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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

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Contents

1. FOREWORD

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The European Observatory on infringements of Intellectual Property Rights (the Observatory) was created to improve the understanding of the role of Intellectual Property and of the negative consequences of Intellectual Property Rights (IPR) infringements. It was transferred from the Commission to EUIPO in 2012 by Regulation 386/2012.

The International Telecommunication Union (ITU) is the United Nations specialised agency for Information and Communication Technologies (ICTs), with responsibilities that include among others the allocation of global radio spectrum and satellite orbits, the development of technical standards that ensure networks and technologies seamlessly interconnect, and efforts to improve access to ICTs to underserved communities worldwide. The goal is to bring the benefits of modern communication technologies to people everywhere in an efficient, safe, easy and affordable manner.

In a study carried out in collaboration with the European Patent Office[1], the EUIPO, acting through the Observatory, estimated that approximately 42% of total economic activity and 28% of all employment in the EU is directly generated by IPR-intensive industries, with a further 10% of jobs in the EU arising from purchases of goods and services from other industries by IPR-intensive industries.

Another study[2] compared economic performance of European companies that own IPRs with those that do not, finding that IPRs owners' revenue per employee is 28% higher on average than for non-owners, with a particularly strong effect for Small and Medium-Sized Enterprises (SMEs). Although only 9% of SMEs own registered IPRs, those that do have almost 32% more revenue per employee than those that do not.

Perceptions and behaviours of European citizens regarding Intellectual Property and counterfeiting and piracy[3] were also assessed as part of an EU-wide survey. This survey revealed that although citizens recognise the value of IP in principle, they also tend to justify infringements at individual level in certain cases.

The Observatory is seeking to complete the picture by assessing the economic impact of counterfeiting and piracy.

In 2016, EUIPO and ITU signed an agreement to collaborate in the publication of a study on the economic impact of intellectual property rights (IPR) infringement in smartphones. The present report is the result of that agreement.

1 - "Intellectual Property Rights intensive industries and economic performance in the European Union", EUIPO/EPO, October 2016.

2 - "Intellectual Property Rights and firm performance in Europe: an economic analysis", June 2015.

3 - "European citizens and intellectual property: perception, awareness and behaviour", November 2013, updated report 2017 (forthcoming).

This exercise is challenging from a methodological point of view, as it attempts to shed light on a phenomenon that by its very nature is not directly observable. To pave the way towards quantification of the scope, scale and impact of IPR infringements, as identified in its mandate, the Observatory has developed a step by step approach to evaluate the negative impact of counterfeiting and its consequences for legitimate businesses, governments and consumers, and ultimately for society as a whole.

Several IPR intensive industries whose products are known or thought to be subject to counterfeiting have been selected. Previous studies have examined the following sectors: cosmetics & personal care; clothing, footwear and accessories; sports goods; toys & games; jewellery & watches; handbags & luggage; recorded music; spirits & wine; medicines; and pesticides.

The sectorial studies published to date estimate the impact of counterfeit goods in the EU marketplace. This eleventh study, covering the smartphone sector, is published in collaboration with ITU, a UN agency with a global focus. Therefore, while it uses a similar methodology to that applied in previous sectorial studies it is not limited to EU countries. Due to the need to include a wider set of countries and to the special nature of the sector, different data sources and adjustments of the methodology were required.

2. EXECUTIVE SUMMARY

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

2.1. Methodology and data

The study aims to estimate the scale of the economic impact of counterfeiting in the legitimate sector. The starting point of this analysis is the number of smartphones sold in 86 countries based on point-of-sale tracking of consumers' purchases. Expected sales are estimated based on new smartphones connections and expected replacement of devices. Subsequently, the difference between expected and actual sales estimated for each country is analysed using statistical methods. This difference can be partly explained by socio-economic factors such as per capita GDP or mobile broadband services prices. In addition, factors related to counterfeiting are considered, such as the legal and regulatory environment[4].

The methodology is explained in detail in section 5.

2.2. Main findings

It is estimated that in 2015, 14 million smartphones fewer were sold by the legitimate industry across the EU than would have been the case in the absence of counterfeiting. This translates to approximately **4.2 billion EUR lost due to the presence of counterfeit smartphones in the EU marketplace**, corresponding to **8.3% of the sector's sales.**

Worldwide, the effect of counterfeiting on smartphone sales is estimated at 184 million units, valued at **45.3 billion EUR or 12.9% of total sales.**

Region[5]-level estimates of lost sales expressed both as a percentage of sales and in euros, are shown in the table below along with the confidence intervals.

4 - The Worldwide Governance Indicator of Government Effectiveness from the World Bank is used in this study. This indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

5 - The countries included in each region are shown in Table 4.

TABLE 1: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY REGION AND CONFIDENCE INTERVALS (2015)

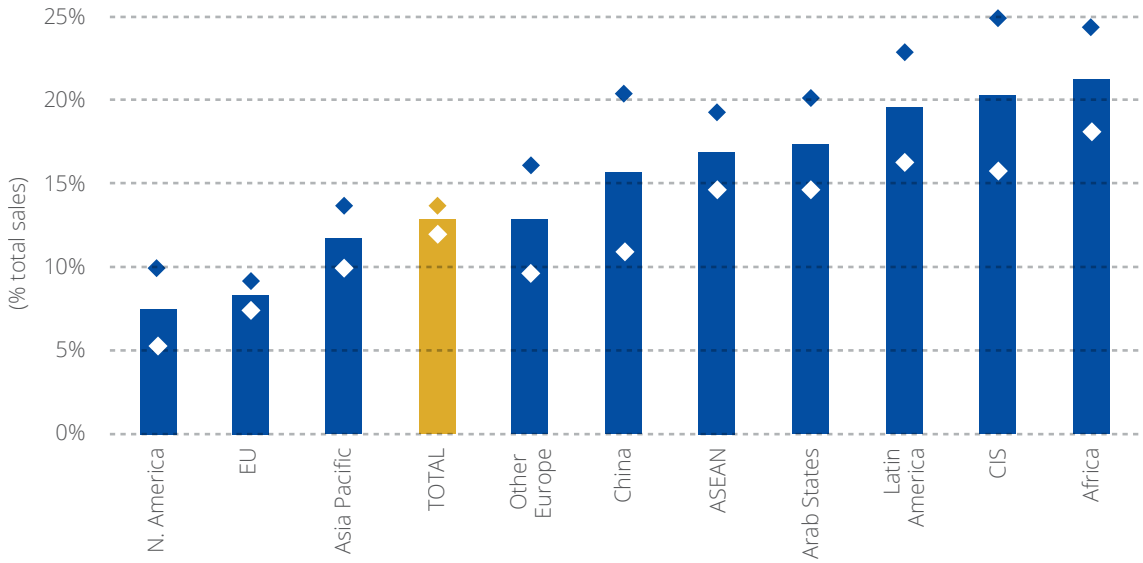
	Lost sales (million EUR)	Lost (%)	Upper	Lower
European Union*	4,212.2	8.3%	9.1%	7.4%
Other European Countries	1,207.0	12.9%	16.1%	9.7%
CIS**	1,122.9	20.3%	25.0%	15.7%
Asia-Pacific***	7,166.6	11.8%	13.7%	10.0%
ASEAN****	2,674.9	16.9%	19.3%	14.6%
Arab States	1,975.7	17.4%	20.2%	14.6%
Africa	1,024.9	21.3%	24.4%	18.2%
Latin America	4,706.5	19.6%	22.9%	16.2%
North America	4,927.2	7.6%	9.9%	5.3%
China	16,335.8	15.6%	20.4%	10.9%
TOTAL	**45,353.8**	**12.9%**	**13.7%**	**12.0%**

*EU28 except Malta and Bulgaria
**CIS Commonwealth of Independent States
*** Asia-Pacific region except China and ASEAN countries
**** ASEAN Association of Southeast Asian Nations
Source: EUIPO calculations

The resulting estimates of lost sales due to counterfeit smartphones in each region are shown in the figure below. The bar indicates the impact of counterfeiting on the legitimate sector's sales, expressed as a percentage of sales, while the diamonds indicate the 95% confidence interval of that estimate[6].

6 - The 95% confidence interval is a statistical calculation which means that there is a 95% probability that the true figure lies between the lower and upper bounds of that interval. For example, for the EU as a whole, the estimated percentage of lost sales is 8.3%, with a 95% probability that the true percentage lies between 7.4% and 9.1%.

FIGURE 1: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY REGION (2015)

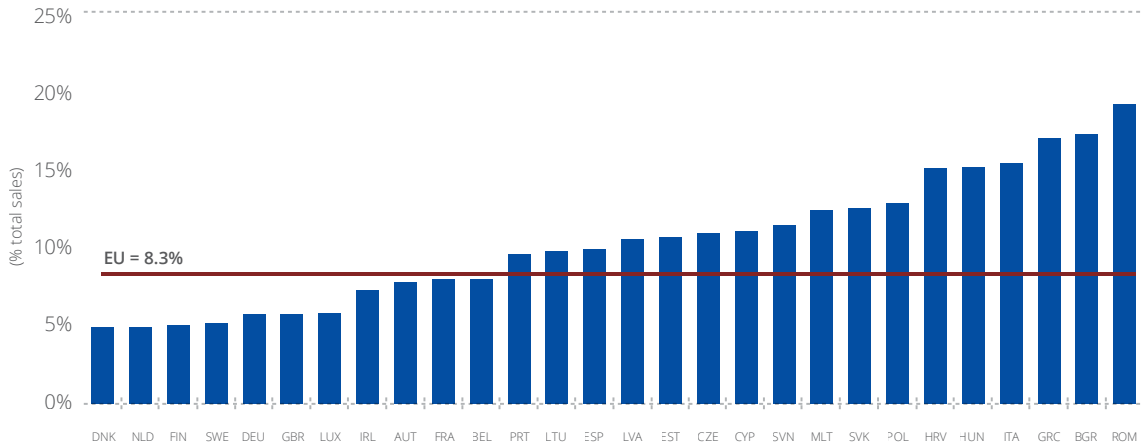


Source: EUIPO calculations

Lost sales in China account for 36% of worldwide lost sales. Lost sales in absolute terms in North America and Latin America are quite similar although in relative terms the losses in Latin America are almost three times higher. North America and the EU are the two regions with the lowest relative impact of counterfeiting on sales, both below 10%.

Among the EU Member States, 11 are below the EU average of 8.3%. The country least affected by counterfeiting in relative terms is Denmark (4.9%), while Romania is the country most affected (19.1%). In absolute terms, the impact is greatest in Italy, with lost sales due to counterfeiting estimated by 885 million EUR; followed by UK at 660 million EUR, Germany (564 million EUR), Spain (386 million EUR) and France (380 million EUR). The five biggest EU Member States account for 2.9 billion EUR lost due to counterfeiting, nearly 70% of total lost sales in the EU.

FIGURE 2: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES IN EU MEMBER STATES (2015)[7]



Source: EUIPO calculations

Country-level estimates of lost sales expressed as a percentage of total sales are shown in the table below.

7 - International Standards Organizations (ISO) country codes are used throughout this report. See: http://wits.worldbank.org/wits/wits/witshelp/Content/Codes/Country_Codes.htm

TABLE 2: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES IN EU MEMBER STATES (2015)

Code	Country	Lost sales (%)
AUT	AUSTRIA	7.7
BEL	BELGIUM	8.0
BGR	BULGARIA	17.2
CYP	CYPRUS	11.0
CZE	CZECH REPUBLIC	10.9
DEU	GERMANY	5.7
DNK	DENMARK	4.9
EST	ESTONIA	10.6
GRC	GREECE	16.9
ESP	SPAIN	10.0
FIN	FINLAND	5.1
FRA	FRANCE	8.0
HRV	CROATIA	15.0
HUN	HUNGARY	15.1
IRL	IRELAND	7.3
ITA	ITALY	15.4
LTU	LITHUANIA	9.8
LUX	LUXEMBOURG	5.8
LVA	LATVIA	10.6
MLT	MALTA	12.4
NLD	NETHERLANDS	5.0
POL	POLAND	12.8
PRT	PORTUGAL	9.5
ROM	ROMANIA	19.1
SWE	SWEDEN	5.2
SVK	SLOVAK REPUBLIC	12.5
SVN	SLOVENIA	11.5
GBR	UNITED KINGDOM	5.7
EU	**EUROPEAN UNION**	**8.3**

2.3. Non-economic impacts of counterfeit smartphones

This report focuses on the economic consequences of counterfeit smartphones. However, there are a number of other impacts in areas such as health and safety, environmental damage, network quality, cyber-security and privacy. A recent report by the ITU singles out the following *non-economic* effects of counterfeit mobile devices[8]:

8 - "Counterfeit ICT equipment", ITU Technical Report, December 2015.

- lowering the quality of service of mobile telecommunication services, thus impacting the experience of consumers and businesses;
- creating a safety hazard for consumers due to use of defective or inadequate components or materials;
- raising cybersecurity-related threats;
- jeopardizing consumer privacy;
- impairing the safety of digital transactions;
- hurting the most financially vulnerable consumers by failing to provide any warranties to the consumer and otherwise violating consumer law requirements;
- creating risks to the environment and consumer health due to the use of hazardous substances in the manufacturing of these devices.

Many of these impacts are particularly serious in regions such as Africa where many consumers rely on their smartphones to an even greater extent than consumers in Europe or North America. The smartphone is often the only way to access the internet, and the main source of banking services (the M-PESA mobile banking service in Kenya being a well-known example). Any malware or other security breach that can be found in counterfeit devices has serious consequences in this context.

Counterfeit products, because of their poor assembly and use of poor quality components, contain hazardous substances that are banned in many countries under the restriction of hazardous substances (RoHS) or national equivalent legislation. This poses risks to both health and safety of the users and to the environment.

While the non-economic impacts outlined in this sub-section are beyond the scope of this report, they are clearly of significant societal importance and must be kept in mind when considering the phenomenon of counterfeit smartphones.

3. INTRODUCTION

A major problem which has hindered the effective enforcement of Intellectual Property Rights (IPR) in the EU is related to a lack of knowledge in relation to the precise scope, scale and impact of IPR infringements. Many attempts to quantify the scale of counterfeiting and its consequences for businesses, consumers and society as a whole have suffered from the absence of a consensual and consistent methodology for collecting and analysing data on counterfeiting and piracy across various sectors. Different approaches have been used, such as surveys, mystery shopping or monitoring of online activities, making it all the more difficult to aggregate results for the whole economy. The very nature of the phenomenon under investigation makes it extremely challenging to quantify reliably, as obtaining comprehensive data for a hidden and secretive activity is by necessity difficult.

These challenges have in turn hindered the tasks of those involved in enforcing IP rights and in charge of establishing precise priorities, programmes and targets for enforcement, as they limit the possibilities to design more focused policies as well as evidence-based public awareness campaigns.

To help overcome these challenges while taking fully into account of methodological constraints, the Observatory developed a specific approach that has so far been applied to the Cosmetics and Personal Care; Clothing, Footwear and Accessories; Sports Goods; Games and Toys; Jewellery and Watches; Handbags and Luggage; Recorded Music; Wine and Spirits; Pharmaceutical; and Pesticides sectors. In the present report the Observatory focuses its attention on the smartphones sector.

The increasing role that mobile devices, specifically smartphones, are playing in communication services, applications and e-services (m-payments, m-agriculture, m-learning and many others) have raised the importance of such devices, and made them essential. The number of mobile phones, which started out as simple voice communication terminals, has steadily increased around the world, evolving towards smartphones in many cases. While this has created economic and social and opportunities for people around the world, it has also raised concerns regarding trust and security of such devices, in particular with policy makers and National ICT Regulatory Authorities (NRAs). When equipment is not fully trustworthy, the quality of service of communication can be affected, personal information may be misused or irrecoverable, and health and security harmed.

3.1. The global market for smartphones

Based on GfK data[9] **1.3 billion smartphones were sold in 2015 globally, meaning that 1 in 6 people in the world have purchased a smartphone** that year, roughly equal to the entire population of China or India.

China, with 20% of the World population and a smartphones penetration of 65 connections per 100 inhabitants[10] is the leading market with 30% of smartphones sold accounting for 385 million units. The Asia - Pacific area[11], with 29% of the total population and a smartphones penetration ratio of 25, registers 221 million smartphones sold in 2015, 17% of total sales; North America has the highest penetration ratio at 78 connections per 100 inhabitants and sales are estimated at 190 million units; and the EU[12], with a penetration of 76, registered more than 150 million units sold[13].

The value of the devices sold in 2015 is 352 billion EUR, hence the average nonsubsidized price[14] of smartphones sold in all countries is 275 EUR. The value of devices sold in China is 105 billion EUR with an average price of 272 EUR per unit. The nine African countries included in this study and the CIS countries show the lowest average prices of 156 and 154 EUR per unit and sales values around 5 billion EUR. In North America total sales amount to 65 billion EUR with an average price of 340 EUR and in EU countries total sales are 51 billion EUR at an average price of 333 EUR. Finally, the average price in the rest of Europe is 439 EUR per unit, resulting in a market value of 9 billion EUR. The table below shows sales and average prices by region.

The figures in this report refer to sales of new smartphones. In some regions, particularly in low-income countries, there is an important market for second-hand and refurbished smartphones. In the refurbished market there is a further potential for IPR infringement, for example when the outer shell of a genuine branded smartphone is combined with non-original components. In principle, the effect of this type of infringement is captured by the methodology used in this study, but in the absence of reliable data it is not feasible to quantify its impact separately. Such quantification could be the subject of a future study.

9 - GfK Retail & Technology GmbH is a German market research institute: http://www.gfk.com/about-gfk/about-gfk/. The data on smartphones used in this report cover more than 90 countries representing 94% of the World population. Only Africa has a lower coverage including 56% of the population in the region, with Ethiopia, Democratic Republic of the Congo and Sudan the most populous missing countries. The data and methodology used in this report are described in Section 5.

10 - Penetration ratio is defined in this report as the number of smartphone connections per 100 inhabitants in contrast with other definitions using subscriptions per 100 inhabitants. The term 'connections' defines wireless accounts and corresponds to the number of SIM cards. This term is different from unique subscribers.

11 - The Asia-Pacific region, as defined in this report, does not include China or the ASEAN countries. Table 4 shows the countries included in each region.

12 - The data for the EU is based on 26 Member States, as data for Malta and Bulgaria was not available.

13 - List of countries included in each region are shown in Section 4.

14 - Nonsubsidized (or unsubsidized) price of a phone is the full price of the device, covering the actual cost paid to the phone manufacturer including taxes such as VAT. This price is comparable among countries and in time, in contrast to the subsidized price often part of a contract for voice and data services, conditional on the acceptance of restricting the device during a period of time to one particular operator. The difference between real cost and the price paid by the consumer is the subsidy paid by carriers.

TABLE 3: SALES AND PRICES OF SMARTPHONES BY REGION (2015)

	Total sales (million EUR)	Total sales (million units)	Average price
European Union*	50,801	152	333
Other European Countries	9,361	21	439
Commonwealth of Independent States (CIS)	5,519	36	154
Asia – Pacific**	60,697	221	275
Assoc. Southeast Asian Nations (ASEAN)	15,789	86	183
Arab States	11,358	48	238
Africa	4,814	31	156
Latin America	24,055	108	222
North America	64,975	191	340
China	104,570	385	272
TOTAL	**351,939**	**1,280**	**275**

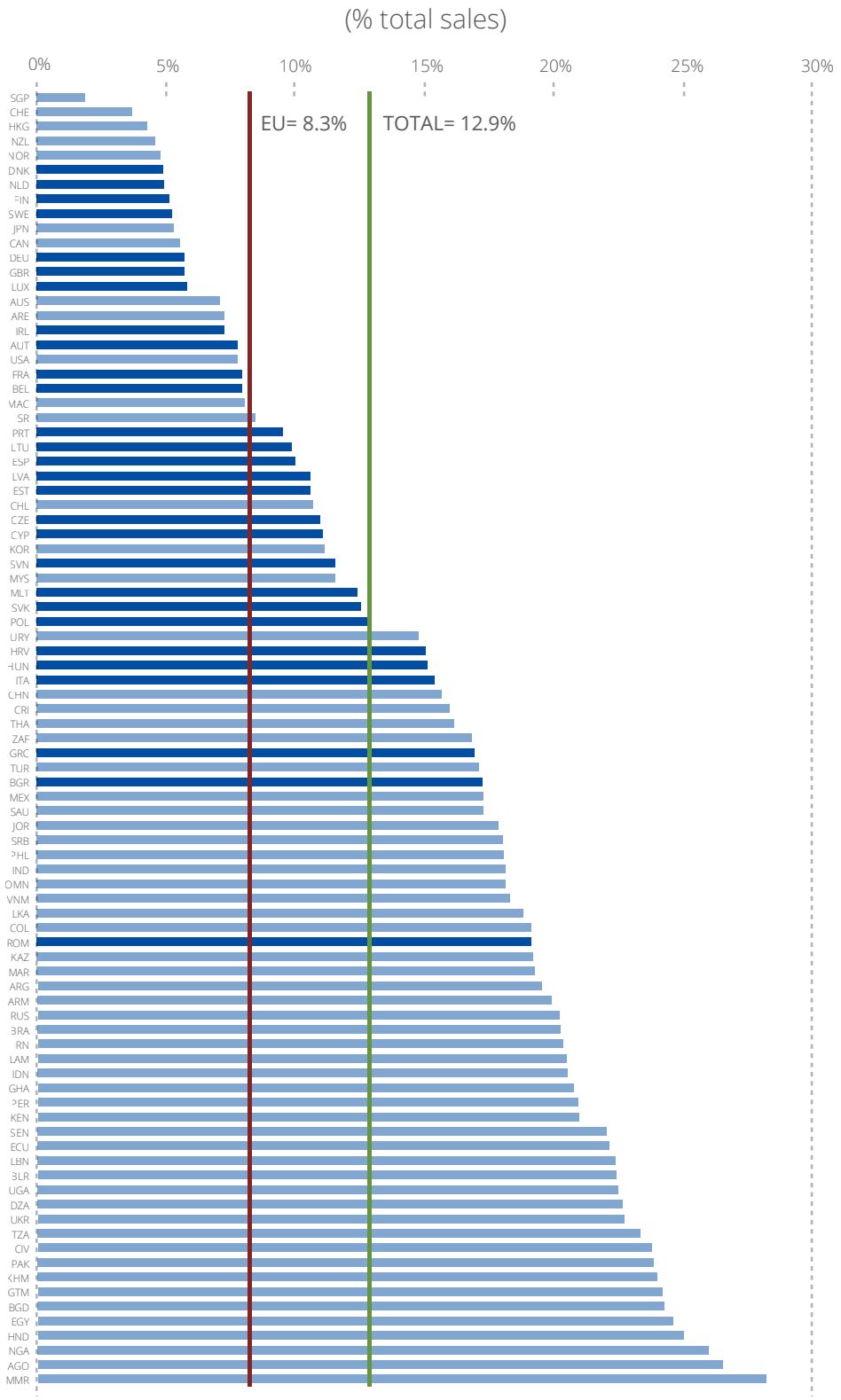
* EU28 except Malta and Bulgaria
**Asia-Pacific region except China and ASEAN countries
Source: EUIPO analysis based on market research data by GfK

4. COUNTRY LEVEL RESULTS

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The resulting estimates of the lost sales due to counterfeit smartphones for all countries analysed are shown in the figure below. For each country, the bar indicates the impact of counterfeiting on the legitimate sector's sales, expressed as a percentage of sales in year 2015. The vertical lines represent the average effect in all countries and in the 26 EU Member States included in the study.

FIGURE 3: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY COUNTRY (2015)



Country-level estimates of losses due to counterfeiting expressed as a percentage of sales, are shown in the tables below along with the average ratios for the regions considered, calculated as the average of the countries in each region, weighted by sales in EUR:

TABLE 4: LOST SALES DUE TO COUNTERFEITING OF SMARTPHONES BY COUNTRY AND REGION (2015)

Code	Region/country	Lost sales (%)
EU	EUROPEAN UNION	8.3
DNK	DENMARK	4.9
NLD	NETHERLANDS	5.0
FIN	FINLAND	5.1
SWE	SWEDEN	5.2
DEU	GERMANY	5.7
GBR	UNITED KINGDOM	5.7
LUX	LUXEMBOURG	5.8
IRL	IRELAND	7.3
AUT	AUSTRIA	7.7
FRA	FRANCE	8.0
BEL	BELGIUM	8.0
PRT	PORTUGAL	9.5
LTU	LITHUANIA	9.8
ESP	SPAIN	10.0
LVA	LATVIA	10.6
EST	ESTONIA	10.6
CZE	CZECH REPUBLIC	10.9
CYP	CYPRUS	11.0
SVN	SLOVENIA	11.5
MLT	MALTA	12.4
SVK	SLOVAK REPUBLIC	12.5
POL	POLAND	12.8
HRV	CROATIA	15.0
HUN	HUNGARY	15.1
ITA	ITALY	15.4
GRC	GREECE	16.9
BGR	BULGARIA	17.2
ROM	ROMANIA	19.1

Code	Region/country	Lost sales (%)
EUR	OTHER EUROPEAN COUNTRIES	12.9
CHE	SWITZERLAND	3.7
NOR	NORWAY	4.8
ISR	ISRAEL	8.5
TUR	TURKEY	17.1
SRB	SERBIA	18.0
CIS	CIS COUNTRIES**	20.3
KAZ	KAZAKHSTAN	19.2
ARM	ARMENIA	19.8
RUS	RUSSIAN FEDERATION	20.2
BLR	BELARUS	22.4
UKR	UKRAINE	22.7
NOA	NORTH AMERICA	7.6
CAN	CANADA	5.5
USA	UNITED STATES	7.8
LA	LATIN AMERICA	19.6
CHL	CHILE	10.7
URY	URUGUAY	14.7
CRI	COSTA RICA	16.0
MEX	MEXICO	17.2
COL	COLOMBIA	19.1
ARG	ARGENTINA	19.5
BRA	BRAZIL	20.2
LAM	OTHER LATIN AMERICAN	20.5
PER	PERU	20.9
ECU	ECUADOR	22.1
GTM	GUATEMALA	24.2
HND	HONDURAS	25.0

Code	Region/country	Lost sales (%)
CHN	CHINA	15.6
ASP	ASIAN AND PACIFIC COUNTRIES	11.8
HKG	HONG KONG SAR, CHINA	4.3
NZL	NEW ZEALAND	4.6
JPN	JAPAN	5.3
AUS	AUSTRALIA	7.1
MAC	MACAO SAR, CHINA	8.0
KOR	KOREA, REP.	11.1
IND	INDIA	18.1
LKA	SRI LANKA	18.7
IRN	IRAN, ISLAMIC REP.	20.3
PAK	PAKISTAN	23.8
BGD	BANGLADESH	24.3
ASEAN	ASEAN COUNTRIES*	16.9
SGP	SINGAPORE	1.9
MYS	MALAYSIA	11.6
THA	THAILAND	16.1
PHL	PHILIPPINES	18.0
VNM	VIETNAM	18.2
IDN	INDONESIA	20.5
KHM	CAMBODIA	24.0
MMR	MYANMAR	28.1

Code	Region/country	Lost sales (%)
ARB	ARAB STATES	17.4
ARE	UNITED ARAB EMIRATES	7.2
SAU	SAUDI ARABIA	17.2
JOR	JORDAN	17.8
OMN	OMAN	18.1
MAR	MOROCCO	19.3
LBN	LEBANON	22.4
DZA	ALGERIA	22.6
EGY	EGYPT, ARAB REP.	24.5
AFR	AFRICA	21.3
ZAF	SOUTH AFRICA	16.8
GHA	GHANA	20.7
KEN	KENYA	21.0
SEN	SENEGAL	22.1
UGA	UGANDA	22.4
TZA	TANZANIA	23.3
CIV	CÔTE D'IVOIRE	23.7
NGA	NIGERIA	26.0
AGO	ANGOLA	26.4

* ASEAN Association of Southeast Asian Nations
**CIS = Commonwealth of Independent States
Source: EUIPO calculations

The biggest relative impact of counterfeiting is observed in Myanmar where 28% of sales are lost due to counterfeit smartphones. Lost sales due to counterfeiting are above 20% in a total of 26 countries, mostly in Africa (8) and Latin America (6).

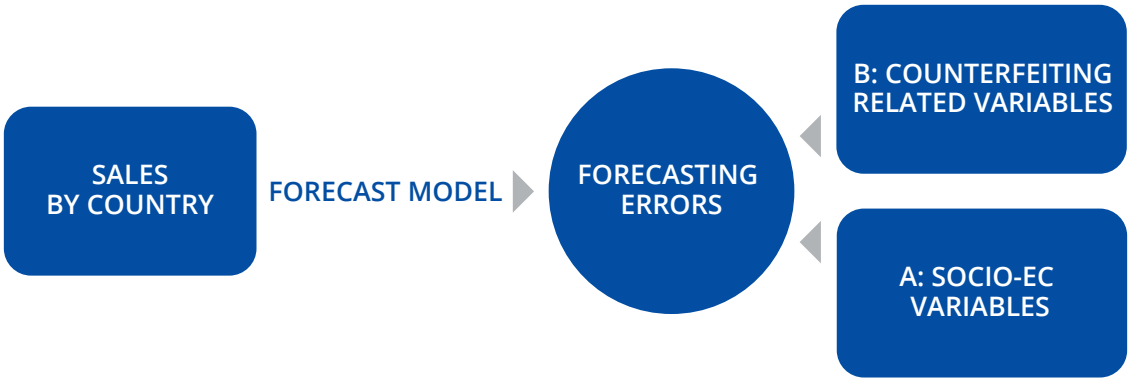
At the other extreme, lost sales due to counterfeiting in Singapore are estimated to be less than 2% of total sales. Another 26 countries have lost sales below 10%, including US and Canada and 14 EU Member States.

5. METHODOLOGY

THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR

The methodology builds on an adaptation of a methodology developed for the European Commission[15] so that it can be used on a sectorial level rather than on a firm level which proved very difficult to apply in practice.

The methodology used for the estimation of the economic effects of counterfeiting is depicted in the following figure:



The first stage is comprised of the compilation of actual sales of smartphones and the development of a forecasting model of sales in each country.

5.1. First stage: real versus expected sales

Data on sales of smartphones in units and value in USD and EUR were purchased from GfK[16]. The database includes quarterly data for the period 2013-2015 of consumer purchases based on point-of-sale (POS) tracking of 86 countries. The POS tracking split sales into different retail channels (technical superstores, operators, other telecommunication specialists, direct sales, etc.) to ensure an appropriate coverage of different distribution channels. When POS data is compared to the total market, which is estimated based on inputs such as annual shipments from vendors to the country and information from third parties (e.g. associations), a coverage gap remains. This coverage gap is usually caused by missing distribution channels, as GfK ensures complete coverage of the channels present in its data by applying extrapolation factors for missing retailers within a channel. To calculate total market sales, the missing channels are extrapolated to reach 100% coverage and this is the value used for this study.

15 - RAND (2012): *Measuring IPR infringements in the internal market.* Report prepared for the European Commission. RAND proposed to analyse ex-post the forecast errors on the level of individual companies, using company-specific explanatory variables. However, attempts at implementing the methodology in this manner were not successful, mainly due to the fact that most companies are not able or willing to provide the required data on past budgeted and actual sales revenues. Therefore, the methodology has been modified to allow its use on sector-level data which can be obtained from public sources.

16 - http://www.gfk.com/solutions/point-of-sales-tracking/point-of-sales-tracking/

The coverage of total sales based on POS data is an average of 83% of total units sold in 2015. Ten countries have a coverage ratio below 50% and 20 countries between 50 and 70%. Among large countries France (55%) and India (43%) show the lowest coverage ratio based on POS.

North American sales are estimated based on proprietary market modelling and consumer research rather than POS data so that sales for United States and Canada are not included separately but as a total for North America. The totals for Mexico, Panama and other Latin America countries[17] are also estimated based on modelling and presented jointly as 'rest of Latin America'.

Finally, values in USD and EUR are based on nonsubsidized retail pricing including taxes such as VAT. Prices at country level can be estimated based on sales in units and EUR and provide the basic information to transform lost sales in units into lost sales in EUR.

Expected sales in units are estimated based on a methodology developed for the ITU[18] by Telecom Advisory Services, an international consulting firm specialising in providing advisory services to telecommunications and technology companies, governments and international organisations. The methodology estimates the number of smartphones sold based on the new connections and new smartphones resulting from replacing obsolete devices. The number of replaced smartphones was calculated based on a replacement factor determined a priori based on the market characteristics of each country. This methodology has been modified to consider different smartphones replacement factors in countries with different characteristics such as the development level in ICT (Information and Communication Technology) as well as the relationship between real sales and smartphones connections in previous years.

The analysis is based on data published by the GSMA Association[19] on the number of smartphone mobile connections[20]. In the present report the number of smartphone SIM connections is used, as opposed to unique mobile subscribers. Therefore, multiple connections of a single subscriber correspond to multiple devices and this is why this measure is appropriate here, although in other studies market penetration is defined based on unique subscribers.

Expected sales are estimated as the yearly increase of smartphone connections (new smartphone users as well as feature phone users who have migrated to a smartphone while keeping the same SIM card) added to the smartphones replaced from previous year (replacing obsolete smartphones). The second term is a replacement factor which depends on the propensity of users to replace their old smartphone with a new one in any given year. This factor differs from country to country.

17 - Bolivia, Cuba, Dominican Republic, El Salvador, Haiti, Nicaragua, Paraguay, Puerto Rico, Trinidad y Tobago and Venezuela are also included in this aggregate, in addition to a number of smaller territories with less than one million inhabitants.

18 - "Methodology for estimating smartphones and feature phones worldwide annual shipments", unpublished manuscript http://www.teleadvs.com/

19 - https://www.gsmaintelligence.com/

20 - The term "connections" defines wireless accounts and equals the number of SIM cards. This term is different from unique subscribers.

Expected sales of country i in year t is calculated based on the following equation:

$$\hat{S}_{it} = (C_{it} - C_{it-1}) + \alpha_i * C_{it-1} \qquad (1)$$

Where $\hat{S}_{it}$ is the number of smartphones expected to be sold in country i and year t and C_{it} is the number of smartphones connections in country i and year t. The coefficient α_i depends on the country i and is estimated based on the relationship between real sales and connections in previous years and represents the share of old smartphones replaced each year.

Therefore, for estimating expected sales in each country, the total number of connections in the current and previous year are needed as well as the value of the coefficient α_i specific to country i.

Prior to the estimation of the α coefficients, a quality check of the connections data has been done to control the influence of outliers. An Intervention Analysis done with the TRAMO software automatic procedure revealed some additive outliers and short term temporary changes. In the end, fewer than 2% of the observations have been imputed as a consequence.

In the subsequent step, countries are grouped based on similar characteristics so that in each group a different α coefficient will be applied. The determination of the countries included in each group is based on a cluster analysis that uses the value of the ICT Development Index (IDI) for year 2014 published by ITU in the publication Measuring the Information Society[21]. This index measures the development in ICT access, use and skills based on 11 quantitative indicators. Four clusters have been initially identified based on hierarchical clusters and single linkages. In each group, countries with similar levels of development in information and communication technology (ICT) are included:

21 - http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2015.aspx

- Low value of IDI: 18 countries with IDI below 4
- Medium value of IDI: 17 countries with IDI between 4 and 5.58
- Medium-high value of IDI:28 countries with IDI between 5.90 and 7.32
- High value of IDI:24 countries with IDI above 7.6

Afterwards, new smartphones connections (C_t-C_{t-1}) and real sales (S_t) collected by GfK as explained before, are compared for all countries in the years 2013 and 2014. As a result of this comparison and the cluster analysis, the final classification of countries is as follows:

Cluster 0: This group includes 14 countries with low IDI values, 6 countries with medium IDI values and 2 with medium-high values. Smartphones sales in these countries in 2015 account for 9.5% of total units sold world-wide, and sales are lower than new connections in every country.

Expected sales of smartphones in these 22 countries and also in the aggregate Rest of Latin America are estimated to be equal to the increase of smartphones connections as demand is driven by new buyers since the penetration ratio is still low.

Algeria	Armenia	Bangladesh
Cambodia	Cote d'Ivoire	Ecuador
Ghana	Guatemala	Honduras
Indonesia	Morocco	Myanmar
Nigeria	Philippines	Rest of Latin America
Romania	Senegal	Serbia
Sri Lanka	Tanzania	Thailand
Uganda	Ukraine	

Cluster 10: Nine countries with medium and medium-high values of IDI presented in the table below register sales slightly above the needs for new connections so expected sales include the new connections and the renewal of 10% of the stock of smartphones each year.

Cyprus	Greece	Iran
Israel	Latvia	Russia
Turkey	Uruguay	Vietnam

Sales of smartphones in the nine countries listed above account for 5.7% of total units sold world-wide in 2015.

Cluster50: Four countries with medium-high values of IDI and eight countries with high values of IDI show a very high replacement factor and so expected sales are estimated as new connections plus 50% of current smartphones. Sales in those mature markets are driven by renewal of devices as demand for new connections is declining due to market saturation. These twelve countries account for 24.8% of smartphones sold in the world in 2015.

Canada	Chile	Germany
Hong Kong	Ireland	Jordan
Lebanon	Saudi Arabia	South Korea
Spain	United Kingdom	United States

Cluster25: The remaining 42 countries cover 60% of the smartphones sold world-wide in 2015 and expected sales are estimated as new connections plus 25% of older smartphones. This group of countries is considered as the base for comparison purposes.

Angola	Argentina	Australia	Austria
Belarus	Belgium	Brazil	China
Colombia	Costa Rica	Croatia	Czech Republic
Denmark	Egypt	Estonia	Finland
France	Hungary	India	Italy
Japan	Kazakhstan	Kenya	Lithuania
Luxembourg	Macau	Malaysia	Netherlands
New Zealand	Norway	Oman	Pakistan
Peru	Poland	Portugal	Slovakia
Slovenia	Singapore	South Africa	Sweden
Switzerland	U. Arab Emirates		

The presence of several highly developed countries in the last group (18 EU Member States as well as Australia, Japan, New Zealand, Norway and Singapore) is explained by lower replacement factors found in those countries, compared with the 12 countries included in cluster50.

The α coefficient (replacement factor) estimated for all 86 countries is 21% and can be understood as an average period of "obsolescence" of four years and nine months.

Finally, equation 1 is used to estimate expected sales in 2015 based on smartphones connections in 2015 and 2014 and different α coefficients: 0; 0.10; 0.25; and 0.50 depending on the cluster in which each country is included.

The forecast error is the difference between expected and real sales and for the purposes of comparability is expressed as a proportion of actual sales, as shown in the following equation:

$$q_{it}^{*} = \frac{\widehat{S_{it}} - S_{it}}{S_{it}} \qquad (2)$$

where S_{it} is the number of units sold in country i and year t (2015) and $\hat{S}_{it}$ is the number of units expected to be sold in that year, as calculated in the previous step.

The relative error q^{*}_{it} measures the extent to which the model has predicted a higher or lower value (as a share of actual sales) versus the actual level of sales, expressed in units.

The errors are presented in the table below. It is evident that these errors exhibit a large degree of variability. They are presented ordered by cluster to consider the fact that for each group of countries expected sales were estimated applying different α coefficients. The highest errors are registered in the first group of countries (Cluster 0), meaning that even though sales are estimated based on the increase of smartphones connections without including any replacement for older devices, in those countries expected sales are on average much higher than real sales.

TABLE 5: RELATIVE FORECAST ERRORS (2015)

Country	Code	CLUSTER	ERRORS
ARMENIA	ARM	Cluster 0	0.3383
BANGLADESH	BGD	Cluster 0	0.6829
CÔTE D'IVOIRE	CIV	Cluster 0	1.2145
ALGERIA	DZA	Cluster 0	0.5180
ECUADOR	ECU	Cluster 0	-1.4372
GHANA	GHA	Cluster 0	0.6481
GUATEMALA	GTM	Cluster 0	0.7112
HONDURAS	HND	Cluster 0	1.2708
INDONESIA	IDN	Cluster 0	0.1750
CAMBODIA	KHM	Cluster 0	1.4425
OTHER LATIN AMERICAN	LAM	Cluster 0	0.3481
SRI LANKA	LKA	Cluster 0	1.2956

Country	Code	CLUSTER	ERRORS
MOROCCO	MAR	Cluster 0	-0.0690
MYANMAR	MMR	Cluster 0	2.6903
NIGERIA	NGA	Cluster 0	0.5253
PHILIPPINES	PHL	Cluster 0	0.2816
ROMANIA	ROM	Cluster 0	0.0954
SENEGAL	SEN	Cluster 0	2.7354
SERBIA	SRB	Cluster 0	0.2974
THAILAND	THA	Cluster 0	-0.5551
TANZANIA	TZA	Cluster 0	1.6593
UGANDA	UGA	Cluster 0	0.2436
UKRAINE	UKR	Cluster 0	1.1774
CYPRUS	CYP	Cluster 10	0.0162
GREECE	GRC	Cluster 10	-0.0489
IRAN, ISLAMIC REP.	IRN	Cluster 10	0.4017
ISRAEL	ISR	Cluster 10	-0.2896
LATVIA	LVA	Cluster 10	-0.1403
RUSSIAN FEDERATION	RUS	Cluster 10	0.2036
TURKEY	TUR	Cluster 10	-0.0453
URUGUAY	URY	Cluster 10	-0.3469
VIETNAM	VNM	Cluster 10	-0.0999
ANGOLA	AGO	Cluster 25	0.0133
CHINA	CHN	Cluster 25	-0.1704
COLOMBIA	COL	Cluster 25	-0.1313
EGYPT, ARAB REP.	EGY	Cluster 25	0.2392
INDIA	IND	Cluster 25	0.0152
KENYA	KEN	Cluster 25	-0.2493
PAKISTAN	PAK	Cluster 25	0.1806
PERU	PER	Cluster 25	0.0475
SOUTH AFRICA	ZAF	Cluster 25	0.1665
UNITED ARAB EMIRATES	ARE	Cluster 25	-0.2725
ARGENTINA	ARG	Cluster 25	0.3422

Country	Code	CLUSTER	ERRORS
BELARUS	BLR	Cluster 25	0.1287
BRAZIL	BRA	Cluster 25	0.1929
COSTA RICA	CRI	Cluster 25	0.0286
CZECH REPUBLIC	CZE	Cluster 25	0.0849
CROATIA	HRV	Cluster 25	-0.0008
HUNGARY	HUN	Cluster 25	0.0113
ITALY	ITA	Cluster 25	-0.1481
KAZAKHSTAN	KAZ	Cluster 25	0.2781
LITHUANIA	LTU	Cluster 25	0.4351
MALAYSIA	MYS	Cluster 25	0.3885
OMAN	OMN	Cluster 25	-0.0145
POLAND	POL	Cluster 25	0.1545
PORTUGAL	PRT	Cluster 25	-0.2662
SLOVAK REPUBLIC	SVK	Cluster 25	-0.1306
SLOVENIA	SVN	Cluster 25	0.0358
AUSTRALIA	AUS	Cluster 25	-0.0626
AUSTRIA	AUT	Cluster 25	0.1442
BELGIUM	BEL	Cluster 25	-0.0866
SWITZERLAND	CHE	Cluster 25	-0.2600
DENMARK	DNK	Cluster 25	-0.0664
ESTONIA	EST	Cluster 25	0.2278
FINLAND	FIN	Cluster 25	-0.0635
FRANCE	FRA	Cluster 25	-0.2867
JAPAN	JPN	Cluster 25	0.0437
LUXEMBOURG	LUX	Cluster 25	0.0703
MACAO SAR, CHINA	MAC	Cluster 25	0.1909
NETHERLANDS	NLD	Cluster 25	-0.3063
NORWAY	NOR	Cluster 25	-0.3469
NEW ZEALAND	NZL	Cluster 25	-0.1065
SINGAPORE	SGP	Cluster 25	-0.0601
SWEDEN	SWE	Cluster 25	-0.2458

Country	Code	CLUSTER	ERRORS
CHILE	CHL	Cluster 50	-0.2830
GERMANY	DEU	Cluster 50	0.5957
SPAIN	ESP	Cluster 50	0.1736
UNITED KINGDOM	GBR	Cluster 50	0.2229
HONG KONG SAR, CHINA	HKG	Cluster 50	-0.1359
IRELAND	IRL	Cluster 50	-0.0796
JORDAN	JOR	Cluster 50	-0.3125
KOREA, REP.	KOR	Cluster 50	0.0762
LEBANON	LBN	Cluster 50	-0.2227
NORTH AMERICA	NOA	Cluster 50	-0.2237
SAUDI ARABIA	SAU	Cluster 50	0.0414

Source: EUIPO calculations

However, the errors are not interesting in themselves. The purpose of this study is not to produce a "good" forecast of smartphones sold but rather to generate a set of relative errors which can then be quantitatively analysed to construct estimates of counterfeiting. Forecasts for 2015 are produced based on connections and the relationship between sales and connections in the previous two years, which ensures that they are comparable and "unpolluted" by a priori knowledge of factors influencing changes in demand.

The second part of the estimation process seeks to determine to what extent these forecast errors can be explained by economic variables and by variables related to counterfeiting.

5.2. The second stage econometric model

Counterfeiting might be one of a number of factors impacting on the level of sales of smartphones, but there are, as outlined earlier, a series of other economic factors which can explain the differential, such as variables related to the economic capacity of households (e.g. broadband services prices or per capita GDP) or any other driver of consumption expenditure.

Having accounted for the influence of economic variables on the sales differential, an attempt is made to assess the extent to which counterfeiting variables, or relevant proxies, can explain the propensity to purchase counterfeit smartphones. These variables might include measures of consumers and market characteristics, as well as the evolution of a country´s legal environment.

Combining the economic and counterfeiting variables allows for the specification of an econometric model whose aim is to explain the aggregated differential between expected and real sales. The model is specified in the following format:

$$q_i^* = \partial * X_i + \beta * Z_i + \varepsilon_i \qquad (3)$$

where X_i is a matrix of explanatory variables unrelated to counterfeiting and Z_i a matrix of variables related to counterfeiting. Finally, ε_i is the remaining error.

Socio-economic variables considered to have explanatory power, unrelated to counterfeiting, include:

1. GDP per capita and GDP growth expressed in Purchased Power Parity (PPP);
2. Exchange rate of the US dollar vs. local currencies;
3. Mobile broadband services prices (ITU) expressed in PPP as well as a share of per capita Gross National Income (GNI).

Variables thought to be **related to counterfeiting** include:

1. Corruption Perception Index (CPI);
2. Intellectual Property Right Index;
3. Worldwide Governance Indicators (World Bank) covering Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption (level and growth);
4. World Development Indicators (WB) related to ICT imports, customs and tourism.

Variables considered to be drivers of counterfeiting are related to the market and institutional characteristics of each country.

The Corruption Perception Index (CPI) is published by Transparency International and measures how corrupt public sectors are seen to be by the public in each country. In this study the updated index is used with reference year 2015.

The Intellectual Property (IP) Rights Index used is published by Property Rights Alliance and measures the strength of protection accorded to IP. The 2016 index is used in this study.

The Worldwide Governance Indicators reflect the perception of government effectiveness, regulatory quality, rule of law and corruption. They are published annually and range from 2.5

for favourable aspects of governance to -2.5 for poor performance. For computational reasons, the indicators have been re-scaled to avoid negative values so that 0 correspond to better performance and higher values indicate a worse situation. These indicators are considered as potential proxies for the perceived risk of buying or selling counterfeit goods.

The rationale behind these variables is that in countries where governance and rule of law are perceived to be weak there is a higher likelihood of consumption of a product to be illicit than in countries with good governance, strong rule of law and low corruption.

World Development Indicators include besides ICT imports and tourism indicators, the burden of customs procedures and logistics performance indexes including the ability to track and trace consignments and the efficiency of the customs clearance process and quality.

For the aggregated regions of North America and the rest of Latin America the indicators are obtained as a weighted average using population as weight with the exception of the GDP variables which use the GDP values by country as weights.

Altogether, 24 different explanatory variables were tested and different econometric techniques were applied in order to select a model with robust econometric results and a clear interpretation.

Some of the variables considered in the modelling process are correlated with each other. High correlation coefficients between explanatory variables (referred to as multicollinearity) are a common problem in econometric analysis. If correlated explanatory variables are included in the model, the estimated coefficients for these variables could be mistakenly considered as insignificant (small t-statistics), although possessing a high overall significance for the model as measured by the F-test. This situation can pose problems when trying to interpret the meaning and significance of parameter estimates and when testing the significance of other variables in the model specification.

For instance, Worldwide Governance Indicators and CPI are highly correlated. Therefore only those variables with the greatest explanatory power are included in the model in order to avoid the problems described above.

The final model is estimated using Two Steps Least Squares (2SLS) to solve problems of heteroscedasticity (confirmed with Breusch-Pagan test) as stability of variance of estimated residuals is a requirement for an acceptable accuracy in the coefficients estimation. Variation Inflation Factor (VIF) test, residuals plots and Information Criteria such as Akaike and Bayesian were also used to select the preferred model[22].

22 - All results of the diagnostic tests are available on request.

Based on residuals analysis, two countries were excluded in the final model (Ecuador and Senegal) as they are considered outliers. The final model was estimated using 80 observations due to lack of explanatory variables for Argentina, Iran and Myanmar.

Variable	Coefficient	Standard Error	t Statistic	95% Confidence interval	
				Lower	Upper
Constant	-0.2451	0.0188	-13.03 ***	-0.2826	-0.2076
Cluster0	0.3505	0.0475	7.39 ***	0.2559	0.4450
Cluster10	-0.0840	0.0147	-5.72 ***	-0.1132	-0.0547
Cluster50	-0.0155	0.0335	-0.46	-0.0822	0.0512
Prices pc GNI	0.0728	0.0122	5.95 ***	0.0484	0.0972
GDP pc PPP	0.0017	0.0004	4.14 ***	0.0009	0.0026
WB Index: Government Effectiveness	0.0753	0.0117	6.42 ***	0.0519	0.0986

R-square = 84.85%

F statistic = 122.85 ***

*** significant at 99% confidence level

The econometric model explains 85% of total variance of the stage 1 forecast errors. The model uses a combination of two economic variables and one counterfeiting related variable besides three dummy variables. For each variable the first column shows the estimated coefficient, the second column shows the standard error, while the third column indicates the statistical significance of the parameter estimates.

The model estimated includes two explanatory variables not related to counterfeiting (mobile broadband services prices as a share of per capita GNI and per capita GDP expressed in PPP) and **one explanatory variable related to counterfeiting: the WB index on Government Effectiveness**[23].

The coefficient estimated for the counterfeiting related variable is positive, so that a higher value of the index in a particular country (which corresponds to poorer regulation) is related to bigger forecast errors.

23 - This indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Three dummy variables are included to allow for different average errors in the clusters built in the 1st step, with Cluster25 as the base. The estimated coefficients capture the effect of omitted variables that are common to each group of countries. The positive sign of the Cluster0 coefficient reflects a higher value of errors in the 23 countries of this group for which expected sales are estimated to be equal to new connections and are on average above real sales. It is not clear which factors explain the positive sign of Cluster0 coefficient but one of them could be sales not included in the GfK data, such as second-hand and refurbished devices and the presence of shared devices prevalent in some developing countries[24].

Based on the coefficient estimated for the counterfeiting-related variable presented above, the impact of counterfeiting is estimated via the following relationship:

$$F_i^* = \hat{\beta} * Z_i$$

Where F^*_i represents the sales lost due to counterfeiting in country *i* (expressed as the fraction of the sector's actual sales) and Z_i is the value the World Bank Index in that country. $\hat{\beta}$ is the estimated coefficient from the table at the beginning of this section with value 0.0753.

Based on the estimation of units lost due to counterfeiting, smartphones prices by country are applied to obtain lost sales in EUR by region. The average prices by region shown in the table in section 3.1 hide big differences among countries within each region. The two regions with lowest prices, CIS and African countries, are also the most homogeneous with a difference between countries with higher and lower smartphones prices of 78 and 85 EUR. The EU, ASEAN and other European countries register differences of more than 300 EUR between the most expensive and the cheapest country. But the most diverse region is Asia - Pacific including the country with lowest prices (Bangladesh) and the one with the highest average price in 2015 (Japan), with a spread of 479 EUR.

24 - Alternative models have been estimated using additional explanatory variables related to counterfeiting such as CPI and IPRI but the Variation Inflation Factor (VIF) test confirms the presence of severe multicollinearity in those models. The coefficient of the WB Index in different models is always significant with 99% of confidence level ranging from 0.0654 to 0.1014 providing a good indication of its stability.

6. CONCLUSIONS AND PERSPECTIVES

The studies aiming to quantify the scale and impact of IPR infringements in cosmetics and perfumes, clothing and footwear, sports goods, toys and games, jewellery and watches, handbags and luggage, recorded music, spirits and wine, pharmaceuticals, pesticides and now smartphones have provided coherent estimates of the size of the problem of counterfeiting for legitimate businesses. These studies have used a common methodology and demonstrated the benefits of working in cooperation with stakeholders to take advantage of their knowledge of market conditions, while relying on official, reputable sources for the analysis.

The eleven sectorial studies published to date will be followed in the coming months by other similar studies covering additional sectors, applying the same methodology and combining it with knowledge from industry, depending on availability of data.

In parallel, the Observatory has carried out a joint study with the Organization for Economic Cooperation and Development (OECD) to estimate the value of counterfeit and pirated goods in international trade. That study, published in April 2016, estimated the value of international trade of counterfeit goods in 2013 at 338 billion EUR (USD 461 billion) globally, corresponding to 2.5% of world trade. The corresponding figures for the EU were 85 billion EUR (USD 116 billion), representing 5% of EU's imports from the rest of the world.

Taken together, these studies complement each other and provide a complete and objective picture of the impact of IPR infringements in Europe and beyond, in order to help policy makers develop effective enforcement policies.

ITU is addressing the growing problem of counterfeited telecommunication/ICT equipment and devices, which is adversely affecting all stakeholders in the ICT field (vendors, governments, operators and consumers)[25]. The ITU-T Study Group 11 (Q8/11) on *Guidelines for implementations of signalling and protocols, and for addressing counterfeited ICT devices* is working on this issue together with other ITU study groups as well as with regional and international bodies concerned with counterfeiting. A *Technical Report on Counterfeit ICT Equipment* was published in December 2015 addressing the nature of the issues related to the counterfeiting of ICT equipment and devices, a review of the international conventions covering this type of infringement of IPR and the activities of organizations in the enforcement of these rights. This report also provides a description of a variety of means to combat the trade in ICT counterfeit products, and a description of national and regional initiatives to combat the counterfeiting of mobile devices.

25 - ITU Activities to combat counterfeit ICT Equipment - http://www.itu.int/en/ITU-T/studygroups/2013-2016/11/Pages/counterfeit.aspx

ITU has also initiated the development of a normative Recommendation on *"Framework for solution to combat counterfeit ICT Devices"* to describe a reference framework and requirements to be considered when deploying anti-counterfeiting solutions.

Finally, ITU is working with OECD on a case study on trade in counterfeit ICT goods, building on the joint EUIPO-OECD 2016 study on trade in counterfeit goods. The aim of the case study is to improve decision-makers' understanding of the nature and scale of the trade in counterfeit goods in the ICT sector. The study will be published in the first half of 2017.

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THE ECONOMIC COST OF IPR INFRINGEMENT IN THE SMARTPHONES SECTOR