European and high income countries. - A causal impact of GDP on telecommunications adoption is found for lower income countries.	Dynamic panel data with first differences, GMM and Granger causality test
Chakraborty and Nandi (2011)		93 developing countries, 1985 to 2007	Mainline penetration (number of access lines)	- A unidirectional impact of telecommunications on economic growth is found in the full sample in the short run; in the long run there is a bidirectional causal link. - Developing, high-growth countries display a particularly strong relationship between mainline telecommunications and economic growth in the long run, so infrastructure investment could be a pivotal instrument in the catch/up process of countries with lower levels of infrastructure and economic development.	Granger causality test

Literatura económica: TIC y crecimiento económico

Author	Data	Key variable	Outcome	Results	Methodology
Waverman et al. (2005)		38 developing countries, 1996 to 2003, and 92 countries low and high income countries, 1996 to 2003, country level	Mobile and mainline penetration	Using a SEM approach that allows endogenizing penetration: - Higher mobile penetration level between 1996 and 2003 led to a significant increase in GDP per capita growth rates from 1980 to 2003. Meanwhile, the level of fixed-line penetration in 1980 did not have a significant effect. Results indicate that mobile phone are an important substitute for landlines. - The effect of mobile adoption was twice as large for low income countries relative to high income countries	Simultaneous Equations Model with GMM estimator; and endogenous growth model
Sridhar and Sridhar (2007)		63 developing countries, 1990 to 2001, country level	Mobile and mainline penetration (number of telephones and mobile phones)	Using a SEM approach that allows endogenizing penetration: An increment of 1 percent in the number of telephones (fixed line and mobile) per 100 inhabitants is associated with a GDP increase between 0.1 and 0.15 percent. Compared to fixed line, the positive impact of mobile telephones is found to be smaller.	Simultaneous Equations Model, three-stage OLS
Lee et al. (2012)		44 Sub-Saharan African countries, 1975 to 2006, country level	Mobile and mainline penetration	- The number of main telephone lines per 100 inhabitants is found to have a significant impact on growth of GDP per capita, while the effect of the number of mobile phone subscribers is not significant. However, this result is driven by the relatively recent introduction of mobile phones; when the sample is restricted to 2000 to 2006, the role of mobile phones is found to be significant. - The impact of mobile phones on GDP growth is higher in countries with low levels of landline penetration (result derived from the negative impact of the interaction term between landline and mobile phones).	Dynamic panel data with two-step difference GMM estimator
Ward and Zheng (2016)		31 Chinese provinces, 1991 to 2010, province and industry level	Mobile and mainline penetration	- From 1991 to 200, the underdeveloped western region of China benefited relatively more from mobile telecommunications than the wealthier eastern region. However, from 2001 to 2010, no such difference in impact is observed. - Mobile and mainline penetration are found to have a complementary impact.	Dynamic panel data with GMM estimators and static two-way fixed effects OLS
Gruber and Koutroumpis (2011)		192 countries, 1990 to 2007	Mobile penetration (number of mobile lines)	Using a SEM approach that allows endogenizing penetration: - All approaches point to a significant positive impact on GDP, with these being the largest in the Instrumental Variable approach. - Impact of mobile lines is nonlinear and increasing in a country's mobile penetration rate and income. Critical mass is identified at a penetration of 30 percent. Mobile adoption causes average growth returns of annually 0.2 percent in high income countries and 0.11 percent in low income countries.	Simultaneous Equations Model; static fixed effects OLS; and Instrumental Variable approaches

Literatura económica: TIC y crecimiento económico

Author	Data	Key variable	Outcome	Results	Methodology
Cronin et al. (1993)	USA, 1958 to 1991 Country and industry level	Wireline telecommunications investment	TFP	- Telecommunications improvements have a unidirectional causal impact on private business and manufacturing productivity. Telecommunications investments account for up to 37% of annual growth in total economy-wide productivity. - Almost all industries benefit. Manufacturing and service sectors such as retail trade benefit the most.	Granger causality tests
Greenstein and Spiller (1995)	USA, 1986 to 1992, country-state-company levels	Wireline telecommunications infrastructure deployment (miles of fiber cable)	Revenues of FIRE and manufacturing sectors	- Infrastructure deployment measured as the rollout of fiber cable has a significant positive impact on real revenue in the finance, insurance and real state sectors. Doubling the number of miles of fiber cable would result in an increase in revenue in the FIRE sector of 10 to 45%. - No significant impact is found or the manufacturing sector. Suggests that improved infrastructure primarily benefit technology intensive industries such as the FIRE sector whereas low-tech industries like manufacturing are less affected.	Instrumental Variable on static cross-section time series; dynamic investment models
Cieslik and Kaniewsk (2004)	Poland, 1989 to 1998, regional level	Mainline penetration (telephone subscribers)	Retail sales	The number of telephone subscribers per 100.000 inhabitants induces a significant, causal impact on retail sales per worker, with the size of the effect varying depending on the model specification.	Static classic production function and OLS; fixed and random effects panel data
Thompson and Garbacz (2007)	93 countries, 1995 to 2003	Mobile and mainline penetration	Productive efficiency	- In low income and Sub-Saharan African countries, mobile and mainline adoption significantly induce improvements in productive efficiency. In Latin America, only increased fixed-line adoption drives significant impacts, while in Asian countries only higher mobile phone adoption is found to increase productive efficiency. - High-income OECD countries with already near-universal telecommunications adoption do not experience further positive effects from increases in telecommunications penetration.	One-stage stochastic-frontier production function deriving inefficiency functions for country groups