

# THE FUTURE ECONOMIC VALUE OF UNLICENSED SPECTRUM

Raul L. Katz

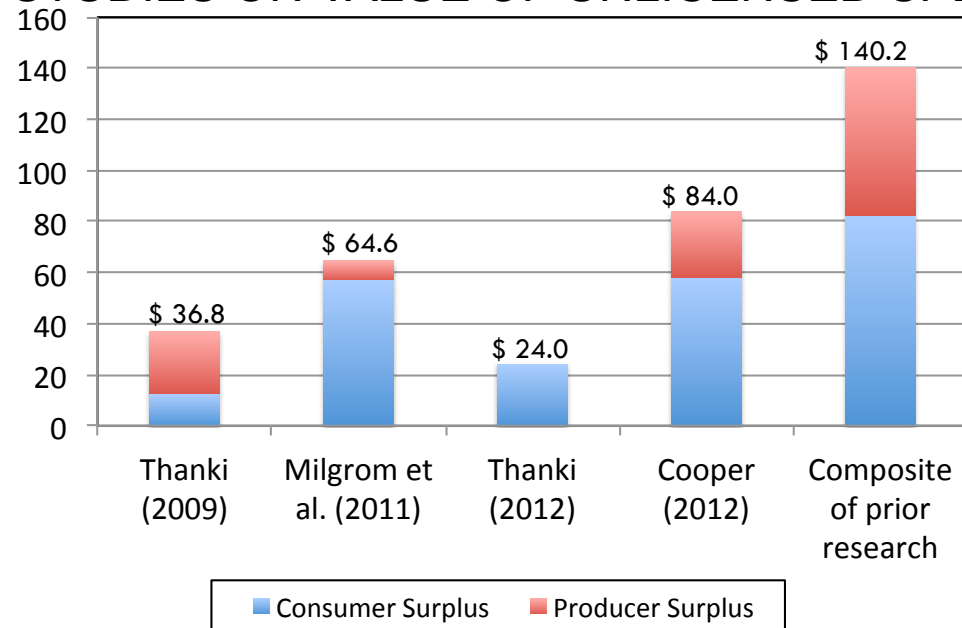
**Telecom Advisory Services, LLC**

What is the future of Wi-Fi?  
Mountain View, September 11, 2014

## THE MEASUREMENT OF ECONOMIC VALUE OF UNLICENSED SPECTRUM IS A COMPLEX TASK

- Unlicensed spectrum is used by numerous devices and services
- In some cases, services are offered as a free good to consumer (how does one quantify the willingness to pay?)
- The diffusion of innovations relying on unlicensed spectrum is proceeding at an extremely fast pace, which renders studies obsolete after a few months
- As a result, there are only a few studies conducted so far

### PRIOR STUDIES ON VALUE OF UNLICENSED SPECTRUM



Source: Compiled by Telecom Advisory Services

OUR PRIOR STUDY ESTIMATED THAT IN 2013 UNLICENSED SPECTRUM GENERATED AN ECONOMIC SURPLUS OF \$ 222 BILLION AND CONTRIBUTED \$ 6.7 BILLION TO THE GDP

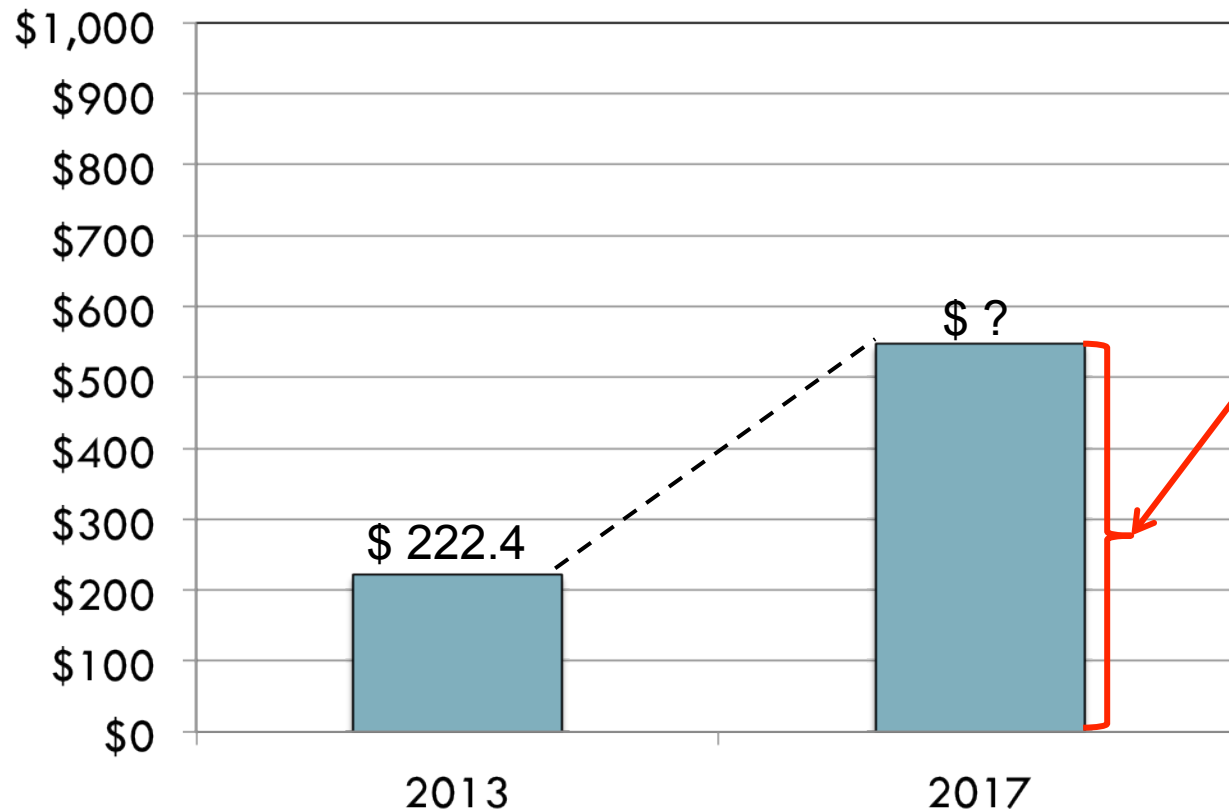
ECONOMIC VALUE OF UNLICENSED SPECTRUM (2013)  
(in \$ millions)

	Consumer Surplus	Producer Surplus	GDP Contribution
Wi-Fi Technology	Free Public Wi-Fi	\$ 1,902	
	Residential Wi-Fi	\$ 36,080	
	Network off-loading		\$ 10,700
	Revenues of Wi-Fi provision		\$ 271
	Faster wireless		\$ 2,831
New Technologies	Wi-Fi only tablets	\$ 7,987	\$ 34,885
	RFID technology	\$ 30,290	\$ 100,540
Innovative Business Models	Bluetooth products		\$ 1,739
	ZigBee products		\$ 267
	WirelessHART		\$ 160
	WISPs		\$ 1,439

Source: Telecom Advisory Services analysis

A DIFFERENT QUESTION TO TACKLE IS HOW MUCH VALUE WE CAN EXPECT UNLICENSED TECHNOLOGIES TO GENERATE IN THE FUTURE

FUTURE ECONOMIC VALUE OF UNLICENSED SPECTRUM



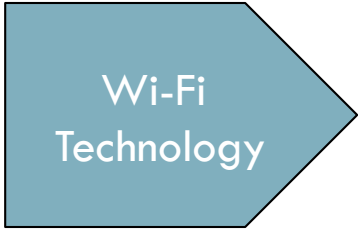
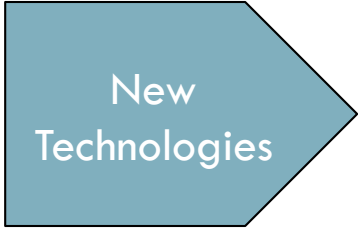
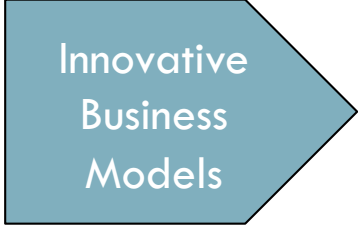
- Higher traffic and adoption of existing applications and technologies (e.g. tablet worldwide shipments, currently at 221 million, are estimated to reach 386 million by 2017)
- Introduction of new applications and technologies (M2M, Smart City sensors)

Source: Telecom Advisory Services analysis

**FIRST SET OF QUESTIONS: WHAT IS THE IMPACT OF GROWTH AND ECONOMICS OF CURRENT APPLICATIONS AND TECHNOLOGIES?**

**FUTURE ECONOMIC VALUE OF UNLICENSED SPECTRUM**

Future increase in consumer and producer surplus as well as GDP contribution

 <p>Wi-Fi Technology</p>	<b>Free Public Wi-Fi</b>	<ul style="list-style-type: none"> <li>• What is the expected growth in Wi-Fi traffic in public sites?</li> <li>• What is the future price of cellular GB?</li> </ul>
	<b>Residential Wi-Fi</b>	<ul style="list-style-type: none"> <li>• What is the growth in annual home traffic of devices with no wireline connectivity?</li> </ul>
	<b>Network off-loading</b>	<ul style="list-style-type: none"> <li>• Are there any changes in carriers' cumulative Wi-Fi CAPEX and OPEX to accommodate future traffic?</li> </ul>
	<b>Revenues of Wi-Fi provision</b>	<ul style="list-style-type: none"> <li>• What is the expected growth of retail Wi-Fi service providers?</li> </ul>
	<b>Faster wireless</b>	<ul style="list-style-type: none"> <li>• What is the increase of average cellular and Wi-Fi speeds?</li> </ul>
 <p>New Technologies</p>	<b>Wi-Fi only tablets</b>	<ul style="list-style-type: none"> <li>• Expected growth of Wi-Fi only tablet shipments?</li> <li>• What is the projected Apple market share?</li> </ul>
	<b>RFID technology</b>	<ul style="list-style-type: none"> <li>• Future adoption of RFID technology in retail and health care?</li> </ul>
 <p>Innovative Business Models</p>	<b>Bluetooth products</b>	<ul style="list-style-type: none"> <li>• What is the growth of Bluetooth enabled devices?</li> <li>• What is the future cost of Bluetooth chipset?</li> </ul>
	<b>ZigBee and WirelessHART products</b>	<ul style="list-style-type: none"> <li>• Expected growth of Zigbee market?</li> <li>• Expected growth of WirelessHART market?</li> </ul>
	<b>WISPs</b>	<ul style="list-style-type: none"> <li>• Expected growth of WISPs subscribers and ARPU?</li> </ul>

Source: Telecom Advisory Services analysis

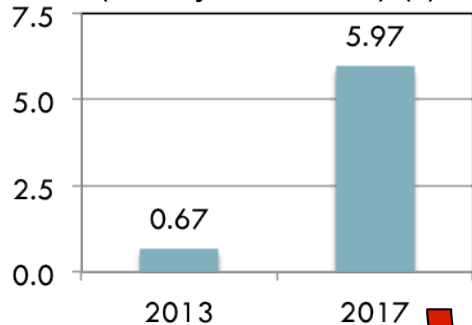
# THE GROWTH IN WI-FI ECONOMIC VALUE RESULTS FROM THE EXPLOSIVE GROWTH IN DEVICES AND UTILIZATION

Growth in devices and utilization...

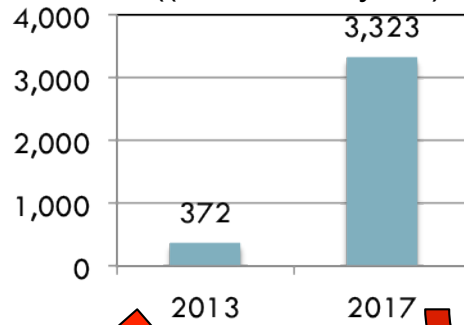
...stable routing rate through free sites...

...surplus declining due to lower cellular prices...

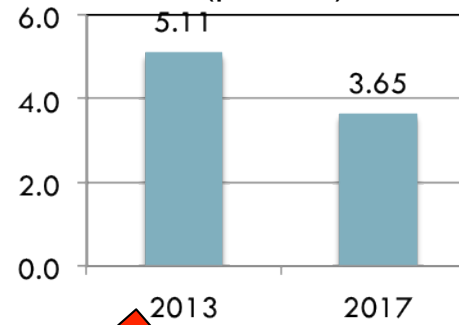
Total Wi-Fi Traffic (Exabytes/month) (\*)



Free Wi-Fi Traffic ((Million GB/year)



Consumer surplus (per GB)



FREE Wi-Fi Value (in \$ billion)

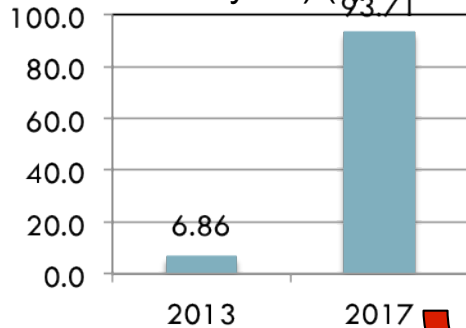
2013	2017
\$ 1.90	\$ 12.13

(\*) Smartphones, tablets, laptops

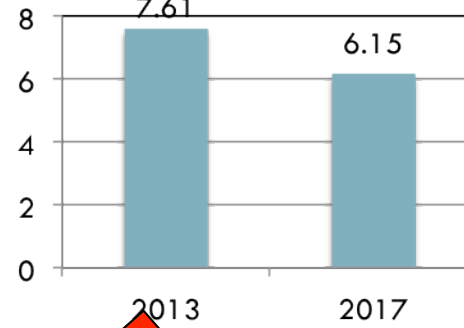
Growth in annual home traffic...

...declining average price per GB...

Total Traffic (Billion GB/year) (\*)



Average Price per GB



Home Traffic Value (in \$ billion)

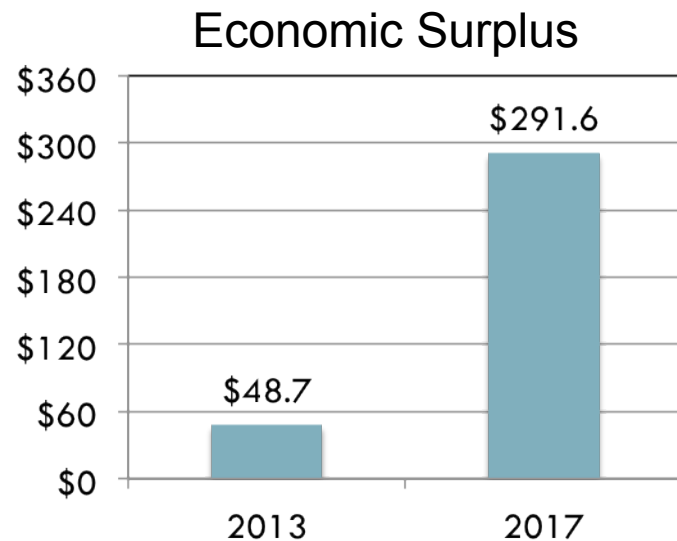
2013	2017
\$ 22.51	\$ 248.39

(\*) Smartphones, tablets, game consoles

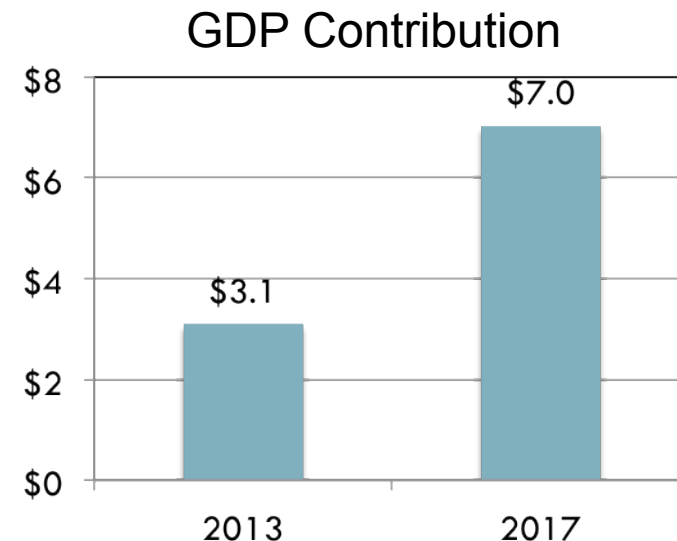
Source: Telecom Advisory Services analysis

**BY 2017, WI-FI TECHNOLOGY IS EXPECTED TO INCREASE ITS TOTAL ECONOMIC SURPLUS TO \$291.6 BILLION , WHILE CONTRIBUTING \$7.0 BILLION TO THE GDP**

## ECONOMIC VALUE OF WI-FI (2013-2017) (in \$ billions)



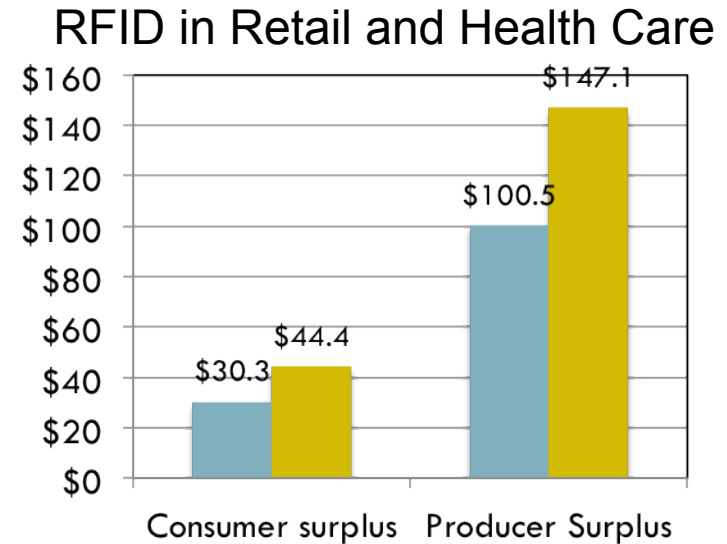
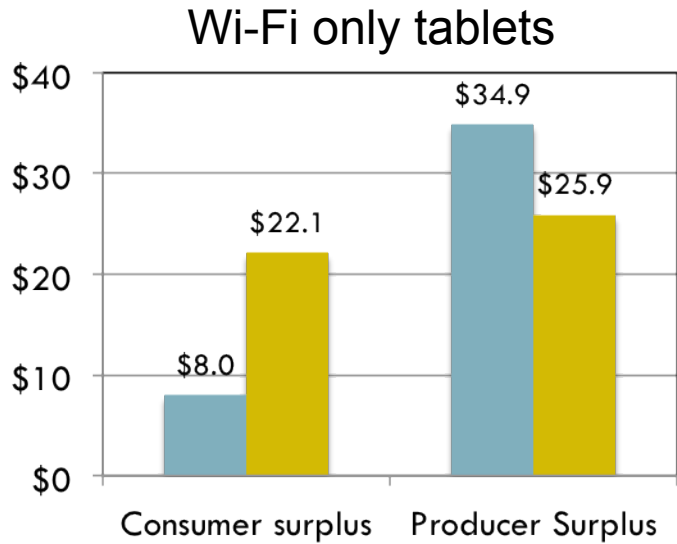
- Increase in diffusion of devices without wireline connectivity
- Growth in traffic generated per device
- Decline in cellular pricing is not enough to neutralize Wi-Fi economic advantage



- Growth of revenues generated by providers of Wi-Fi services in public places
- Contribution to GDP of increase in average wireless speed resulting from Wi-Fi off-loading

**ECONOMIC VALUE GENERATED FROM NEW TECHNOLOGIES – WI-FI TABLETS AND RFID – WILL INCREASE TO \$239 BILLION FROM \$174 BILLION**

**ECONOMIC VALUE OF NEW TECHNOLOGIES (2013-2017)  
(in \$ billions)**



- Increase in global shipments with US manufacturers preserving share (68%)
- Decline in Wi-Fi only devices to 82%
- Apple's market share (manufacturer with highest producer surplus) will decline to 30%
- Prices will remain constant, with increasing willingness to pay

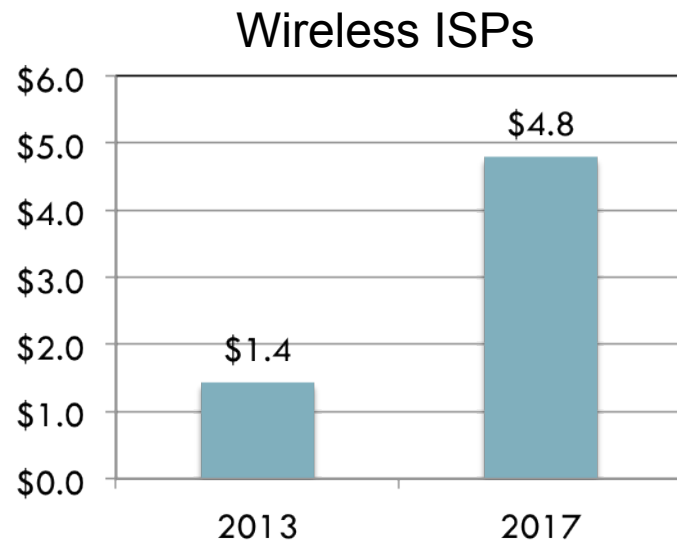
- Cost savings and consumer benefits assumed to remain constant through 2017
- Economic value increases by 10% by increased adoption and usage of RFID devices

Source: Telecom Advisory Services analysis

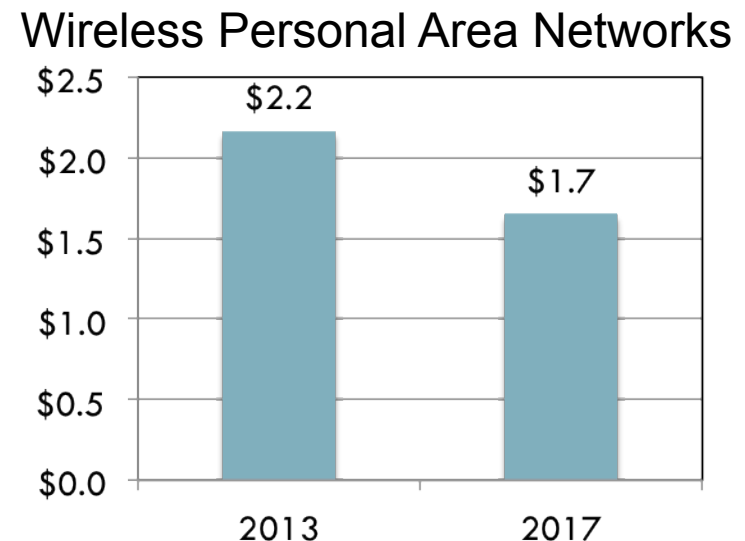


**FINALLY, INNOVATIVE BUSINESS MODELS WILL INCREASE THEIR CONTRIBUTION TO GDP FROM \$6.4 BILLION FROM \$3.6 BILLION**

**ECONOMIC VALUE OF NEW BUSINESS MODELS (2013-2017)  
(in \$ billions)**



- WISPs subscribers to increase 8 million from 3 million
- ARPU to increase from \$39.99 to \$50.00



- Smartphone shipments to reach 183 million, PCs 356 million, printers 725 million
- Bluetooth chipset to decline from \$1 to \$0.20
- Zigbee market to grow 33%

Source: Telecom Advisory Services analysis

IN SUM, BY 2017 ECONOMIC SURPLUS FROM EXISTING TECHNOLOGIES WILL DOUBLE FROM 2013 TO \$ 531 BILLION WHILE GDP CONTRIBUTION WILL RISE TO \$ 13.5 BILLION

ECONOMIC VALUE OF UNLICENSED SPECTRUM (2013-17)  
(in \$ millions)

		Consumer Surplus		Producer Surplus		GDP Contribution	
Wi-Fi Technology	<b>Free Public Wi-Fi</b>	\$ 1,902	\$ 12,130				
	<b>Residential Wi-Fi</b>	\$ 36,080	\$ 268,740				
	<b>Network off-loading</b>			\$ 10,700	\$ 10,700		
	<b>Revenues of Wi-Fi provision</b>					\$ 271	\$ 468
	<b>Faster wireless</b>					\$ 2,831	\$ 6,565
New Technologies	<b>Wi-Fi only tablets</b>	\$ 7,987	\$ 22,112	\$ 34,885	\$ 25,881		
	<b>RFID technology</b>	\$ 30,290	\$ 44,350	\$ 100,540	\$ 147,110		
Innovative Business Models	<b>Bluetooth products</b>					\$ 1,739	\$ 767
	<b>ZigBee products</b>					\$ 267	\$ 835
	<b>WirelessHART</b>					\$ 160	\$ 50
	<b>WISPs</b>					\$ 1,439	\$ 4,800

Source: Telecom Advisory Services analysis

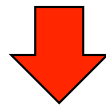
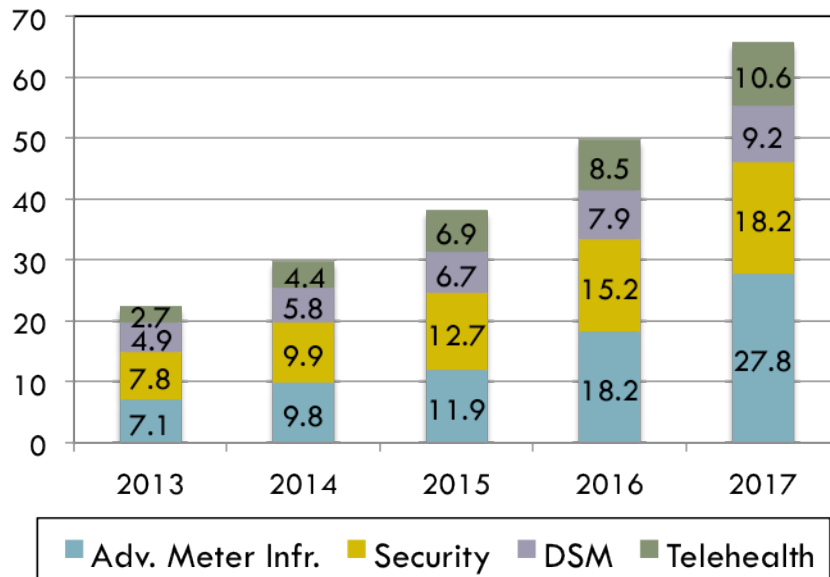
## SECOND SET OF QUESTIONS: WHAT IS THE IMPACT OF STILL EMERGING TECHNOLOGIES?

EMERGING TECHNOLOGY	SUBSET	EXAMPLES OF IMPACT
High Speed Wireless	<ul style="list-style-type: none"> <li>• WirelessHD</li> <li>• WiGig</li> </ul>	<ul style="list-style-type: none"> <li>• Ease of deployment of in-house devices</li> <li>• Complement residential Wi-Fi networks</li> </ul>
Low Frequency Wi-Fi	<ul style="list-style-type: none"> <li>• Broadband provision in wide areas</li> </ul>	<ul style="list-style-type: none"> <li>• Rural broadband coverage</li> </ul>
Machine to Machine	<ul style="list-style-type: none"> <li>• M2M applications relying on unlicensed spectrum</li> <li>• Wearable devices</li> </ul>	<ul style="list-style-type: none"> <li>• Improved energy consumption</li> <li>• Security</li> <li>• Health monitoring</li> </ul>
Smart City Deployments	<ul style="list-style-type: none"> <li>• Distributed networks of wireless intelligent sensors</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce pollution concentration</li> <li>• Optimization of energy consumption and traffic flows</li> </ul>
Agricultural automation	<ul style="list-style-type: none"> <li>• Network of wireless sensors</li> <li>• RFID tags for field data collection</li> </ul>	<ul style="list-style-type: none"> <li>• Increase in Total Factor Productivity</li> </ul>

FOR EXAMPLE, UNLICENSED SPECTRUM IS A CRITICAL ENABLER OF MACHINE TO MACHINE TECHNOLOGY, WHICH WILL CONTRIBUTE OVER \$31 BILLION TO THE GDP

## MACHINE TO MACHINE MARKET(2013-17)

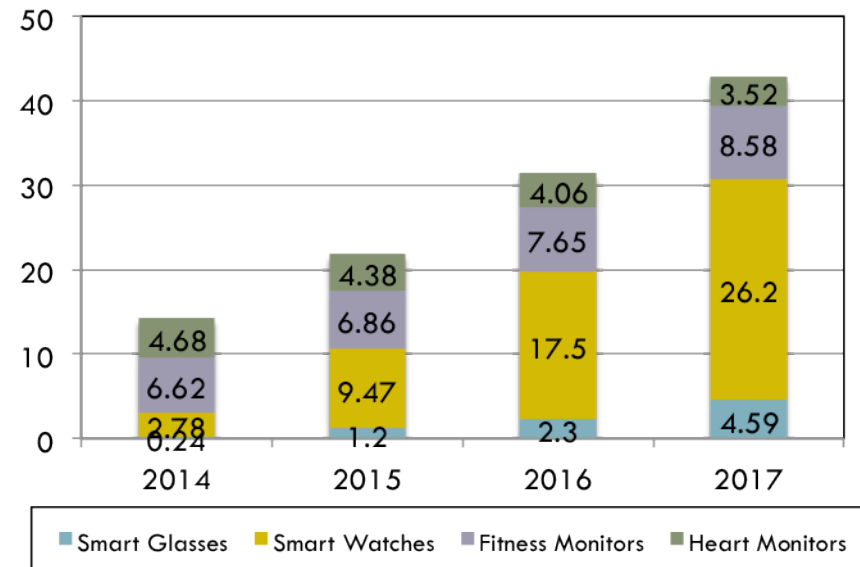
### Unlicensed Spectrum Devices



**2017 US Market**

**\$ 27.8 billion**

### Wearable Devices



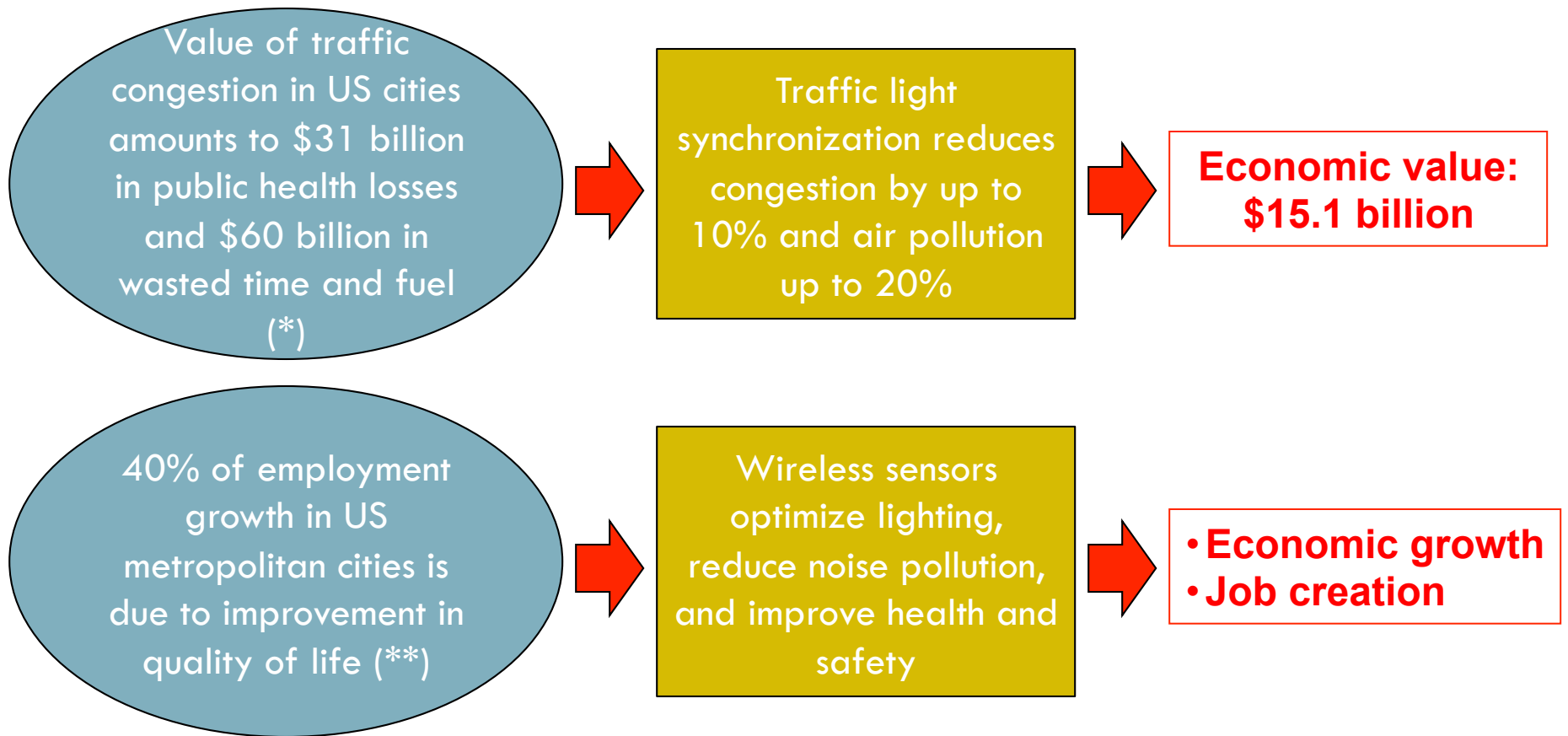
**2017 US Market**

**\$ 3.69 billion**

Source: Telecom Advisory Services analysis

SMART CITY WIRELESS SENSOR NETWORKS ARE ALSO A CRITICAL PLATFORM TO REDUCE POLLUTION AND IMPROVE URBAN QUALITY OF LIFE

SMART CITY NETWORKS ECONOMIC IMPACT



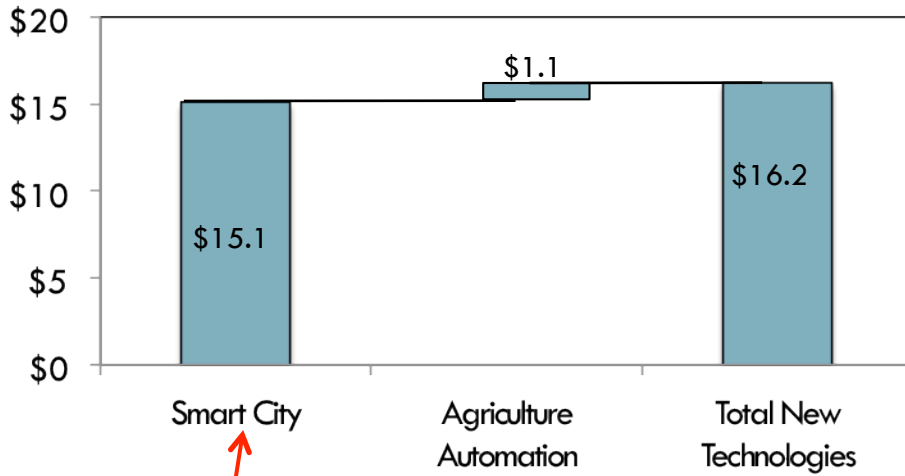
(\*) Harvard Center for Risk Analysis (2010); Texas Transportation Institute (2007)

(\*\*) Shapiro (2005). *Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital*

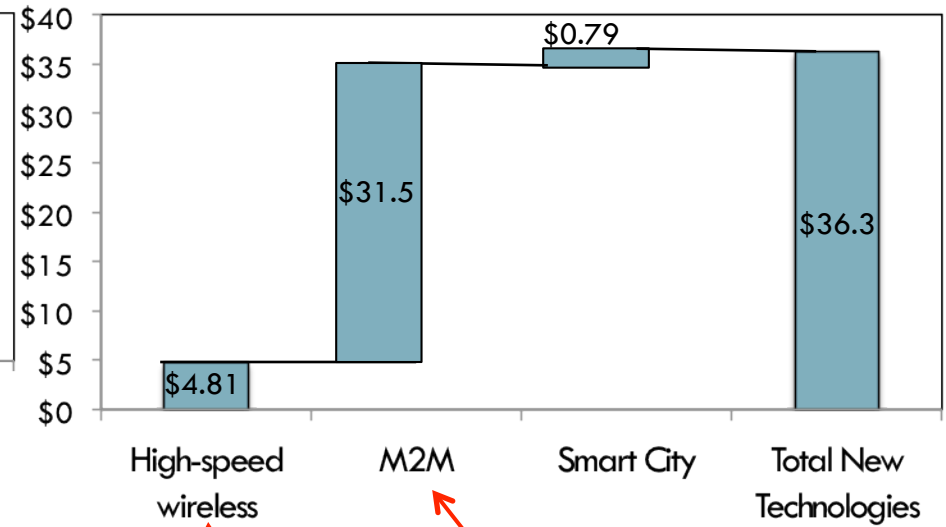
**NET NET, EMERGING TECHNOLOGIES OPERATING IN UNLICENSED SPECTRUM WILL GENERATE AN ECONOMIC VALUE OF \$ 16.2 BILLION AND CONTRIBUTE \$36.3 BILLION TO THE GDP**

**ECONOMIC VALUE OF EMERGING TECHNOLOGIES**  
(in \$ billions)

**Economic Surplus**



**GDP Contribution**



- Reduction of traffic congestion and air pollution

- Improvement of producer surplus derived from TFP

- Substitution of HDMI and cable replacement

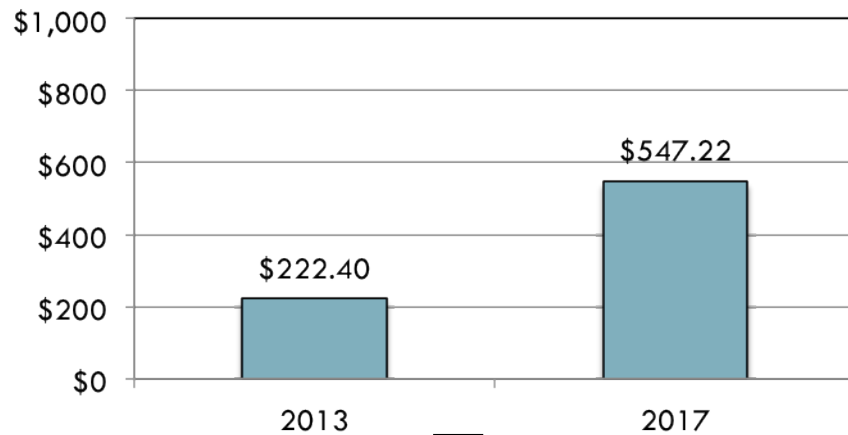
- Sum of revenues of AMI, Security, DSM, Telehealth and wearables

Source: Telecom Advisory Services analysis

TO SUM UP, FUTURE IMPACT OF UNLICENSED SPECTRUM WILL MORE THAN DOUBLE IN ECONOMIC SURPLUS AND GROW SEVEN TIMES IN TERMS OF GDP CONTRIBUTION

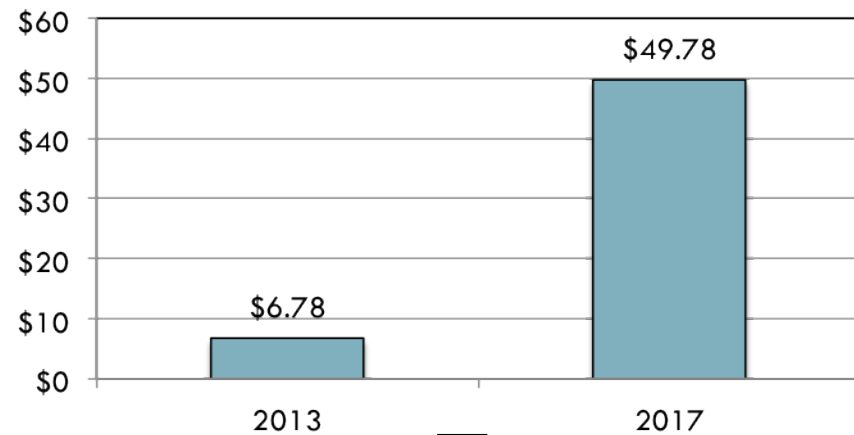
## FUTURE ECONOMIC VALUE OF UNLICENSED SPECTRUM

### Economic Surplus



- Wi-Fi represents 53% of the future value of unlicensed spectrum (cellular off-loading traffic is growing at 68%, residential Wi-Fi base will reach 86% by 2017, average traffic per tablet is grow five times)

### GDP Contribution



- M2M represents 63% of the future GDP contribution of unlicensed spectrum
- GDP contribution of low-frequency Wi-Fi was not estimated
- The market for agriculture automation technology has not been estimated

**THE ACHIEVEMENT OF THE AFOREMENTIONED IMPACT IS CONTINGENT UPON ADDRESSING SOME SPECTRUM BOTTLENECKS**

BOTTLENECK	SITUATION	RISKS
High-density urban areas	<ul style="list-style-type: none"> <li>• In device dense environments, data overheads consume between 80% and 90% of capacity (Wagstaff, 2009; Van Bloem, 2011)</li> <li>• Wi-Fi traffic growth in central city locations up to 6 times higher than on their cellular networks (Aegis, 2013)</li> </ul>	<ul style="list-style-type: none"> <li>• Unless 160-100 Mhz of additional spectrum are made available, risk of substantial service degradation</li> <li>• The limitation on speed increase will have an impact of \$4.4 billion</li> <li>• Potential disappearance of Wi-Fi service provider industry (\$468 million reduction in GDP contribution)</li> </ul>
Residential Wi-Fi	<ul style="list-style-type: none"> <li>• In-door video distribution by off-net devices is putting considerable pressure on home routers</li> <li>• Full migration to 802.11ac will require approximately 10 years</li> </ul>	<ul style="list-style-type: none"> <li>• Unless 120 MHz are allocated by 2017, residential Wi-Fi will become a capacity bottleneck</li> <li>• Consumers will have to switch to either wireline distribution or cellular networks (\$14 billion value erosion)</li> </ul>

Source: Telecom Advisory Services analysis



## THE IMPLICATIONS OF STUDY FINDINGS FOR MANAGEMENT OF THE SPECTRUM ARE STRAIGHTFORWARD

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- Unlicensed spectrum, as an enabling resource, is a critical driver of innovation and value creation
- These effects, as proven through the evidence generated in the study, support a policy that preserves unlicensed spectrum
- Furthermore, given the exponential growth in utilization of technologies such as Wi-Fi, it is reasonable to consider the potential expansion of the amount of unlicensed spectrum
  - Designation of the U-NII-4 spectrum for unlicensed use would be valuable for small cell deployments
  - Portions of the 3.5 GHz, with rules that allow for secondary users to access the band when not in use by the federal government, could enable better quality of service
  - The 600 MHz band could be well suited to off-loading some of the residential Wi-Fi traffic

## **TELECOM ADVISORY SERVICES, LLC**

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