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ICTs' Spatial Diffusion Waves

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ICTs' Spatial Diffusion Waves

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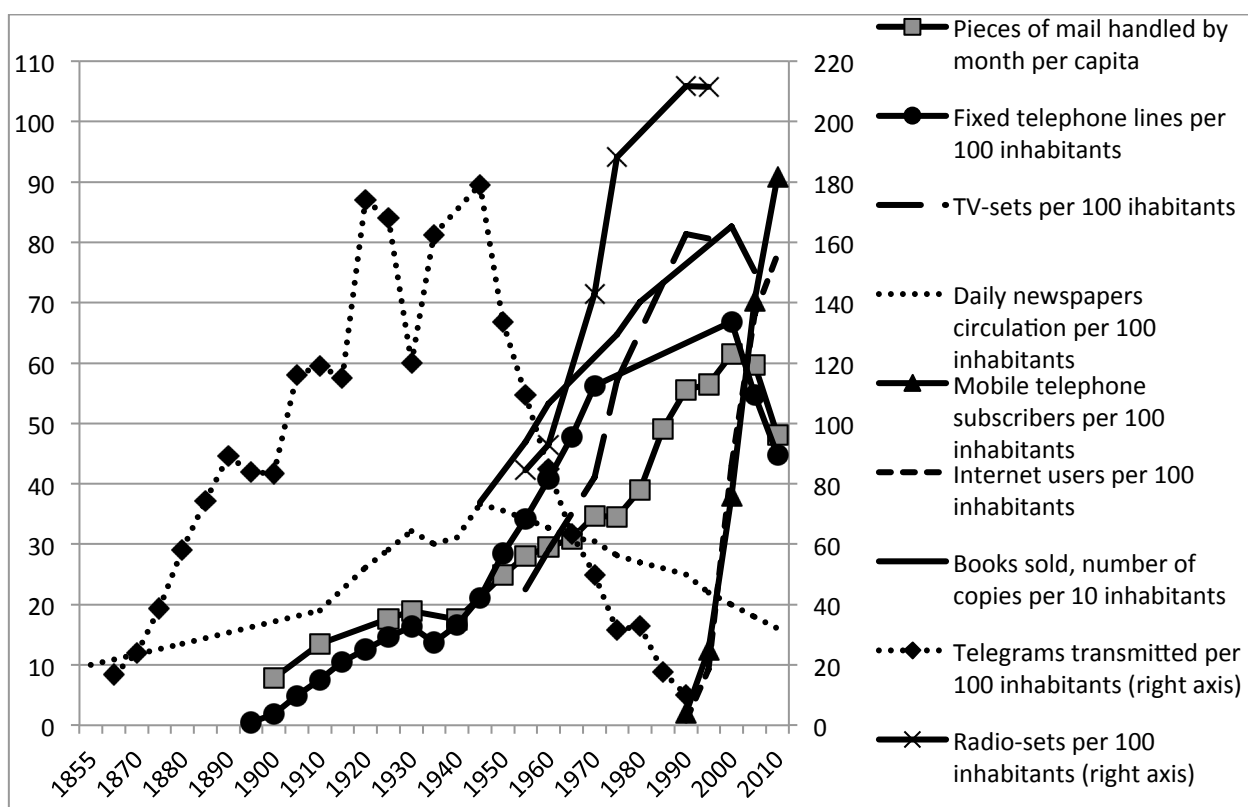
Spatial diffusion of information and communication technologies (ICTs) is a global continuous accumulative process. But is it uniform or cyclic? Is it possible to skip some of its historical stages? What is a specific feature of the modern stage? Are there any patterns of ICTs interaction? And how do different ICT innovations work on globalization? To answer these questions a study has been undertaken based on official statistics on ICTs global penetration and traffic flows (print press, postal service, telegraph, telephone, radio, television, mobile phone, Internet) received from governments (including USA and Russia) and international organizations (ITU, UN, etc.) covering the period of the latest 20—150 years.

1. Innovation waves in the field of ICTs

Obtained graphs shown that ICTs development and spatial diffusion are wave-like in the long term. ICTs diffusion waves could be seen at the Fig. 1, where results of the investigation on life cycles of different ICTs are presented by the example of the USA.

The telegraph – an ICT innovation, which started the epoch of the instant transmission of information through a distance, – now has finished its sesquicentennial history in the USA and many other countries of the world. The decline of the telegraph's role was mainly caused by a competition with other telecommunications: telephone and telefax in the beginning and the Internet's e-mail and mobile phone – at the final stage. In 2006 the main American telegraph provider – Western Union – stopped maintaining telegraph services. The same processes are under way all over the world. In Germany international telegrams reception was stopped in 2001, in the Netherlands the telegraph service was closed in 2004, in Australia – in 2011, in India – in 2013, etc.

In the fixed telephone's life cycle a growth stage lasted in the USA and in the whole world from the end of the XIX to the end of the XX centuries. Approximately since 2000 a dramatic reduction of telephone traffic volumes and network density has started. It was caused by a mobile telephony expansion, which just in 5 years has reached the same level of a network density as the fixed telephony – in more than 100 years. It indicates a tendency of shrinking ICTs' life cycles or their separate stages in the modern age, a tendency of rising dynamics in ICTs diffusion.



* 1855-1910 rr. – telegrams transmitted by Western Union; 1920-1970 rr. – telegrams transmitted by all the telegraph companies of the USA.

Figure 1. ICTs life cycles by the example of the USA, 1855–2010.

Statistics source: U.S. Bureau of the Census, 1901–1994.

A publishing industry in the 2nd half of the XX century has been demonstrating a divergence. On one hand a newspaper has entered the decline stage of its life cycle more than a half a century ago. A reduction of daily newspapers circulation per capita started in the 1950s due to the diffusion of radio and television, and in the 1990s and especially in the 2000s it redoubled by the competition with the Internet, which drew away the most part of advertisement. By the end of the XXI century's 1st decade newspapers in the USA have entered a crisis stage. Daily newspapers circulation per capita has reached the level of the beginning of the XX century. On the other hand, while newspapers circulation has been falling, a number of books sold kept rising and reached its maximum in the USA at the turn of the XX and XXI centuries. However today already all paper information storage media are being actively replaced by their electronic analogs (web versions of newspapers and e-books) in the framework of the process of traditional ICTs digitalization. Thus, it could be stated that the "Guttenberg age" – the era of paper information storage media launched by the printing press invention in the middle of the 1440s – has entered a postindustrial stage of its development.

Traditional postal communication for a long time has managed to keep a competitive niche of the most mass and the cheapest kind of telecommunications. Correspondence volumes have been constantly growing in the USA and in the world as a whole until the beginning of the 1990s. In the end of the XX century, with a development of the Internet, e-mail, e-banking, e-government and other e-services, the traditional post in the USA and globally went into stagnation, and since the mid-2000s postal correspondence volumes started decreasing, multiplied by the global financial crisis of 2008.

Thus, every innovation in the field of ICTs, once being invented and passed by the period of a rapid quantitative growth and geographical expansion, at a certain moment reaches a peak in its development. Then its life cycle gets into a decline stage, until the full innovation disappearing in some cases. As a rule, it is caused by a displacing pressure of new innovations – more efficient and competitive, better incarnating the spirit of time.

2. Spatial effects of ICTs interaction, competition and convergence

Yet in some cases old innovations slow down the diffusion of new ICTs. For instance, in the USA the early launch of analog cellular networks in the beginning of the 1980s and longtime underestimation of digital standards have negatively effected the further development of the mobile telephony. It is one of the reasons for a comparatively low level of cellular network density in the USA today (less than 100 subscribers per 100 inhabitants). Another example – a holding effect on the Internet development in France in the 1990s of the “Minitel” – big national information network already existing at that time (Castells, 2000).

Moreover, detailed analysis of the mobile telephony expansion in correlation with the fixed telephony and the Internet revealed the following facts. First, when waves of different ICT generations overlap, a “resonance effect” appears caused by the inertness of the ICT infrastructure: large investments of the past decades slow down the further innovation processes (Mogilevkin, 2010). It is more typical for developed countries. For example, relatively high initial level of fixed telephone penetration (more than 50 telephone lines per 100 inhabitants in the beginning of the 1990s) is the main reason for relatively low paces of mobile telephony growth in comparison with the most of developing countries. And in the countries with an underdeveloped fixed telephony network there was almost no infrastructure inertness, and expansion of the new ICT – cellular phone – started almost from green field. It is the main cause for its great dynamism. For example, in 1990 a level of telephone penetration in Russia was rather low in comparison to developed countries and the world average level (14 telephones per 100 inhabitants in Russia, 35/100 – in the world and 70/100 – in Sweden). However, thanks to the rapid mobile telephony diffusion in the beginning of the XXI century just within a decade

Russia has made a mighty heave, has overcome Sweden and many other countries and has become one of the world leaders by the integrated telephone penetration level (Fig. 2). The same achievements have been demonstrated by Argentina, Dominica, Panama, Surinam, Ukraine, Romania, Albania, Saudi Arabia, Oman, and Maldives.

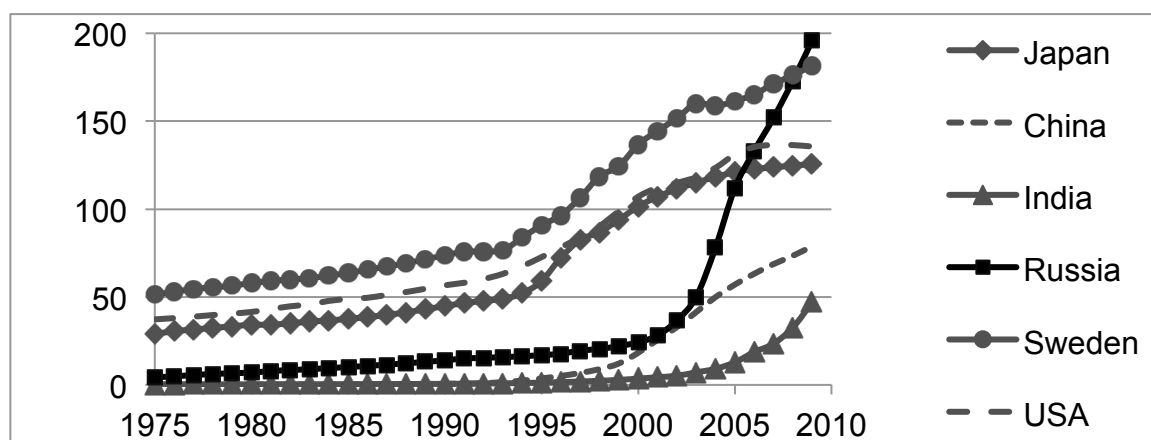


Fig. 2. Fixed and mobile telephone subscribers per 100 inhabitants, 1975—2010.

Statistics source: International Telecommunications Union, 2011

Thus, secondly, some stages of ICT development can be skipped, and developing countries can even implement the “overcoming” scenario of a catching-up development through the advanced ICTs development. For instance, the following stages can be skipped: fixed telephony and mass computerization¹. It is illustrated at the Fig. 3, where results of analysis of different ICTs penetration per 100 inhabitants are presented. Generally, the higher a country’s level of socio-economic development, the more diversified and balanced its telecommunication infrastructure. Therefore, in highly developed countries of the global Core² the Internet, fixed and mobile telephony and mass media are equally and evenly diffused (Fig. 3A). In the Semi-periphery countries misbalances occur, formed by an exaggerated development of the mobile telephony in comparison with the other ICTs (Fig. 3B). And in the Periphery countries the

¹ It could be seen from the experience of some countries (Argentina, Jamaica, Azerbaijan, Albania, Iran and others), that for reaching relatively high indicators of Internet penetration a high level of households’ computerization is not necessary. In developing countries and regions, due to a poor fixed infrastructure development and a low level of population revenues, a role of a personal device for the Internet access has been taken by a mobile phone instead of a computer.

² According to the Core-Periphery theory, the following countries belong to the Core of the world economy: USA, Canada, European Union, Japan, Australia and New Zealand, Singapore and Israel. The Semi-periphery is formed by the East European countries, Russia, Ukraine and Belarus, China and India, new industrial economies of Asia and Latin America, and also Turkey, Saudi Arabia and South Africa. And the majority of countries of Africa (except South Africa), Central Asia, Middle East, Central America and the less developed countries of the South America create the Periphery of the global economy.

domination of one or two ICTs is most significant (Fig.3C). Thus, the newer and more universal ICTs can compensate for the lack of preceding telecommunications diffusion.

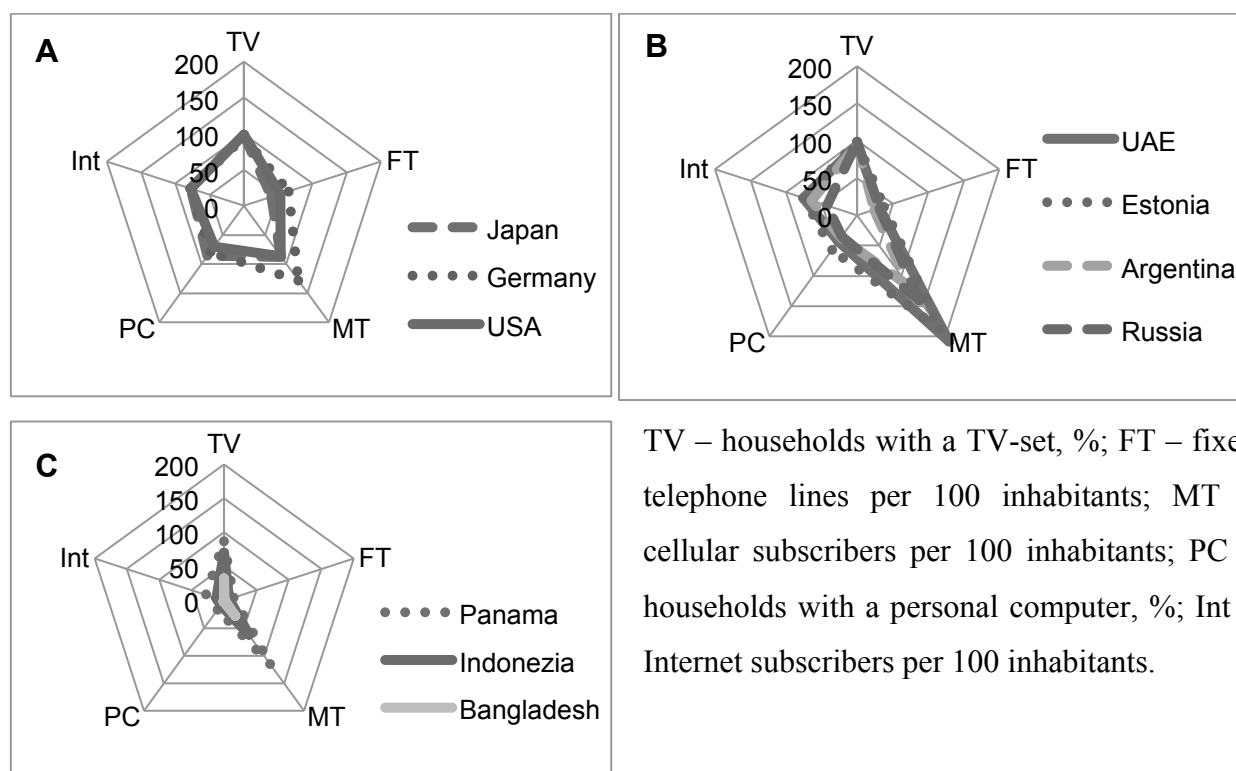


Fig. 3. Telecommunications infrastructure types, 2008—2010.

Source: Own elaboration on the basis of International Telecommunications Union, 2011

Specific feature of the modern Digital Age is ICTs convergence. The Internet absorbs the functions of other telecommunications (traditional press, postal service, telephone communications, television, etc.) and becomes a universal information and communication platform, which is a result of ICTs convergence. A key principal of the global telecommunication system which is under formation today is a principal of a universal network. The universal network infrastructure is being developed for storage, processing and transmission of all kinds of information, with universal canals for information transmission and universal data centers. As a result, an integrated universal system of global digital communications is being developed on the Internet basis. It is an outcome of the modern globalization age, just as the telegraph formed the first global information network in the epoch of the early globalization (the end of XIX – the beginning of XX centuries).

3. Globalization and international communicative openness of countries

There is a wide spread idea, that today the world is globalized and integrated as never before. However, globalization, as well as informatization, arises in the XIX – beginning of XX centuries, in the period of the first wave of humanitarian globalization (1846—1913) or the

“golden age” of international economy (1870—1913). At that time the world economy was hardly less integrated than today, and the globalization process was developing with even higher pace in 1870—1913 than during the last 40 years (Sintserov, 2004). The key role in its development was played by “the Victorian Internet” – the telegraph – an innovation in the ICT sphere, which opened the epoch of direct communication “at the speed of thought” and started “dematerialization of long-distance information flows” (Standage, 1998; Wenzlhuemer, 2012). For the international economy a shift from windships, which previously had been delivering goods and information, to steamships and the telegraph was a revolution. It has made a breakthrough in a global system of a commercial information exchange, formed a global market, and an integration effect from the information space shrinkage was instant and unprecedented by scale. Later, after the period of the global disintegration (1914—1945) the second wave of the world integration began. Then, since the 1980s, under the influence of scientific-technical and information revolution, a globalization period has begun, the key component of which is the global information society formation.

In the modern age communication and information opportunities of individuals and society as a whole have increased billion times. Geographical space and time have shrunk more than ever. New ICTs enable information – a key resource of the modern world – to overcome easily any physical barriers and state boundaries. Thus, ICTs form the global information space, where from every place on the Earth it is possible to communicate with any other place. But do people fully use international opportunities provided by the newest ICTs? And are there any differences between countries and regions in this sphere?

The analysis of the global telephone traffic (fixed and mobile), covering 158 countries (International Telecommunication Union, 2011), and global letter-post traffic, covering 154 countries (Universal Postal Union, 2011), proved that the average level of a country’s ‘communicativeness’ is largely determined by the level of its socio-economic development (Fig. 4). The higher a country’s development level is, the more actively telecommunications are used. In general, in highly developed countries with a GDP per capita of 20,000–35,000 USD an individual makes 3,340 minutes of telephone calls a year and sends 172 postal letters a year. In countries with a GDP per capita of 10,000–20,000 USD a person talks half as much (1 500 minutes a year) and sends almost 3 times fewer postal letters (62.5). In states with a GDP per capita of 5,000–10,000 USD a person talks 3 times less by telephone (1,040 minutes) and sends 5 times fewer letters (35 letters). And in countries with a GDP per capita of less than 5,000 USD an average person talks 6 times less by a phone (570 minutes) and sends 14 times fewer postal letters (12 letters a year).

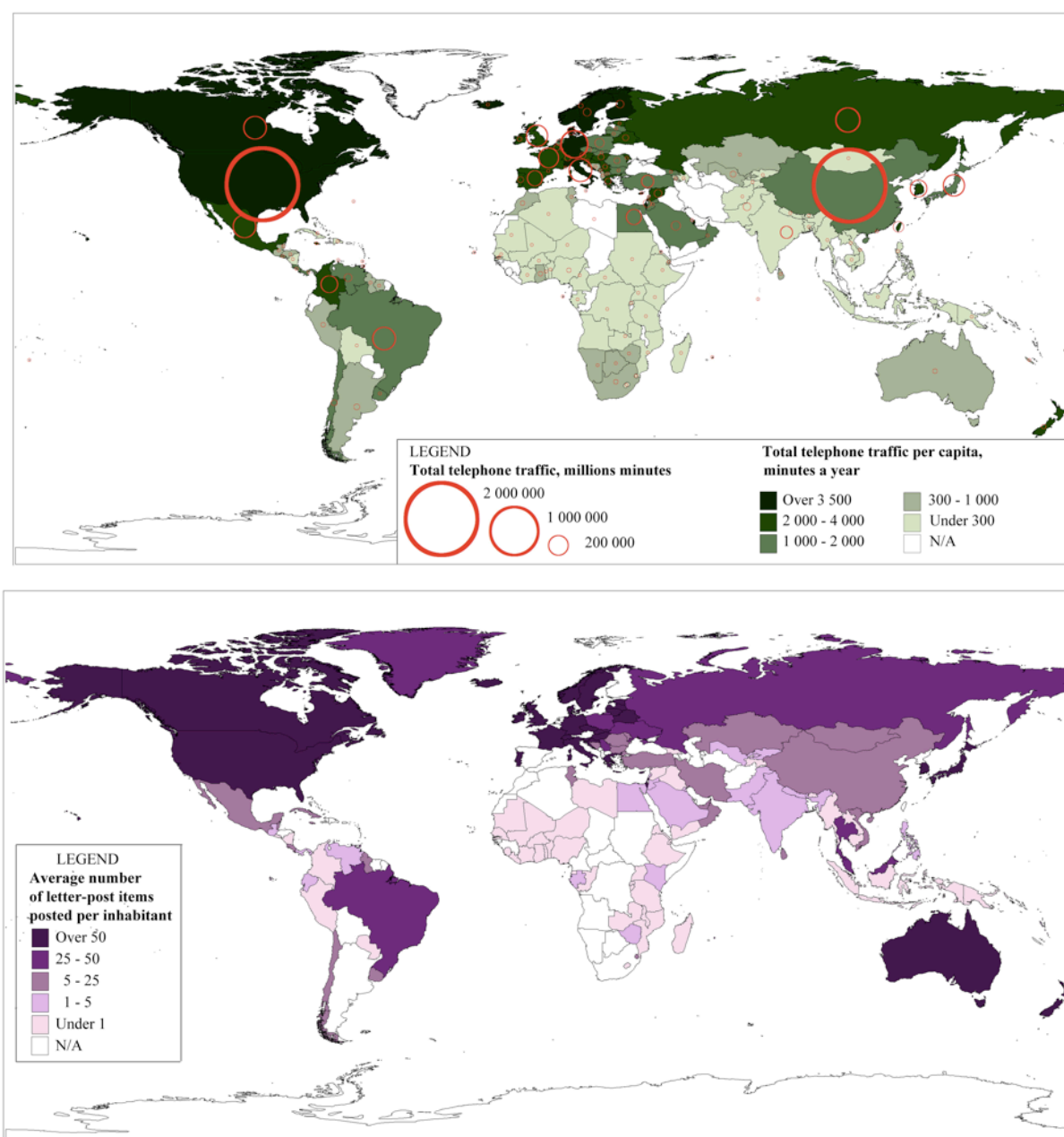


Fig. 4. Telephone and postal communicativeness by country, 2007/2011

Source: Own elaboration on the basis of International Telecommunications Union, 2011; Universal Postal Union, 2011

Thus, we can see that the global gap in telecommunications usage shrinks when going from traditional to the newest kinds of telecommunications. This is another proof for the fact that the newer and more universal ICTs can compensate for the lack of diffusion of telecommunications previously and make the global information space more uniform (Nagirnaya, 2013).

International traffic flow analysis could help to assess the level of a country's integratedness in the global economy and the world socio-economic space in terms of information interactions. As an important indicator of international communicative openness, the

share of international traffic in the total traffic volume has been defined and studied by the example of telephone and postal traffic flows (Fig. 5).

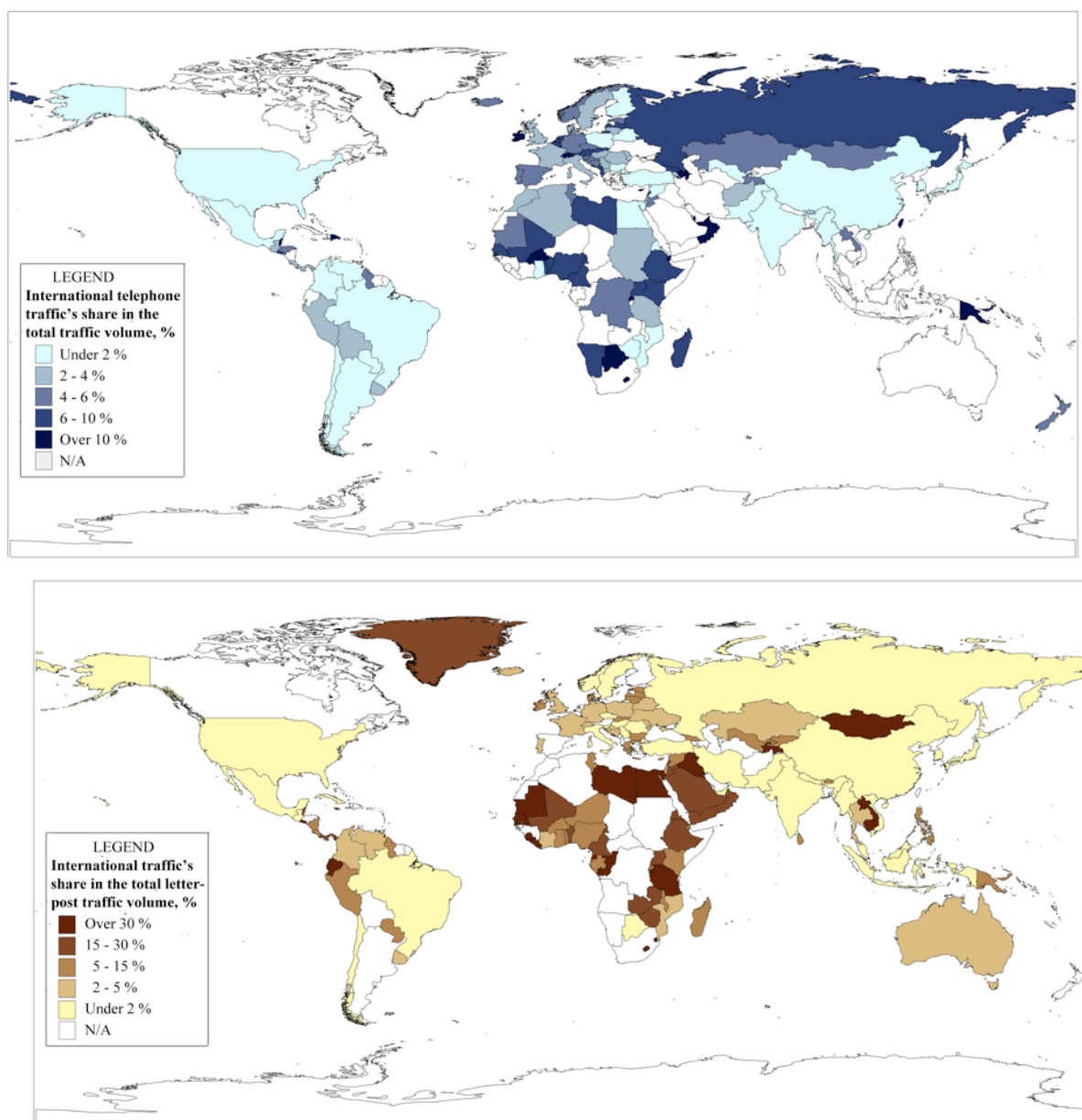


Fig. 5. International communicative openness of countries, 2007/2011

*Source: Own elaboration on the basis of International Telecommunications Union, 2011;
Universal Postal Union, 2012*

It has been found that the lowest level of 'telephone openness' is typical for big developing countries – China and Brazil, where the share of international traffic is just 0,2%. The comparison between China and Taiwan revealed interesting contrasts: these territories have comparable total volumes of the outgoing international traffic (5—6 billion minutes per year), however, if in China its share in the total traffic is only 0,2%, than in Taiwan – more than 10%, and in Hong Kong it reaches 32%. In Russia 7% of telephone traffic is international. It is caused by historical relations with the former USSR states and by a high share of migrants from these

countries in the population of Russia – 8,5% (in Brazil and China immigrants' share in the population is less than 0,3%).

'Telephone openness' reaches its highest levels in small and micro economies, many of which are islands. For example, in Sent-Vincent and Grenadines 76% of telephone traffic is international, in Dominican Republic and Djibouti – 52–53%. Among the microstates with high international traffic a special attention should be paid to “tax harbors” – offshores with hypertrophied international specialization. The examples of tax harbors, besides the highly mentioned Sent-Vincent and Grenadines, are Bermuda Islands, where the share of international traffic is 49%, Belize – 25%, etc. The high international openness is often usual for small countries with a specific geographic location (Lesotho (28%), Rwanda (39%)), and also for a number of less developed countries with a big territory and poor infrastructure, and, as a result, with small volumes of domestic traffic (Mauritania, Ethiopia, Mali, Madagascar). Among the less developed countries the lowest share of international traffic is typical for closed economies, such as Myanmar (0,3%).

Based on the comparison between telephone and postal openness, we can say that generally the global disparities in the level of international communicative openness are similar for different kinds of telecommunications³. In general the international communicative openness of a country is determined by the economic and demographic size of a country, the level of its socio-economic development and the type of its political regime, and also by the level of its involvement in the international division of labour and in international migration and investment processes (Table 1).

According to the conducted statistical analysis, in the modern world only 4% of the global telephone traffic is international, so 96% of traffic is domestic (Fig. 6). It is an important feature of the organisation of global information, social and economic space. However, the telephone traffic dynamics over the first decade of the 21st century shows that the international traffic volume grows at priority rates, and its share in total telephone traffic is increasing in a majority of countries⁴.

³ However, there are some exclusions. Some countries have a high level of telephone openness, but a low level of postal openness (Russia, Botswana); other counties have a low level of telephone openness, but a high level of postal openness (Egypt, Mongolia, Tanzania, etc.).

⁴ It shall be noted that international voice traffic migrates actively from the fixed and cellular networks to the Internet telephony (IP-telephony), which has been developing rapidly during the 1st decade of the XXI century. In 2000 just about 3% of the global international voice traffic was realized by the IP-telephony, and in 2010 – already 27%, including 12% - by Skype. According to the forecasts, systems like Skype will become the main mean of international voice traffic translation by 2015 (Telegeography Research, 2012).

The structure of the world's traditional letter post is similar: only 1,3% of it crosses international borders (Fig. 6, 7). The volume of international mail is decreasing at the global level: from 8,7 billion letters in 1980 to 8,5 billion in 1990, 7,5 billion in 2000 and 4,7 billion letters in 2011 (Universal Postal Union, 2012). The regions resisting this trend are Latin America and the Caribbean and Asia-Pacific. The share of international letters in the total number of letters has reduced more than two-fold over the period of 1980-2008: from 2,8% to 1,3%.

Table 1. International openness determinants.

	International traffic's share in a total traffic, %		Ratio of goods export to GDP, %, 2007	Immigrants share in population, %, 2006	Cumulative foreign direct investments per capita, thousands USD, 2009
	Telephone traffic, 2007	Letter-post traffic, 2011			
USA	1,2%	1,3%	8%	13%	10
Japan	1,6%	0,3%	15%	1,6%	1,6
Germany, UK, France, Italy	3-5%	1,6-2,5%	15-30%	4-12%	7-18
European small countries *	5-15%	2-23%	30-70%	7-37%	24-226
European microstates **	22-38%	58-63%	160-180%	35-77%	N/A
World	4%	1,3%	25%	9%	2,6

* Sweden, Norway, Switzerland, Ireland, Belgium, Netherlands, Luxembourg

** Andorra, Monaco, Lichtenstein

Sources of data: International Telecommunications Union; Universal Postal Union; CIA World Factbooks; World Bank; United Nations; International Monetary Fund; the author's calculations.

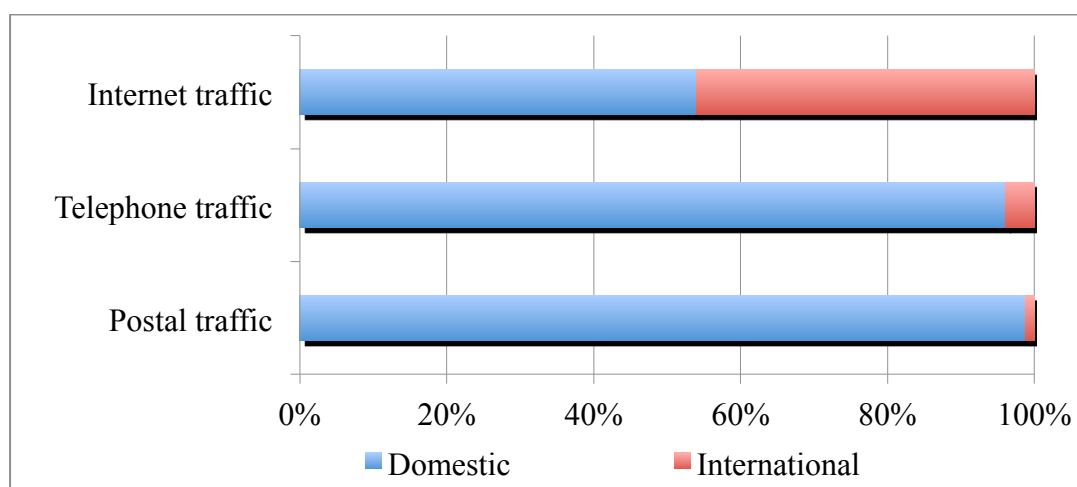


Fig. 6. The share of international traffic in the total global traffic volume by different types of ICTs by the end of the 1st decade of the 21st century

Source: Own elaboration on the basis of Telegeography Research; Sisco; International Telecommunications Union; Global Postal Union

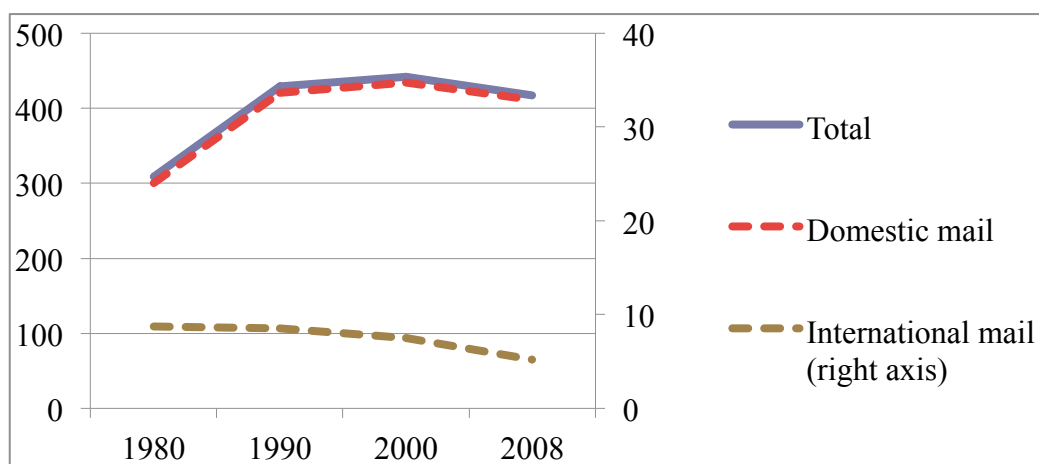


Fig. 7. Number of letter-post sent, thousands of millions, 1980-2010

Source: Own elaboration on the basis of Global Postal Union

Other trend has been discovered for the Internet traffic flows. Over 46% of global Internet traffic is international (Fig. 6, 8) and its share is growing rapidly⁵. Moreover, the spatial structure of the international Internet traffic is changing very fast. The share of regional traffic – traffic flowing within the borders of a macroregion – is constantly growing, and today it makes up more than three quarters of total international traffic. For example, 75% of European international Internet traffic flows within the regional borders (it is the highest value among all the world regions); in Asia and Latin America – about 30%; North America – 15%; in Africa – near 1% (Telegeography Research, 2011).

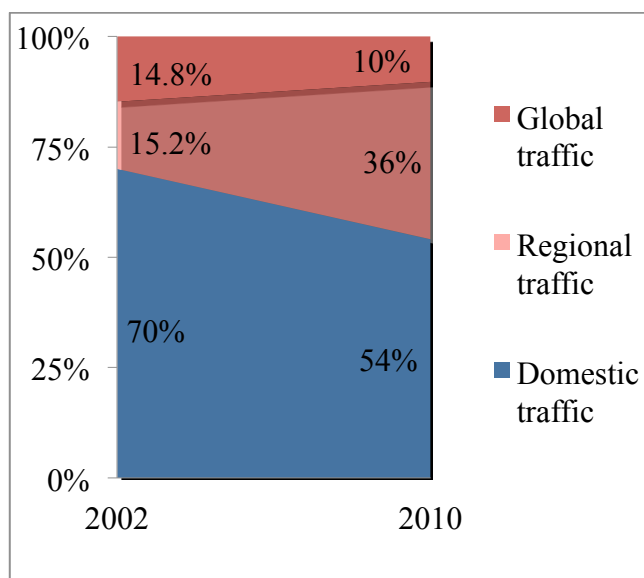


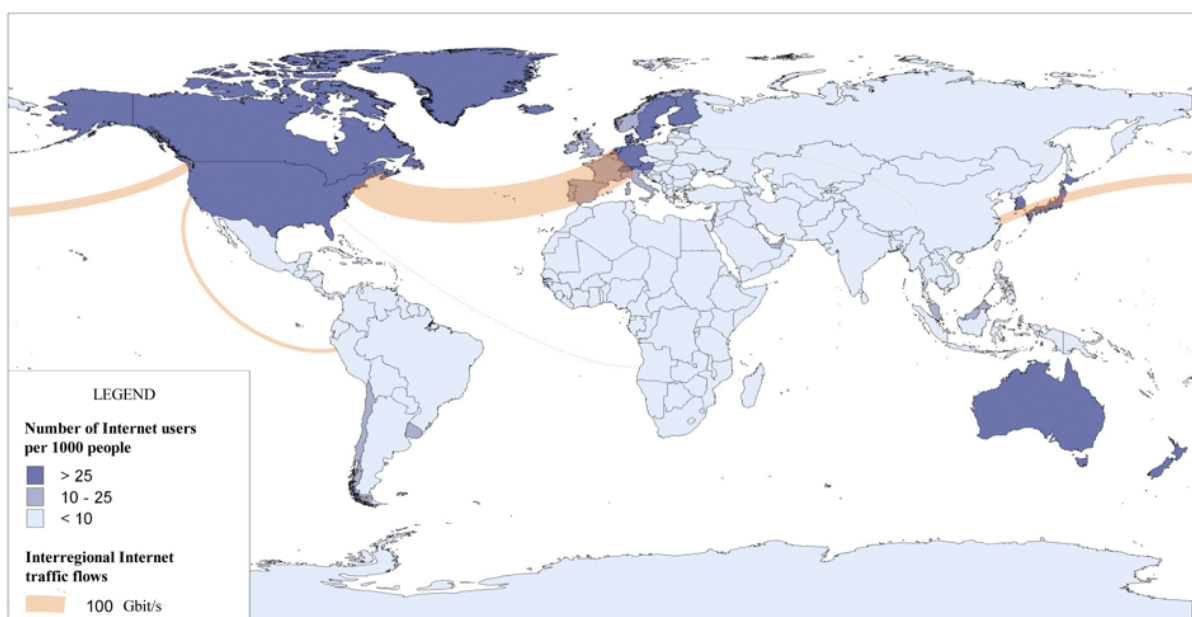
Fig. 8. Shifts in the global Internet traffic structure over the first decade of the 21st century

⁵ In the global Internet traffic structure video dominates (more than 50%), and according to Cisco forecast, its share will reach 90% in 2014.

Source: Own elaboration on the basis of Cisco, 2012; Telegeography Research, 2012; the author's calculations

The share of the global (i.e. interregional) Internet traffic has decreased more than two-fold over the last 10 years. While at the turn of the 20th and 21st centuries half of international traffic circulated between different macroregions of the world, today it is less than a quarter. It was caused by a high concentration of the global Internet infrastructure: initially all the technical capacities for storage and creation of web sites were situated in the USA. However, it generated the obvious threat to the information security of other countries and regions. In 2001 the European Union published a Report on the ‘Echelon’ system of information interception, which belongs to the USA (90%) and also the UK and Australia. After the publication of the Report, European and other countries started taking measures to ensure their information security, and in particular to direct their Internet traffic routes in such a way as to avoid the USA. As a result, over one decade a great decentralisation of the global Internet infrastructure happened. In all the regions except Latin America the share of international Internet bandwidth connected to the USA has declined significantly.

Nevertheless, the USA remains the hugest intercontinental Internet hub today. As at the end of the last century, the largest interregional traffic flow connects North America and Europe (Fig. 9). However, the share of this route is decreasing rapidly. If 10 years ago it composed almost three quarters of all the interregional Internet bandwidth, then now it is already only 39%. It is caused by the rapid growth of other traffic routes: North America – Latin America (22% of total interregional Internet bandwidth); Europe – Asia-Pacific (10.7%); and North America – Asia-Pacific (22%).



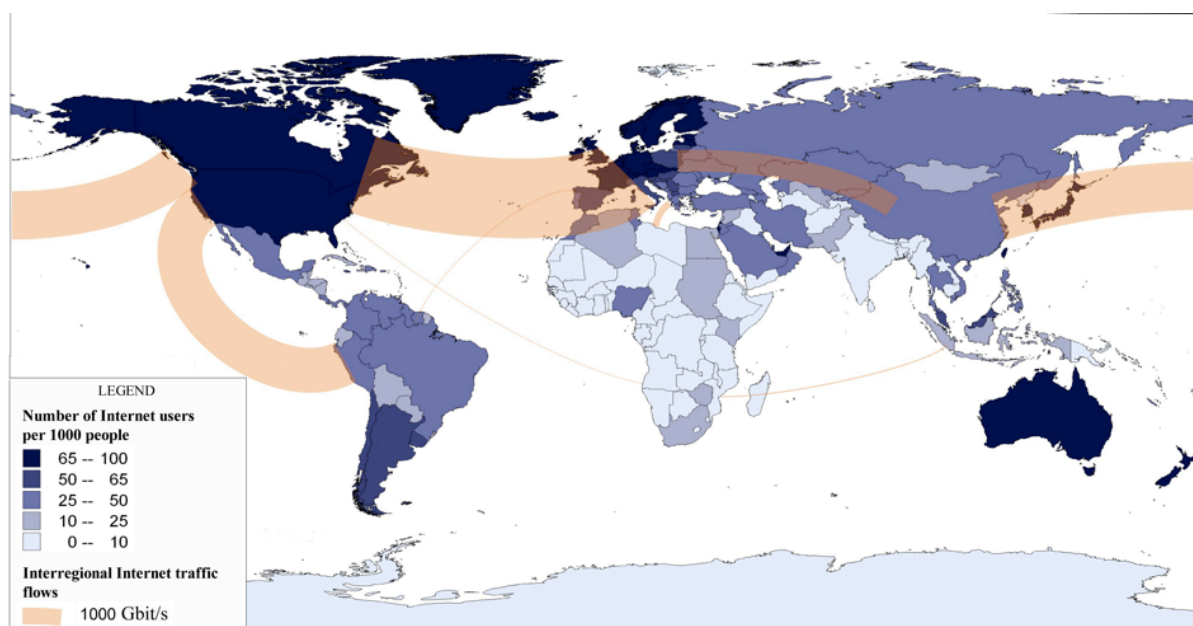


Fig. 9. The global Internet diffusion and the largest interregional Internet traffic routes, 2000 and 2011

Source: Own elaboration on the basis of International Telecommunications Union; Telegeography Research; <http://www.InternetWorldStats.com>

Conclusion

The study has shown that ICTs diffusion is wave-like in the long term. New innovation waves accelerate the decline of the old ones. But in some cases, when waves of different ICT generations overlap, a “resonance effect” appears caused by the inertness of ICT infrastructure. Through advanced ICTs development it is possible for developing regions to skip some stages of informatization and even implement the “overcoming” scenario of catching-up development.

Specific feature of the modern stage is ICTs convergence: an integrated universal system of global digital communications is being developed on the Internet basis. It is an outcome of the modern globalization age, just as telegraph formed the 1st global information network in the early globalization epoch.

According to our analysis, each next generation of ICT innovations provides more international communicative openness (defined by a share of international traffic in a total traffic volume). In the modern world only 4% of the global telephone traffic is international, just 1% of the traditional postal mail crosses international borders. Another trend has been discovered for the Internet traffic, 46% of which is international, and this share is growing rapidly. The last point is largely caused by the multicomponent structure of the Internet traffic, special features of the World Wide Web organization and the territorial gap between producers and users of the Internet content⁶. Nevertheless it reflects clearly that when moving from traditional to the newest

⁶ Today the majority of the Internet users are from developing countries (more that 60%). However, more than 62% of all the web sites (country code Top-Level Domain) belong to the

ICTs, a spatial scale of communication grows from mostly local to international. The obvious trend of the latest decades is a rise of the international traffic's share in communicative interactions conducted by the newest telecommunications, and a decline of the international traffic's share in traditional ICTs' traffic flows.

Despite the unprecedented technical opportunities for global communication, modern people still use ICTs mostly for communication with their relatives, friends and colleagues, who live in the same city and with whom they interact regularly face to face. However, there are significant global disparities in 'telecommunicativeness' and international communicative openness of countries. They are caused by a number of factors: socio-economic, administrative and geographic.

This study expands the understanding of ICTs diffusion process, presenting it in a long term and in an integrated manner, and its results could be important for informatization policies and strategies elaboration.

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USA, and more than 87% web sites – to the developed countries as a whole. Thus, despite the rapid shrinkage of the quantitative gaps in the Internet penetration between developed and developing countries, the qualitative gap still remains. There is still the developing countries' dominance in the sphere of the Internet content creation

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