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Exploring the Influence of International Agreements on the Development of Science-based Regulatory Systems in Developing Economies

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This article examines three developing countries to identify capacities for innovative science policy: Brazil, South Africa and the Philippines. Using membership in regional trading agreements, we assess whether these three nations have aligned their science/innovation policy with the partners of their trading agreements. This assessment provides insights into the potential trade-offs that other developing nations will need to consider as they contemplate the adoption of genetically modified crops.

Keywords: plant breeding techniques; regional trade agreements; regulatory frameworks; science-based regulation; socio-economic–based regulation

1. Introduction

Nearly 40 years ago, at the 1973 Gordon Conference on Nucleic Acids, the first public discourse on genetic engineering was held. Discussions concentrated on the initial rDNA research involving E. coli. These discussions led to the 1974 call for a public moratorium on further rDNA research, to enable research scientists to learn more about the technology of gene splicing, including the safety of those working in the laboratories (Berg et al., 1974). The 1975 Asilomar Conference that followed brought together leading scientists and government regulators to engage in a full and open discussion about the potential risks of genetic engineering. These leading international experts developed safety guidelines for subsequent research, rather than have them developed and imposed by government regulators, with the American National Institutes of Health overseeing the process and adopting the guidelines for subsequent research funding (Singer, 1976). Discussions pertaining to the safety and regulation of genetic engineering have subsequently continued for nearly 40 years.

The importance of the Asilomar Conference cannot be understated, as it provided the governing standards for this initial research such that the innovative science of genetic engineering could advance. Throughout the 1970s, scientists engaged in research that provided them with the knowledge of how microorganism genomics functioned, and this knowledge was transferred to animals and then plants (Khoury and Smyth, 2007). The event that is recognized as being the first public discussion about molecular genetics and plants was the 1983 Miami Winter Symposia, where three of the four world-leading researchers presented their research involving transgenic tobacco (Fraley, Rogers and Horsch, 1983; Framond et al., 1983; Schell et al., 1983). Again, regulatory frameworks were developed in the late 1980s and early 1990s to regulate genetically modified (GM) plants (Smyth and McHughen, 2008; Smyth, 2009).

The underlying constant in all of this is that innovation is being driven by new scientific discoveries and, in the case of new crop varieties, new plant breeding techniques (Lusser et al., 2011). To ensure that the new crop varieties resulting from the application of innovative breeding techniques are given regulatory approval in a timely manner, the regulatory framework that oversees the regulation of GM plants has to be efficient in that it renders repeatable decisions within an acceptable period of time. This staple of regulation was dramatically highlighted by the 2012 decision of BASF to relocate all of its plant biotechnology research from Europe to North and South America, with a loss of over 200 research positions[1] (BASF, 2012). In part, this decision was based on the fact that it took the European Union 13 years to render approval for a BASF variety of GM potato (BASF, 2010). The regulatory uncertainty in the EU regarding the approval process for GM crops is directly responsible for reducing crop innovation research in the European Union.

As is noted in the March editorial of *Nature Biotechnology* (2012, 197), "[i]n the European Union, since the mid-1980s, regulators have shifted from evidence-based risk assessments to implementation of rules that specifically discriminate against transgenic products and emphasize the precautionary principle." The inclusion of the precautionary principle into the framework for the regulation of GM crops by the European Food Safety Authority (EFSA) has precipitated a movement away from science-based regulation to socio-economic–based regulation. In other words, this has meant the politicization of risk in the European Union, especially since EFSA renders its scientific decisions to the European Commission, where variety approval decisions are made. When the regulation of GM crops in the European Union resided with the member states, the regulations were science-based, but following the 2002 creation of EFSA and the centralization of regulation, regulators were no longer able to rationalize the rejection of GM crop technologies based solely on science and have now moved to the inclusion of socio-economic risk assessments as a means of rationalizing the rejection of GM crop innovations. Socio-economic considerations are considerably more nebulous and frequently lack substantiated methodologies that are capable of providing results that can be quantified. As BASF has already indicated, regulations based on socio-economics are not equipped to deal with innovation.

Future innovations are going to be increasingly correlated with the efficacy of the regulatory system into which the innovative crop varieties will be commercialized. Regulatory frameworks that are science-based and provide consistent and timely decisions will be preferred by companies engaged in innovative agricultural research over regulatory systems that have incorporated socio-economic–based regulations. Given that there is a substantial trans-Atlantic gap in the global regulation of GM crops, the question arises of how regional trade agreements are positioned to address regulation in this area. While the regulatory environments in both North America and the European Union have been well defined, we examine three developing countries and the role that regional trade agreements play in the regulation of GM crops. The countries we examine are Brazil, South Africa and the Philippines, while the trade agreements governing the regulation and trade of GM products are the Free Trade Area of the Americas (Brazil), the Cotonou Agreement (South Africa) and the Asian-Pacific Economic Cooperation Forum (the Philippines).

It is important for developing countries or economies to form strategic partnerships with science-based regulatory jurisdictions in order to access knowledge and key technologies that will be valuable tools in addressing food security. Science-based industrialized countries are driving the international trade in products of agricultural biotechnology, and in this article we examine whether developing nations will align themselves with the technologically innovative countries or with countries that shun science-based innovation and with which they have regional or historical alliances. Our hypothesis is that developing nations will align their science/innovation policy with nations with which they have a strong regional trading affiliation.

This article assesses how agricultural biotechnology is regulated in Brazil, the Philippines and South Africa, providing insights into the impact economic and trade agreements have on domestic science and innovation policy. The following section provides the background to the article. Section 3 presents our case studies on Brazil, the Philippines and South Africa, their attachment to international trade and strategic agreements and an introduction to their respective regulatory systems. Section 4 provides a policy assessment of the implications of the findings. Finally, Section 5 offers some concise final thoughts.

2. Trade Agreements and Policy Implications

Trade alliances, partnerships or multi-country agreements are designed to facilitate trade between nations that have mutual interests. The European Economic Community (EEC) was established in the 1950s with the objective of reducing tariff barriers and establishing a common tariff between the founding members (Treaty of Rome, 1957). Similarly, the Canada-U.S. Free Trade Agreement (CUSTA) between Canada and the United States was established in the 1980s to reduce tariffs that impeded trade between the two nations. In the case of Canada and the United States, each country was the largest export market for the other’s exports; hence there was a sound economic rationale to enter into an agreement that facilitated trade between the two. The Canada-U.S. Free Trade Agreement came into effect in 1988, and the success of this agreement resulted in the subsequent negotiation and ratification of the North American Free Trade Agreement (NAFTA) between Canada, Mexico and the United States in 1994.

One of the underlying reasons for entering into a freer trade agreement with neighbouring countries is that strong trade relationships already exist. For example, Canada and the United States are both exporting nations, with billions of dollars of trade crossing the border every day, and there were considerable synergies in harmonizing the trading relationship between the two countries. Similarly, the original members of the EEC have attracted other nations that share strong trade relationships with the members and had sought to join the EEC over the preceding decades. Other examples of neighbouring nations seeking to improve trading relations can be found in the 1967 Association of Southeast Asian Nations (ASEAN) and the 1969 Andean Pact, which became the Andean Community of Nations in 1996. Countries are free to enter into multiple trade agreements; membership in one trade agreement does not preclude participation in others.

The transition from the General Agreement on Tariffs and Trade (GATT) to the World Trade Organization in 1995 resulted in more than just an international trading agreement for the WTO member countries. The establishment of the WTO was the result of a seven-year negotiation process. Concurrent with this, many nations were involved in the establishment of regional trading agreements that would further facilitate trade. One example of these efforts was the 1989 establishment of the Asia-Pacific Economic Cooperation (APEC) Agreement, which expanded in terms of the founding membership during the Uruguay Round of GATT. Following on the heels of the WTO Agreement were efforts to establish the Free Trade Area of the Americas, efforts which were ultimately unsuccessful.

Trade, and opportunities to increase trade, reduce tariffs and strengthen trading relationships, underpin the rationale for the establishment of many international and regional agreements. International agreements can also exist due to historical colonial connections such as the British Commonwealth or the association of French-speaking nations known as 'La Francophonie'. Both of these organizations include numerous African nations. There are several Africa-based trade organizations, with the more effective ones being the Common Market for Eastern & Southern Africa (COMESA) and the Southern Africa Development Community (SADC).

While numerous agreements exist to foster trade at regional levels, other entities exist at this level to facilitate research and innovation. The Consultative Group on International Agricultural Research (CGIAR) is a global network of 15 different organizations that share a common objective to improve human health and nutrition. The research undertaken through this global partnership ranges from that which focuses on a specific crop, such as the work of the International Rice Research Institute (IRRI) based in the Philippines or the International Maize and Wheat Improvement Center (CIMMYT – Centro Internacional de Mejoramiento de Maiz y Trigo), to that which focuses on wider research objectives, such as the work of the International Livestock Research Institute in Kenya.

While trade agreements and the commitments made under these agreements, especially in terms of reducing domestic tariffs, have an impact on member countries, what is uncertain is the degree to which these agreements impact science/innovation policy. While trade agreements require the reduction of tariffs and in some cases the harmonization of tariffs across a group of nations, these issues remain relatively fiscal, involving little in the way of social policy issues. That is not to say that fiscal issues are not policy issues; they are. Science and innovation policy issues certainly contain a strong fiscal component due to the large public research programs that exist domestically in all nations, but the policy issue broadens to include what types of innovation to support. For example, the Bush administration in the United States would not provide federal funding for stem cell research.

The challenges of delving into science and innovation policy issues are underscored by the Canadian Regulatory Cooperation Council report (Government of Canada, 2011). The Regulatory Cooperation Council (RCC) was formed early in 2011 under the Perimeter Security and Economic Competitiveness agreement that exists between Canada and the United States. The objective of the RCC is to simplify and align regulatory approaches in both countries, where possible. Two specific areas identified in the Joint Action Plan were agriculture and food (more specifically, food safety systems), and biotechnology. Key priorities to be dealt with regarding agriculture and food are the mutual recognition of food safety systems and the development of common approaches to food safety requirements and policies. Priority areas for biotechnology between Canada and the United States are a joint review process to deal with the issue of asynchronous approvals as well as a common policy for dealing with the low-level presence of unapproved products. CUSTA came into effect in 1988 and, over 20 years later, both nations are still grappling with how to harmonize and streamline policy and regulations that will further support trade between them, proving that this process is neither simple nor easy.

The challenge facing Canada and the United States on science policy harmonization is also complicated by the fact that regulation of agricultural biotechnology products has been occurring for 20 years. The first GM crop varieties entered the regulatory systems of both Canada and the United States in the early 1990s, with the first product being approved in the United States in 1994 (GM tomato). Escaler, Teng and Powell (2012) highlight these challenges on a much broader scale in their review of agbiotech regulations across APEC member nations, concluding that inconsistent regulatory policies do act as barriers to agbiotech innovations. Castle, Loeppky and Saner (2006), in an assessment of innovation policy as it pertains to biotechnology, posit that there are five obstacles that governments/regulators must address: the complexity obstacle; the regulatory culture obstacle; the reactive mode obstacle; the myth of sound science obstacle; and the domestic focus obstacle.

The complexities of the interactions among trade policy, economic policy and science policy have been examined in detail in books edited by Evenson and

Santaniello (2006) and by Just, Alston and Zilberman (2006). Within science-based trade systems such as the WTO, trade in products of agricultural biotechnology has been problematic, and the problems are compounded as nations consider implementing socio-economic considerations as part of their innovation policy. Socio-economic assessments of genetically modified organisms (GMOs) have become controversial under the Cartagena Protocol on Biosafety (CPB), a supplement to the Convention on Biological Diversity (Falck-Zepeda, 2009). The objective of the protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of "living modified organisms resulting from modern biotechnology" that may have adverse effects on the conservation and sustainable use of biological diversity, also taking into account risks to human health and specifically focusing on transboundary movements (Secretariat of the Convention on Biological Diversity, 2000, Article 1). The move away from science-based innovation policy has created considerable angst at an international trade level (Smyth, Phillips and Kerr, 2009; Smyth, Kerr and Phillips, 2011).

To a certain degree, it appears that there is the emergence of a movement away from global, science-based trade agreements to more regional alignments. In part, this is underscored by the competition between the WTO and the CPB as global bodies to guide and oversee international trade in agbiotech products. The WTO is championed by Canada and the United States, with their science-based approach to science and innovation policy, while the European Union, with its focus on socio-economic policies, leads the promotion of the CPB. With the rise of regional trade agreements, the question of how and where developing countries should align themselves increases in significance. Should developing nations align with their strongest trading partners? Or should they align with those where there is a cultural belief that innovation requires more than science-based policy and that socio-economic considerations need to be part of innovation policy?

3. Trade Conventions and Other Agreements: Influencing Factors for Development of Science-based Regulatory Systems in Developing Nations

3.1 Brazil and Free Trade in the Americas

The Free Trade Area of the Americas (FTAA) was a proposed trade agreement designed to reduce trade barriers between all countries in the Americas. The agreement, essentially, was to be an extension of the NAFTA between Canada, Mexico and the United States. Co-chaired by Brazil and the United States, the FTAA was comprised of a total of 34 member countries that participated in the negotiations.[2]

Given the geo-political realities of the Americas, it was not surprising that developed member nations (Canada and the United States) sought to expand trade in services and to increase intellectual property rights through the FTAA while less developed member nations sought to end agricultural subsidies and free trade in agricultural goods.

Brazil, for its part, took a leadership role among the less developed nations that were party to the agreement, while the United States took a similar role for the developed nations. Formal negotiations for the agreement began in 1998, but by 2005 negotiations had broken down, due – in large part – to opposition from Brazil and Venezuela on agricultural subsidies (FTAA, 2012). In his 2001 report, Jank (2001, 5) stated that the FTAA "[would] only materialize when all countries adopt a balanced approach to the negotiations and engage in a win-win situation." In his review of the trade data at the time, Jank suggested that Brazil would have to make considerably more trade concessions than would the United States through the FTAA. In his words,

> Brazil faces the risk of losing industrial production capacity, jobs, and trade surpluses. In other words, if the FTAA is not a balanced agreement, Brazil may incur more losses than gains, which would make the integration undesirable for the economy as a whole though it may benefit consumers…. (Jank 2001, 1-2)

Had the FTAA been signed, it would have created the largest free trade zone, with output of nearly US$13 trillion and with 800 million consumers from Alaska to the tip of South America (Export Virginia, 2012). The focus of the participating countries in the FTAA has now moved to bilateral agreements between members. Although largely unsuccessful, the FTAA highlights not only the strategic commonalities between the United States and Brazil, but also some of the deficits at work, particularly in trade negotiations.

Today's Brazil evolved out of the political turmoil of the 1980s and was part of a larger trend of democratic transitions that occurred through Latin America and in Eastern Europe at the time. After two decades of military dictatorship (which began in the mid 1960s), Brazil came to enjoy more political freedom in the mid 1980s, when important barriers to political participation were lifted. Although still constrained by enormous debt in an overpopulated continent, Brazil's economy grew faster in 1985 and 1986 than that of any other country in the world (Hagopian and Mainwaring, 1987). Today Brazil is one of the fastest growing economies, with an average annual GDP growth rate of over 5 percent. Political and economic uncertainties are now under control, with Brazil moving towards fiscal sustainability over the last two decades. Brazil has taken important measures to liberalize and open its economy. This liberalization has fundamentally changed the country's competitiveness level on a global scale and has provided a foundation for foreign investment and private sector development in the nation (Schwab, 2009). As with all existing members of the GATT, Brazil became a member of the WTO in January 1995. Brazil signed on to the Convention for Biodiversity in 1992 and ratified the convention in the same year.

Brazil is rapidly emerging as a global leader in GM crops. In 2011, for the third consecutive year, Brazil was the engine of growth globally, increasing its production acreage of GM crops by a record 4.9 million hectares. That is equivalent to an impressive year-over-year increase of 20 percent. In total, Brazil accounts for 19 percent of the global production of 160 million hectares and is consolidating its position by consistently closing the gap with the global leader, the United States (James, 2011).

Until 2007, only two biotech events had been approved by Brazil's regulatory authority. A fast-track approval system allowed Brazil to approve eight events in 2010, and as of 15 October 2011, an additional six events had been approved in 2011. A total of 25 new biotech events were approved from 2007 to 2011 (Kalaizdonakes, 2011). Brazil approved the first stacked soybean with insect resistance and herbicide tolerance for commercialization in 2012. Notably, EMBRAPA, a public sector institution, recently obtained approval to commercialize a domestic GM virus-resistant bean (James, 2011).

The explanation for the early adoption and success of agricultural biotechnology in Brazil has much to do with the expansion of world demand for soy over the past several decades. Together with Argentina and Paraguay, Brazil provided 55 percent of the world's soy exports in 2008 (Turzi, 2010). Working their way from a GM moratorium (which ended in 2003) to science-based policies and a regulatory system in as little as ten years, Brazil has demonstrated that, in some ways, it is quite strongly and strategically aligned with the United States. That being said, Brazil is in a part of the world (South America) where there is a greater level of variation of regulatory permissiveness, ranging from outright prohibitions encoded in national constitutions, as in the case of Bolivia, to extremely tolerant policies that actively promote the technologies, as in Argentina (Rhodes, forthcoming).

While it could be argued that Mercosur is a more important trade agreement for Brazil than the FTAA, this article focuses on the trade relationships between developing and industrialized countries. This is why the FTAA has been chosen, as it forced Brazil to make a difficult decision regarding past and future trade loyalties. Brazil has strong historical alliances to Europe and was the leading supplier of non-GM soybeans in the late 1990s and early 2000s. The problem for Brazil was that the soybean-exporting firms in the early 2000s were finding it increasingly difficult to source non-GM soybeans for the European market. Genetically modified soybeans entered Brazil through Argentina and Paraguay, and while Brazil enacted a moratorium on GM crops, the government was unable to halt the rapid advancement of the technology. (Indeed, the situation was so problematic that it caused many in the commodity trade industry to question the efficacy of those responsible for the testing of imports within the EU.) With the benefit of hindsight it is evident that Brazil concluded that its ability to continue to serve the EU demand for non-GM soybeans would become increasingly problematic, given the massive popularity of GM technology, and that aligning their trade policy in agriculture with the Americas would deliver a higher level of benefit that aligning this policy with the EU.

3.2 The Philippines and APEC

The Asia-Pacific Economic Cooperation (APEC) forum was first developed in 1989 with founding members Australia, Brunei Darussalam, Canada, Indonesia, Japan, Korea, Malaysia, New Zealand, Singapore, Thailand, the United States and the Philippines. In following years many other nations joined. Hong Kong, China and Chinese Taipei joined in 1991, Mexico and Papua New Guinea followed in 1993, and Chile acceded in 1994. In 1998, Peru, Russia and Vietnam joined, taking the full membership of APEC to 21 countries (APEC, 2012).

Food security is a major concern of APEC. Member nations are concerned with the quality, availability and cost of food. To that end, APEC addresses food security by promoting productivity growth and encouraging the development and adoption of new agricultural technologies. Specifically, groups within APEC help to address these concerns. These structures include the Agriculture Technical Cooperation Working Group and a forum on High-Level Policy Dialogue on Agricultural Biotechnology (HLPDAB) (APEC, 2012).

In 2002, the first of the High-Level Policy Dialogues on Agricultural Biotechnology took place. Policy makers use the HLPDAB to develop regulatory frameworks, facilitate technology transfer, encourage investment and strengthen public confidence regarding biotechnology. HLPDAB is very involved in the promotion and implementation of regulatory harmonization and has significant interest in reducing trade disruptions through application of the Codex Alimentarius Annex (APEC, 2012).[3, 4]

The Philippine economy is predominantly agricultural; the country devotes almost one-third of its total land mass to agricultural production, which employs a third of its population. Rice and corn are the major staple crops cultivated for food and feed, but production remains insufficient for domestic needs (Ludlow and Yorobe, forthcoming). The Philippines' early participation and membership in APEC presumably plays a key role in the country's policy development around science and its (relatively speaking) early adoption of GM crops. Alignments with more developed economies, facilitated through APEC, would allow for collaborative opportunities as well as provide the Philippines with access to technology and other scientific knowledge. Again, openness to GM technology is evident in the country's development of science-based policy and its regulatory environment. The Philippines became a member of the WTO in January 1995, signed on to Convention for Biodiversity in 1992 and ratified the convention in 1995.

The Philippines was the first in the ASEAN region to establish a GM regulatory system, becoming a model for other countries. Its regulatory system was formalized by Executive Order No. 430 in 1990, creating the National Committee on Biosafety of the Philippines (NCBP). The committee was given the mandate of identifying and evaluating potential hazards for the introduction of GMOs into the country and formulating and reviewing national biosafety policies and guidelines.[5] The committee is responsible for the research and development stages of the regulatory process, while the Bureau of Plant Industry of the Department of Agriculture regulates commercial production and use (Ludlow and Yorobe, forthcoming).

As one of the few developing countries with a functioning biosafety system, the Philippines became the first country in Asia in 2002 to commercialize a GM crop, insect-resistant Bt corn, for planting by farmers. Since 2004, IFPRI's Program for Biosafety Systems has been working closely with key regulatory agencies and the National Committee on Biosafety to implement activities aimed at strengthening the Philippines' biosafety system. Some key overarching goals underlying these efforts are to aid in the adoption and development of science-based policies that address post-commercialization requirements, to support confined field trials of locally developed GM products, and to facilitate field trials and eventual commercialization of GM crops[6] (IFPRI, 2012). The National Academy of Science and Technology (NAST) in the Philippines has developed a vision or mission statement that refers to "… a progressive Philippines anchored on science" with a goal, if possible, "… to provide science-based solutions [and leadership] to its most difficult challenges" (NAST, 2012, 1). The efforts of NAST are supported and led by the Department of Science and Technology, which is in charge of establishing national development priorities to address economic and social challenges in the Philippines, including the following: brain drain in the science and technology field; education;[7] low levels of investment in R&D; and a lack of technology transfer and commercialization (Stads, Faylon and Buendia, 2007). According to a study by Torres et al. (2012), adoption of biotech crops in the Philippines is largely farmer driven, with the primary advantages identified by growers as economic and agronomic in nature.

3.3 South Africa: Technology, Trade and Aid

The Cotonou Agreement between the EU and the African, Caribbean and Pacific (ACP) group of countries – including South Africa – was signed in June 2000. This agreement evolved from an original treaty signed in 1957 between the European Community and the sub-Saharan Africa, Caribbean and Pacific countries. Following this original treaty, the Lomé Conventions I-IV developed, with the original Lomé Convention signed in 1975. Core principles of the original agreement included the following:

- the principle of non-reciprocal preferential trade concerning most exports from ACP countries to the EEC;
- the principle of equality of the partners, and respect for the sovereignty, interdependence and mutual interests of the partners; and
- the right for each state to determine its own policies and development strategy.

The initial Lomé I agreement achieved a significant reduction of tariffs on agricultural and industrial products. This implied that the ACP countries were able to export a number of commodities to the EEC almost free of duty (Bjornskov and Krivonos, 2001).

At the expiration of the first Lomé Convention in 1979, the strong African growth of the 1960s had come to a complete halt, and the ACP group had lost its importance to the EEC trading community. These economic problems continued to worsen by the time the second Lomé Convention expired in 1985, with several African countries experiencing serious debt crises (Bjornskov and Krivonos, 2001). Lomé III came into existence in 1985, lasting for five years, and Lomé IV existed for a period of ten years, starting in 1990. This last of the Lomé conventions included numerous stipulations for human rights but was not compatible with WTO regulations in the area of trade.

To address these shortcomings, a new agreement, the Cotonou Agreement, was reached in February 2000 (United Nations, 2003). Currently, the Cotonou Agreement has 79 member countries from the ACP, including South Africa, which joined ACP in 1998 (EC, 2012a). The Cotonou Agreement's objectives are to reduce poverty while contributing to the peace, security and democratic political stability in ACP countries. The most recent version of the agreement was signed in March 2010 and will be up for renewal again in 2015. The European Development Fund is the main instrument for providing assistance for community development under this agreement (European Commission, 2012a).

South Africa, although part of the ACP group of countries, has not been party to the preferential trade arrangements granted under the Cotonou Agreement. South Africa joined in the negotiations with the Southern African Development Community or SADC EPA Group in February 2007 as part of the Economic Partnership Agreements (EPAs) (the trade pillar of the Cotonou Agreement). While other African countries signed an interim EPA in 2009, South Africa has opted not to join at this stage. Its trade relations with the EU are largely governed by the Trade, Development and Co-operation Agreement (TDCA) (EC, 2012b). The TDCA was signed in Pretoria in October, 1999. The TDCA aims "… to establish a free trade area over a 12 year period covering 90% of bilateral trade" (EC, 2012b). The implementation of this trade agreement is administered by the Joint Cooperation Council. The most recent meeting was the 12th Joint Cooperation Council, held in Brussels, 20 July 2011.

Strategic alignments and trade relations with the EU are important for South Africa. South Africa is the EU's largest trading partner in Africa and one of the strongest economies in sub-Saharan Africa. South Africa's exports to the EU are growing and the composition of those exports is becoming increasingly more diverse over time (exports to the EU from South Africa in 2010 were €18 million). The EU is also, by far, South Africa's most important development partner, providing for 70 percent of all external assistance funds (EC, 2012b).

Despite the strong strategic and trade relationship between South Africa and the EU, South Africa's trajectory in science-based policy and regulatory development appears to have followed a North American lead. During apartheid, science operated exclusively for the benefit of the ruling white class, which constituted less than 15 percent of the population (TWAS, 2009). Prior to 1994, South African policy was substantially affected by apartheid and the economic sanctions that were imposed on the country by virtually all other industrialized nations. Undoubtedly, this led to substantial economic and trade impacts on South Africa. Trade sanctions inhibited the transfer of technology, and the country was forced to rely on internally developed solutions. Consequently, a newly democratic, post-apartheid country faced the new challenge of how to reorient South Africa's scientific capacity to serve the needs of the majority.

Unlike the former Soviet Union, for example, which also experienced turbulent change in the early 1990s, science in South Africa was not exclusively a government enterprise. In fact, the private sector accounted for more than 50 percent of the investment in research and development in South Africa during apartheid. The private sector subsequently remained an important actor in the country's R&D activities after democracy took hold (TWAS, 2009).

Tumultuous political and social change in South Africa in the 1990s led to a drastic reduction in public investments in scientific research. The private sector provided a welcome cushion, softening the impact on the scientific and technological agenda through its investments. Despite this blip on the country's economic and political map, South Africa's scientific capacity has grown and evolved due to the country's responsiveness to tumultuous change and the fact that it has a long-established and relatively well resourced (private sector) scientific community. This may well explain South Africa's early adoption of GM crop production, which was given a strong push by the country's scientists (Cooke and Downie, 2010). South Africa has grown GM crops since 1997, when Bt cotton was first approved for commercial release.

Government efforts in science in South Africa have been led by the Department of Science and Technology. The Genetically Modified Organisms Act, passed in 1997 and amended in 2006, is the main piece of legislation governing the production and use of GMOs in South Africa. According to the act, administered by the Department of Agriculture, all applications to develop GMOs or release them into the environment must be approved by the Executive Council, consisting of six to eight departments (including agriculture, health, environmental affairs and science and technology). Decisions by the council are reached by consensus and are based on the recommendations of an advisory council of scientists. If an application is approved, a permit is issued by the registrar of the GMO Act (Cooke and Downie, 2010).

South Africa is also a signatory to other international agreements, including the WTO, which it joined in 1995. In 2003, South Africa ratified the Cartagena Protocol on Biosafety and since that date has adopted much stricter controls on the importation of GM products from abroad, more on protectionist grounds than due to concerns about safety. As of 2010, South Africa has a moratorium in place on imports of new GM varieties (Cooke and Downie, 2010).

South Africa is now the ninth-largest producer of biotech crops in the world, growing 2.3 million hectares of genetically modified maize, cotton and soya in 2011 (James, 2011). More than 90 percent of the cotton, 80 percent of the soya and 62 percent of the maize now grown in South Africa is GM (van der Walt, 2009). South Africa is also unusual in that it produces and exports both GM and non-GM food products and maintains production systems for both (Cooke and Downie, 2010). The EU, as a large export market, also factors into this.

4. Analysis and Results

In this section, we more closely examine trade and international strategic relationships of Brazil, the Philippines and South Africa with the industrialized nations of Canada, the United States and the EU. For the purposes of our analyses, we draw on trade data and triangulate our results with qualitative data drawn from historical, political and science-based policy/regulatory developments of the three developing nations. Our overarching assumption or hypothesis here is that science-based innovation and regulatory policy development in developing nations are influenced by trade and strategic relationships with industrialized nations via key international agreements (FTAA, APEC and the Cotonou Agreement).

4.1 Trade Analysis

Using trade data as a proxy, we contrast, compare and qualify the nature of trade relationships between developing nations (Brazil, the Philippines and South Africa) and developed nations (Canada, the United States and the EU) (see table 1).

Table 1 Relative Distributions of Exports of Maize, Soybean and Cotton from Brazil, the Philippines and South Africa into Select Developed Nations (1995 – 2009)

	Canada			**United States**			**European Union**		
	Maize	Soybean	Cotton	Maize	Soybean	Cotton	Maize	Soybean	Cotton
Brazil	0%	0%	0%	0.1%	0.3%	0%	99.9%	99.7%	100%
The Philippines	7.7%	0%	0%	92.3%	0%	100%	0%	0%	0%
South Africa	0.02%	0.7%	0%	2.3%	91%	100%	97.7%	8.3%	0%

Source: Food and Agriculture Organization Tradestat, 2012.

Based upon the distribution of trade in maize, soybeans and cotton (GM crop varieties currently under production in Brazil, the Philippines and South Africa), it appears that relationships between the developing nations of interest and developed economies are differentiated (see table 2). Brazil has strong connections to the EU (relative to its connections with Canada and the United States), as almost all (more that 90 percent) of its maize, soybean and cotton production is exported to the EU. The EU is Brazil's biggest trading partner, accounting for 22.5 percent of its total trade in 2009. Brazil is the single biggest exporter of agricultural products to the EU, accounting for 12.4 percent of total EU imports in 2009, and ranks as the EU's tenth trading partner (EC, 2012c).[8]

On the other hand, the Philippines, based upon our data, has absolutely no trade relationship with the EU. Most of the Philippines' production of maize and cotton is exported to the United States. South Africa exports all of its cotton and most of its soybean production to the United States, while a majority of its maize is exported into the EU. Trade relationships between the developing nations and Canada are weak or marginal, with distribution of trade in crops of interest ranging between 0 percent and 7.7 percent.

Table 2 Strength of Relationship Based upon Trade in (Potentially) GM Crops

	Canada	United States	European Union
Brazil	marginal	marginal	strong
The Philippines	marginal	moderately strong	nil
South Africa	marginal	moderately strong	moderate

Both trade and strategic relationships between developing nations (Brazil, the Philippines and South Africa) and developed nations (Canada, the United States and the EU) are illustrated in figure 1. The illustration reflects not only the characterization of trade relations between select countries (as offered up in the aforementioned tables), it also shows representative linkages between countries based upon strategic relationships reflected through joint membership in the three agreements of interest in this study: the FTAA; APEC; and the Cotonou Agreement.

4.2 Scientific Trajectories and Regulatory Analysis

The alignment of innovation and science policy with any one particular trade alliance is not evident in our assessment. In fact, the nations are members of both the WTO and the Cartagena Protocol on Biosafety, indicating a mix of science-based and socio-economic–based risk assessment (table 3). Brazil is a dominant soybean exporter to the EU, but this does not appear to be an impediment to the adoption of GM soybeans and other GM crops. The same can be said of South Africa in that it relies on EU export markets and receives considerable development aid from the EU, but this has had a minimal impact on the development of GM crops. The Philippines, while less geographically aligned with either the Americas or the EU and while having some strong connections with Australia, is showing signs of being quite innovative with its science policy. The fact that the Philippines is developing a domestic low-level presence (LLP) policy would indicate that the country sees a role for biotechnology and GM crops in the future and is putting policies in place now to address future comingling incidents that will inevitably occur with imported products.

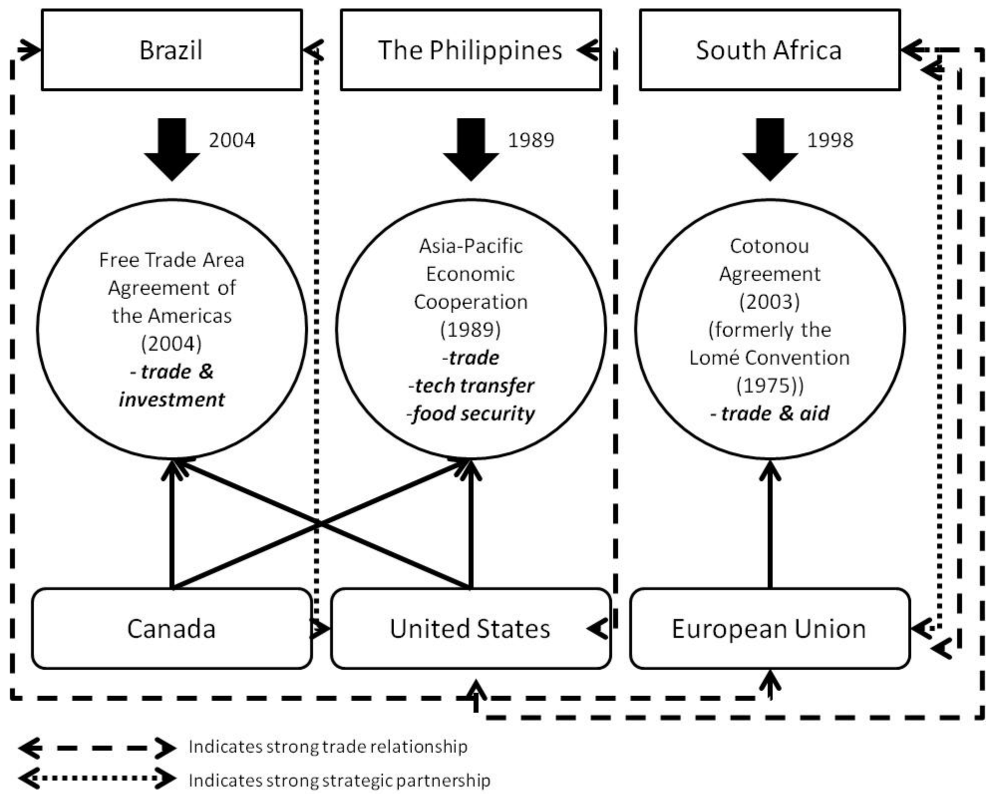

Figure 1 Illustrating trade and strategic relationships.

It would appear that the liberalization of domestic trade policy is something that governments embrace, which could raise enough voter angst to result in a sitting governments losing an election, but this does not seem to be the case. However, innovations and science policy are another matter. One thought is that with markets that were, to some degree, isolated due to the style of government until the late 1980s and early 1990s, the liberalization of trade policies is an acceptable first step toward greater global integration. Canada and the United States have been strong trading and economic partners dating back over 100 years, and still they face challenges in innovation and science policy alignment. Compared to Canada and the United States, these three developing nations are relative newcomers to the policy alignment conundrum.

In terms of domestic policies where developing nations will have increased flexibility regarding alignment with desired trade partners, trade policies would head such a list. In no way does this suggest that trade policies are readily restructured – witness the seven-year negotiation process of the Uruguay Round of the GATT discussions as well as Brazil's assessment of participating in the FTAA. The process of negotiating changes to domestic trade policy provides experience and understanding about what is required of a nation and the concessions that must inevitably be made to ensure agreement at the end of the day. While governments of developing nations may feel comfortable negotiating concessions about domestic trade policy and tariffs, engaging in dialogues regarding innovation and science policy is, literally speaking, a very different kettle of fish. In any event, harmonization of innovation and science policy should be expected to take a considerably longer period of time, if the Canada-U.S. experience is taken as an example.

Table 3 Innovation and Science Policy Alignment Matrix

	Brazil	**The Philippines**	**South Africa**
Political status	Democratic/developing	Democratic/developing	Democratic/developing
Economic status	Producer/exporter	Producer/domestic consumption	Producer/domestic consumption/exporter
Major strategic partners	United States	Australia	EU (aid), South African countries
Major trading partners	EU (soybeans)	United States	EU, United States
Global area of GM crops in 2011	30.3 million hectares (soybean, maize, cotton)	0.6 million hectares (maize)	2.3 million hectares (maize, soybean, cotton)
LLP Policy	n/a	Developing	n/a
Science-based regulations development status	In place, evolving	In place, evolving	In place, evolving
Science-based policies/initiatives		LLP policy, National Biosafety Framework, other policies currently in place and under development	
Science-based policy goals	Development and trade	Education, attraction of educated ex-pats, trade & commercialization	Development and trade
WTO status	1995	1995	1995
CBD status	Ratified in 1994	Ratified in 1995	Ratified in 2003
CPB status	Ratified in 2004	Ratified in 2004	Ratified in 2010

5. Policy Implications and Conclusions

According to James (2011), developing countries accounted for close to 50 percent of all GM crops planted worldwide in 2010. Growth rates for GM crops in developing countries were twice as fast and twice as large in developing countries in 2011, at 11 percent or 8.2 million hectares, versus 5 percent or 3.8 million hectares in industrial countries. Brazil, the Philippines and South Africa are leaders of developing nations in terms of adopting and implementing science-based policies and regulatory systems. Their role in shaping the future of GM crop development and in setting examples for other developing nations cannot be understated.

Our interest in this study was to explore the effects or influence that select trade and strategic international agreements had on the development of science-based policy and regulatory systems in key developing countries, in particular, Brazil, the Philippines and South Africa. Our hypothesis was that agreements would serve as bridges to industrialized nations (Canada, the United States and the EU), countries that would then, in turn, influence the adoption of either science-based or socio-economic–based regulatory systems in developing nations. Again, our underlying assumption here would suggest that trade relationships would greatly influence a developing nation's adoption of a certain kind of regulatory system (science-based or socio-economic–based). What we uncovered is that development of regulatory systems in developing nations is not as simple as that.

The decision to adopt GM crops is much more than a regulatory decision. There are a number of factors that come into play which are context-dependent in terms of their importance and application: political history; geopolitical factors (such as co-location to GM-free jurisdictions); agricultural production trade relationships; and strategic relationships (including historical relationships and aid) as well as historical science-based trajectories including science-based policy development.

Developing countries, although partially influenced by trade-related and strategic partnerships, develop science-based regulatory policy for a number of reasons, including and not limited to what are deemed to be broader goals for innovation: to ensure north-south trade and ongoing investments and to be competitive in global markets (Brazil); to ensure that domestic production levels are maintained and domestic supply needs are met (The Philippines); and to maintain continuing investment in technology development and trade/strategic partnerships and in aid (as in the case of South Africa). Science-based regulatory capacities in developing countries are in various states of development. Trade matters, but domestic policy appears to evolve independently of trade and aid relationships:

> Historically, South American exporters like Brazil and Argentina had maintained synchronicity with the EU to minimize potential low level presence occurrences by slowing their regulatory approval process. In recent years, however, they have shifted away from such policy reviewing and approving new biotech events with much higher frequency. (Kalaitzondanakes, 2011)

Interestingly enough, the effect of the CPB, with its socio-economic rationale for regulating GM crops, seems to have a minimal role regarding trade agreements. All three developing nations have ratified the CPB, yet in terms of regulating the approval of new GM crop varieties, it is clearly being applied in a substantially different way than it is applied in the EU. Given the high number of GM variety approvals in Brazil, the precautionary principle of the CPB is given considerably less weight in regulatory decisions than it is given in the EU. This would appear to be the case, as the production of GM crops is growing rapidly in the three developing nations. Trade agreements, therefore, can be considered to be based on science-based policies rather than governed by socio-economic considerations.

Development of science-based policies and regulatory systems is a complex process. Merging socio-economic considerations with science-based approaches only increases the complexity of regulatory decision making. That being said, South Africa is an example where this type of blend of regulatory approaches appears to take place. Although the country appears to have adopted a more North American, science-based approach to regulating GM, in some ways – in trade and protectionist ways – it responds to GM imports from a socio-economic perspective, much like the EU. The influence of the trade/aid relationship between the EU and South Africa (facilitated through bilateral agreements such as the TDCA) cannot be underestimated either.

In this article, we hypothesized that science-based policy and regulatory systems in developing nations are driven by relationships with industrialized nations carved out through international trade agreements, and even trade itself. But that does not seem to be the case. The issue is more complex than that. There appear to be a number of factors – all context-dependent – that influence adoption and development of science-based policies and regulations in developing countries. The presumed 'strong arm' of international trade agreements appears to play only a partial role. We could not draw definitive distinctions between trading partners and science-based policy development for our countries of interest: Brazil, the Philippines and South Africa.

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Endnotes

1. While this figure is the publicly announced figure, agricultural biotechnology experts have privately indicated that the more accurate figure would be over 800 jobs.
2. Not including Cuba.
3. The Philippines and the EU: The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967 by the five founding member countries of Indonesia, Malaysia, the Philippines, Singapore and Thailand. Today, ASEAN encompasses ten Southeast Asian countries with the addition of Brunei Darussalam (1984), Vietnam (1995), Laos (1997), Burma/Myanmar (1997) and Cambodia (1999). ASEAN as a whole represents the EU's third-largest trading partner outside the European Union (after the United States and China), with more than €206 billion of trade in goods and services in 2011. The EU is ASEAN's second-largest trading partner after China, accounting for around 11 percent of ASEAN trade. http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/regions/asean/.
4. Other APEC countries are developing science-based regulatory polices as well with the assistance of agencies/departments from the United States. In 2012, Robert D. Hormats (Under Secretary for Economic Growth, Energy, and the Environment) made the statement that "… the Indonesian government established a science-based regulatory system and embraced the potential of agricultural biotechnology. There are currently multiple crops undergoing field trials in Indonesia, with the first expected commercialization to occur later this year." The U.S. government is assisting Vietnam to establish a biotech regulatory framework by building the capacity of Vietnamese authorities to administer a science-based system (see http://www.state.gov/e/rls/rmk/2012/188110.htm).
5. National Committee on Biosafety of the Philippines, 2006. *Executive Order No. 514: Establishing the National Biosafety Framework, Prescribing Guidelines for Its Implementation, Strengthening the NCBP, and for other Purposes.* Monograph, Taguig City, Philippines.
6. Partnering agencies/organizations within the Philippines: The Biotechnology Coalition of the Philippines; Bureau of Plant Industry–Department of Agriculture, Ecosystems Research and Development Bureau–Department of Environment and Natural Resources; National Academy of Science and Technology; National Committee on Biosafety of the Philippines; the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development; Department of Science and Technology; University of the Philippines Los Baños. International partners: the Agricultural Biotechnology Support Project; the Biotechnology Information Center; Southeast Asian Regional Center for Graduate Study and Research in Agriculture; Calvin College; Donald Danforth Plant Science Center; International Rice Research Institute; and Michigan State University.
7. Special training in science in the Philippines is offered by the Philippine Science High School. The International Rice Research Institute, founded by the

Rockefeller and Ford foundations and US AID in 1960, conducts training programs in the cultivation, fertilization and irrigation of hybrid rice seeds. The Southeast Asian Regional Center for Graduate Study and Research in Agriculture maintains genotype and information banks for agricultural research.

8. The backbone of the EU's future bilateral trade relations with Brazil will be a wide-ranging EU–Mercosur Association Agreement which will also result in the creation of a vast free trade area. This agreement, which is currently under negotiation, should provide a boost to regional trade integration among the countries of Mercosur and stimulate new opportunities for trade with the EU by removing tariff and non-tariff barriers to trade. The Mercosur–EU AA will cover, among other issues, trade in goods and services; investment; intellectual property rights aspects, including protection of geographical indications; government procurement; technical barriers to trade; and sanitary and phytosanitary aspects (http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/countries/brazil/).