

# Maximizing the Benefits of Technology in Emerging Economies: the Prospects and Challenges of Technology Transfer to Local Firms in Ghana

**Stephen Asirifi Essel**

CASS European Institute of Management Studies /  
Ghana Technology University College  
Accra, Ghana

## Abstract

The paper is based on a study that reviewed the various forms and benefits of technology transfers that are available to emerging markets. The study also reviewed the prospects and challenges with the transfer of technology by multinational companies (MNC) in advanced economies to emerging economies that can be adapted and made suitable to meet their needs. The paper acknowledges that technology development is very essential for emerging markets and as research and development is low in these economies attracting technology transfer is a viable alternative that they can pursue. However, there were concerns that technology transfer could not be divulged from the cultural and environmental circumstances of the recipient country. It was also revealed that MNC are interested to invest in emerging economies that have strengthened their intellectual property rights protection mechanisms as this give them confidence to do business and get protected. It was identified that four key factors for technology transfer are communication interactivity, distance, technological equivocality which refers to the degree of correctness of knowledge and technology to be transferred, and motivation. The paper focuses on addressing concerns emerging markets face in attracting appropriate technology. It further suggests to academic researchers in emerging economies the need to perform research so that appropriate and suitable forms of technology transfer mechanism are made available to policy makers and business leaders.

**Keywords:** Culture, emerging economies, foreign direct investment, licensing, technology transfer

## 1. Introduction

Emerging market economies are characterized by a rapid growing GDP rate of between 6 – 10 with improving standard of living and a growing middle class and they are becoming attractive destinations for exports, sourcing and foreign direct investment (FDI). According to Tung & Aycan, (2008) the word emerging market was coined by International Finance Corporation of the World Bank in 1981 to describe middle to higher income developing countries and this has being broaden to include all developing countries with Gross National Income (GNI) per capita of \$9,265 or less. In the works of Hoskisson, Eden, Lau, & Wright, (2000) they indicated that an emerging economy must satisfy two criteria's, first a rapid pace of economic development and secondly government policies geared towards economic liberalization and a free trade system. They further argued that the adoption of marketing policies by emerging market economies have raised important strategic issues for both domestic and foreign businesses and these are opening their economies to foreign markets (Hoskisson et al., 2000). This liberalization and open systems has seen an influx of foreign goods and services to the economies of emerging

markets and participating in globalization which has been described by Grosse (2003) as the homogenization of people's tastes and demand patterns due to increased access to information and transportation of products and services across borders. He further indicated that globalization is seen as a threat to the loss identity as people embrace lifestyle from other parts of the world (Grosse, 2003) . These therefore present issues about how firms in emerging markets could develop competitive capabilities that will enable them to compete favorably against rival products and services from different countries.

According to Hirt (2012) globalization is also seen as an opportunity for developed countries to obtain markets for their surplus by selling goods, transferring technology, and receiving returns from equity in firms they have acquired or supported. Developing countries also gain from advanced technology and knowledge that allows employment for citizens and improved living standards. According to Hirt (2012), the corporations and firms in developed countries sees the transfer of technology to rapidly developing economies as an important strategy for the growth of their businesses. As they seek to identify emerging economies that can offer low

wages and hence low production cost, making them attractive for technology transfer from firms in the industrialized regions of the world. Firms in emerging economies are now confronted with the liberalized and privatization policies of their governments coupled with activities of globalization that is allowing goods, services, ideas, capital and technology to move across borders to compete with foreign firms locally(Hirt, 2012).

This paper's main objective is to explore how emerging markets are at an advantageous position to benefit from technology that is being deplored as their economies are becoming attractive to economies and firms from the industrialized countries. Two main specific objectives have been developed to achieve this. First, is to review the various forms and benefits of technology transfer to emerging economies like Ghana and how they can maximize these benefits to their advantage. Secondly, will provide a review of the prospects and challenges of technology transfer to the economy and local firms in Ghana. Hence, I ask these research questions, what are the various forms and benefits of technology transfer to emerging economies? What are the prospects and challenges of technology transfer to local firms in Ghana.

The paper is organized into four sections, this section has provided the introduction, and the next section will briefly discuss the methodology used for this research, which will be followed by the findings or results and ends with discussions and conclusions.

## **2. Methodology/Methods and materials**

This paper adopted a critical review of existing literature on technology transfer from developed economies to emerging economies. This approach was adopted as there is a gap from emerging economies concerning the appropriate technology that has to be transferred from developed economies. There is the need for emerging economies to identify technologies that has to be transferred so that it will be beneficial to end-users. This review was able to reveal critical issues that are of immense concern to emerging economies and opportunity for local firms in Ghana to take advantage of as well as further research in this context.

## **3. Results/Findings**

### **3.1 Technology and emerging economies**

Emerging economies are characterized by the low technology nature of their products and several authors have reviewed that advance in

technology can reduce costs associated with communication and coordination. According to Li-hua & Khalil (2006), technology has a lot influence on individuals, business, society and the environment, hence advances in technology helps create national and individual wealth, improve standard of living and quality of life. They further asserts that technology "represents the combination of human understanding of natural laws and phenomena to make things that fulfil our need and desires or that perform certain functions"(Li-hua & Khalil, 2006). They indicated that technology is made up of hardware, software and know-how which is the skills, knowledge and experience required and hence it is seen as a systematically developed set of organized information, skills, rights and services.

#### **3.1.1 What is Technology?**

Li-hua & Khalil (2006) also cited in their work a definition of technology by the United Nations Conference on Trade and Development (UNCTAD) as an item which "is bought and sold like capital goods, human labor, management, and specialized scientists, information of both technical and commercial character, including that which is readily available, and that its subject to proprietary rights and restrictions (Li-hua & Khalil, 2006). Another definition of technology from UNCTAD's draft on "International Code on the Transfer of Technology" cited by Musunuri (2014) described it as "a systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service". He further indicated that emerging economies on their path to economic development have been supported with technology transferred from the developed countries without assessing the appropriateness and suitability of these technologies from the developed economies (Musunuri, 2014).

This clearly cautions emerging economies to effectively assess the appropriateness and suitability technologies that get transferred to their economies in their quest to achieve economic development. I also believe that emerging economies should also prepare themselves and be abreast with technological development going in the west that could be appropriate to their economies, so that when transfer of technology take place they could adapt it to suit their conditions. This is what this paper seeks to achieve by exploring the various forms and benefits of technology that can be transferred to emerging economies.

### **3.2 Forms of technology transfer for emerging economies**

Li-hua & Khalil (2006), has argued that the concept of technology consist of these four elements: technique, knowledge, organization and the product. Hirt (2012), indicated that technology is an important strategic instrument for achieving strategic goals for both developed and developing economies. In the developed countries it is seen as a huge market potential whiles in the developing countries it leads to the creation of wealth and prosperity (Hirt, 2012). This indicates that emerging economies that receive appropriate technology could be on the path to experience wealth and economic development and I may ask that are they aware that their markets are seen as huge potential for technology transfer and are they ready to take advantage of this potential. Li-hua & Khalil (2006), argued that technology and knowledge transfer occurs when foreign and local managers work and collaborate on international joint venture projects and that technology transfer cannot take place without knowledge transfer.

Hirt (2012), cited a definition of technology transfer by UNCTAD as “the transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service”. He further indicated that the transfer of technology comprises the movement of science and technology from one group to the other and involve hardware or tangible and intangible assets such as intellectual capital, intellectual properties, service innovation, and information technology Hirt (2012); Li-hua & Khalil (2006). According to Fu, Pietrobelli, & Soete (2010), they identified that importing machinery and equipment is another channel for knowledge and technology transfer and acquisition. They further indicated that for these technologies to benefit the receiving partner or developing economies there have to be substantial technological learning and reverse engineering so as to grasp the technologies embedded in the imported product.

Technology transfer is often recognized as involving a supplier located in an advanced economy and a recipient from an emerging economy, Hirt (2012), argues that transfer occurs by converting the technology into various elements. The first element involves transforming the technical information from the supplier’s side, then this is transferred and reproduced as new technology for recipient after all technical, cultural and environmental considerations have been made (Hirt, 2012). Various authors have

outline various forms of technology transfers that takes place from high tech advanced countries to innovation challenged developing economies. According to Hirt (2012), three form of technology transfer can take place, first, there is the person-embodied where there is the transfer of know-how and engineering personnel from a supplying country to a recipient country and this must be carried out by paying attention to the cultural environments. Secondly, there is the process-embodied form of technology transfer where there is the transfer of documents, blueprints and patent rights and its processes. Finally there is the product-embodied, where there is the transfer of the physical product itself like equipment, machinery and tools. Other authors, Klintenberg, Wallin, & Azimoh (2014), also argued that there are two kinds of technology transfer, the vertical technology transfer where technologies are transferred from research and development stage to commercial implementation. The second type is the horizontal technology transfer, where transfer takes place from one geographic location to another i.e. from a developed to a developing country, he further asserts that for a successful technology transfer it requires that the skills and knowledge for operation and maintenance of the technology is essential to yield an improved capacity for the recipient country (Klintenberg et al., 2014).

According to Asghari & Rakhshanikia (2013), technology transfer methods can be put into five groups, foreign direct investments (FDI), cooperation investment, direct sell or buy, turnkey projects and licensing.

In this work, Sung (2009) cited Devine et al who indicated that there are three acceptable models of technology transfer, the Appropriability Model which relies on the importance of quality research and competitive market pressures to achieve transfer. Secondly, there is the Dissemination Model which seeks to focus on the disseminating of innovation to individual users. Lastly, is the Knowledge Utilization Model which seeks to focus on the interpersonal communication, organizational barriers and the facilitators of the transfer (Sung, 2009).

### **3.3 Benefits from technology transfer**

According to Asghari & Rakhshanikia (2013), emerging economies can learn from the experience of industrialized and newly industrialized economies who have benefited from the transfer of suitable and modern technologies that has allow them to increase their productivity

and develop their industries. They further indicated that successful technology transfers have occurred in these countries due to how they have created and inspired their national plans and actions to align with technology development. Secondly, they took advantage of the saturation of investment in advanced countries and welcomed international companies to invest in their economies. Maskus (1998), argued in his work that advanced technologies will be transferred when developing countries are able to develop and improve on their intellectual property rights (IPRs) programmes, which will also cause innovation to thrive. He indicated that nations that become interested in adopting stronger IPRs protection have attracted advanced technologies and also encouraged their own innovation. This is because patents, copyrights and trademarks may facilitate information transfer and technology diffusion by disclosing details during application and these information can be used by local firms to develop what is called follow-up products that do not violate the original patent (Maskus, 1998).

Another important benefit of technology transfer has been outlined by Takakuwa & Veza (2014) as trade as it allows goods or equipment to move from advanced countries or “leaders” to developing countries or “followers”. Through this movement “followers” receive technology which aid them to produce other goods that they can also export, an example can be seen in the transfer of packaging technology in Ghana, where trade has offered a lot of packaging forms to Ghanaian businesses to adopt and use locally and also export to neighboring countries. The importance of trade is also affirmed by Maskus (1998) and that it allows for technologically advanced inputs to be traded to the benefits of developing countries.

Another benefit that accrue to emerging economies due to technology transfer is the development of a competent indigenous technological capacity as indicated by Maskus (1998), where he highlighted that it paves the way for investment in the education and training of human capital. And this may include support for research and development, and aid to local innovation that can thrive on access to the global information infrastructure (Maskus, 1998).

In maximizing these benefits from technology transfer, emerging economies must position themselves to prepare the infrastructure, the business environment and the needed human resource to absorb the transferred technology as discussed by Li-hua & Khalil (2006), for which I agreed with. They argue that putting this in place

is seen as the first phase of technology transfer where low to middle technologies like manufacturing and process technologies in producing household goods are adopted and diffused to suit indigenous cultural and environmental situations (Li-hua & Khalil, 2006).

### **3.4 Prospects and challenges of technology transfer to local firms**

Technology is seen to contribute to the development of the society and economy of a nation through the discovery, the transfer, the diffusion and application of new knowledge as argued by Sung (2009), hence a major component for every economy. Advances in Information Communication Technologies (ICT) and declining cost of producing, processing and diffusing knowledge are further transforming economic activities, hence effective management and transfer of technologies are essential for organizations and countries (Sung, 2009). Technology transfer have been argued by various authors that it has the potential to bridge the gap between developed and developing countries as indicated by Klintonberg et al. (2014), and also to tool to reach economic growth and also provide a basis for achieving new technologies as outlined by Asghari & Rakhshanikia (2013).

There exist huge prospects for the gains of technology transfer to be reaped by emerging economies, if they are able put in place the basic foundations and structures to attract. Klintonberg et al. (2014), discussed that for a successful technology transfer to take place some enabling factors have to exists, the country must allow foreign equipment and knowledge to enter at low cost. Local players who act as recipient must have the required abilities and technological infrastructure and lastly there must be a demand for the technology being transferred. According to Maskus (1998), emerging economies must balance the need for technology acquisition, market access and diffusion as technology transfer offer them the opportunity to strengthen their IPRs policies and become attractive for more advance technologies.

Padilla-Pérez (2008), argues that technology transfer is part of the process of developing indigenous capabilities of local firms through global-local interactions which can vary from disembodied technology (patents and licenses) to technology embodies in machines or people. He further indicated that the activities of multinational enterprises (MNE) from the sale of technology to the provision of technical services that may occur through alliances and equity

ownerships makes it possible for local firms to receive such technology for their advantage (Padilla-Pérez, 2008). Hence, for host nations to maximize the benefits of these technology transfers to local firms, a database should be developed to identify local firms that require a form of technology for their operations, so that the government will create the appropriate enabling environment for such transfers to take place. Some of these factors that will impact on how MNEs will pursue and support technology transfers to host nations has been described by Padilla-Pérez (2008) to include the existing production and technological absorption capabilities of the host; the quality and availability of local resources; encouragement to innovation, research and development; entrepreneurial environment that attract skilled workers from developed countries; and the policies and attitudes of local governments to MNEs (Padilla-Perez, 2008) (Hoekman, Maskus, & Saggi, 2005).

In Costantini & Liberati (2014) works, they commented on how technology transferred to developing countries especially those technologies in ICT, health and education may help to reduce drastically communication, diseases and illiteracy among these economies. They further argued that due to these positive impacts which could be enormous and hence any technology transfer and diffusion must look at how it will incorporate human development systems (Costantini & Liberati, 2014). It could be seen that technology transfer cannot be divulge from human development, I agree that any transfer that takes place should also seriously package a human development approach, so that spill overs from the transfer will benefit majority of the people. Since developing economies have low levels of human development, they can also position themselves and encourage investment in education and training in technology aspects that there are anticipation of transfers, so that when these occurs they can benefit substantially from it. Prospects also exists for emerging economies concerning technology transfer and the use of ICT as in their work Liu & Nath (2013), obtained empirical data on the use of ICT based on acquisition and transmission of information; and international internet bandwidth indicates that there is a positive effects on imports and hence technology transfer. They further argued that emerging economies should promote technology transfer through trade by introducing policies that increase the use of ICT. Emerging economies therefore can harness the potential of information technology (IT) for their local firms as this has

been indicated by Roztocki & Weistroffer (2008), that domestic firms can use IT to improve their operational efficiency and competitiveness as it compensates for the lack of other resources in the firm like research and development.

Another prospect for increase absorption and diffusion of technology through trade for emerging economies is the potential to increase their technological efficiency and hence their productivity and growth as this is echoed by Henry, Kneller, & Milner (2009). As they believe that continuous technology transfers will lead to absorption of foreign innovations with an eventual spillover of these innovations to other local firms.

### 3.4.1 Challenges to technology transfer

In the work of Musunuri (2014), he discussed how several authors have stated that emerging economies have made efforts to receive technology from industrialized economies so as to bridge the economic gap between them, with little success. He said some of the reasons that has being cited includes (Musunuri, 2014) (Asghari & Rakhshanikia, 2013) (Roztocki & Weistroffer, 2008):

- The lack of technological infrastructure and internal market systems that are needed for successful absorption of technology like hardware, technical education, capability to carry out research, etc.
- There is the lack of well-structured technological policies based on local capacities, cultural, economic, and human resources as any technology that do not take account of these interactions will be difficult to succeed in emerging economies.
- The packaged technology that is transferred including machinery and production plans may include obsolete and irrelevant technology that may not meet the needs of emerging economies.
- Emerging economies technological transfer have been mostly technological imports through FDI with little emphasis on the assimilation and development of relevant expertise needed.
- Emerging economies are poor in absorbing and putting to use technologies transferred which is due to the lack of education, low investment in research and development, weak financial system and the poor quality of government systems that exists in developing economies.

- Absence of a coherent and strategic plan for technological development for most emerging economies.
- Economic factors such as lack of tax systems, unstable foreign currency and low economic growth rate.
- The masculinity and feminine cultural attributes of donor and recipient country can greatly inhibit the technology transfer process.
- There is scarcity of academic research in technology transfer issues specifically to emerging markets, as business are hesitant to provide researchers with information they deem to be sensitive, hence peculiar issues to emerging economies are not available.

#### 4. Discussions and conclusions

This paper has highlighted the operational circumstances of emerging economies and how they are gradually adopting international business strategies to transform their economies and bridge the development gap between themselves and the developed economies. It was revealed that emerging economies can be identified with a rapid pace of economic development and the adoption of policies to create a more liberalized economy. This paper also revealed that most emerging markets are characterized by poor logistical infrastructure and network which makes movement of goods and services difficult and expensive, and this is also coupled with low investment in energy and telecommunication infrastructure (Prater, Swafford, & Yellepeddi, 2009).

However, it was also highlighted that emerging economies are becoming attractive destinations for MNC in developed countries because of low operational cost and a growing population and/or a growing middle class. This attractiveness has resulted in emerging economies receiving considerable inflows of FDIs which come with it some element of technology which is transferred from high tech advanced countries to an emerging economy. These transfers can take place through imports of machinery and equipment, licensing, patent protection, etc. (Hoekman et al., 2005). This paper hence focused on the forms of technology transfer available, the benefits, the prospects and challenges that emerging economies will be exposed to as they make efforts to close the development gap. This context was chosen because various authors in international business and on emerging markets have traced how technology development is

intertwined with human development, hence technological development will yield human development and aid in economic development as well.

Extensive literature review has been carried out on technology transfer and I strongly agree with Sung (2009) assertion that technology transfer requires the collaborative activity between two or more individuals who are separated by structural, cultural and organizational boundaries. This therefore have an impact on the recipient of the technology; hence the appreciation of the human and cultural context of any technology transfer is critical for the successful absorption and diffusion of that technology. Sung (2009), further cited in his work four key factors for technology transfer as communication interactivity, distance, technological equivocality which refers to the degree of correctness of knowledge and technology to be transferred, and motivation.

The review also identified several authors who commented on the benefits that emerging economies will gain from technology transfer for whom I agree with but my major concern is how we can maximize these benefits to our advantage. What can emerging economies do so that they position themselves to benefit immensely from the benefits discussed above? Empirical evidence from some authors have strongly indicated the need for emerging economies to strengthen their IPR protection measures as MNC will want to invest and transfer technologies to economies that have strong IPR regimes as they can offer them some form of protection against copyright and other abuses. The registering and licensing of their patents even allow the economies to obtain access to their information for local firm to provide follow-up products and services.

There are a lot of prospect that exist for emerging economies to tap in as was revealed from the above discussions especially there is the opportunity for increased technological efficiency as they continue to receive transferred technology that is culturally and environmentally suitable to their needs. Despite these benefits and prospects that this paper highlighted, there are some challenges that could limit emerging economies from maximizing the benefits to be obtained from technology transfer as technology absorption is still low in these economies. I believe emerging economies should seriously take steps to address these challenges such as supporting the investment in research and development and appropriate technological policies that could compel MNC to partner and/or adopt local firms

and support them with technology transfer. Efforts are being made by the government of Ghana in collaboration with her donors are seeking to fund technological initiatives through the Council for Technical and Vocational Education and Training (COTVET) program.

## 5. Conclusion and further research

In conclusion, technology development is a key factor for emerging economies to bridge the development gap and hence there is the need for more empirical research coming from scholars in emerging markets to highlight and offer solutions for business leaders and policy makers to deal with this. I believe that this conceptual based paper should pave the way for an empirical based research to be carried that will make available data on the technology transfer situation for local firms in Ghana.

Further research could be carried out, that will assess the various forms of technology transfer that has being made available for a business or for an industry, and the benefits and challenges they encountered in the absorption and diffusion of technology in their businesses.

Currently working on a further study which is assessing the impact of technology transfer to firms in the Information Communication Technology (ICT) sector of the Ghanaian economy where an empirical data will be obtained and analyzed for this exercise.

## Reference

- [1] Asghari, M., & Rakhshanikia, M. A. (2013). Technology transfer in oil industry , significance and challenges. *Procedia - Social and Behavioral Sciences*, 75, 264–271. doi:10.1016/j.sbspro.2013.04.030
- [2] Costantini, V., & Liberati, P. (2014). Technology transfer , institutions and development. *Technological Forecasting & Social Change*, 88, 26–48.
- [3] Fu, X., Pietrobelli, C., & Soete, L. (2010). Technology and Indigenous Innovation in Emerging Economies : Technological Change The Role of Foreign Technology and Indigenous Innovation in Emerging Economies: Technological Change and Catching Up. Washington, D.C.: Inter-American Development Bank. Retrieved from [www.iadb.org](http://www.iadb.org)
- [4] Grosse, R. (2003). The Challenges of Globalization for Emerging Market Firms. *Latin American Business Review*, 4(4), 1–21. doi:10.1300/J140v04n04\_01
- [5] Henry, M., Kneller, R., & Milner, C. (2009). Trade , technology transfer and national efficiency in developing countries. *European Economic Review*, 53, 237–254. doi:10.1016/j.euroecorev.2008.05.001
- [6] Hirt, C. (2012). Technology transfer in Asia: challenges from a cross-cultural perspective. *Journal of Technology Management in China*, 7(1), 4–21. doi:10.1108/17468771211207312
- [7] Hoekman, B. M., Maskus, K. E., & Saggi, K. (2005). Transfer of Technology to Developing Countries : Unilateral and Multilateral Policy Options. *World Development*, 33(10), 1587–1602. doi:10.1016/j.worlddev.2005.05.005
- [8] Hoskisson, R. E., Eden, L., Lau, C. M., & Wright, M. (2000). Strategy in Emerging Economies. *Academy of Management Journal*, 43(3), 249–267.
- [9] Klintonberg, P., Wallin, F., & Azimoh, L. C. (2014). Successful technology transfer : What does it take ? *Applied Energy*, 1–7. Retrieved from <http://dx.doi.org/10.1016/j.apenergy.2014.01.087>
- [10] Li-hua, R., & Khalil, T. M. (2006). Technology management in China : a global perspective and challenging issues. *Journal of Technology Management in China*, 1(1), 9–26. doi:10.1108/17468770610642731
- [11] Liu, L., & Nath, H. K. (2013). Information and Communications Technology and Trade in Emerging Market Economies. *Emerging Markets Finance & Trade*, 49(6), 67–87. doi:10.2753/REE1540-496X490605
- [12] Maskus, K. E. (1998). The Role of Intellectual Property Rights in Encouraging Foreign Direct Investment and Technology Transfer. *Duke Journal of Comparative & International Law*, 9, 109–161.
- [13] Musunuri, D. (2014). Appropriate Technology and Economic Development of Emerging Economies – A Myth or a Reality. *Journal of Technology Management for Growing Economies*, 5(1), 51–62.
- [14] Padilla-Perez, R. (2008). A regional approach to study technology transfer through foreign direct investment : The electronics industry in two Mexican regions. *Research Policy*, 37, 849–860. doi:10.1016/j.respol.2008.03.003
- [15] Prater, E., Swafford, P. M., & Yellepeddi, S. (2009). Emerging Economies : Operational Issues in China and India. *Journal of*

- Marketing Channels*, 16, 169–187.  
doi:10.1080/10466690802477475
- [16] Roztock, N., & Weistroffer, H. R. (2008). Information Technology Investments in Emerging. *Information Technology for Development*, 14(1), 1–10.  
doi:10.1002/itdj.20084
- [17] Sung, T. K. (2009). Technological Forecasting & Social Change Technology transfer in the IT industry: A Korean perspective. *Technological Forecasting & Social Change*, 76(5), 700–708.  
doi:10.1016/j.techfore.2008.03.011
- [18] Takakuwa, S., & Veza, I. (2014). Technology Transfer and World Competitiveness. *Procedia Engineering*, 69, 121–127.  
doi:10.1016/j.proeng.2014.02.211
- [19] Tung, R. L., & Aycan, Z. (2008). Key success factors and indigenous management practices in SMEs in emerging economies. *Journal of World Business*, 43(4), 381–384.  
doi:10.1016/j.jwb.2008.04.001