

Supplemental Background Paper

Commodities, Development, and Technology

International Workshop on Nanotechnology, Commodities, and Development

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Global Dialogue on Nanotechnology and the Poor: Opportunities and Risks

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1. INTRODUCTION

This paper is a supplement to the main background paper for the Commodities Workshop,¹ the paper on “Nanotechnology, Commodities, and Development.”² This supplemental paper is intended for people interested in more detailed information regarding the issues described in section 2 of the main paper. Specifically, this paper provides the following information:

- An overview of commodity markets, commodity dependence, and poverty;
- An overview of the history, trends, and key issues in global commodity markets and how these issues affect commodity-dependent developing countries; and
- A description of issues at the intersection of commodity dependence, development, and technology.

2. COMMODITIES, DEVELOPMENT, AND TECHNOLOGY

2.1. Commodities and Commodity Dependence

Commodities are raw materials (e.g., agricultural products, metals, minerals) and primary-level products (e.g., textiles, plastics, building materials) that are traded in bulk quantities in international markets. Commodities are distinct from other traded goods in that they rarely vary in terms of quality and, therefore, are typically traded solely on the basis of price. Consequently, commodity markets tend toward strong competition and downward pressure on prices. This homogeneity also means that shocks to the supply or demand for a commodity affect prices for all producers, exposing them to high income risk.³

¹ International Workshop on Nanotechnology, Commodities, and Development held on 29 – 31 May 2007 in Rio de Janeiro, Brazil

²“Nanotechnology, Commodities, and Development” is available online at <http://www.merid.org/nano/commoditiesworkshop>.

³ Samuel G. Asfaha, “Remunerating Commodity Producers in Developing Countries: Regulating Concentration in Commodity Markets,” in *Trade-Related Agenda, Development and Equity (T.R.A.D.E.) Analysis Series* (Geneva: South Centre, 2005).

Modern commodity markets typically trade futures contracts on commodities. These futures contracts are standardized agreements to buy or sell a specific commodity at a specified time in the future for a specified price, thereby allowing producers to protect themselves against price drops and consumers to protect themselves against price rises. Futures contracts are also bought and sold by speculators for profit and contribute liquidity to the system. Such contract trading originated with traditional commodities such as grains and livestock and now includes a range of agricultural and non-agricultural commodities and derivative products such as coffee, cotton, sugar, soybeans, maize, energy, metals, minerals, textiles, rubber, and many others.

A country's level of commodity dependence is generally measured by the share of export earnings of the top one to three export commodities in Gross Domestic Product (GDP), total exports, and/or government revenues, as well as by the percentage of people engaged in commodity production. Commodity-dependent countries rely on commodities for a significant share of their export earnings and employment. They also derive a substantial share of their government revenue from commodity consumption and tariffs and taxes on commodity exports.⁴

2.2. Commodity Dependence and Poverty

Commodities remain a significant driver of economic activity in 95 out of the 141 developing countries that continue to rely on commodity exports for more than half of their export earnings.⁵ Although the use of natural resources and production of commodities may contribute to economic development and enhanced public welfare, many developing countries that are highly dependent on commodity exports as a primary source of revenue appear low on the United Nations Development Programme's Human Development Index. Similarly, dependence on commodity export earnings among those nations considered by the World Bank and International Monetary Fund (IMF) to be the Least Developed Countries (LDCs) has actually increased from 59 percent to 72 in the last 40 years.⁶

Commodity dependence poses a number of challenges for developing countries that often use their export earnings from trading commodities on international markets to finance their human development efforts. First, developing countries most often specialize in the least profitable parts of the global production chain and in markets facing long-term declines in prices and erratic price instability. Second, even though there has been a significant increase in international trade since the 1960s, developing country exports have not kept up with exports from the developed world and, consequently, account for a shrinking share of world trade.⁷ Additionally, commodities have lost a significant portion of their purchasing power against manufactured goods, which represents a significant decline in the terms of trade for commodity exporting countries.

Price volatility makes it difficult for countries that earn a significant share of their government income from commodity exports to maintain the availability of resources needed for public investments in infrastructure and public services such as health, education, administration, and law enforcement, damaging the sustainability of human development efforts. Additionally, declining commodity prices cause an increase in the ratio of debt service to export earnings, making macroeconomic planning difficult for commodity-dependent developing country (CDDC) governments and exposing these countries to higher debt vulnerability. This debt risk, in turn, limits the ability of these countries to attract foreign direct investment (FDI) and, again, reduces

⁴ Christopher Scott Musso, "Beating the System: Accelerating Commercialization of New Materials" (Massachusetts Institute of Technology, 2005).

⁵ Common Fund for Commodities, "Overview of the Situation of Commodities in Developing Countries" (paper presented at the Eleventh Meeting of the Intergovernmental Follow-Up and Coordination Committee on Economic Cooperation Among Developing Countries, Havana, Cuba, March 21-23 2005).

⁶ Joe Guinan, "The Commodity Problem," German Marshall Fund, <http://www.gmfus.org/trade/commentary/article.cfm?id=6>.

⁷ Asfaha, "Remunerating Commodity Producers in Developing Countries: Regulating Concentration in Commodity Markets."

the efficacy of development efforts. In fact, 37 of the 42 countries categorized by the World Bank and IMF as Heavily-Indebted Poor Countries (HIPC)s are currently dependent on commodities for more than half of their export earnings, with 15 of them depending on commodity export earnings for more than 90 percent of their total export revenues.⁸

Many CDDCs are now also net food importers. LDCs have increased the share of their export earnings spent on food imports from 43 percent in the 1970s to 54 percent in 2001.⁹ Such reliance on food imports can have serious implications for these countries' food security when combined with the deteriorating terms of trade that they are also facing.

The United Nations Conference on Trade and Development (UNCTAD) estimates that a total of two billion people—a third of the global population—are employed in commodity production, half of those in agriculture.¹⁰ Within developing countries, primary commodity producers are often among the poorest segments of the population. In most cases, these people are entirely reliant on their commodity production activities as their source of income.¹¹ Declining commodity and farm-gate price¹² have decreased the power of workers employed in agricultural and mining sectors to bargain for wages.¹³

2.2.1. *Recent History of Commodity Markets*

During the United Nations Monetary and Financial Conference in 1944, the Allied Nations ratified the Bretton Woods Agreements, the first international system to set rules for commercial and financial relations among independent countries. Still in the midst of World War II, the planners of Bretton Woods were motivated to develop a system to ensure economic stability and continual availability of raw materials at stable prices as they rebuilt their economies. The planners favored a liberal international economic system enforced through governmental intervention that minimized foreign exchange controls and trade barriers.

The Bretton Woods system established the International Bank for Reconstruction and Development (IBRD) – now a part of the World Bank Group – to underwrite loans and issue securities to help fund postwar economic recovery, and the International Monetary Fund (IMF) to maintain the financial system's rules and instruments and to grant loans to member nations with financial difficulties. The rules set forth by the IMF and IBRD obliged each country to maintain a fixed exchange rate, make its currency fully convertible into other currencies, and reduce tariffs and other barriers to trade and capital flows.¹⁴

Favorability toward active market interventions also ushered the implementation of national and international commodity market interventions to stabilize prices and guarantee sustained availability of raw materials. State marketing boards (SMBs) were set up within commodity producing countries to provide stable output and input (i.e., seeds, fertilizer, technical assistance) prices for producers.¹⁵ International commodity agreements (ICAs) were also established to stabilize commodity prices by smoothing short-term price fluctuations and countering long-term

⁸ Musso, "Beating the System: Accelerating Commercialization of New Materials".

⁹ Common Fund for Commodities, "Overview of the Situation of Commodities in Developing Countries".

¹⁰ UNCTAD, "Trends in World Commodity Trade, Enhancing Africa's Competitiveness, and Generating Commodity Gains" (paper presented at the African Union Extraordinary Conference of Ministers of Trade on African Commodities, Arusha, Tanzania, November 21-24 2005).

¹¹ Musso, "Beating the System: Accelerating Commercialization of New Materials".

¹² A basic price with the "farm gate" as the pricing point, that is, the price of the product available at the farm, excluding any separately billed transport or delivery charge. (<http://stats.oecd.org/glossary/detail.asp?ID=940>)

¹³ Guinan, "The Commodity Problem."

¹⁴ John Braithwaite and Peter Drahos, "Bretton Woods: Birth and Breakdown," in *Global Business Regulation* (Cambridge: Cambridge University Press, 2005).

¹⁵ Sheila Page and Adrian Hewitt, "World Commodity Prices: Still a Problem for Developing Countries?," (London: Overseas Development Institute, 2001).

price declines. ICAs also provided a vector for conducting multilateral discussions on commodity supply levels and solutions to oversupply.¹⁶

By the mid-1980s, a number of factors contributed to changes in the Bretton Woods system. The U.S.'s growing trade deficit and declining hegemony, combined with Europe and Japan's growing economic power, the collapse of the gold standard, and the rise of international banking syndicates, which enabled large international capital transfers and made it profitable to hedge against exchange rates, led to a new era of economic interdependence.¹⁷ The significant increase in world commodity supplies also made the collapse of ICAs and the resulting decrease in commodity prices advantageous for commodity consumers.¹⁸

Beginning with the mid-1980s, most developed countries and the IMF and World Bank had rejected intervention in international trade markets and begun supporting market liberalization and deregulation. The IMF and World Bank adopted Structural Adjustment Programs (SAPs) as conditionalities on new loans. SAPs generally required the implementation of free market programs to reduce market protections, such as tariffs and price controls, and increase competition by limiting the ability of governments to affect prices.¹⁹ They also required the liberalization of the borrowers' internal markets, including dismantlement of SMBs, privatization, and deregulation.²⁰

2.2.2. Global Trends in Commodity Markets

Due to the undifferentiated and global nature of commodities, commodity-producing countries face several persistent challenges in international markets, including long-term declining commodity prices, short-term price volatility, and declining terms of trade.

Real commodity prices have declined an average of 3 percent annually since the late 1970s. Data from the World Bank indicates that real prices for agricultural commodities and metal and mineral commodities declined 47 percent and 35 percent respectively between 1980 and 2002. Conversely, prices for manufactured goods have increased relative to commodity prices during the same period, resulting in a deterioration of terms of trade for countries that export commodities and import manufactured goods.²¹

While the severity of price declines and volatility varies for different types of commodities, most commodity producing countries have experienced these trends to some degree due to structural, institutional, and policy factors. These factors include: (i) oversupply and overcapacity of production, (ii) asymmetries in commodity markets, and (iii) changes in market power.

2.2.3. Oversupply and Overcapacity

Many commodities, especially temperate commodities like cotton, sugar, and wheat, are in chronic oversupply due to significant increases in world output of those commodities during the last two decades. While economic principles regard oversupply as a short-term disequilibrium in supply and demand that is automatically resolved by market forces, commodity markets seldom self-adjust and, moreover, tend toward perennial increases in oversupply. When facing price declines, farmers and producers attempt to maintain their income levels by increasing their

¹⁶ Sophia Murphy, "UNCTAD XI: Challenging the Commodity Crisis," (Minneapolis, MN: Institute for Agriculture and Trade Policy, 2004).

¹⁷ Commission on Intellectual Property Rights, "Integrating Intellectual Property Rights and Development Policy," (London: 2002).

¹⁸ Musso, "Beating the System: Accelerating Commercialization of New Materials".

¹⁹ Nicola Bullard, "Taming the IMF: How the Asian Crisis Cracked the Washington Consensus," in *The Economic Crisis in East Asia and the Impact on Local Populations* (Roskilde University, Denmark: 1998).

²⁰ Musso, "Beating the System: Accelerating Commercialization of New Materials".

²¹ Ibid.

output. This, in turn, increases oversupply and further depresses prices, resulting in long-term and persistent price declines.²²

The dissolution of ICAs and SMBs during the last two decades has removed some of the tools commodity producers once used to combat price declines. Without means to control the volume of commodities available to the market, producers are less able to negotiate prices and more exposed to the downward pressure of competition on prices.²³

The World Bank and IMF's SAPs and other donor policies prescribed to promote internal market liberalization, export orientation, and market diversification in developing countries have also contributed to the problem of oversupply. Through a so-called "fallacy of composition," these policies concurrently encouraged multiple developing countries to increase their commodity production and exportation or to diversify their markets to include specific high-demand commodities, resulting in further market saturation and declining prices.²⁴

Government subsidies and price supports given to agricultural commodity producers in developed countries, in some instances, have compounded the problem by encouraging production, leading to surpluses and dumping of these surpluses in international markets at prices below the cost of production for unsubsidized producers.²⁵

In addition to these policy and institutional factors, technological changes and developments that affect supply capacity or demand for commodities can also contribute to oversupply. Technological advances enabling greater productivity and expansion of production at a faster rate than population or demand growth can result in overcapacity, excessive output, and a related decline in prices. Technology can also result in the creation of synthetic substitutes for commodities used as inputs in the production of intermediate and final goods, displacing market demand for those commodities.²⁶ More detailed analysis of the effect of technology on commodity markets is provided below in section 2.3. "Technological Advancement and Commodity-Dependence."

Consumer preferences can also significantly influence commodity prices. Income levels among commodity consumers have steadily grown. As consumers have more income to spend, they tend to purchase a greater variety of and more expensive and high-value goods, resulting in a displacement of the commodities they previously consumed.²⁷

2.2.4. Market Asymmetries

Though different commodities experience price fluctuations of varying severity, data from UNCTAD indicates that commodity price instability has generally increased over the last decade. Commodities are uniquely vulnerable to short- and medium-term price fluctuations because their price cycles are typically asymmetrical, meaning periods of commodity price rises tend to be shorter than periods of price declines. Additionally, demand for commodities tends to be poorly responsive to changes in price (low elasticity of demand), implying that small changes in the supply of commodities result in a proportionately higher change in price.²⁸

Adjusting for price fluctuations is considerably challenging for producers. Farmers, especially, face a variety of factors that can affect their crops positively or negatively, including good and bad weather, pests, diseases, and others. The inability of farmers to anticipate these supply

²² Ibid.

²³ Ibid.

²⁴ Thomas Lines, "Market Power, Price Formation and Primary Commodities," in *Trade-Related Agenda, Development, and Equity (T.R.A.D.E.)* (Geneva: South Centre, 2006).

²⁵ Murphy, "UNCTAD XI: Challenging the Commodity Crisis."

²⁶ Musso, "Beating the System: Accelerating Commercialization of New Materials".

²⁷ Ibid.

²⁸ Ibid.

disruptions eliminates the possibility for them to restrict or expand production to smooth prices.²⁹ Additionally, farmers face a significant time lag between price spikes and the ability to bring new production to the market. Typically investments made to increase production during periods of rising prices result in the new crops reaching the market just as prices are stabilizing, resulting in oversupply and disproportionately long periods of price decline.³⁰ Similarly, tree crops such as rubber and many mined metals and minerals require several months of planning before production outputs that can be sold.

The futures markets on which commodities are sold can make it profitable for speculators to buy and sell commodities during periods of price volatility, especially because these markets allow speculators to pay a small portion of the full price upfront and to trade with paper contracts rather than the physical commodities themselves. While some say that speculation smoothes price fluctuations by offsetting changes in demand, others say that speculators exacerbate fluctuations by riding price trends. Still others say that speculation is stabilizing during periods of normal fluctuations, but exacerbating when significant shortages or surpluses occur.³¹

2.2.5. Changes in Market Power

Developing countries typically export commodities as raw or primary inputs, which subsequently undergo processing, distribution, and other forms of value-addition before being sold as finished goods to the final consumers. While raw commodities are supplied by a large number of small-scale producers, they are bought by an increasingly small number of vertically-integrated multinational processing and distribution companies, or intermediaries.³²

Intermediaries have more bargaining power than commodity producers over farm-gate prices because they control the middle of the value-chain between raw input and finished product, intermediaries are able to transfer drops in retail prices to primary producers by decreasing farm-gate prices, and transfer high farm-gate prices to consumers by increasing retail prices.³³

The increase in intermediaries' levels of horizontal and vertical integration also has significant implications for commodity dependent countries. Profits are generally higher in those stages of the value chain where the barriers-to-entry are the highest. For example, the barriers to entry and, consequently, profit potential are typically lowest at the raw material production stage. Profit potential grows in the value-addition stages where there are a number of barriers to entry, including government and regulatory barriers (e.g., tariffs, environmental requirements), market structural barriers (e.g., economies of scale, large initial investments), and strategic barriers based on the activities of market incumbents (e.g., branding, patents). Some developing countries have had difficulties developing sufficient capacity or infrastructure to overcome many of these barriers. As a result, they may experience even greater losses in bargaining power and farm-gate prices as intermediaries continue to grow vertically and horizontally.³⁴

2.2.6. Mechanisms for Addressing Commodity Risks

Several reports have identified a range of strategies to help developing country commodity producers reduce their exposure to and manage commodity risks such as price declines and price volatility. These strategies include, but are not limited to:

- Diversification of export products;
- Market-based risk management mechanisms such as catastrophe and weather insurance, future and option contracts, long-term sales contracts, and others;

²⁹ Lines, "Market Power, Price Formation and Primary Commodities."

³⁰ Murphy, "UNCTAD XI: Challenging the Commodity Crisis."

³¹ Lines, "Market Power, Price Formation and Primary Commodities."

³² Asfaha, "Remunerating Commodity Producers in Developing Countries: Regulating Concentration in Commodity Markets."

³³ Ibid.

³⁴ Ibid.

- Government risk management schemes such as official foreign exchange reserves, price stabilization funds, marketing boards, or buffer stocks;
- Government policies such as price floors, subsidies, and other support programs;
- International commodity agreements and other strategies to control international supply of commodities.³⁵

These reports also indicate that all of these mechanisms can be challenging for developing countries to use. Diversification strategies can be expensive and can take several years to implement. Market-based mechanisms can also be expensive and, in many cases, inaccessible or non-existent for those developing country sectors that are most risky. Government policies and strategies have often proven inefficient because they require large government expenditures during times of diminished government income. And, international agreements have also often been found to be inefficient due to their significant coordination requirements.

As a result, international organizations have developed and continue to develop new and strengthened approaches to help developing countries manage their vulnerability to commodity price risks. In addition to risk management mechanisms, these approaches often include complementary elements such as education, technical assistance, and frameworks for implementing risk management strategies. The following are some of these organizations and their commodity risk management activities:

- UNCTAD's Commodity Branch provides training seminars for government policymakers on the use of policies for commodity-linked financing, as well as training seminars for local banks on establishing vehicles to help domestic commodity producers and traders access credit markets. UNCTAD has institution-building projects with farmers' organizations, domestic banks, and local commodity exchanges. UNCTAD has also convened a number of governmental expert meetings to raise awareness of the lack of risk management tools for developing countries.³⁶
- The World Bank's International Task Force on Commodity Risk Management in Developing Countries (ITF) works with producers, traders, exporters, and input suppliers within a given developing country and sector to determine the risk exposure of different stakeholders at different stages of the value-chain and to identify and implement appropriate market-based price risk management tools (e.g., derivative markets, future contracts) to minimize these risks. The ITF also facilitates the identification and formation of cooperatives, financial institutions, and traders to serve as intermediary institutions to aggregate individual, small-scale producers and assists with the development of institutional capacities such as management, communications, and financial and marketing practices. Additionally, the ITF works with private-sector risk management providers such as international banks and financial institutions to develop methods for hedging risks associated with lending to developing country producers, creating more financing opportunities for these producers. The World Bank also publishes price forecasts and market data and analysis and researches and publishes policy reports on a range of commodity price risk management issues.³⁷
- The IMF's Compensatory Financing Facility (CFF) provides financial assistance to member nations that have temporarily lost export earnings to price shocks and, as a result, are facing an imbalance of payments. The IMF also provides so-called "stand-by arrangements in the credit trenches," which provide financial assistance to member nations experiencing an imbalance of payments that is longer-term and resulting from a

³⁵ See for instance: IMF, "Fund Assistance For Countries Facing Exogenous Shocks," (Washington, DC: 2003); Panos Varangis, Donald Larson and Jock R. Anderson. "Agricultural Markets and Risks: Management of the Latter, Not the Former. (February 2002)

³⁶ See: <http://r0.unctad.org/commodities/mandate.htm/>.

³⁷ See: <http://www.itf-commrisk.org/itf.asp?page=10/>.

spectrum of export price and other shocks. Additionally, the IMF's Poverty Reduction and Growth Facility (PRGF) provides increased financing on top of already committed resources to developing countries experiencing price shocks.³⁸

- The Common Fund for Commodities (CFC) finances international buffer stocks and projects to improve structural conditions in commodity markets (e.g., marketing initiatives, integrated pest management, vertical diversification).³⁹
- The European Community operates STABEX, a mechanism for stabilizing export earnings of African, Caribbean, and Pacific country agricultural sectors, and SYSMIN, the counterpart mechanism for mineral and mining sectors. These schemes focus on stabilizing export earning shocks associated with price or production drops for individual commodities instead of countries.⁴⁰

Various international commodity organizations (e.g., International Grains Council, International Natural Rubber Organization) have also developed and implemented commodity agreements to protect buyers and sellers from price shocks. International commodity trading and processing companies, investment banks, and commodity futures merchants, too, offer various commodity risk management mechanisms, though the availability of these tools for developing countries continues to be very limited.

In addition to these mechanism that are intended to help developing countries cope with commodity market fluctuations, several organizations have been developing resources and activities aimed at helping developing countries harness the potential benefits of science, technology, and innovation to reduce commodity dependence and identify and manage potential risks of technologies. For example, South Africa's national mineral research organization Mintek and international gold producer AngloGold Ashanti launched Project AuTEK in 2000 to research and develop new industrial applications for gold to ensure the stability and profitability of the nation's large gold industry.⁴¹ These activities recognize the important links between technological advancements and commodity-dependence. The following section will explore these linkages in more detail.

2.3. Technological Advancement and Commodity-Dependence

In recent years, a number of reports have focused on the near- and long-term positive and negative implications of science, technology, and innovation for commodity dependent developing countries (CDDCs) and developing countries in general.

Some authors have argued that developing countries will not be able to catch up with developed countries simply on the basis of domestic resource mobilization or increasing the share of exports. Nor will increased net resource flows be sufficient in the absence of the ability to appropriate the competitive gains from the domestic generation of new technologies and new products. These authors fear that, unless countries develop robust science and technology capacity, the technology gap will widen as developing countries are reduced to the production of manufactured goods whose prices increasingly behave as those of primary commodities, with declining terms of trade relative to knowledge based goods of developed countries.⁴²

³⁸ IMF, "Fund Assistance for Countries Facing Exogenous Shocks."

³⁹ See: <http://www.common-fund.org/?pag=2/>.

⁴⁰ Samuel Malone, "Managing Default Risk for Commodity Dependent Countries: Price Hedging in an Optimizing Model," in *Economics Series Working Papers*, ed. Department of Economics University of Oxford (Oxford, UK: 2005).

⁴¹ See: <http://www.apecforesight.org/>.

⁴² Oscar H. Farfan, "Understanding and Escaping Commodity-Dependency: A Global Value Chain Perspective," (Washington, DC: The World Bank Group, 2005).

The successful application of science and technology for development will require that developing countries address a broad range of issues. Participants in Meridian Institute's Global Dialogue on Nanotechnology and the Poor: Opportunities and Risks⁴³ (GDNP) have identified a range of cross-cutting issues that should be considered when technologies are developed and deployed. These issues are described in Section 2 and Appendix 1 of Meridian Institute's paper "Nanotechnology, Commodities, and Development."

Given the Commodity Workshop's focus on the linkages between nanotechnology, commodities, and development, the following sections address, specifically, the role of science and technology in CDDCs' efforts to address the challenges they face. As described below, these countries face a range of potential opportunities and challenges associated with accessing and applying technological advances to reduce their commodity-dependence and economic vulnerability.

2.3.1. Technological Advancement – Opportunities

Commodity-dependent developing countries may pursue a number of opportunities resulting from technological advancement in their commodity sectors, including, but not limited to: growing export of manufactured goods and moving up in the value chain; wage and capital growth; and improved access to global markets and trade.

Manufactured Export Growth and Value-Chain Movement

The period following market liberalization and the opening of developing countries' economies has also seen a significant growth in manufactured exports from developing countries. Some people contend that the success of some CDDCs, such as Chile, Indonesia, Malaysia, and Thailand, in increasing their commodity export earnings and GDPs in the midst of declining prices is related to expansion of trade to include non-traditional, high-growth commodities, including processed goods, and their increases in productivity in traditional commodities production.⁴⁴

Manufactured export growth, however, has been largely geographically fragmented. While a number of developing countries such as China, India, Indonesia, Pakistan, and Latin American countries have experienced high growth of manufactured exports, other countries, most prominently those in sub-Saharan Africa, have shown no sustained growth.⁴⁵

Even among those developing countries that have experienced high growth of manufactured exports, there are differences in the degree to which technological advances have been responsible for driving the international competitiveness of those exports. A study from UNIDO shows that a number of developing countries, including Mauritius, Sri Lanka, and some Latin American countries, have experienced high growth of manufactured exports amid low productivity growth because they have focused their industrialization efforts on sectors in which they have preexisting comparative advantages, that is those with large raw material and low-skill labor input requirements. Other countries, including Korea, Singapore, China, India, Malaysia, Indonesia, Pakistan, and Thailand, have experienced high manufactured exports growth accompanied with high productivity growth. These nations have generally shifted their production away from commodity-based and labor-intensive sectors towards more technologically advanced sectors such as electrical machinery, electronics, and transport equipment. Accordingly, those developing countries that have not seen growth in manufactured exports typically have experienced neither sectoral industrialization nor growth in productivity.⁴⁶

⁴³ More information about the GDNP, including background papers and materials from meetings, is available at: <http://www.merid.org/nano>.

⁴⁴ Nanae Yabuki and Takamasa Akiyama, "Is Commodity-Dependence Pessimism Justified? Critical Factors and Government Policies That Characterize Dynamic Commodity," (Washington, DC: World Bank, 1996).

⁴⁵ Charles Cooper, "Technology, Manufactured Exports and Competitiveness" (paper presented at the Global Forum on Industry, New Delhi, India, October 16-18 1995).

⁴⁶ *Ibid.*

Wage and Capital Growth

While the adoption of technological advances may not determine a developing country's rate of manufactured exports growth, it does influence labor and capital growth, both of which are linked to development and poverty alleviation.

Those developing countries that have experienced the greatest growth in productivity due to technological advancement have also had the highest growth in real earnings per worker while maintaining stable labor and capital levels. Those countries maintaining more traditional manufactured export sectors, on the other hand, have typically seen a decrease in real wages as they attempt to exploit low labor costs to maintain competitiveness against more advanced countries.⁴⁷

Continued reliance on traditional production and exports has been tied to greater difficulties, including limited access to capital investment and a less skilled workforce, for introducing innovation and technological advances at a later time or in other sectors.⁴⁸

Access to Global Trade and Markets

In its 2005 report, UN Millennium Project's Task Force on Science, Technology, and Innovation suggested that the global rise in mobility, connectivity, and interdependence as a consequence of globalization has resulted in a number of factors that have increased the importance of technological advancement in developing countries.

One of these factors is the rise of globalized production networks, as well as their available foreign direct investments, that take advantage of geographic differences in costs and capabilities along their production chains. Another factor is the increased importance of a country's technological capabilities for acquiring preferential access to new technology markets in developed countries, new export markets, and development assistance, as well as for induction into trade circles and economic treaties.

A third factor identified by the Task Force is the importance of innovation and technology for eliminating the reliance of developing countries on commodities exploitation as the basis for economic development, specifically because of the challenges caused by commodity price declines and instability.⁴⁹

2.3.2. Technological Advancement – Challenges

Developing countries, to varying degrees, may face a number of significant internal and external challenges to adopting technological advances and, even more so, developing profitable innovations. Most developing countries continue to lag behind the developed world in terms of technological strength as measured by patents and scientific publications, exports of high-tech goods, and gross enrollment in tertiary science education.

Knowledge, Workforce, and Capacity

The capacity of a developing country to successfully use imported technology depends significantly on the existence of an indigenous technological capacity and its related strategies for acquiring, learning, and distributing new technologies.

Many developing countries lack the necessary skilled workforce to engage in the development of profitable innovations. The World Bank's *World Development Report* from 2001 indicated that the US, Japan, and Germany have close to 4,000 research scientists and engineers per million people, compared with 121 per million in Malaysia, Thailand, and Brazil. Compared to the 3 to 1

⁴⁷ Ibid.

⁴⁸ Yabuki and Akiyama, "Is Commodity-Dependence Pessimism Justified? Critical Factors and Government Policies That Characterize Dynamic Commodity."

⁴⁹ Calestous Juma and Lee Yee-Cheong, "Innovation: Applying Knowledge in Development," (UN Task Force on Science, Technology, and Innovation, 2005).

ratio of GDP per capita for these two groups of countries, this "knowledge gap" is ten times greater than difference in income. Some say that this gap will continue to grow because of the loss of scientists, or brain drain, from developing countries to developed countries.

Many developing countries have faced challenges in developing or maintaining a skilled workforce. Brain Drain, or the migration of skilled and educated individuals from one nation to another, has adversely affected many countries, especially in Africa, where retaining capacity is often a more important issue than capacity development itself. It has been estimated that for a number of African countries, more than 30% of its highly skilled professionals are lost to the OECD countries.⁵⁰ However, in recent years, countries like India and China, which for decades saw many of their most talented professionals move abroad, have started to reverse this trend. Studies show that effectively managing the diaspora has played a large role in capacity development by creating jobs, raising incomes and generating disciplined, efficient workforces that have in turn provided a platform for economic growth.⁵¹

Additionally, some contend that technological development requires the ability to network with researchers and companies in other countries because many emerging technologies require multiple components and multiple areas of expertise. Capturing such economies of scale is often best done by large multinational companies or large interdisciplinary research centers. This requirement is especially a challenge for the many researchers and governments in developing countries that continue to lack access to computers and the Internet.⁵²

Intellectual Property Rights

Intellectual Property Rights (IPRs) could present both opportunities and challenges for developing countries interested in stimulating innovation and creating opportunities to generate income.⁵³ Some argue that IPRs: stimulate invention and new technologies that increase production; promote investment; facilitate technology transfer; and improve the availability of beneficial products. They also argue that existing IPRs can be used to capture value of distinct products from developing countries (e.g., trademarks to "brand" and capture more of the value of distinct, high quality products). Others argue that IPRs do little to stimulate invention in countries that lack human and technical capacity, and that they are ineffective at stimulating research to benefit poor people because the poor will not be able to afford the products. They feel that IPRs limit the option of technological learning through imitation and allow foreign firms to drive out domestic competition by obtaining patent protection and to service the market through imports, rather than domestic manufacture.⁵⁴

Important for developing countries is the continuing trend towards the global harmonization of IP protection. In particular the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property (TRIPs) has accelerated this trend by making minimum standards of IP protection mandatory for WTO members. Other international agreements also drive the trend towards international harmonization, for instance bilateral or regional trade and investment agreements and the ongoing discussions in the World Intellectual Property Organization (WIPO).⁵⁵

Opening Investment Capital

The challenges many developing countries' face with providing the economic, regulatory, and governance environment needed to sustain technological development have made the acquisition

⁵⁰ Andrés Solimano, "The International Mobility of Talent and Its Impact on Global Development: An Overview," (UN-ECLAC, 2005).

⁵¹ The World Bank, "Engaging the Diaspora to Deal with Brain Drain," <http://go.worldbank.org/1PL7U44T40>.

⁵² Avinash Persaud, "The Knowledge Gap," *Foreign Affairs* 80, no. 2 (2001).

⁵³ World Intellectual Property Organization, "Record Year for International Patent Filings," ipFrontline, <http://www.ipfrontline.com/depts/article.asp?id=14241&deptid=6>.

⁵⁴ Commission on Intellectual Property Rights, "Integrating Intellectual Property Rights and Development Policy."

⁵⁵ Farfan, "Understanding and Escaping Commodity-Dependency: A Global Value Chain Perspective."

of investment capital for technology difficult. Investors are also reluctant to invest in technology and innovation in developing countries because the productivity of and return on these investments is likely lower than in developed countries, especially because the addition of money will not necessarily increase capacity constraints such as lack of facilities and scientists.⁵⁶ Faced with numerous investment opportunities in developed country start-ups and large companies, capital investors are less willing to pursue opportunities in developing countries where there are greater risks and fewer assurances to high returns.

Some people refer to this inability to acquire investments for technology as a Catch-22: developing countries are unable to technologically develop because they can not access capital, and they can not access capital because they are unable to technologically develop.

Overspecialization

Some people attribute CDDCs' deteriorating terms of trade to the ability of the developed world and multinational intermediaries to leverage technology to help move them into the more profitable stages of the production value chain. By using technology to drive their value-added activities such as developing innovative production and distribution processes, developed countries and intermediaries have been able to create and dominate new product markets. Furthermore, the costs and capacity required to research, develop, and implement such technologies function as barriers to entry for developing and poor countries.⁵⁷

As noted in section 2.3.1. "Technological Advancement — Opportunities," some people contend that expanding exports to include non-traditional, high-growth commodities and processed products and increasing productivity in traditional commodities is critical to reducing developing countries' dependence on commodities. Others, however, contend that technology and innovation continue to be the cause, and not the cure, to the problem of commodity-dependence and the relative deterioration in the position of developing countries. According to this view, technology can actually lead countries to decrease the diversity of their markets in order to capture economies of scale. Friends of the Earth International suggests this effect could be comparable to the agriculture and forestry sectors' recent increase in the use of a limited range of species that are compatible with the technology and processes that they have adopted and the growing preference of the international processed food industry to use soy for an increasing number of technologically-enabled applications, which is displacing demand for other crops.⁵⁸

These groups also suggest that because it is so much cheaper to adopt existing technologies rather than adapt or develop new technologies, almost all producers end up adopting the same technologies and producing the same products. They say that this not only causes oversupply and declining prices in the market for that new product, but also worsens the overall condition of CDDCs by displacing market diversity and making it harder to cope with supply shocks.⁵⁹

It has also been argued that countries may be driven to adopt technologies that may initially enable them to capitalize on the increasing demand for products with pre-determined specifications in niche markets, but that increased production could result in gluts in those niches and leave those countries with technologies that may not meet their local production conditions.⁶⁰

2.3.3. Technological Advancement – The Potential for Disruption

Speculation on the potential for technological advances and innovation to disrupt existing commodity markets is complex and varies greatly depending on the commodity, technology, and

⁵⁶ Juma and Yee-Cheong, "Innovation: Applying Knowledge in Development."

⁵⁷ Asfaha, "Remunerating Commodity Producers in Developing Countries: Regulating Concentration in Commodity Markets."

⁵⁸ Friends of the Earth International, "Trade and Specialisation," <http://www.foei.org/trade/activistguide/special.htm>.

⁵⁹ Ibid.

⁶⁰ Ibid.

countries in question. Generally speaking, technological advances can displace demand for commodity exports by enabling cheap, localized, or unrestricted production of that commodity or the production of substitutes with comparable or better performance at competitive prices. Conversely, technological advances can increase demand for commodity exports by creating new products and production methods that use a particular commodity as an input.

Some people say that the rapid pace of technological development and adoption creates significant disruptive risks to the economies of CDDCs, especially considering the difficulty many of these countries have adjusting to market shocks.

Technology proponents counter that where technology may be disruptive to traditional markets or displace existing producers and products, it will also create and drive significant macroeconomic growth by enabling poorer, less-skilled populations to undertake activities previously restricted to a small group of rich specialists.⁶¹

Some proponents also say that emerging technologies do not pose a disruptive risk because they take decades, not years, to implement in markets. They add that, even when technology is adopted rapidly, consumer tastes tend to change slowly, preserving demand for traditional products. Some risk analysts have further posited that technological change will be very predictable because so many groups are engaging in technology forecasting in anticipation of "the next big thing." One analyst offers as proof that the discount rate, a key indicator of investment uncertainty, decreased in almost all economies during the 1990s, despite the unprecedented levels of technological expectations.⁶²

The Case for Bottom-Up Disruptions

One theory regarding disruptive technologies, most prominently put forth by economist Clayton Christensen, argues that the actual rate of technological innovation almost always outpaces the ability or willingness of consumers to benefit from any product or process improvements enabled by the innovation. Additionally, most disruptive technologies and products appear on the market as a cheaper but less reliable alternative to an existing product and are subsequently ignored by consumers and rejected by suppliers. As a consequence, most disruptive technologies underperform against existing products and processes when they first emerge and eventually settle in a niche market for less discriminating consumers. As the quality of the technology or product improves over time, however, more consumers adopt it until it eventually redefines the market. One example offered by Christensen is the integration of steel mini-mills during the 1970s and 1980s. These mini-mills created steel products from scrap steel in small electric ovens using a significantly simpler and cheaper method than traditional blast furnace approach. When first introduced, the steel from these mini-mills was inconsistent in quality and, therefore, only used by the small concrete reinforcement niche market. As the mini-mill process and steel quality improved, however, its lower cost allowed it to take advantage of a much larger market, including sheet steel and structural beams.⁶³

Such bottom-up disruptions present two opportunities for developing countries. First, it provides a potential route through which they can enter a market currently dominated by developed countries or large companies. Second, as Christensen argues, rather than introducing these technologies in developed-world applications, where they would compete with established technologies, companies will introduce them in products for the billions of untapped customers in developing countries, with hopes of later expanding to mainstream markets.⁶⁴

⁶¹ Clayton Christensen, Thomas Craig, and Stuart Hart, "The Great Disruption," *Foreign Affairs* 80, no. 2 (2001).

⁶² Michael Mainelli, "Beyond the Technology Frontier," *European Business Forum*, no. 16 (2004).

⁶³ Nicholas G. Carr, "Top-Down Disruption," *Strategy and Business*, no. 39 (2004).

⁶⁴ Christensen, Craig, and Hart, "The Great Disruption."

However, even if opportunities related to technology are identified and potential risks are appropriately evaluated and managed, there is still a risk that only small minorities of people will benefit from its opportunities, while large majorities, mainly in the developing world, will not. Some academics have argued that many previous technology introductions and revolutions, including the industrial revolution, have benefited the rich while further marginalizing the poor. Some organizations argue that based on current trends key technologies will further concentrate economic power in the hands of multinational corporations and that the poor are unlikely to benefit from a technology that is outside their control. Furthermore, the organizations state that the poor and marginalized are seldom in a position to foresee or adjust quickly to abrupt economic changes.⁶⁵

3. CONCLUSION

Commodities remain an important driver of economic activity in 95 out of the 141 developing countries that continue to rely on commodity exports for more than half of their export earnings. Commodity dependence poses a number of challenges for developing countries, in particular for LDCs, that often use their export earnings from trading commodities on international markets to finance their human development efforts. Long-term price declines, price volatility, and declining terms of trade make macro-economic planning difficult and hurts the incomes of the millions of people who depend on commodity production for their livelihoods.

In order to reduce poverty and meet the Millennium Development Goals (MDGs), it is crucial to address the problems of commodity dependent countries. Efforts to address these problems will require multi-faceted, coordinated approaches, which may include capacity-building, access to information, institution building, and access to resources (including science and technology) to, for instance, reduce commodity dependence, enhance the viability of commodity sectors, and increase participation in value chains and realize better returns. Despite a significant amount of activity in relevant topic areas, there are few programs that work comprehensively on the linkages between commodities production, development, and emerging technologies, such as nanotechnology. Efforts to assist commodity-dependent developing countries in meeting their development challenges and efforts to assess the implications of technological advancements for developing countries continue to remain largely disconnected.

This paper is a supplement to the paper on “Nanotechnology, Commodities, and Development” and is intended for people interested in more detailed information regarding: the history, trends, and key issues in global commodity markets and how these issues affect commodity-dependent developing countries; issues at the intersection of commodity dependence, development, and technology; and mechanisms for developing countries for anticipating and adjusting to fluctuating demand for or new markets for commodities.

⁶⁵ ETC Group, "Down on the Farm: The Impact of Nano-Scale Technologies on Food and Agriculture," (Ottawa: 2004).