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The impact of network competition in the mobile industry

October 2014

George Houpis, Jose Maria Rodriguez, Thomas Ovington and Goran Serdarevic

Abstract

In 2000, there were as many countries served by a single mobile network as by network competition. Today, only 30 countries, representing less than 3% of the world's population, are served by a single network. There has been considerable discussion about the optimal number of network operators in the mobile industry. More recently, some regulators and governments have considered implementing a single wholesale network to deliver next generation mobile services due to concerns around low coverage, inefficient duplication of costs and lack of competition. To date, the authors are not aware of such single wholesale networks fully implemented in mobile industry. What is clear is that single wholesale networks represent a U-turn with respect the way in which the mobile industry has developed worldwide. Therefore, it is important to carefully examine the available evidence on the performance of mobile markets in countries with a single mobile networks, as this is could shed some light on the expected performance of single wholesale networks. The key result is that countries with network competition have higher coverage, higher take-up and greater innovation than countries with a single mobile network, controlling for other relevant factors. This paper represents a significant contribution to the literature, as the authors are not aware of any other papers that have considered the impact of network competition compared to single networks on outcomes such as coverage. The results of the paper have significant policy implications, as they imply that moving away from the network competition model into the world of single wholesale networks could cause considerable consumer harm, which may be difficult to reverse once there has been a move away from network competition.

The opinions expressed in this article are the authors' own and do not reflect the view of Frontier Economics Ltd. This is a preliminary version of the paper, please do not cite. This paper builds on a project that the authors carried out for the Global System Mobile Association (GSMA).

Key words: regulation, single mobile network, competition, mobile telecommunications

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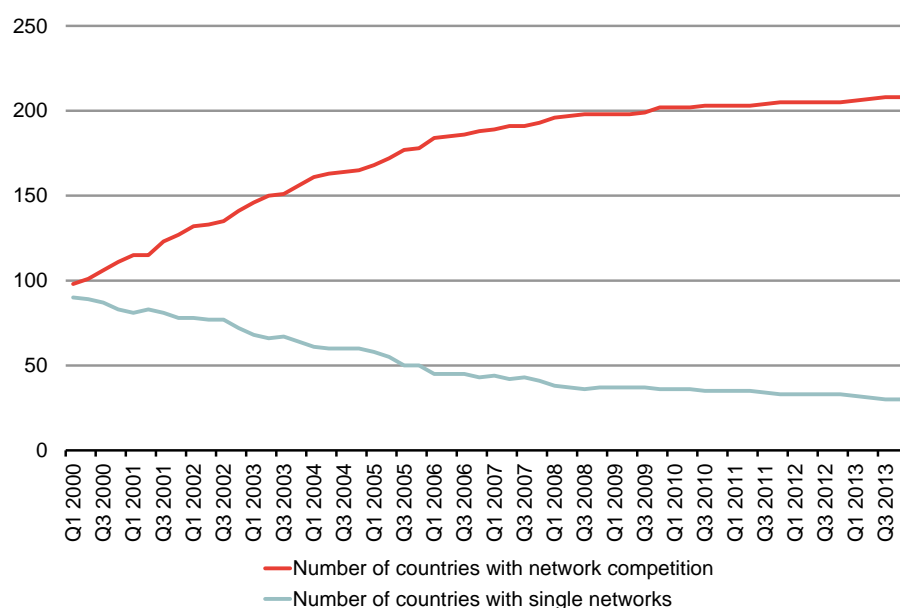
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1. Introduction

In 2000, there were as many countries served by a single mobile network as by network competition. Today, only 30 countries¹, representing less than 3% of the world's population, are served by a single network. This strong shift towards network competition is shown in the following graph.

Figure 1. Number of countries with network competition and single networks



Source: GSMA intelligence database

This increase in network competition has arisen partly due to the actions of regulators, who have a) at times reserved spectrum for new entrants b) encouraged interoperability between networks and c) re-allocated more spectrum from other industries such as broadcasting to mobile. Nevertheless, during the past 15 years, the extension of network competition has produced unprecedented growth and innovation in mobile services, particularly in developing countries. The number of mobile users increased almost 20 times, from 0.13 billion to 2.5 billion. Mobile services became widespread,

¹ Andorra, Bahamas, Cocos (Keeling) Islands, Comoros, Cook Islands, Cuba, Diego Garcia, Djibouti, Eritrea, Ethiopia, Falkland Islands, Greenland, Kiribati, North Korea, Marshall Islands, Micronesia, Monaco, Montserrat, Myanmar, Nauru, New Caledonia, Niue, Norfolk Island, Saint Pierre and Miquelon, San Marino, Sao Tomé and Príncipe, Svalbard and Jan Mayen, Swaziland, Tuvalu and Åland Islands.

with more than 90 per cent of the world's population now having mobile coverage² and almost half of the world's population covered by mobile broadband (3G) networks³. At the same time, the cost of mobile services has halved in developing countries, while the average price paid has fallen by more than 80%, while usage⁴ has increased by almost 120%. Turnover in the mobile sector has grown to represent 1.5% of global Gross Domestic Product (GDP), supported by an investment in mobile networks of almost \$2 trillion since 2002.

Arguing about the optimal number of network operators in the mobile industry is not new. This debate has been present since the early days of mobile competition in the 90s and more recently in the context of mergers and the setting of spectrum caps in 4G auctions. However, the novelty now is that some regulators and governments are considering implementing some form of a Single Wholesale Network (SWN) to deliver next generation mobile services (4G). For example, there are currently SWN proposals in Mexico, Kenya, South Africa, Rwanda and Russia. This could represent a radical departure from the competing networks approach to the development of mobile services which has been favoured by policymakers around the world for the past 30 years.

The exact details of the SWN proposals vary across countries. However, a common theme is that the SWN would typically have a competitive edge on the existing networks, for instance by having access to all 700 megahertz (MHz) spectrum, and that the government would have some ownership of the SWN. As a result, the SWN would be expected to remove competition at the wholesale-level, but there would continue to be retail competition. Other operators, including existing network operators, would have to largely rely on wholesale agreements with the SWN to offer next generation mobile services to its retail customers.

SWNs have been proposed for a variety of reasons, with the exact rationale depending on the specific country in question. However, the reasons can be split into three broad categories. First, there have been concerns that competing operators will not deliver enough or fast enough network coverage, particularly in rural areas. Second, some

² <http://www.gsma.com/aboutus/gsm-technology/gsm>

³ Source: International Telecommunications Union (http://www.itu.int/net/pressoffice/press_releases/2013/41.aspx#.U33cLH9wamQ, retrieved on June 20, 2014)

⁴ Minutes of use per connection (GSMA intelligence)

parties have argued that network competition leads to unnecessary duplication of costs and spectrum fragmentation. Third, in cases where authorities consider that network competition is not working, they view the combination of an SWN and many mobile virtual network operators (MVNOs) as a way of increasing competition.

A key question is whether these concerns are valid and how an SWN would perform relative to a counterfactual of network competition. There have been no SWNs to date in the mobile industry, so it is difficult to test directly how an SWN would perform. There have been some examples of SWNs in the fixed sector, such as in Australia, Singapore and New Zealand. However, fixed networks exhibit greater economies of scale than the mobile sector, so it is not possible to accurately predict the success of SWNs in the mobile sector based on SWNs in the fixed sector. The SWNs in the fixed sector do nonetheless highlight some of the challenges in setting up and running an SWN. For example, the SWN in Australia was on the verge of collapsing at one point. If an SWN were to fail, then this could cause serious consumer detriment, given the lack of alternative network operators that consumers could switch to.

As shown by the figure above, there have been several countries that have relied on only one vertically-integrated mobile operator, either government owned or privately owned. Therefore, in this paper the authors compare the outcomes under network competition relative to single networks, as a proxy for SWNs. While they recognise this is not a perfect equivalent to an SWN, because the SWN will introduce retail competition via network access to the SWN, it can be used as a 'second-best' approximation to assess the expected long-term effects of moving away from network competition to an SWN model.

Ideally, the authors would want to compare consumer outcomes in (a) countries with network competition (i.e. competition between multiple vertically integrated network operators) with (b) outcomes in countries with a single wholesale network, with competing retail providers and (c) outcomes in countries with a single (vertically integrated) network provider. The lack of data on (b) implies that it is not possible to do this comparison because they do not have data on (b). It is still useful to compare (a) with (c), for which they have significant data, primarily because

- a significant proportion of costs for mobile operators are incurred at the network-level rather than at the retail-level and the wholesale network services account for more than 50% of the value added of mobile services; and
- most of the innovation and technology adoption that has driven the very significant improvements in efficiency happens at the ‘wholesale network’ level.

Therefore, their analysis still provides a useful insight into the expected performance of SWNs compared to network competition model.

The authors assess the impact of network competition on network coverage, take-up and innovation. They find that network competition delivers superior outcomes to single networks. This paper represents a significant contribution to the literature. To the authors’ knowledge, no other papers have considered the impact of network competition compared to single networks on outcomes such as coverage⁵. This may be partly because it is difficult to get data on coverage, particularly at the country-level rather than at the operator-level. Although there has been much discussion around the optimal number of mobile network operators, there has been much less consideration of whether network competition should be preferred to single networks.

The policy implications of the results are also significant, as they imply that regulators and governments could be taking a considerable risk by implementing SWNs in the mobile sector, which could lead to worse outcome for end users in terms of availability and quality of mobile services. Moreover, once an SWN has been established, it will be difficult and time consuming to then return back to network competition.

The rest of this paper is structured as follows:

- In section 2, the authors discuss the expected impact of network competition on a range of outcomes;
- In section 3, they explain their empirical approach for assessing the impact of network competition;
- In section 4, they present their results;

⁵ Gruber (2001), Gebreab (2002), Gruber and Verboven (2001), and Kalba (2003) all assessed the impact of the level competition on mobile take-up. However, they did not explicitly consider the impact of single network.

- In section 5, the authors conclude and consider the policy implications of their results; and
- In an appendix, they provide further details on the data used.

2. Theory: the impact of network competition

Proponents of SWNs argue that network competition results in lower network coverage, particularly in rural areas. This is because there are likely to be some areas where it is only profitable for one operator to roll-out its network. If multiple operators roll-out their networks to these areas, then the operators may not have sufficient retail customers to be able to cover their costs.

In reality, there are reasons why you wouldn't expect coverage to be lower under network competition.

First, under network competition, operators will be trying to get ahead of their rivals. When it is not profitable for multiple operators to rollout in a particular area, it may nonetheless be possible for one network to gain a 'first mover' advantage and capture the entire retail demand in the area. Once they have done so, they can be confident that it would be unprofitable for any other operator to follow, at least until the given area becomes commercially viable for more than one operator.⁶

Second, there are many examples of network sharing across countries. Network sharing can mean that rather than duplicate costs such as towers, infrastructure and equipment, competing networks can share these costs. This makes extensive network roll-out more viable.

Third, coverage obligations imposed at the time of licence award have been used to ensure faster roll out and greater coverage in many countries. The Government provides indirect funding, to the extent that network operators will pay the Government less for a licence which includes obligations to cover areas which are otherwise uneconomic for them to do so.

⁶ This is consistent with the observation that mobile operators in a given country often have different levels of coverage supports, indicating that some areas may only be covered by one operator. At the same time, the authors recognise that coverage is a dynamic concept and with the decreasing cost of equipment and the increasing demand for mobile services one would expect that more areas become economically viable for multiple networks.

Fourth, network competition puts pressure on operators to minimise costs. Even though it may be difficult for operators to reduce the unit prices of network equipment, they are able to ensure that they optimise their network and minimise their operating expenditure. Lowering costs should help make it economically viable to roll-out to more areas, which will increase coverage.

Fifth, if unregulated, a network monopoly will have less incentive to extend coverage than network competitors in the same way as a monopoly produces less output than a competitive market.

Advocates of SWNs rarely consider the impact that single networks could have on innovation. Even though mobile technologies are typically developed at an international level, the speed at which they become available to consumers depends crucially on *national* policies and market structures. Innovation, broadly defined, drives the speed of adoption of new technologies and technology upgrades in mobile networks. This has a major effect on reducing the unit costs of services for consumers and extending profitable network coverage. One reason why technology upgrades are so important is that each new technology generation delivers significant gains in spectral efficiency. Given that spectrum is scarce, this leads to much needed increases in capacity in mobile networks, Innovation also determines the range of services which consumers can enjoy over the networks that have been built.

In addition, SWNs will require heavy regulation in the form of access prices to the SWN, coverage obligations, introduction of new services and deployment of new technologies. Given information asymmetries and regulatory failures, regulation is likely to lead to sub-optimal outcomes.

3. Literature review – existing empirical evidence

The authors have reviewed the existing literature on the impact of competition on take-up of telecommunication services and investment in the sector. The available evidence indicates that there is a positive link between competition, service diffusion and investment. None of these studies, however, directly looks at the performance countries with a single mobile network compared with network competition countries. Moreover, the global data set used provides a unique insight into the performance of single mobile networks.

The relationship between competition and performance of telecommunications markets has received a significant attention in the academic literature over the last two decades, in particular following the liberalisation of mobile market in a number of countries.

The primary focus of these studies seems to be the link between competition and the diffusion of telecommunications services. Early contributions include Gruber and Verboven (2001a,b), Gruber (2001) and Wallsten (2001). Considering a sample of European countries, Gruber and Verboven (2001a) find a significant impact on the diffusion process by the introduction of competition. Gruber (2001) focuses the analysis on Central and Eastern European countries. The results show that the speed of diffusion increases with the number of firms in the market. The analysis also shows that simultaneous entry is more effective than sequential entry in accelerating the diffusion speed. Gruber and Verboven (2001b) extend the analysis to cover a wider geographic landscape. The paper finds that the introduction of second entry licenses had a significant impact on the diffusion of mobile services. Wallsten (2001), on the other hand, explores the effects of privatisation, competition, and regulation on telecommunications performance, considering evidence from 30 African and Latin American countries in the period 1984-1997. The analysis reveals that competition – measured by mobile operators not owned by the incumbent – is correlated with increases in per capita number of mainlines, payphones, and connection capacity, and with decreases in the prices of local calls.

More recent studies include Rossotto et al. (2005), Rouvinen (2006) and Li and Lyons (2012). Rossotto et al. (2005) analyse the impact of opening up telecommunications to

competition in the Middle East and North Africa (MENA) region on the sector's performance and on the participation of the region in the World economy. Their empirical research shows that increased market competition boosts demand for fixed and mobile telephone services by lowering prices to users. Their estimates also suggest that greater competition is associated with increased productivity of labour in telecommunications as measured by revenues per employee. Using a wide data set covering a large number of countries, Rouvinen (2006) examines the diffusion process of digital mobile telephony in developed and developing countries. Overall, the analysis finds that competition promotes the diffusion process. Li and Lyons (2012) use a sample of 30 countries over the period 1991-2006 to assess the determinants affecting the speed of mobile penetration. They find that network competition results in faster diffusion rates as compared with a monopoly.

There is also wide research looking at the relationship between competition and penetration of telecommunication services, particularly in the context of broadband diffusion. For example, Fink et al. (2002) consider a panel data set of developing countries in Africa, Asia, the Middle East, Latin America and the Caribbean covering the period 1985-99. 86. They investigate how competition in the local market segment affects performance measured as labour productivity and number of mainlines. They find that both privatisation and competition lead to significant improvements in performance.

Focused on broadband penetration and using data from a sample of 20 Organisation for Economic Co-operation and Development (OECD) countries, Bouckaert et al. (2010) find that competition between platforms has been the main driver of broadband penetration, whereas service-based within platform competition appears as an impediment to penetration. Similarly, using quarterly data from the fourth quarter of 2000 to the first quarter of 2004 for 16 Western European countries, Höffler (2007) concludes that without cable competition, the number of broadband subscribers would have been approximately 10 percent lower. Other articles that have found similar results are Denni and Gruber (2006), Distaso et al. (2006), and Aron and Burnstein (2003).

Also in the context of broadband communications, a number of studies have emerged investigating how competition affects prices and quality. While this is still a nascent literature, existing research shows that competition between network operators have a

positive impact on quality, as measured by broadband speed. This is found in Nardotto et al. (2013), Smith et al. (2013). The latter paper further finds that competition between networks leads to lower prices.

In the existing literature, there has also been much debate about the impact of market concentration on innovation. On one side of the debate is the Schumpeter view, which considers that high market concentration increases innovation, as it is easier to reap the return on investments with higher concentration and there are economies of scale in research and development (R&D). On the other side of the debate is the Arrow view, which states that lower market concentration increases the incentive to innovate as firms will want to get ahead of their rivals and thereby steal their customers. This is also known as the replacement effect. With lower market concentration, there will also be more firms who are searching for innovations and this also increases the probability of an innovation being discovered⁷.

The overall impact of market concentration on innovation therefore depends on whether the Schumpeter or replacement effect dominates. In an attempt to consider both effects and reconcile existing mixed evidence, the seminal paper by Aghion et. al. (2005) built a dynamic model where current technological leaders and their followers in any industry can innovate, and innovations by leaders and followers all occur step-by-step. Their key result is the identification of an inverse-U shape relationship between competition and investment, which is supported by their empirical analysis using panel data from UK companies, covering the period 1968 to 1996.⁸

There are a number of studies which have empirically assessed the relationship between competition and investment in the mobile industry. Hounghonon and Jeanjean (2014) and Friesenbichler (2007) find an inverse U-shape relationship between competition and investment. Instead, the study by Kim et. al. (2011)⁹ finds a U-shape relationship between investment and the level of concentration, measured by the Herfindhal-Hirschman Index (HHI). Focusing on the relationship between

⁷ Geroski (1990): "Innovation, Technological Opportunity, and Market Structure," *Oxford Economic Papers*, Oxford University Press, vol. 42(3), pages 586-602, July.

⁸ As a measure of innovation they use the average number of patents taken out by firms in an industry, while their main indicator of competition is the Lerner index. They proxy the price cost margin by operating profit net of depreciation, provisions and an estimated financial cost of capital divided by sales.

⁹ Kim, J. Kim Y., Gaston N., Lestage R., Kim Y. and Flacher D. (2011): "Access regulation and infrastructure investment in the mobile Telecommunications industry", *Telecommunications Policy* 35 (2011): 907-919.

competition and investment in the mobile industry in China, Kang et al (2012) find a positive correlation between market concentration and competition.

Outside the mobile industry, in the context of fixed broadband networks, there is empirical research looking at the relationship between the type of competition (inter-versus intra-platform) and investment. While evidence is mixed,¹⁰ service based (or within platform) competition seems to deter investment when compared with infrastructure based competition or competition between alternative networks. For example, by examining the variation in facility-based investment in loops across U.S. states and over time, Crandall et al. (2004) find a higher growth of facility-based lines relative to ULL¹¹ lines in the states with higher costs for ULL. Similarly, Jung et al. (2008), using a panel data model (static and dynamic) with US data, concludes that “it is uncertain that competition spurred by the mandatory sharing policy in this sector stimulates ILECs’ incentives to invest in new infrastructure.”

On a related matter, there are a number of studies investigating the relationship between liberalisation and investment in the telecommunications sector. Overall, this literature has found a positive relationship between liberalisation and investment.¹² Within this line of research, a number of articles have looked at the interaction between competition and investment. These include Alesina et al.(2005), Li (2008), Wallsten (2001) and Zhang et al.(2008), who find a positive relationship between competition and investment. Recently, Lestage et al. (2013) have found that greater competitive pressure fosters infrastructure investment by state-owned incumbents but reduces investment by private incumbents.

4. Approach and data used

The key question is how an SWN would perform relative to a counterfactual of network competition. As there are no examples of SWNs in the mobile industry, it is not possible to answer this question directly. However, there are countries that only have a single vertically integrated network. Therefore, to help gain an insight into the potential impact of an SWN, the authorshave compared the outcomes between

¹⁰ Studies differ in a number of dimensions, including: data set, control variables, statistical approach, etc.

¹¹ Lines based on local loop unbundling.

¹² See the literature review included in Lestage et al. (2013).

countries that have network competition and countries that have single networks. In particular, they have assessed the impact of network competition on overall population and geographic coverage, overall take-up and innovation (3G take-up).¹³

The data on network coverage comes from the GSMA. The level of coverage is estimated based on the location of base stations in each country, the reach of these base stations and the distribution of inhabitants across the country. This provides estimates of network coverage for the country as a whole, rather than for individual operators. In general, it is difficult to get data on network coverage across a broad range of countries, which is one of the reasons why this paper adds to the existing literature, as the authors are not aware of any other papers that have analysed the impact of mobile competition on coverage.

The authors have also estimated the impact of single networks on overall take-up. SWN proponents claim that SWNs could also reduce costs by avoiding inefficient duplication. As it is difficult to assess the direct impact of single networks on costs, due to a lack of data availability on network costs, Costs are likely to feed through into prices and thereby influence take-up which is why they have assessed the impact of single networks on overall mobile take-up¹⁴.¹⁵

Finally, the authors have assessed the impact of single networks on innovation by considering the impact on 3G take-up. As 3G represented an upgrade to mobile networks which made mobile internet much more widespread, 3G is a good proxy for the impact that SWN could have on innovation. This is an important point, since innovation plays such a large role in the mobile sector.

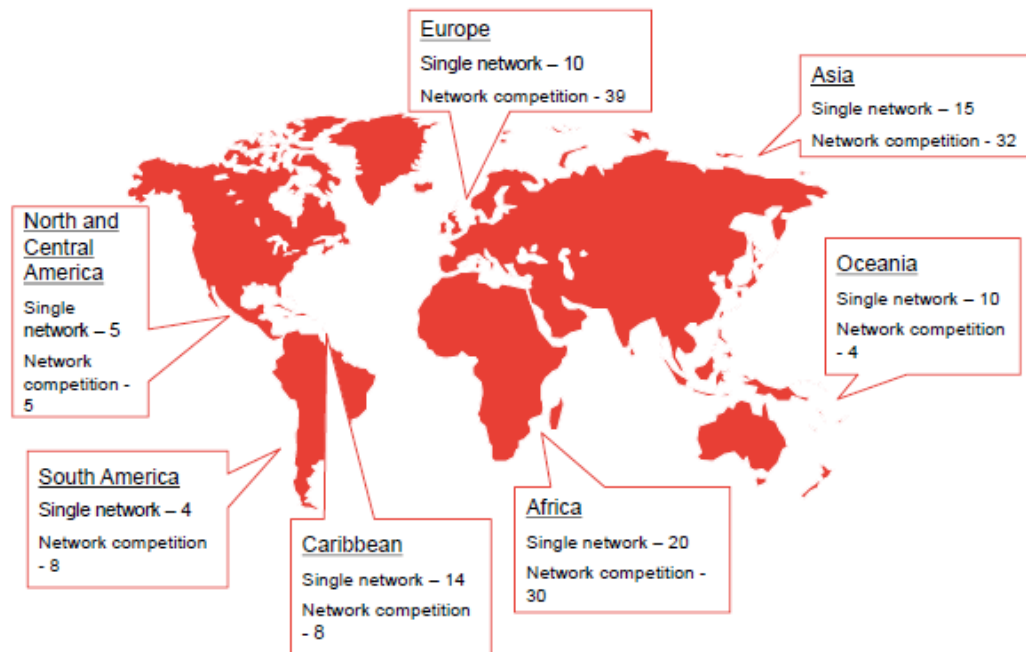
For the analysis on coverage and overall take-up, the authors have used data from 2001. This is because there were significantly more single network countries when using historical data. The year 2001 is the first year in which there is coverage data for a wide range of countries. The other benefit of using data from 2001 is that there was considerable variation in the level of coverage across countries (in contrast, many

¹³ Due to the lack of reliable data on innovation, the authors consider that the take-up of more advanced mobile technologies (that allow provision of mobile broadband services) can be used as a reasonable proxy for the level of innovation in a given market.

¹⁴ Mobile take-up is measured based on the number of unique mobile subscribers. This is different to the number of SIM cards since some subscribers have more than one SIM card.

¹⁵ The authors have not carried out an analysis of prices, as they are difficult to measure in mobile markets due to the complex nature of tariffs. One option is to use the Average Revenue Per Minute, but the GSMA does not have a comprehensive data set for this variable.

countries now have close to 100 per cent coverage). The following map shows the number of countries with single networks and network competition across different regions in 2001.



For the analysis on 3G take-up, the authors have used data from 2012q4, given that 3G is still a relatively new technology in some countries.

As shown by the following graphs, it appears that outcomes on coverage, overall take-up and 3G take-up are more favourable under network competition. The graphs show that this conclusion still holds when splitting the sample based on the population of countries¹⁶. **Figure 2** shows that overall population coverage was considerably higher in countries with network competition (70.4% compared to 53.4% when including all countries regardless of their size)¹⁷. The authors have carried out the same analysis for area coverage (see **Figure 3**). Again they find that coverage is much higher in countries with network competition (47.9% compared to 31.4% when including all countries regardless of their size).¹⁸ The authors have also considered how the take-up

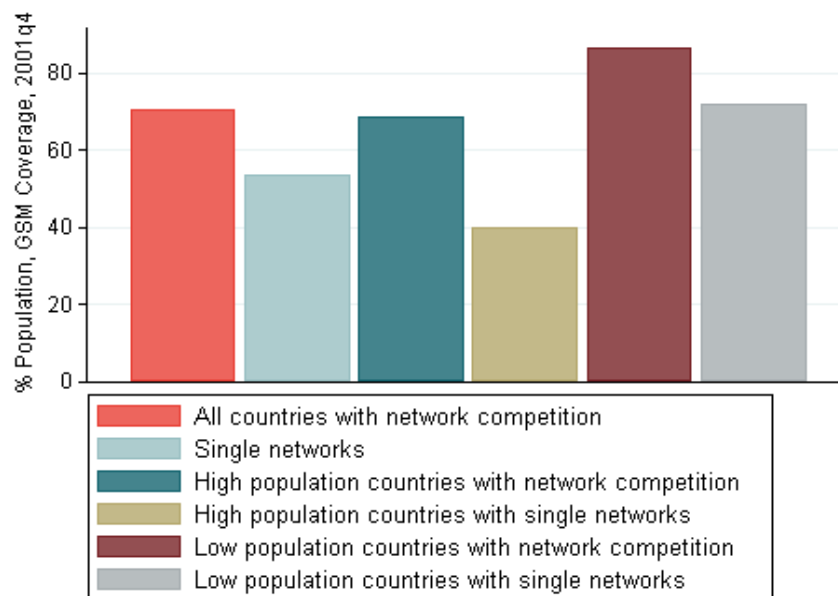
¹⁶ Low population countries are defined as countries with fewer than a 1 million inhabitants.

¹⁷ This difference is statistically significant with a p-value of 0.0029.

¹⁸ The difference for all countries is statistically significant with a p-value of 0.0229.

of 3G¹⁹ compares across countries. (Figure 4). The results also show that 3G take-up is much higher in countries with network competition.

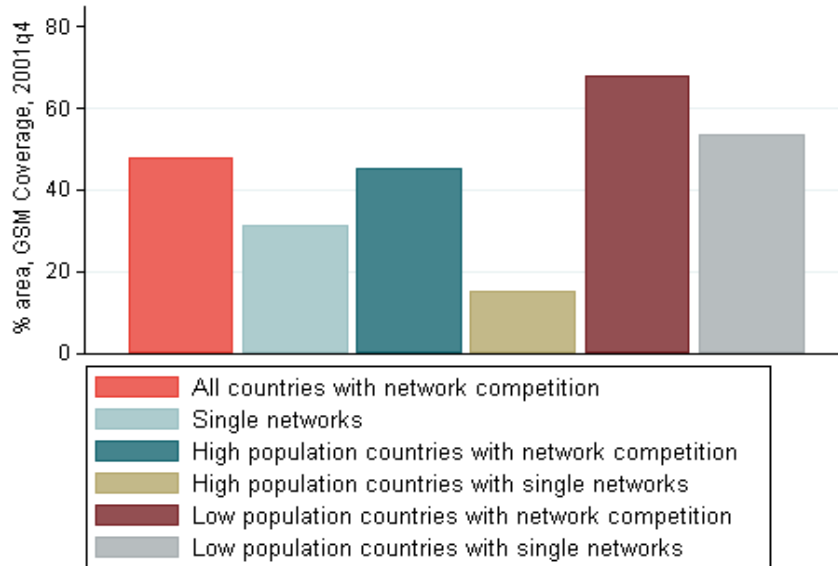
Figure 2. Total population coverage in countries with single networks and network competition (population split)



Source: Analysis based on GSMA data

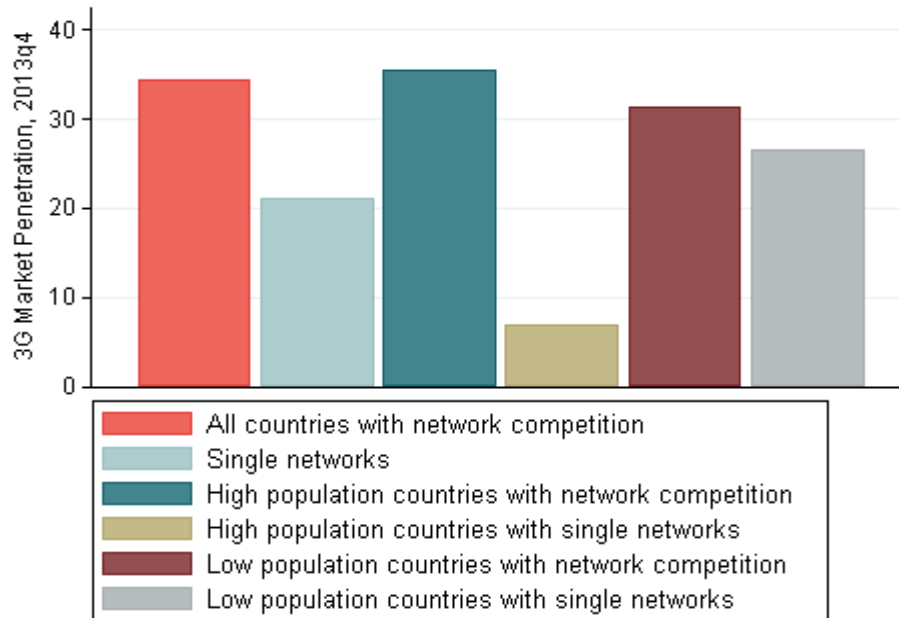
¹⁹ 3G take-up is measured based on the number of SIM cards. Although this will overstate the number of unique subscribers, the authors have no reason to believe that this will affect the relativity between take-up in countries with single networks and network competition.

Figure 3. Total area coverage in countries with single networks and network competition (population split)



Source: Analysis based on GSMA data

Figure 4. Take-up of 3G in countries with single networks and network competition²⁰



Source: Analysis using GSMA data

To assess whether the graphical analysis of the impact of network competition is accurate, the authors have performed an econometric analysis. This helps ensure that the differences in outcomes between countries with single networks and network competition are not driven by other factors. All of the regressions are carried out at a single point in time, so do not include a time dimension. This means that they are relying on variation across countries, rather than variation that arises due to countries switching between single networks and network competition.

The impact of single networks has been captured by using a dummy variable, which takes a value of 1 when a country has a single network and 0 otherwise. The authors have identified which countries have single networks by using the GSMA's database on network deployments. This data set shows when operators launched networks across different countries. In a few select countries, such as Lebanon and Syria, there may be multiple operators that are owned by the government, which means that such operators may compete less intensively with each other than under separate owners.

²⁰ The authors have not shown a graph with the countries split by GDP per capita due to a lack of data availability.

As a sensitivity analysis, we have therefore reclassified these two countries as single networks, which has only a very minimal impact on the results.

The authors have included different explanatory variables in their regressions to help isolate the impact of single networks. They have included a range of demographic variables, including GDP per capita, population size and population density. As a sensitivity check, they have also included a variable measuring the number of years since 2G was launched in the country. The time at which 2G is launched could impact coverage and take-up as it is a variable that is largely outside of the control of operators because it depends on when regulators or the Government decided to provide the necessary licences and spectrum. There are clearly other variables that could affect the outcome in mobile markets, such as prices, subsidies, coverage obligations and the degree of network sharing. However, it is difficult to collect data for these metrics for such a broad set of countries as the authors have in their sample. Ultimately, the question is whether any of the omitted variables might also be correlated with whether there is network competition. The answer is probably yes, at least for prices. However, this bias would actually lead us to understate the impact of network competition on coverage. As prices will be higher in single network countries, the estimated parameter in the regression will be higher for countries with single networks. Therefore if anything, the authors would be overestimating the impact of single networks on coverage and take-up

The following equations show the different specifications:

- (1) *Overall population coverage* = $\alpha + \delta * \text{single network} + \beta * \text{GDP per capita} + \gamma * \text{population} + \eta * \text{population density}$
- (2) *Overall area coverage* = $\alpha + \delta * \text{single network} + \beta * \text{GDP per capita} + \gamma * \text{population} + \eta * \text{population density} + \zeta * \text{time since 2G}$
- (3) *Overall mobile take-up* = $\alpha + \delta * \text{single network} + \beta * \text{GDP per capita} + \gamma * \text{population} + \eta * \text{population density}$
- (4) *Overall mobile take-up* = $\alpha + \delta * \text{single network} + \beta * \text{GDP per capita} + \gamma * \text{population} + \eta * \text{population density} + \zeta * \text{time since 2G}$
- (5) *3G take-up* = $\alpha + \delta * \text{single network} + \beta * \text{GDP per capita} + \gamma * \text{population} + \eta * \text{population density}$

The following table shows the summary statistics for the variables of interest. All of the data comes from the GSMA database.

Table 1. Summary statistics for overall coverage and take-up regressions

Variable	Mean	Median	Standard deviation	Minimum	Maximum	Quarter
Overall area coverage	44.25%	32.37%	0.39	0.04%	100%	Q4 2001
Overall population coverage	66.28%	71.73%	0.31	0.02%	100%	Q4 2001
Overall take-up	19.53%	11.77%	0.2	0.03%	76.94%	Q4 2001
GDP per capita (current \$)	8,208	2,191	12,689	92	75,703	Q4 2001
Population (million inhabitants)	30.2	5.2	1.21*10 ⁸	596	1,290	Q4 2001
Population density (inhabitants per m²)	371	73	1,757	0.14	16,183	Q4 2001
Time since introduction of 2G (quarters)	8,208	2,191	12,689	92	75,703	Q4 2001

Table 2. Summary statistics for 3G take-up regressions

Variable	Mean	Median	Standard	Minimum	Maximum	Quarter
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	deviation					
3G take-up	28.82%	32.37%	0.2	0.02%	239%	Q4 2012
GDP per capita (current \$)	13,610	4,948	20,144	231	115,038	Q4 2012
Population (million inhabitants)	30.1	4.8	1.25*10 ⁸	596	1,380	Q4 2012
Population density (inhabitants per m²)	400	73	1,969	0.14	19,509	Q4 2012

The authors have estimated their regressions using Ordinary Least Squares (OLS) with robust standard errors to correct for heteroskedasticity. In the academic literature, there is a debate as to whether there is a two-way relationship between market structure and market outcomes. For example, it is sometimes argued that market outcomes could impact the number of players in the market as well as vice versa. If there is such a two-way relationship, then it may not be appropriate to use OLS. However, they do not consider this to be the case in this particular situation. When and whether a mobile market moves from one to several operators is largely determined by when regulators or the Government decide to liberalise the market. This decision will in most cases be independent of market outcomes. Even if the decision was influenced by market outcomes, it is unclear in which direction the relationship would run. On the one hand, regulators or the Government may decide to liberalise markets once they reach a certain size or level of performance. On the other hand, regulators or the Government may decide to liberalise markets if they consider that the market is underperforming.

5. Econometric results

In this section, the authors present their econometric results. They show that single networks lead to lower coverage, take-up and innovation, as measured by 3G take-up.

The table below shows that single networks have lower population and area coverage once other factors have been controlled for. In particular, the results show that having a single network reduced total population coverage by between 12 and 21 percentage points (depending on whether time since 2G was introduced is controlled for) and reduced area coverage by between 15 and 24 percentage points.

Table 3. Regression results for population and area coverage

	Overall population coverage	Overall population coverage	Overall area coverage	Overall area coverage
Single network	-12.20**	-20.79***	-14.55***	-23.58***
GDP per capita	0.000812***	0.00117***	0.00109***	0.00146***
Population size	-3.00e-08*	-1.83e-08	-4.17e-08***	-2.90e-08**
Population density	-0.00105	-0.00102	0.000194	0.000221
Time Since 2G was launched	1.574***		1.636***	
Constant	29.97***	61.28***	3.445	36.1***
Observations	137	137	136	136
R-squared	0.521	0.324	0.471	0.335

Source: Frontier analysis using GSMA data

In the next table the authors present the results on the impact of single networks on take-up. The results suggest that having network competition increased overall take-up by between 7 to 12 percentage points depending on whether the time since 2G was

introduced is included in the model. These results suggest that even if single network countries had launched 2G at the same time as countries with network competition, take-up would still have been lower in single network countries.

The table also shows the results of the impact of single networks on 3G take-up. Again, they have found that single networks have a detrimental impact. The results suggest that having network competition increased 3G take-up by 17 percentage points once other factors have been accounted for. These results suggest that single networks are slower to innovate.

Table 4. Regression results for take-up

	Overall take-up	Overall take-up	3G take-up
Single network	-6.928***	-12.34***	-16.91***
GDP per capita	0.00104***	0.00118***	0.00109***
Population size	-1.63e-08***	-1.19e-08**	-2.13e-09
Population density	-0.000991	-0.000847	0.00730***
Time since 2G was launched	0.515***		
Constant	4.014**	13.49***	11.99***
Observations	175	175	157
R-squared	0.683	0.616	0.716

Source: Frontier analysis using GSMA data

In addition to the above specifications, the authors have also conducted a number of sensitivity tests (not shown). In particular, they have used a later time period (2005) for the overall coverage and take-up regressions, have used a measure of political risk based on data from the World Bank and have included urbanisation. None of these

sensitivity tests change their overall conclusion that network competition delivers favourable outcomes.

6. Conclusions and policy implications

This paper has added to the existing literature by assessing the impact of mobile network competition on a range of outcomes, including network coverage. The key conclusion is that mobile network competition has delivered superior outcomes to single networks. Clearly, the paper does not provide a complete assessment of all of the determinants of consumer outcomes, as it is challenging to accurately capture all differences in regulatory frameworks and market conditions across countries. However, it does highlight the importance of network competition, and provides a platform for future research into how best to leverage network competition to achieve positive consumer outcomes.

The empirical evidence on the evolution of mobile markets suggests that network competition leads to higher coverage. The authors found that population coverage was up to 21% higher in countries with network competition compared to countries served by a single network, all else equal.

There are several plausible explanations for why coverage isn't higher in single network countries. Due to operators trying to gain a first mover advantage, under network competition, it is still possible that certain areas may only have one operator if it isn't profitable to have more than one operator. There is also widespread evidence of network sharing and coverage obligations, which both lead to higher coverage. Also, when faced with competition, operators will be under pressure to minimise their costs, which will help make more areas economically viable and extend network coverage. Lastly, it seems that regulatory obligations to extend coverage in these countries, if existed, has not been as effective as network competition. This is not surprising given that regulation is less effective than competition to enhance welfare.

Their results also show that overall take-up is higher in countries with single networks, which as in the case of coverage, indicates that such markets are performing better. Lastly, they found that countries with network competition have greater innovation. For instance, they found that having network competition increased 3G take-up by 17 percentage points compared to having a single network, once other factors have been accounted for.

The findings are consistent with the previous research showing significant benefits of competition on outcomes in mobile markets. At the same time, the research is unique in its focus and the results are based on a sufficiently large dataset to provide a sufficient basis for Governments and policy authorities to consider much more carefully the potentially detrimental impacts of SWNs. At the same time, the authors recognise that there are further areas in which their research could be further expanded and improved. In particular, extending their analysis to panel data will introduce time dimension and allow to better control for country specific effects that might be driving performance of individual mobile markets. In addition, distinguishing between different forms of single network solution, i.e. countries where some form of retail competition might be present or retail prices are subject to regulation (in contrast with ‘true’ single network monopolies) could provide some additional insight into the expected performance of SWNs.

The results of their analysis have significant policy implications, as they indicate that implementing an SWN could have an adverse impact on consumers. Governments and regulators should consider carefully the benefits of introducing SWNs as a replacement to competition between mobile networks. Moving to a regulated monopoly provision of wholesale network mobile services involves a significant risk of such policy measures slowing down technology innovation. This subsequently affects the associated consumer benefits from the complete removal of the incentive to compete at the network level, which appears to be critical for innovation.

The experience from fixed segment (e.g. NBN in Australia) indicates that setting up an SWN will be challenging, as governments and regulators will need to address a range of issues, such as whether the assets and customers of the existing operators are transferred to the SWN, the governance arrangements of the SWN, and attracting investors for the SWN. Once an SWN has been established, it will need to be regulated on an ongoing basis, given that it will have monopoly power. Setting prices and expected quality levels for a monopolist is never easy, and will be particularly challenging in this scenario, as there will be a lack of historical data. If the SWN does end up failing, then it will not be straight-forward to return to network competition, during which time consumers could suffer considerably.

At the same time, there are several policy options that regulators and governments can rely on if they are concerned about the level of mobile coverage. For example, they

can encourage network sharing agreements, they can provide rural subsidies and/or they can set coverage obligations when selling spectrum rights. These alternatives are far less risky than an implementing an SWN and still allows the mobile sector to benefit from network competition. Therefore, the authors believe that Governments considering some form of intervention in mobile markets should carefully assess pros and cons of different policy measures, taking into account the risks attached to untested solutions such as SWN and the potential long-term consequences on the mobile markets in a given country.

7. Appendix – Summary of the data

Table 5. Countries with single and multiple networks in Q4 2001

Single network countries	Multiple network countries
78	127

Table 6. Countries with single and multiple networks in Q4 2012

Single network countries	Multiple network countries
33	205

Table 7. Correlation between dependent and independent variables in the coverage regressions

Variable	Overall area coverage	Overall population coverage	Overall take-up	Single network dummy	GDP per capita	Population	Population density	Time since 2G
Overall population coverage	0.8394	1						
Overall take-up	0.7657	0.7430	1					
Single network dummy	-0.2329	-0.2822	-0.2239	1				
GDP per capita	0.5112	0.4856	0.7185	0.0325	1			
Population	-0.1104	-0.0702	-0.1035	0.1292	-0.0716	1		
Population density (inhabitants per m²)	0.2082	0.1478	0.1672	0.1198	0.4517	-0.0175	1	
Time	0.5427	0.6154	0.5514	-	0.3018	0.1265	0.113	1

since	0.254	9
introducti	2	
on of 2G		

Table 8. Correlation between dependent and independent variables in the 3G take-up regression

Variable	3G take-up	Single network dummy	GDP per capita	Population	Population density
Single network dummy	-0.1261	1			
GDP per capita (current \$)	0.7622	-0.0596	1		
Population (million inhabitants)	-0.0563	-0.0207	-0.0607	1	
Population density (inhabitants per m²)	0.5327	-0.0236	0.2419	-0.0217	1

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