The Implications of Nano-technologies for Developing Countries - Lessons from Open Source Software

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A necessary strategy to overcome the challenges of development is the application of science and technology to socio-economic problems. Policy-makers are therefore concerned with enabling the right environment to develop, diffuse and effectively use new research and technologies. Part of this process then is to understand the implications of new and emerging technologies such as nanotechnologies. In this regard, there have been calls to adopt open access practices particularly for the benefit of developing nations. However, there has been little analysis to date on the efficacy of such an approach. This brief paper explores the merit of such arguments by looking at the open access experience of software from a developing country point of view.

Nanotechnologies and Developing Countries

Nanotechnology and nano-science refers to the development of materials at the scale of a nanometer or 1 billionth of a meter. The opportunity to create physical structures at such a small scale has led to a host of applications in areas such as medicine, energy, material sciences, electronics and national security. Accordingly, nanotech allows for new solutions to old problems such as those in developing countries. For example, problems to which nanotechnologies can be applied include developing low-cost renewable sources of energy, potable drinking water, controlling the transmission of HIV/AIDS, creating employment through the development of new industries, and food security (Bruns, 2004; Bürgi & Pradeep, 2005; Hassan, 2005; Schummer, 2007). In fact, Salamanca-Buentello, et al. (2005) linked several existing nanotechnologies to the achievement of key Millennium Development Goals.

The extent to which nanotechnologies are beneficial to developing countries has also been the source of some debate. Some argue that nanotechnologies will only help to widen the gap between the have's and have not's; and in the case of developing countries this will occur while increasing the dominance of MNCs (Schummer, 2007). Others are more conditional and place more emphasis on the context in which the technology is applied (Invernizzi, Foladori, & Maclurcan, 2008). In addition, some developing countries (e.g. Brazil, China and India) are much more advanced in terms of nanotechnology pointing to a South-South gap (Hassan, 2005; Maclurcan, 2005).

Even if we were to take a more positive outlook, several challenges remain before developing countries can improve their development or use or nanotechnologies. These include low average incomes, limited human resources, training and educational facilities, IPRs, and trade barriers (Maclurcan, 2005). In this sense, some have posited an alternative approach to the development of nanotechnologies which could better serve developing countries – open access.

Open access or the peer production model

The commons based peer production model as defined by Benkler (2006) is a collaborative production process that is usually active outside the context of the market. There are three features that distinguish it from what we can call closed production which emphasizes the use of traditional intellectual property rights (IPRs) regimes. First, peer production is not driven by price signals as opposed to closed production models under IPRs. Second, peer production is not guided by a managerial hierarchy typical of for-profit entities. Third, the inputs and outputs of production are shared openly with similar constraints (in terms of distribution) placed on everyone.

These definitions lead to two observations. First, we should not view these approaches to production in dichotomous terms. In reality, most types of knowledge production combine different approaches and find themselves somewhere on a spectrum between completely closed and completely open access model. Second, both models can be applied to almost all sectors. While this is obvious for closed production, peer production can also have a wide applicability such as in open source biotechnology (Hessel, 2006). In her research on innovative communities, Shah (2006) illustrates how the open access model is used in areas such as windsurfing and snowboarding.

Open Access Nanotechnology in Developing Countries

Einsiedel & Goldenberg (2004) argue that the use of IPRs could reduce access and limit commercial opportunities for nanotechnologies in developing countries. Ultimately, when such practices lead to monopolistic markets it could also limit innovation. Furthermore, examples of the way patents have been employed in areas such as GM maize have led to concerns about ownership of technologies with a potentially wide impact.

Also of note is the pattern in which IPRs are now applied in developed countries and what this means for the South. Schummer (2007) suggests that the scope of what can be protected through patents have widened substantially implying that knowledge production is moving more towards the private and away form the public realm. This places developing countries at a disadvantage because they are less likely to have the resources to purchase relevant licenses or engage in patent filings and litigation. Several features of the nanotechnology sector make patenting unique. There is a trend to file patents earlier and more often in the production process; the cross-sectoral nature of nanotech applications means that firms hold patents in industries where they are not active; and universities have become very active in filing patents. The result is that there could be a potential patent thicket developing in nanotechnology fields (Lemley, 2005).

The impact on developing countries could be detrimental under these scenarios. Thus some observers have pointed to the use of open access production as a way of improving the potential of nanotechnology generally (Bruns, 2001). This could help to overcome some of the limitations mentioned above for example by reducing the potential for monopolies, the concentration of patents in the North or by increasing the safety of nanotech applications for humans through collaborative (and therefore greater scrutiny) production. Also nanotech production could consist of hybrid production models (open and closed) applied to different components of the system (Bruns, 2004).

There are a few examples of projects that aim to employ an open access approach to nanotechnology production (see http://opensourcenano.net/ and http://www.aerogel.org/). Also one hypothetical solution that could move nanotechnology towards a knowledge product akin to software is "Molecular Description Language" (see Prisco, 2006).

<u>The case of Free and Open Source Software</u>

These examples are however limited and so in order to better understand the potential of open access, we examine the case of Free and Open Source Software (FOSS) in developing countries with a view on drawing some lessons for nanotech. To do this we relate results of a recently completed research project on the distributional consequences of FOSS across seven (including three developing) countries. This will allow us to go beyond some of the postulated outcomes of open access on nanotechnologies mentioned above. Under FOSS, the source code of a software package is typically made available to users without any fees. Software can be copied, modified, expanded or re-distributed usually under certain restrictions. These constraints can vary depending on the type of license used. However, most FOSS licenses include some form of free distribution and allow modification to the source code. This then facilitates peer production.

This definition highlights one of the main differences between FOSS and nanotech, which is that FOSS is more akin to a knowledge good and therefore makes the application of peer production easier. However, there are several important similarities. Both are pervasive in that they can be applied to a variety of sectors throughout society; they are both emerging in the sense that their concomitant industries and applications are still evolving; and they can be described as transformative.

The application of FOSS to developing countries also parallels the arguments for nanotechnologies in terms of the breadth of applications. Benefits include skills development, supporting the growth of a local software industry which would be linked to the rise in the use of FOSS (eg. low barriers to entry), localization of popular software, greater diffusion of associated technologies such as personal computers (through cheaper operating systems such as Linux) and achieving vendor independence as sovereign governments would be less dependent on foreign software companies (Dravis, 2003; Kshetri, 2004; van Reijswoud & de Jager, 2008; Wong, 2004).

From our analysis of FOSS in developing countries, we found that the scale of the FOSS industry varies across countries but was more ostensible in the larger developed economies with several global players standing out. In most developing countries no significant FOSS commercial activity was observed. In some cases the government was a major customer for the local industry and therefore their approach to FOSS firms was significant. For example, even where public policies called for greater use of FOSS (typical in some developing countries); there were instances where government actions indirectly affected the diffusion of FOSS. This included the skewed procurement policies of governments toward proprietary software, the implicit requirement of proprietary software for accessing government services and the strengthening of existing IPR regimes through the use of software patents.

We also found evidence of the benefits for developing countries mentioned above. However, in all cases, one of the main costs was in terms of the expertise required to effectively use FOSS. In some cases, this cost proved too prohibitive to enable its use. Also, we found low levels of diffusion across all countries. The use of FOSS was even lower in the developing countries in the sample. This limits the extent to which the benefits of FOSS can be felt throughout a society. Of even greater concern are the horizontal and vertical differences among the small segments within our country sample using FOSS. For example, larger firms were more likely to use FOSS as were those involved in ICT related businesses. Even larger educational institutions were also more likely to use FOSS. This could stem from the costs of acquiring the requisite skills to develop and use FOSS. The skill requirement is most evident when we looked at a survey of actual FOSS developers which showed that this area was dominated by a small group with very similar characteristics such highly educated, high-income and mostly from North America and Europe. Other surveys have pointed to increased participation in FOSS projects by programmers from India, Brazil and Russia.

Implications for nanotechnologies in developing countries

Thus even though the benefits of FOSS (in terms of economic efficiency and innovation) appear great, the low levels of use can limit its impact on society. Also the distribution of these benefits appeared to be highly skewed across all countries in our sample. The implication is that to realize such benefits on a larger scale, governments need to address two main issues. First, there is the expertise cost which developing countries must address in terms of training in order to leverage the benefits of the open access model. The second point is that governments should not inflate existing IPRs to point where they constrain the use and development of FOSS. For example the passage of the Digital Millennium Copyright Act and the practice of software patents in the US are geared towards the promotion of proprietary software rather than FOSS.

While current trends in IPRs practices do not augur well for developing countries, the appeal for open access can be great. However, the example of FOSS shows that without adequate human resources, developing countries will still not experience a level playing field. Another relevant point from the FOSS case is the need for proper enforcement of IPRs. In one instance, we found that local FOSS entrepreneurs found it hard to get employment because it was easy (yet illegal) to get copies of proprietary software, therefore making the whole concept of open access moot.

Finally, one important consideration is to identify the appropriate business model for open access nanotechnology firms. With FOSS, most firms provide support services (training/development) to their customers since there are no software license fees. In the case of nanotech this could also be the case, but firms will be less inclined to do so where marginal production costs are significant. This implies that, for example, open access models could be more useful for the nanotech design market.

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