THE IMPACT OF OPEN SOURCE SOFTWARE ON KNOWLEDGE-BASED GROWTH IN DEVELOPING ECONOMIES

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Abstract

This paper examines the importance of free, libre and open source software (FLOSS) for the economic growth of developing economies. A valuable and farsighted investment into economic growth, knowledge can greatly benefit the developing economies. In order to achieve knowledge-driven growth, open source standardization and participation in the FLOSS community of developers are advised. The various benefits FLOSS offers to developing economies are considered. Recent best practices from the developing World are offered. Finally, in order to understand why some countries in the developing world are switching to FLOSS, while others maintain the safety net of commercial software, the various impediments to FLOSS standardization are proposed.

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INTRODUCTION

Free, libre and open source software (FLOSS) is all software that is licensed to give users the right to freely use and redistribute it. Further, its license allows modifying the source code in order to make adjustments, fix problems, customize or even resell the modified versions of it. The acronym FLOSS was invented in 2001, in order to unite different types of understanding of this particular concept of software under one non-politicized term. Although free, libre and open source generally refer to the same thing these words tend to carry different ideological meaning. Free and libre are two alternative terms associated with the same concept of freedom in software use. Free software is a concept proposed by Richard Stallman, the founder of a free Unix-like operating system GNU, that has given ground for the later creation of Linux. "Free" here refers to the philosophical freedom this software should provide; in contrast, "open source software focuses on the perceived strengths of its peer-to-peer development model" (Shampton, 2009; p.1). Thus, the word "open" reflects the way this software is created, while "free" represents the freedom in its use. The acronym FLOSS was later picked up by the European Commission in their studies on open source and was also generally accepted in academic research. Whatever the term used to define it, software that is open to use, distribute and modify remains a valuable contributor to the world economic activity. The most prominent examples of FLOSS are Linux-based operating systems, Mozilla Firefox web browser, LaTeX free document markup language, Open Office, as a free alternative to the Microsoft Office, etc.

The reason we have chosen to compare and contrast FLOSS to the Windows operating systems (OS) and software, rather than any other proprietary software alternatives, as for instance Mac OS, is that Microsoft dominates the desktop operating systems market by far with its 93%

against Mac's 6% (see Figure 1 below). Mac offers a high level of technical efficiency; however, its price is also significantly higher than the Windows OS and cannot be considered as a low-cost solution for the developing countries. It is also not as widely subject to piracy and its document formatting cannot be seen as a generally accepted standard.

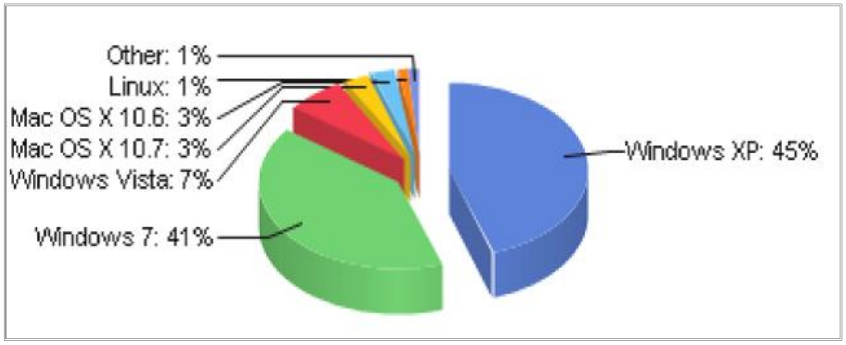

Figure 1. Desktop Operating System Market as of May 2012. Source: NetMarketShare.com

In line with the endogenous growth model, which states that economic growth is the result of internal changes in the economy, like investment into human capital, innovation and knowledge, that alter the economy's level of production and by this also affect the economy's growth rate (Kohn and Marion, 1988), it will be argued in this thesis that FLOSS constitutes a valuable low-cost policy solution for boosting knowledge-based growth in the developing economies.

Specific cases will demonstrate that the developing countries are already switching to open source software, which is in many respects more beneficial compared to the proprietary software for such countries (Story, 2004). The selected cases will show the extent of savings provided by the adoption of FLOSS, the fall in piracy that may in part be a result of FLOSS deployment in the given area, and the overall participation in software development from the side of the given developing countries. The strengths and the weaknesses offered by FLOSS will be examined from the scope of their possible impact on the developing nations. The considered

benefits include cost reduction, compliance with the world intellectual property standards and a number of technical characteristics that prove to be beneficial to the developing countries.

A separate section will discuss the limitations of FLOSS and the common stepping stones to its mass deployment, be it technical complications for the developers, or the fact that open source software is losing out to the proprietary software vendors in the field of entertainment. Some of the reasons for proprietary software's lock-in will be proposed, such as information asymmetry in the desktop operating systems use, switching costs associated with FLOSS deployment, network effect in the generally accepted proprietary document format, etc.

Policy recommendations that can help the developing world diversify away from proprietary software and better realize growth based on skilled labor capital will conclude this paper.

CHAPTER 1: The Value of Open Source Software

Among the key factors to motivate the developing countries to choose FLOSS are its cost-reducing character, the anti-piracy campaign and security concerns. The cost factor stands out by far, as proprietary software prices are rather high when considered from the standpoint of the average incomes of people in the developing world (Rajani, 2003).

The reduction of cost is tied to the type of licensing that comes with FLOSS, a legal standard that ensures faster generation of innovation, sharing the modifications and ease of use. Able to download the software for free, schools in India, government bodies in Africa, and many other countries in the developing world, are ensuring an almost costless spread of technology throughout their economies.

Moreover, FLOSS can serve as a means of fighting software piracy in the developing world. Anti-piracy campaigns can, in fact, stimulate the adoption of FLOSS. Being less capable financially to pay for the licensed software, and at the same time willing to omit legal prosecution in case of pirated content use, small enterprises, NGOs and government institutions are beginning to opt for the open source software.

In terms of security FLOSS is argued to have major superiority over proprietary software (Payne, 2002; Rajani, 2003; Aitbaev, 2004). Not only do the viruses designed for Windows not function on Linux, but also Linux operating systems are constantly updated in such a way that they are changing their characteristics, mutating so to say, every time they are updated. Consequently, a Linux-based operating system simply cannot “catch” a virus. Furthermore, commercial software is largely tied to the anti-virus business, which adds to the total cost of proprietary software use. Let us now take a closer look at the main factors to influence the

decision-making process market actors are faced with while choosing between commercial software and FLOSS.

1.1 The Cost Factor in Opting for FLOSS

The market model that is chosen for a product has major implications for the consumers' surplus. While the standard market production and development model produces a good and sells it to end users, the open source model allows publishing the source code, so that anyone can have access to it. Thus, anybody has the right to use the code, modify and redistribute it free of loyalties or fees. Not only does it lower the production costs of a good or a service, but it also provides property rights by means of effective licensing. Generally speaking, the FLOSS license allows the developer to take the source code that is open, modify, share it with the community and finally to claim intellectual property rights on the binary code. Both the speed of modification and the maintenance of property rights have prompted the public to agree that the open source operating systems: "increase social welfare by increasing the viability of such development efforts and thereby lowering prices" (Casadesus-Masanell et al, 2006; p. 1).

The FLOSS' legal structure is key in ensuring low cost. Once the code is generated and modified, be it with the help of individual programmers, or global companies, the general public license (GPL) requires all modifications to the source code to be shared with the open source society. This ensures faster software development compared to the regular market model used for the commercial software. While the source code is always open, binaries can be copyrighted and sold. Thus, the final consumer may, if the producer decides to charge him/her, pay for using the final good, but as the production costs are significantly lower than the non-open-source products' production costs, overall efficiency and technological progress of the society will grow at a larger

pace than under the standard business model. Hence, even if a fee is charged for binary software, its price will be considerably lower than the commercial software produced without the help of FLOSS, as the input taken to create it was smaller due to the free access to the source code.

The lower labor costs constitute another advantage for the developing world, as for these countries the costs associated with training or re-training users to operate FLOSS-based systems are not as high as they are in the developed countries. Thus, it takes comparatively little switching costs in order to adopt FLOSS.

1.2 Complying With the World Intellectual Property Standards

Software piracy remains one of the burning topics in the media to this very day. Its adverse effect on the software business should by no means be underestimated, as the current level of PC software theft is estimated at as high as $59 billion (BSA, 2010) annually. While the interested parties are trying to modify the legal framework in order to enforce intellectual property rights, the reasons for excessive piracy have to remain in the policy-makers' sight. Causes of piracy may be broad and diverse, and may vary from the mere availability and impunity of non-copyrighted software use, to the cultural trends promoting piracy in a given country. However, what is also important to note is that there appears to be a negative relationship between the average income per capita and the level of software piracy throughout the world (see Figure 2on the next page).

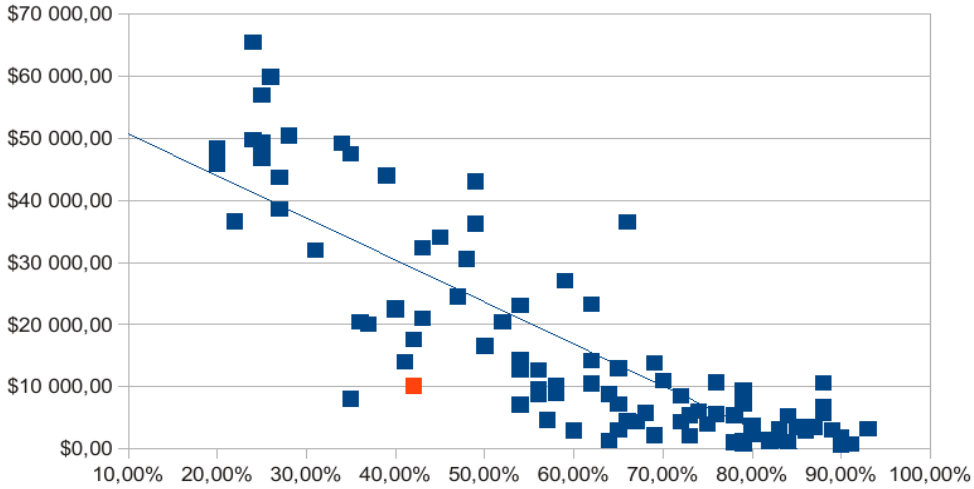

Figure2. Relationship between nominal income per capita and piracy rate in the selected 102 countries. Source data: International Monetary Fund (2011), Business Software Alliance (2010).

The most concentrated region on the Figure is where the piracy rate is above 50%, while GDP/capita is below the world average of $11 144 GDP/capita (represented by red on the Figure). Suffice to say, emerging economies now account for more than half the global value of PC software theft, which is $31.9 billion annually (BSA, 2010).

For countries with the highest piracy rates, namely Bangladesh, Indonesia, Armenia and Yemen, the average monthly salary is around $357 (see Appendix, Table 2), while the price of a licensed copy of Windows 7 is about $170. Buying a licensed copy of Windows would imply having to spend half of the monthly wage of an average citizen. Since average food expenses still take up half of the households' income (CivilEats, 2010), piracy appears to be a necessity for the given countries.

Piracy cuts down profits of companies by billions, which is exactly why FLOSS can help the developing world fight its dependence on software piracy. By switching from the pirated software to open source products, a user gets free regular updates to keep his/her operating system safe, and at the same time the global piracy levels go down. The penetration of open source into the developing countries may not boost the proprietary software use at first, however

in the long-run, diversifying away from the pirated software use may be beneficial to the global society. As the demand for pirated software goes down, pirated content supply has a larger chance of becoming obsolete.

Complimentary to the world open source user community expansion is the growth in the number of programmers ready to add to the development of FLOSS in these countries. Thus, not only does FLOSS allow for compliance with the Trade Related Aspects of Intellectual Property Rights (TRIPs) agreement, but it also facilitates the development of a local software community (May, 2006). This community of developers may be seen as a culture of IT intelligence, which FLOSS allows to learn by doing, by participating and ideas-sharing. As it will be argued in the following subsection, for the developing world FLOSS offers easy access to software development, which would otherwise require considerable starting capital to try oneself in software development. This is advantageous for the knowledge-based growth in these countries, as by participating in the FLOSS community of developers young professionals can learn the intricacies of the programming business and can also get their name known in the IT world.

At this point, it is important to mention how Open Source is generating profit and why thousands of developers choose to contribute to it. If FLOSS is free of charge, how then does it go in line with the capitalist market model that is our frame of reference today? Contrary to the impression one might get from its name, open source does generate considerable revenue. In line with the capitalist model, open source software developers are in general paid for their work, and FLOSS companies are also generating revenue. This is because FLOSS operates mainly through paid service provision, which includes customer support of both households and businesses, tutoring individual users, customizing software for specific use, and daily tech support. Individual programmers, on the other hand, have an incentive to contribute, because for them

FLOSS presents a way to make a portfolio to better the future employment opportunities and get their name known in the software development business. Mostly, however, developers are paid for their work, as for example, according to Linux Foundation's estimations, at least 70% of Linux operating system developers are on salary(as of Dec 2010). Moreover, there exist a number of Linux-based distributives that, just like Windows, are proprietary software. Their main advantage is in their lower price, mainly due to the fact that the source code used to generate the software is open and thus the costs involved in their development are lower. Its other advantage is in the speed of updating and bug-fixing, as the whole open source community is constantly monitoring and working on fixing any inconsistencies in the software. Apart from that, there are multitudes of funds that are sponsored by the leading corporations, not only as a publicity gesture, but also as an investment in research and development (R&D) in order to later be able to profit from the innovations generated by the open IT community.

1.3 The Technological Superiority Offered by FLOSS

FLOSS products can offer a number of benefits concerned with security, given that its technical structure is immune to viruses and is generally more efficient in RAM use. The open sourced Linux kernel started off at world-class research centers in 1991. Hence, its operating efficiency was chosen as the main target for improvement. Given the fact that Linux was initially designed for research, interface friendliness and availability of computer games were not in the developers' scope of interest. History insured that Linux, which took a non-commercial path and was used for research, was locked in that particular user-group of technicians and IT developers. Meanwhile, Microsoft concentrated on satisfying the needs of the general market, which meant making the desktop operating system user-friendly and providing a wide set of games to recruit the younger generation. This is how Linux ended up outrunning Windows in terms of efficiency, but losing

out on the desktop operating systems market, with its 1.43% (registered distributives only) of desktop users, against Microsoft's share of 83% (W3Counter, 2011). On the other hand, Linux's market share in the server sector is 71% compared to Microsoft's 16% (W3Counter, 2011). And in the field of supercomputers, machines used for massive data processing and research, such as probabilistic analysis and forecasting, Linux runs on 92% of machines, while Microsoft OS is no longer used to run the world supercomputers.

In terms of security, FLOSS-based operating systems do not have an auto-run, which means they simply deny unauthorized access from the side of the virus programs. What also adds to its technical efficiency is that unlike Microsoft operating systems, Linux is modular, which means program functions are broken down into modules, each of which accomplishes a separate function (Nguyen, 2004). This provides for better scalability and productivity to the FLOSS software due to its modular structure (Aitbaev, 2004). RAM use is more effective in FLOSS as folders can be shared by different program functions. For any modifications, updates or hardware installation the system will address a file with proper permissions. Thus, even if a problem occurs, only the corresponding file shall be damaged, while the rest of the data remains secure.

Other technical differences that ensure Linux's superiority in terms of efficiency are its RAM use efficiency and scalability. First of all, Linux can use RAM memory for much longer before swapping to disk, while Windows does not support such features. With the later the processes are moved out of RAM to swap space on disk more often; hence, Windows users generally experience a slower response-time from the computer. Moreover, swap partition, a special feature aimed exclusively at paging operations, which reduces slowdown due to disk fragmentation at the time of general use (Ubuntu Documentation, 2010), is missing in Windows entirely. Instead of swap partition Windows uses a swap file, a system file which stores the

contents of the working memory in case of the later's overload. Swap file's input-output speed is much lower compared to swap partition, offered by Linux. What is also an important technical characteristic of Linux is that its core uses less memory, and thus is able to run on any primitive electronic device, plus Linux uses Shared Libraries effectively, which helps to economize on space (Protasova, 2011).

Higher information privacy offered by FLOSS has prompted governments to opt for open source software instead of the proprietary one. In the case of proprietary software "there is really no sure way of ascertaining the absence or presence of backdoors [i.e. spyware], but in the case of FLOSS, one can always go back to the source and check it line by line" (Rajani, 2003; p. 66).Security of the software is ensured by constant monitoring from the side of the open source community. Any adjustments are made fast, as they do not require vendor permission for modifications. As the code is transparent and can be checked by anyone, all the problems can be fixed instantaneously (Galitzine, 2009). Information generated on the government level is of high value to the countries themselves, thus the surest way to omit information leakage may be to switch to open source.

Another reason for which it is essential to standardize on open products is to overcome vendor lock-in. For instance, the standardization on Microsoft Office DOC format may be an issue because it requires the acquisition of the Windows operating system. The process of ODF's adoption is slow also for another reason, as DOC is subject to the network effect. A network effect, or the demand-side economies of scale, is when "a good or service becomes more valuable when more people use it" (Investopedia.com).This is how the given user decides to use DOC if s/he knows the readers will also use the DOC format. This would be the surest way to maintain the original document's formatting. Currently, DOC is the most widely used standard, as it is

proposed by default at any Windows desktop operating system, which ensures its lock-in.

This is why world economies, like the EU, Japan, Malaysia, India, and South Korea, are gradually switching to the open document format (ODF) as their official standard on the government level (Casson and Ryan, 2006). An open standard does not tie a user to one distributor, as an open sourced program that can support an open format can be downloaded to any desktop operating system. The proprietary programs too are starting to support the open formats, but this process is slow, for the lack of incentive from the former. Moreover, the document's formatting may be lost if a file is converted between the two standards.

On the downside of the currently available ODF format is that there are no macro and script specifications in ODF. This means that a macro, i.e. a standard collection of commands that is possible to apply to a given text to modify its formatting according to an available template, varies from application to application, and may not always maintain the same formatting between different applications (Fioretti, 2005).This flaw is yet to be corrected through standardization of script specifications.

Open compilers present another important contribution to the world economies, the developing part in particular. Compilers are programs that translate instructions, usually from a high-level computer language (closer to human language form) to a lower-level computer language, for a computer to process. Compilers are a precondition for creating software. Without open compilers programmers would be left to buy from giants like IBM that offer them for a rather high price, for instance, an average C/C++ compiler can costs over $4 000. This "entrance" price can be enough to lock separate developers and small IT companies out of producing a product. This is particularly the case for programmers from the developing world. Thus, using the open compilers and an open source operating system on top of that, much more small scale

programmers are able to participate in the IT business, as they do not need to pay the high fixed price to start developing.

All the updates and the FLOSS programs are free to be downloaded and used. Any person who has Internet access can download Linux on his computer, and then download any number of programs for Linux without inquiring any costs. It is a general practice for a user to download a number of similar programs to solve the same problem in order to choose the best one – a program that can provide maximum efficiency to that particular user. This practice is only possible when the software is free of charge.

CHAPTER 2: Best Practices from the Developing World

Governments have been introducing FLOSS as a way to cut costs and to better comply with the world intellectual property standards. There is a multitude of successful cases of FLOSS deployment from the developed world, the US government for instance is currently operating solely on FLOSS, which is said to save it up to 12 billion dollars annually (O'Reilly, 2009). Below we present a number of selected cases from the developing world; they may serve better as a benchmark for other less-developed countries. The results of effective FLOSS adoption for the given developing countries were:

- Achieving major savings;
- Job creation coupled with growth in skilled labor;
- Fall in piracy.

Countries that have chosen to introduce policy directed at open source deployment experienced considerable decrease in piracy. For instance, piracy rates in Taiwan have decreased by 6%, and 7% in India, and 15% in China over the last ten years of active policy-making directed at open source, while the world average has gone up by 3% over the same period of time (BSA data, own calculations).In 2004 the commercial value of the PC software that was being pirated in emerging economies accounted for less than third of the world total, in 2010 however it accounted for more than half (BSA Report, 2010). This signals an importance of aiming the developing countries in careful policy strategy that could decrease the piracy rates in the given countries.

2.1 The Cases of Open Source Standardization in Government Structures

Let us first consider the case of Taiwan, where the state policy-makers have decided to diversify away from the proprietary software vendor Microsoft in order to support their own open source

project. With the tightening of Intellectual Property Rights law in May 2002 to comply with the WTO standards, the government has decided to team up with the local open source society, keeping focus on building an infrastructure for an active online collaboration in the field. This implied the creation and maintenance of a blog for developers to interact in local languages. Moreover, continuous technical and legal assistance was provided by the Institute of Information Science of the Academia Sinica (Tyng-Ruey, 2004).The Taiwanese government spent $3.4 million for this purpose (Chuang, 2003). A large share of these funds was to go for the establishment of six educational centers around Taiwan to train open source developers.

As a result of effective policy implementation, the estimated savings were expected to reach $59 million in royalty payments to Microsoft, while the benefits to the private sector could be as high as $295 million (Taiwan's Central News Agency, 2002). What is also interesting to note is that software piracy rate has gone down by 6% with the government's first introduction of the project in 2002, while the world average has gone up by 3% over the same period of time (see Figure 3 bellow) and is presently less than the world average.

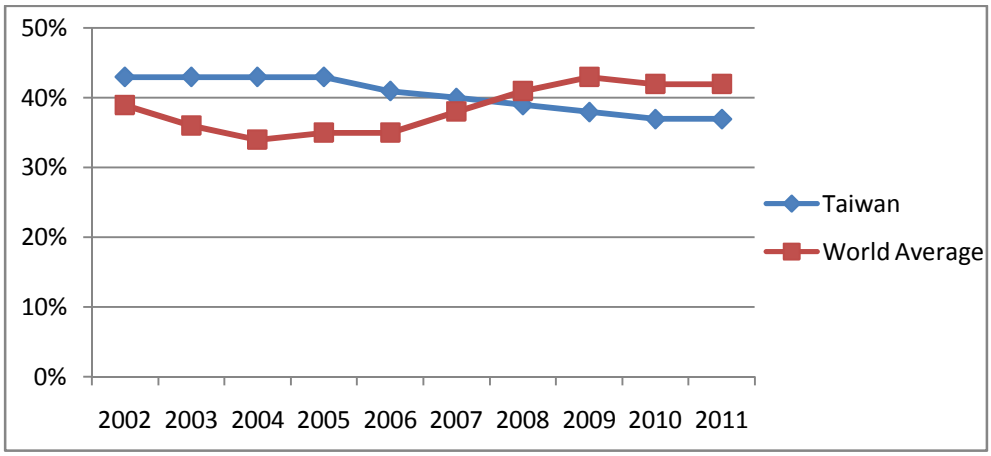

Figure 3. Piracy rates in Taiwan compared to the world average over the period of 2002-2011. Source data: Business Software Alliance (2011).

The next valuable lesson can be presented by China, where all government departments

have committed to use open source. The Chinese government has taken the Red Hat Linux distribution and developed their own distribution named Red Flag Linux, which was recompiled to better suite the language and other country-specific needs of the given user group (Thompson, 2002). To date, Red Flag Linux has won a 30 percent share of the Chinese software market (Pan and Bonk, 2007). Such a fast-paced growth in open source desktop operating systems' share can be partly explained by the low income per capita coupled with a high level of industrialization in the given country.

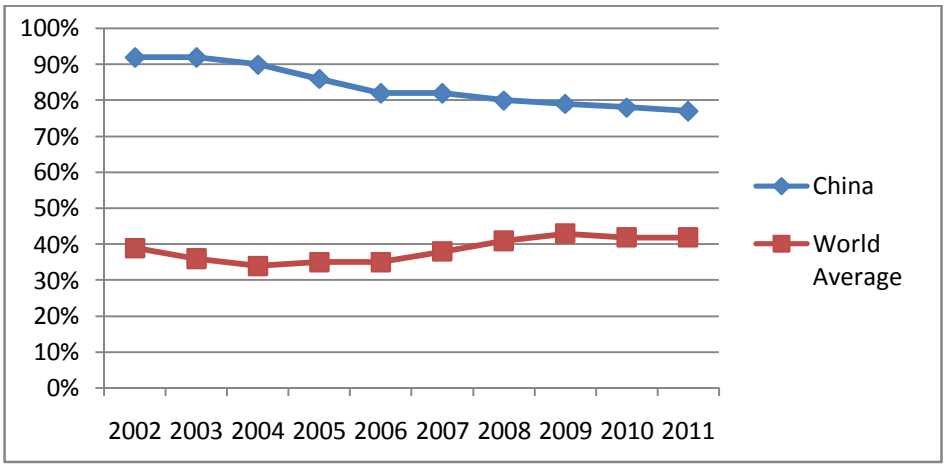

Figure 4. Piracy rates in China compared to the world average over the period of 2002-2011. Source data: Business Software Alliance (2011).

Figure 4 above shows the trend in falling piracy rate over the last nine years, which can partly be explained by the successful government policy directed at open source deployment. While the world average has grown by 3% over the given period of time, in China piracy rate has fallen by as much as 15%. Piracy rate in China remains above the world average, which signals the need for further policy action.

FLOSS is also argued to stimulate the local software industry in Africa (Chonia, 2003). Major African countries, Tanzania, Uganda, Ghana and Zambia are switching to FLOSS. Africa is a major recipient of charity in the form of proprietary software; however this dependence on

charity is now being reconsidered and viewed by the government officials as unhealthy. The South African government explains its pro-FLOSS policy by wanting to participate in the software creation, and to be more than just its consumer. As a major part of Africa is very poor, the field of IT is frequently overlooked when designing policy and distributing funds. However, such lack of action can only widen the gap between Africa and the developed world. Apart from job creation and global IT market participation of Africa, on the more basic level, computerization can open access to free knowledge through Internet.

2.2 The Cases of Open Source Standardization in Education

Let us now consider the most relevant cases of effective Linux-based operating systems implementation in the field of education from the developing world. The selected cases are represented by India and Brazil, state policy of which are aimed at low-cost computerization of schools through open source.

India's most southern part, the state of Kerala, represents a valuable case of effective policy-making in the field of education. With its population of 31.8 million people, schools in Kerala save up to $10,000,000 each year, using open source software (Trak.In, 2011). It all started in 2009, when the government of Kerala decided to gradually switch to an Open Source school management system called Fedena. As result of an Indian open source initiative, Fedena was created and customized specifically for the Indian schools, keeping in mind all the preferences the teaching staff sounded. The main problem faced by Kerala before Fedena was offered, was that most of its rural areas were not equipped with broad band Internet connection, and thus Fedena was customized for the local area network (LAN) version of the software, a network connecting computers in the given rural areas.

Another important feature of Fedena was its simple interface, designed to accommodate anyone with basic computer skills. This has created a base for an easy boost in computer literacy and simplified the acceptance of the software throughout Kerala. Consequently, by 2011 as many as 13,000 schools with over 7 million students were equipped with the open source school management software (PluggdIn, 2012). To ensure efficiency and stability of Fedena implementation, the Education Department of the Government of Kerala to this day constantly keeps track of the software's use, while the open developers make the necessary modifications and amendments to better fit the open source product to the needs of specific schools.

The Indian government has acted as a key motivator in FLOSS adoption through its initiative to setup a National Resource Centre for Free and Open Source Software as soon as 2005 (NRCFOSS, 2005). This breaking point can be also observed on Figure 5, on the next page, as this is the time when piracy rates have begun to go down in India. Figure 5 presents a trend in the falling piracy rates in India compared to the world average over the period of 2002-2011. On it we can see that although piracy has been falling in India before active government policy directed at FLOSS deployment was initiated, the most active fall in piracy can be observed starting from 2009 when the government has chosen the open source course. Other factors however should be taken into the account to fully understand the causal link between piracy and open source adoption.

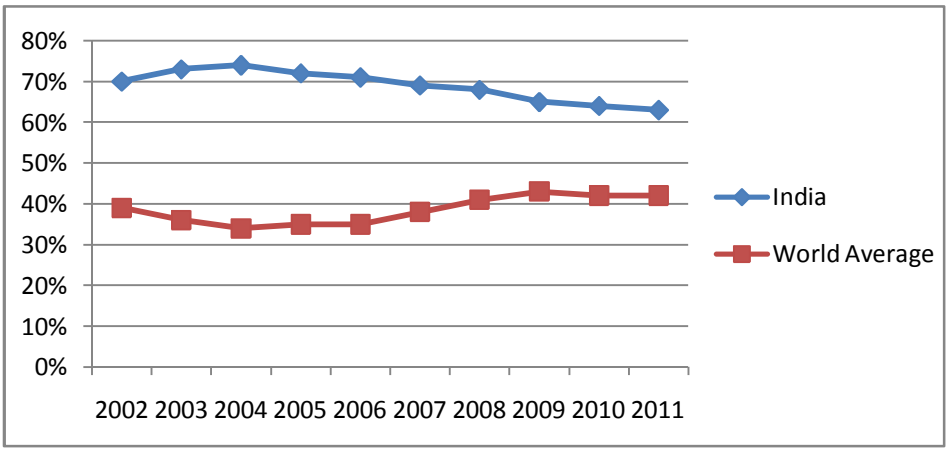

Figure 5. Piracy rates in India compared to the world average over the period of 2002-2011. Source data: Business Software Alliance (2011).

Brazil constitutes another example of effective FLOSS implementation in the field of education. In 2006, the Brazilian government decided to promote computer literacy by subsidizing the purchase of cheap computers running Linux in the poor communities of the country (Casson and Ryan, 2006). Mandriva, a publicly traded open source software company, teamed up with the global hardware vendor Intel in order to compile a low-cost product designed to accommodate the Brazilian schools. Mandriva spent almost a year in order to customize the Linux-based operating system specifically for the school use. The per-student cost was estimated at $200. Although the project is presently in the beginning stage of its development, the potential market is estimated at 1.5 Million units (Mandriva Official Website, 2010). In addition, these computers will be produced in Brazil, as a part of Intel's plan to better reach the consumers from the developing world, e.g. Brazil, Mexico, India, at the same time creating jobs that are to contribute to economic development of this region.

2.3 The Value of LaTeX Open Standard in Academia

Standardization on free LaTeX text editor in academia is yet another valuable example of

effective FLOSS standardization. LaTeX is a document markup language for the TeX typesetting system (Ubuntu Manual). LaTeX is a free language in which documents are written; however there is also a multitude of FLOSS editors available that all operate under LaTeX to provide extended flexibility in formatting. LaTeX is particularly valuable in working with technically-complex text, which for instance is loaded with formulas, or has to contain bi-level letters used in many languages. Unlike the Microsoft Office text editor that uses the "what you see is what you get" approach in writing formulas, LaTeX employs the "what you see is what you mean" approach, as it doesn't show the user immediately how the layout will look like. Although somewhat unusual when first attended to, LaTeX can greatly save time for the creation of large documents containing complex text and formulas.

Nowadays, in most of the academic journals, submission in TeX format is highly advised. According to the Science and Engineering Field Classification made by the National Science Foundation, the number of journals from different scientific fields, that support the free LaTeX standard amounts to over 400 journals. Approximately 10% of journals did not accept articles in LaTeX in 1996 (Feruglio, 1996). Although the present-day statistic is missing, by now this percent can be expected to have shrunk further.

The importance of scientific research supported by FLOSS can be particularly seen in Ukraine, where the scientific heritage of the previous political regime can best be observed in the fundamental sciences. Historically, Ukraine participated in active militarization, which required research in the field of physics, cybernetics and mathematics. Once the military incentive for research became obsolete, public financing of the fundamental sciences has greatly decreased. Still, the scientific culture remains, and unlike the military aspect of it, it is important for it to not become lost as well. World economy can benefit from active scientific collaboration, as the

growth in the world knowledge pool drives technical innovation.

Scientific centers in the developing world lack funding, and so FLOSS offers them a chance to contribute to the world knowledge pool at low cost. Open source LaTeX readers are of particular value, as they provide the scientists with a costless opportunity to be published in the world-class journals, be part of the world intellectual community, to participate in conferences and continue the culture of academic research and educatedness.

CHAPTER 3: Impediments to Standardization on FLOSS

There are a number of problems concerned with FLOSS, which interfere in the global transfer from proprietary software to open source. The steppingstones may be classified into path dependence, or the lock in of the proprietary software, technological complications developers of FLOSS may face, and a need for free Internet collaboration as a precondition for FLOSS development.

Despite the problems described in this section, open source software remains the best option for the developing countries. The problems presented bellow present the reasons why proprietary software continues to be the consumers' choice. These should be considered as points to work on, rather than a viable justification for FLOSS not being considered for the developing countries.

3.1 Path Dependence in Proprietary Desktop Operating Systems Use

As presented by S. J. Liebowitz and S. E. Margolis, path dependence means that where we go next depends not only on where we are now, but also upon where we have been in the past (1999). The present situation with the desktop operating systems being dominated by closed-source vendors like Microsoft is also largely the result of its past success. In line with Brian Arthur's "increasing returns to adoption" theory, that argues that specific practices become more valuable to each user as the total number of users rises (1989), proprietary software can be seen to outpace FLOSS in the desktop operating systems deployment as it was the first one to access the IT market. As proprietary software was the first one to access the market and became the widely accepted standard, mass adoption of open source has become a challenging endeavor. Although somewhat inferior in terms of technical efficiency, Windows is a standard generally accepted by

the market.

Human psychology plays a major role in the persistence of proprietary software use in the general public. Microsoft has employed effective marketing in promising ease of use and a wide variety of entertainment activities to its users. It is correct though that the number of open source and Linux-compatible games is incomparable to the ones run on Windows. The younger generation may feel reluctant to switch to a Linux-based operating system for this very reason. Moreover, when Linux-based operating systems first began to appear, the attention of the masses was drawn to their high complexity in use. As time passed, the rough edges of the software have been smoothed out and the need for any programming experience to be able to freely use FLOSS products has become obsolete. However, the public still has the impression that FLOSS is best employed by programmers and research institutes, because there is a certain information asymmetry in the PC user group. Knowledge of Linux's technical superiority is not truly available to the end user, and although no less friendly than Windows, Linux user interface is still generally thought of as inferior.

Apart from just being used to using Windows, the average user's gaming preferences, and the current lock-in of proprietary standards, like the DOC format and XLS spreadsheet file format, PC users frequently face a lack of incentive to switch. One of the reasons is that it would imply inquiring switching costs in the form of retraining in order to operate the new software. Fear of the unknown product and unwillingness to spend time in order to reinstall the operating system are also contributing to the high switching cost associate with FLOSS adoption. Furthermore, hardware frequently comes with preinstalled proprietary software on it, price of which is already included into the total cost. This last problem has been frequently addressed by antimonopolists and open source activists and so the situation is changing slowly for the benefit of free choice.

Another reason for the general public's reluctance to switch to Linux is that proprietary

software they are used to can be easily pirated. Moreover, when a person begins to use pirated proprietary software at home, s/he will want to also have the same proprietary software at work. In order to not be fined, the company will end up paying for the software that was the choice of its employees. This situation may play a role in skewing the incentives to take action against piracy from the side of the proprietary vendors themselves, as fighting piracy may in fact create a larger FLOSS user base.

3.2 Impediments to the Developers

The problem that the developers are faced with when choosing to develop FLOSS is that there is no centralized framework, like in the case of other proprietary software products. Windows for instance has its .NET framework for developers, which is a standard one for most of its applications. With open source however there is a multitude of languages that the community can use, which all have their pluses and minuses to the developers. For instance, C/C++ is a lower level language compared to Python, which makes it more complicated to work with. Python, on the other hand, although easier to work with, is less energy efficient than C/C++ and is slower. The fact that there is no single standard framework is two-sided: it offers greater flexibility and specificity in addressing different tasks, but at the same time complicates the interaction between developers working on similar tasks but on different frameworks.

This issue can be best addressed by working out a single multilanguage framework, similar to .NET, which would simplify the interaction within the open source community. This is however not possible at the moment, as this change is associated with major switching costs. A low-cost alternative has been recently developed, which offers to use JavaScript through the Qt framework which is argued to become a new standard in the coming days. It combines JavaScript,

which is easy to write code in and has been in wide use for many years now, with the lower-level C/C++ that is used for the critical parts. Another alternative is the new framework based on a higher level language Vala using GNU Tool Kit. This last framework offers the same ease of use as the abovementioned Python, but is compiled into C, and later translates the data into bite-code. This technique frees Vala from the flaws of Python.

The lack of trained IT professionals in the developing countries is yet another important factor impeding the spread of FLOSS adoption in the developing countries (Rajani, 2003). To overcome this problem, the list of classes in schools and universities should include opensource-related material on top of the classes directed at proprietary software.

3.3 Free Knowledge Flow and IPR Protection

Open source is based entirely on active online collaboration. However, such technologically-driven development, as provided by open source, can be harmed by policy that is directed at censoring the Internet space. In this respect, the introduction of Stop Online Piracy Act (SOPA) and Protect IP Act (PIPA), and the Anti-Counterfeiting Trade Agreement(ACTA) should be closely examined before ratification. These acts are designed to fight intellectual property infringement, and in this respect they can be welcomed. While protecting intellectual property rights may be a positive motive, the given legislature is frequently considered to be going too far, and can severely diminish the development of open source software, which can have adverse effect on the prospects of the developing economies as well.

These bills have very vague criteria and are expected to overreach, by allowing to put a website out of business after a single complaint (Hesseldahl, 2012). Websites can end up having little resource, in order to not be suspected of infringing copyrights and trademarks. Developing

countries can suffer the most, as for them knowledge-based growth is fundamental in generating economic growth (Piech, 2004).

As knowledge is one of the most crucial factors for economic growth, free knowledge flow should be of particular interest for the developing countries. Software development is fueled by means of ideas-sharing and common knowledge generation, which requires free Internet space for such a form of creative collaboration to take place. Although Intellectual Property Rights (IPR) are designed to protect high input industries and ensure active generation of new knowledge, the global effect of Intellectual Property Rights and their positive impact on knowledge generation have to be questioned, as:

> They have particularly raised the cost of investments for countries that had neither abundant cheap labor nor high amounts of intellectual property resources. Moreover, IPRs may have later exerted negative effects even on IP-rich firms, as the proliferation of conflicting rights has led firms to increasingly inhibit each other's investments. (Pagano et al, 2009; p.1)

Hence, such policies, as the recent attempt to introduce the SOPA and PIPA in the United States House of Representatives, undermine free knowledge flow and technological development that would otherwise be driving economic growth in the developing world. And although SOPA and PIPA are temporarily taken off the table, the issue of how far intellectual property rights policy should and will go remains in the air. Moreover, the trajectory taken by the US can serve as a benchmark for other countries and hence should be chosen with careful consideration.

The reasons free knowledge flow can be harmed by the aforementioned policy resolutions are many and are also largely controversial. With SOPA/PIPA the power over online piracy is given into the hands of the interested parties, as the senators that were pushing this act through are argued to be pursuing the interests of the media magnates. Giving them the power to close down online media sources can lead to the former monopolizing the media content distribution. Internet activity is difficult to trace, which means that the measures taken by SOPA can be easily

taken advantage of. Other than asking to delete pirated content as before, the website will be held responsible and judges will be allowed to block access to such websites. This can harm the information sharing spirit of the Internet, and by this decrease the value of knowledge itself.

Let us now compare the American-born SOPA/PIPA to the multinational ACTA treaty that is presently under way. When the whole world was actively fighting the initiatives of the U.S. Congress, the signing of the ACTA agreement entered its final stage. A line of active protests has helped stop SOPA in its beginning stage of ratification. ACTA, on the other hand, has already been negotiated for about five year now, and just recently, after Australia, Canada, Japan, Morocco, New Zealand, Singapore, and South Korea, some of EU member states, and Mexico have ratified it, has become known of in the media. Unlike SOPA, the main concern ACTA presents is that its scope and ratification is international. As an international legal framework, ACTA is to create a new government body that shall be legally superior to the country-born legislature. It is to introduce criminal liability for violation of intellectual property rights in all participating countries. It is also known that the Internet service providers and content hosters will be required to monitor compliance with copyright for their subscribers and provide information to the organization upon first request (Technology News, 2012; TechTheFuture, 2012).

So far very little is known of the extent of changes that will follow with ACTA's ratification, but the European Commission itself states that ACTA is not about creating new laws, but is based on the existing legislature that has long existed through TRIPs (European Commission on ACTA, 2012). According to them, ACTA is about enforcing the existing set of rules that will not be more severe than before. However, its international scope fuels public concern, as any attempts to restrict Internet activity can potentially harm the ideas-sharing spirit

that drives common knowledge generation. In this respect, open source plays an important role, and so the policy aimed at intellectual property should be designed in such a way that small entrepreneurs worldwide are not locked out of the high-tech market.

CONCLUSIONS AND POLICY SUGGESTIONS

It may be concluded that overall open source constitutes a fine example of free knowledge flow and should serve as a positive example for technological development worldwide. Developing countries would and already do greatly benefit from open source software, which is in many respects more beneficial compared to proprietary software for such countries. Not only does FLOSS provide a low-cost means of participation in the world of technology, bringing and adding innovation to it, but it also provides superior technical efficiency that can prove useful in its further adoption.

There are certain steps that can boost further adoption of FLOSS throughout the developing countries. FLOSS is in great need of thoughtful publicity that would correct the information asymmetry that the potential user group is faced with. This can be done by initiating conferences, media publications and free installation sessions similar to those proposed and initiated in the US by the founder of the Free Software Foundation Richard Stallman.

In terms of technical efficiency for developers, a common framework can also prove useful in uniting developers worldwide with a mission to boost FLOSS community participation and interaction. In this last respect, policymakers can only act out to draw public attention to the new developments.

What is closer to the scope of influence of the developing countries' policymakers is the diversification of the educational programs in schools and universities. Educational curricula should include FLOSS on top of the proprietary software material that is currently being taught at IT-related classes and courses worldwide.

What is also an easy to realize solution that can boost FLOSS deployment and help overcome proprietary software lock-in is the introduction of open standards. Open document format (ODF), along with open document spreadsheet (ODS) and the LaTeX document markup language should be gradually switched to from the existing proprietary formats throughout all public institutions and organizations.

Additionally, any changes to the present Intellectual Property Rights legislature should be constantly monitored and be attended to with careful consideration. Although the possible outcomes that treaties and bills aimed to fight piracy can have for the open source society have been argued to be largely negative, further research is required to find the golden middle that has to be sought by policy-makers in order to keep intellectual property safe enough to ensure active generation of new knowledge and would yet allow for enough freedom that the open source society can collaborate, having that common incentive - to create.

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APPENDIX

Table 1. Data used to estimate Figure 1. Source data: Piracy Rates from Business Software Alliance (2011), annual nominal GDP/capita from International Monetary Fund's 2011 report.

Country	Piracy Rate, %[1]	Annual Nominal GDP/capita
Australia	24,00%	$65 477,00
Bangladesh	90,00%	$678,00
Brunei	66,00%	$36 584,00
China	78,00%	$5 414,00
Hong Kong	45,00%	$34 049,00
India	64,00%	$1 389,00
Indonesia	87,00%	$3 509,00
Japan	20,00%	$45 920,00
Malaysia	56,00%	$9 700,00
New Zealand	22,00%	$36 648,00
Pakistan	84,00%	$1 201,00
Philippines	69,00%	$2 223,00
Singapore	34,00%	$49 271,00
South Korea	40,00%	$22 778,00
Sri Lanka	86,00%	$2 877,00
Taiwan	37,00%	$20 101,00
Thailand	73,00%	$5 394,00
Vietnam	83,00%	$1 374,00
Albania	75,00%	$3 992,00
Armenia	89,00%	$3 033,00
Azerbaijan	88,00%	$6 832,00
Belarus	88,00%	$5 881,00
Bosnia	66,00%	$4 618,00
Bulgaria	65,00%	$7 202,00
Croatia	54,00%	$14 457,00
Czech Republic	36,00%	$20 444,00
Estonia	50,00%	$16 583,00
Georgia	93,00%	$3 210,00
Hungary	41,00%	$14 050,00
Kazakhstan	76,00%	$10 694,00
Latvia	56,00%	$12 671,00
Lithuania	54,00%	$13 075,00
Moldova	90,00%	$1 969,00

[1] Piracy Rate = Unlicensed Software Units/Total Software Units Installed

Montenegro	79,00%	$7 317,00
Poland	54,00%	$13 540,00
Romania	64,00%	$8 863,00
Russia	65,00%	$12 993,00
Serbia	74,00%	$6 081,00
Slovakia	42,00%	$17 644,00
Slovenia	47,00%	$24 533,00
Ukraine	86,00%	$3 621,00
Argentina	70,00%	$10 945,00
Bolivia	80,00%	$2 315,00
Brazil	54,00%	$12 789,00
Chile	62,00%	$14 278,00
Colombia	54,00%	$7 132,00
Costa Rica	58,00%	$8 877,00
Dominican Republic	76,00%	$5 639,00
Ecuador	67,00%	$4 424,00
El Salvador	80,00%	$3 855,00
Guatemala	80,00%	$3 182,00
Honduras	73,00%	$2 116,00
Mexico	58,00%	$10 153,00
Nicaragua	79,00%	$1 239,00
Panama	72,00%	$8 514,00
Paraguay	83,00%	$3 252,00
Peru	68,00%	$5 782,00
Uruguay	69,00%	$13 914,00
Venezuela	88,00%	$10 610,00
Algeria	84,00%	$5 304,00
Bahrain	54,00%	$23 132,00
Botswana	79,00%	$9 481,00
Cameroon	82,00%	$1 230,00
Egypt	60,00%	$2 970,00
Iraq	85,00%	$3 513,00
Israel	31,00%	$31 986,00
Jordan	57,00%	$4 675,00
Kenya	79,00%	$851,00
Libya	88,00%	$5 691,00
Mauritius	56,00%	$8 777,00
Morocco	65,00%	$3 083,00

Nigeria	82,00%	$1 490,00
Oman	62,00%	$23 315,00
Saudi Arabia	52,00%	$20 504,00
Senegal	78,00%	$1 076,00
South Africa	35,00%	$8 066,00
Tunisia	72,00%	$4 351,00
Turkey	62,00%	$10 522,00
Yemen	90,00%	$1 340,00
Zambia	82,00%	$1 414,00
Zimbabwe	91,00%	$741,00
Canada	28,00%	$50 436,00
United States	20,00%	$48 387,00
Austria	24,00%	$49 809,00
Belgium	25,00%	$46 878,00
Cyprus	48,00%	$30 571,00
Denmark	26,00%	$59 928,00
Finland	25,00%	$49 350,00
France	39,00%	$44 008,00
Germany	27,00%	$43 742,00
Greece	59,00%	$27 073,00
Iceland	49,00%	$43 088,00
Ireland	35,00%	$47 513,00
Italy	49,00%	$36 267,00
Malta	43,00%	$21 028,00
Netherlands	28,00%	$50 355,00
Portugal	40,00%	$22 413,00
Spain	43,00%	$32 360,00
Sweden	25,00%	$56 956,00
United Kingdom	27,00%	$38 592,00
World Average	42,00%	$10 144,00

Table 2.Selected Countries With The Highest Piracy Rates And Their Average Monthly Wage Levels. Data Source: National Statistics Offices, 2011.

Country	**Average Monthly Wage, $**
Bangladesh	83
Indonesia	660
Armenia	471
Yemen	216
Average	**357,5**

Table 3.Countries Chosen For The Case Studies With Their Annual Piracy Rates For The Period Of Ten Years (2002-2011). Source Data:Business Software AllianceAnnual Reports (2002-2011).

Country/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Brazil	55%	61%	64%	64%	60%	59%	59%	56%	54%	53%
Taiwan	43%	43%	43%	43%	41%	40%	39%	38%	37%	37%
India	70%	73%	74%	72%	71%	69%	68%	65%	64%	63%
China	92%	92%	90%	86%	82%	82%	80%	79%	78%	77%
WorldAverage	39%	36%	34%	35%	35%	38%	41%	43%	42%	42%

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