Emerging Technologies and Inequalities: Beyond the Technological Transition

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The innovation systems approach to societal development includes a critique of the common focus on high technologies in the development process. Even in affluent economies, directing resources exclusively to high technologies neglects the broader innovative processes undertaken by doing, using, and interacting. In developing economies, with fewer resources, too strong a focus on high technologies is unlikely to produce as much benefit as a more inclusive concept of innovation.

Emerging technologies are defined as those that are new, science-based, and of potentially broad impact (Cozzens et al., forthcoming). They are a particular subset of high technologies, located at what some call the technological frontier. Affluent countries compete for leadership in emerging technologies like bio- and nano-technologies, and some less affluent countries have in the past found significant opportunities in the wide open spaces of the technology emergence process.

This paper looks at five examples of emerging technologies from the viewpoint of several developing countries, with particular attention to their distributional consequences. None of the examples represents the kind of dramatic opportunities that get so much attention in the innovation studies literature – there are no Koreas, Taiwans, or Singapores here. Precisely because of this, these cases may be more representative of the dilemmas emerging technologies present for countries that are trying to achieve inclusive growth.

The paper presents some of the results from a cross-national, cross-technology study of the distributional effects of emerging technologies. The five technologies studied were: genetically modified (GM) maize, mobile phones, open source software, plant tissue culture, and recombinant insulin. The eight countries included were: Argentina, Canada, Costa Rica, Germany, Jamaica, Malta, Mozambique, and the United States. Half are high-income and half are low or middle income countries. This paper focuses on the results of the study in the four low and middle income countries.

Emerging technologies are a strategic research site for examining the interaction of inequalities between countries and inequalities within countries.[2] Conceptually, we

[1] This paper draws in particular on case studies done as part of Project Resultar on Argentina, Costa Rica, Jamaica, and Mozambique, by Isabel Bortagaray, Lidia Brito, Roland Brouwer, Mario Falcao, Sonia Gatchair, and Dhanara Thakur. The Mozambican case studies were done as Work Package Four of ResIST, a project funded by the European Commission (see http://www.resist-research.net/home.aspx). Mark Knell is co-leader of that work package with Susan Cozzens. The case studies in the Americas were funded as Project Resultar by the U.S. National Science Foundation under Grant SES 072-6919. All opinions, findings, conclusions and recommendations are those of the author and do not necessarily reflect the view of the sponsors

defined emerging technologies in this project as new and research-based, with potential broad impact. Operationally in the project, we have studied the actual distributional consequences of selected biotechnologies and information and communication technologies (ICTs). The research aims to

1. describe the dynamics that link emerging technologies to patterns of inequality;
2. identify the roles of public interventions in those dynamics; and
3. develop a framework that policy actors can use prospectively to analyze the distributional valence of a specific new technology in a particular national context.

Our central research question is how policy interventions affect distributional outcomes for the same technology under different national conditions.

Studying Emerging Technologies

Why study emerging technologies in this project? First, precisely because they are new, emerging technologies are the site of change and growth in both global and local economies. The techno-economic networks that support them are still young and malleable, but are projected to be more significant as time goes on. They therefore represent a good place for public interventions towards equality, if such interventions were needed. Second, because emerging technologies are research-based, they are more likely to be sold at high prices (as firms try to recoup research and development costs) and to demand high levels of skills in the production process. Both these characteristics give emerging technologies a higher potential than older technologies for increasing inequalities in access and employment.

Third, emerging technologies stand at the intersection of global and national distributive processes. The dominant pattern in emerging technologies has been that new technologies have been developed in North America, Europe, or North Asia (the "Triad" regions), then diffused to other parts of the world, either when a multi-national firm decides to place a production facility there or when the technology becomes available for purchase. The benefits and costs that people experience in the creating, producing, and using countries experience as a result of this process vary greatly among countries and technologies, but the global pattern of inequality may seem well established. Technology-creating countries will always appear to be those starting the revolutions, and technology-using countries will always appear to be trying to catch up, when we consider only this pattern.

To create a different pattern, however, many non-Triad countries invest in their local capabilities in emerging technologies, not only to provide better absorptive

[2] Any attempt to develop a crisply defined research agenda on inequality is challenged by the many dimensions of the phenomenon. At a very fundamental level, Sen (1992) points out that inequality is a multi-dimensional space, with different observers valuing different "focal inequalities," from abstract property rights through basic human needs. Empirically, there are income inequalities between and within countries; vertical and horizontal inequalities within countries; inequalities in other areas like computer access (the "Digital Divide"), health outcomes ("health disparities"), and environmental conditions ("environmental injustice"). Inequality and inequity are different concepts -- one descriptive, one normative – although they are seldom carefully sorted out (see Cozzens 2007 for a discussion in S&T policy).

capacity, but also as the basis for using the emerging technology to meet local needs and create local competitive advantage. Indeed, the Millennium Project task force on innovation (Juma and Lee 2005) recommended that every developing country invest in three "platform technology" areas, namely, biotechnology, ICTs, and nanotechnology. These investments might create a re-distributional pattern with significant implications for the relationships between technologies and inequalities.

Our study has provided an opportunity to examine both of these patterns in action. We assumed that reality is more complex than either the "dominating North" or "optimistic South" views, and we set out to describe the actual distributional dynamics generated by emerging technologies in various national contexts.

Initial Concepts

The basic logic of the data gathering and analysis has been that *technological projects* affect *inequalities* in *valued items* through pathways that are technology-specific, mediated by *national conditions*, and shaped by *public interventions*. Before turning back to the specific technological projects the study is examining, let us pause over each of these other concepts.

The term *technology* above is shorthand for the concept of ***technological projects***, that is, organized efforts of a group or institution. While private industry is the main source of technological projects, public institutions or civil society groups may also put them into motion. The study is based on the assumption that technological projects are always inherently distributional, and that the distributional aspects of individual projects and portfolios of projects are open to choice.

Inequality is the unequal distribution of something people value. This project has not only considered inequality in incomes, the focus of the economic literature on the topic, but also inequalities in the distribution of the benefits and costs of technological projects. We explicitly include both vertical inequalities (the rich-poor dimension) and horizontal inequalities (differences by gender, ethnicity, or other culturally defined factors).

In this project, we have focused on inequalities in three ***valued items***, each generated through a different relationship to the emerging technology: business opportunities, employment, and benefits/costs. Since under our definition, emerging technologies are research-based, innovation plays a strong role in bringing them into being, when the other necessary forms of capital and organizational skill are present. This is the process of technology *creation*. New intellectual capital for one actor can destroy the value of the intellectual property of another as, for example, when synthetic fibers undermined natural fiber-based industries and devalued knowledge and skills many developing countries possessed. Conflicts over intellectual property are a common feature of the process of incorporating an emerging technology into a national context. We have therefore included examination of the distributional aspects of those issues in our study. The ownership of intellectual property has been treated in context as part of capital accumulation and business ownership.

Relatively few jobs are associated with the creation of technology, but many are generated when the technology goes into *production, marketing, and sales*. Competition among countries for manufacturing production jobs is fierce, and technology-creating countries do not always win. Jobs can be generated directly, through production or sales

of the technology, indirectly through raising the productivity of another business, or indirectly as the wages of workers in the new or expanding industry are spent in the local economy (the multiplier effect). Production jobs in ICTs or pharmaceuticals can significantly affect small economies, as can successful commercial agriculture. However, the higher labor productivity of new production processes may mean that fewer jobs are generated through these processes than through other industries, and they may be accessible to a narrower segment of the population. Employment is thus a key variable we have tracked in our analysis.

Technologies are ultimately designed to deliver benefits in health, food, environment, etc. through *use*. These benefits are technology-specific, as are the costs that might be generated in a specific national context. For example, the benefit from insulin would be better control of blood sugar and improved quality of life for diabetics, but if the insulin is only available to affluent consumers, these benefits could increase health disparities. To receive benefits, people must have access to the technology, through private purchase or public procurement, so in each case study we have characterized *access* to the technology in question. .

The distributional effects of technological projects are mediated through a variety of ***national conditions***, which are seldom discussed in the literature on technological impacts. As a starting point in analyzing the effects of these conditions, we described our case study countries in terms of national income level, poverty, general human capital in the form of educational attainment and specialized training of the nation's citizens, and technological capability. The last is a complex concept, only imperfectly captured in the many current indicators and indexes related to it, and we looked for its presence beyond the indicators in our cases. These are the kinds of general factors that we expected to be associated with common patterns across technologies within countries.

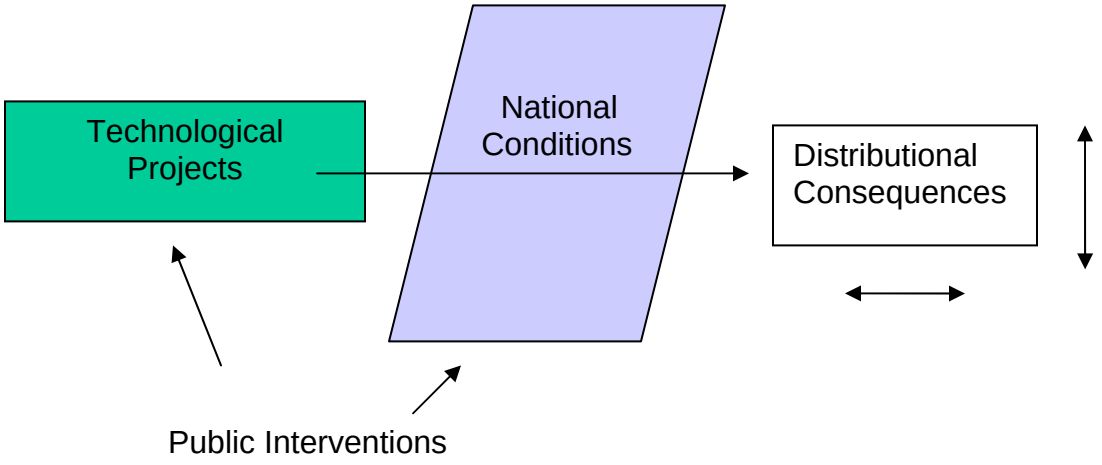
Finally, because it was oriented to a policy audience, our study characterized the policy instruments available to S&T decision makers to influence distributional consequences. We refer to these generically as ***public interventions,*** because they constitute a mix of policies, programs, and other kinds of actions. These interventions may either act to shape the technological projects themselves, for example through inputs from public research programs or incentives to firms, or by affecting national conditions, for example, through investments in education to build human capital. Likewise, the absence of public intervention can influence technological projects profoundly, for example, the inability to establish a regulatory environment that creates trust.

Our early consultations with policy audiences about the project[3] produced an initial list of candidate areas for public intervention, including regulatory policies (e.g., biosafety regulations that affect whether small or large farmers are more likely to benefit from planting a new crop); ownership provisions, for example, loose or tight intellectual property protection; shaping employment options through labor regulations; targeting specific technologies for faster development through public research; public procurement policies that provide markets for particular technologies, for example, health service

[3] Project ResIST began with world regional consultations with policymakers in Africa, Latin America, and Europe.

purchases of recombinant insulin; and policies that develop human capital through specific training or general educational opportunities.

Figure One. Basic Model



Choice of Technologies

We chose to study these issues through case studies because of the complexity of the relationships we are studying and the importance of context. As a team, we are very familiar with the available quantitative indicators, and therefore skeptical that they reflect the complexity of the dynamics we want to study. Our qualitative approach allowed us to put quantitative information in context, and at the same time to describe and compare factors that could not be included in a statistical analysis.

We chose technologies for case studies in light of our exploration of the literature and the conceptual framework of the study. One criterion was newness; we ruled out much older information and communication technologies like telephones and computers. Another criterion was relevance across the range of countries in the study. We would gain much less insight studying technologies that were only relevant in affluent countries. We tried to respond to opportunities arising from our team's experience and connections, and we attempted to balance the set in terms of the technological projects of large corporations versus smaller challengers.

In the ICT area, we focus first on *mobile telephones*. They are nearly ubiquitous: we have been able to study the mobile phone business in every country included in the study. The specific inventions that go into each mobile handset have origins in a number of different countries, and production is done on a distributed global basis. Furthermore, this technology is still evolving, with the emergence of third generation (3G) standards that are outside mainstream use in most countries (except Japan and South Korea). There are a number of creative uses of the technology, including by female entrepreneurs ("mobile phone ladies") in poor communities receiving microfinance. Because telephone

service is a public utility, we expected to see a variety of public interventions in our cases. Indeed our preliminary review of national ICT policies in Africa, Asia, and the OECD countries, based on 62 policy documents available in English, showed wide variation in approaches, with nearly a third mentioning social inclusion or redistribution as one goal of the policy.[4]

To provide a counter-balance to the corporation-centered story of the mobile phone industry, we have also explored the open source software movement. Even in the poorest country of our group, Mozambique, small businesses were growing up based on customization of open source software. The open source movement represents an alternative, democratized form of innovation (von Hippel 2005), and has raised policy issues like the current debate on whether the European Union should use Linux exclusively as its operating system (Thurston 2007).

In biotechnology, we divided our choice of cases into agricultural and health areas, which are quite distinct in industrial connections, production processes, and users. A good list exists of the genetically-modified crops in production worldwide and the countries that plant them (James 2005). We were surprised to find that we could study a common genetically-modified crop planted in most of the countries of the study. Again, we chose a technology that has received less attention in the past. The literature on social impacts of GM crops has focused on soy and Bt cotton. GM maize, our case study technology, is in production in several countries in Europe as well as widely in the Americas and in South Africa.

There were, however, at the time we planned our study, only 21 countries in the world that were planting genetically-modified crops, including only one in Africa (James 2005). To limit our study of agricultural biotechnology to these crops would have kept us from exploring why biotechnological capability is so high on the agendas of S&T policymakers in a much broader set of countries. We therefore decided also to include case studies of the application of a much older biotechnology technique, plant tissue culture (PTC). Again, Mozambique provided a vivid example that helped us choose this focus: While the technique is about 30 years old in the North, tissue culture of plants has only been possible in Mozambique in the past few years, through a new facility constructed with funds from the U.S. Agency for International Development. Following through on the lesson learned from this story, we included analysis of several different locally-important crops that were reproduced through tissue culture in the various countries in the study. The obvious candidate in Costa Rica was bananas, where almost all banana plants are grown in a laboratory, with 50% of the production by multinationals and the other 50% by 35 independent farmers. The focal crop across some other countries was potatoes, one of the fastest-growing food crops in the world.

Finally, we wanted a technology example from health biotechnology. Of the 256 biotechnology-based drugs approved by the U.S. Food and Drug Administration at the time our study started,[5] only a few fell in areas where the World Health Organization has

[4] This review was done by Dhanaraj Thakur.

[5] Approved Biotechnology Drugs – Biotechnology Industry Organization http://www.bio.org/speeches/pubs/er/approveddrugs.asp Accessed Jan.02, 2007

identified "essential medicines," important for developing countries.[6] A considerable and sometimes charged literature already exists on one such category, the drugs for HIV/AIDS (see for example Dodier 2005, Homedes 2006, Galvao 2005, Baghadi 2005). We chose a quieter case for our analysis. Recombinant insulin was the very first biotechnology-based drug approved by the U.S. Food and Drug Administration (Walsh 2005), and thus had the longest history of distributional consequences to trace. It is an important drug, becoming more important by the year as the global epidemic of diabetes expands (World Health Organization 2003). As with mobile phones, we were able to study the use of recombinant insulin in every country in the study. While it was developed first in the United States and one U.S. firm still produces it, the largest producer is now Novo Nordisk, a Danish firm, which markets recombinant insulin in 179 countries. Social responsibility is a hallmark of Novo Nordisk, which is well known for working with non-governmental organizations, and operates with a "triple bottom line," that is, financial, environmental, and social sustainability. The case thus gave us a chance to contrast business styles and philosophies.

Choice of Countries

Our partner project ResIST confined its efforts to three world regions, Europe, Africa, and Latin America/Caribbean, making the judgment that available resources did not permit the inclusion of Asia in its empirical studies, as important as developments there are. Resultar followed the lead of our partner project in this. The ResIST participants studied selected target technologies in their own countries: Germany, Malta, and Mozambique, and followed GM maize into the Czech Republic. The Resultar team has complemented their efforts with a range of case studies in the Americas. In the end, the set included four "developed" countries and four "developing" ones, with a range of national income levels within each group.

Table One: Countries

	Argentina	Canada	Costa Rica	Jamaica	United States	Germany	Malta	Mozam-bique
Population[7]	38.7m	32.3m	4.3m	2.7m	296.5m	82.5m	404,000	19.8m
GNI/capita[8]	$4,470	$32,600	$4,590	$3,480	$43,740	$34,580	$13,590	$310
Technolo--gical Achieve-ment[9]	.381	.589	.358		.733	.583	na	.066

[6] WHO Model List of Essential Medicines http://whqlibdoc.who.int/hq/2005/a87017_eng.pdf The WHO Essential Medicines list comprises the most efficacious, safe, cost-effective medicines for priority conditions.
[7] World Bank, World Development Indicators, data for 2005
[8] Gross National Income per capita, World Bank, World Development Indicators, data for 2005
[9] United Nations, Human Development Report 2001.

Methods

Our method is comparative case study. Each case is a technology-country pair, as indicated in the table below. We have gathered information for each case using a common protocol, drawing information from published sources and interviews. We are in the process of coding the reports on each case in NVivo, a qualitative analysis software tool, using a common set of categories: national conditions, technological project, public policy sphere (including public interventions), distributional consequences in business opportunities, employment, benefits and costs. Using this analysis, various team members have produced integrative chapters for each technology. The team leaders are in the process of synthesizing findings across the technologies. Team members are also identifying policy implications within the national contexts they have studied.

Table Two: Case Study Matrix

	AR	CA	CR	Ger	Jam	Mal	MZ	US
Mobile phones (8)	XX	XX	XX	XX	XX	XX	XX	XX
Open source (6)	XX	XX	XX	XX		XX	XX	XX
rDNA Insulin (7)	XX	XX	XX	XX EU	XX	XX	XX	XX
GM maize (5)	XX	XX	XX			XX CZ		XX
Tissue cultured crop (4)	XX	XX	XX		XX		XX	XX

Selected Results

One of the main lessons learned from the cases concerns diversity. On the one hand, the specific distributional consequences of the technologies are quite different and are clearly strongly influenced by all the factors displayed in the model: how the technological project was shaped by its champions; national conditions, in particular skills and poverty; and public interventions. On the other hand, the public interventions in each technology were relatively standard. And the overall distributional patterns followed some general patterns that we were able to see much more clearly from the comparison than we could have from individual cases.

In an earlier paper,[10] we discussed at length the lessons learned with regard to various parts of the model, so we only summarize here the main points of that analysis.

> The t*echnological project* was quite an important concept in the study. Each technology was shaped differently both by its champions and by the policy environment into which it was introduced. These differences profoundly affected both the business opportunities connected to the technologies and consumer access. For example, the introduction of competition in mobile phone markets stimulated the introduction of pre-paid plans, which have had a huge impact on accessibility for low income consumers.

[10] Cozzens et al., PRIME Latin America conference, Mexico City 2008.

National conditions play a different role than we pictured when we started the project. Distributional consequences are not mediated by averages, like those given above for the case study countries, but rather by specific conditions for particular individuals, firms, or company. Some of the relevant conditions, however, are created by national governments, for example, an electricity infrastructure to underpin rural mobile networks. (If those conditions are specific to the technology, then we include them under "public interventions" rather than "national conditions.")

Public interventions, a somewhat broader concept than pubic policies and programs but closely related, are key variables in our analysis. As the focus technologies were being commercialized or applied, we found five main categories of interventions in the cases: public procurement; public utility oversight; anti-trust actions; health and safety regulations; and environmental protection. The first three are mildly to strongly re-distributive, while the latter two affect access negatively because while reducing overall risk they also raise costs.

With regard to the distribution of *business opportunities*, two factors were clearly significant. One was intellectual property protection. In some of our cases, multinational corporations held tight control of intellectual property around a new technology, limiting the opportunity for other firms to enter the market. A second constraint on business opportunity, however, is skill. If an environment does not have enough people at a high enough skill level to support or extend the technology, the ownership question is moot.

Direct *employment effects* of the emerging technologies in our study were small, with the exception of the mobile phone service industry. In mobile phones, new jobs were created directly with the new form of service, but as land line subscriptions begin to drop, jobs will be lost in that part of the telephone business. For the other technologies, high-technology manufacturing jobs tended to stay in affluent countries (e.g., in recombinant insulin), and there was a modest shift from lower-skilled, more dangerous jobs to somewhat higher-skilled, less dangerous ones. Our study did not include any of the countries that experienced rapid growth in employment through electronics manufacturing – indicating that those experiences may be the exception rather than the rule.

Considering the distribution of *benefits and costs* from the five technologies, we found a number of effects of public interventions (policies). Whether the product reached a particular consumer was usually due to a combination of action by the producing firm and the receiving government, along with specific conditions within a consuming firm or family. It was definitely not the case that the technology inevitably dropped in price until it reached a mass market; public interventions played a big role in shaping the market. What we are calling the "distributional boundary" for each technology is drawn by a combination of ownership structure, specialized skills, general educational levels, and infrastructure – and price, which is itself often influenced by competitive conditions set by the state.

The Technological Transition

We are beginning to tie these various observations together with a new concept, a structural feature of the global economy that we call the technological transition.[11] One set of diffusion and adoption dynamics is characteristic above the transition point and another set below. Predictable shifts in dynamics therefore occur for any given technology at the point of transition. We suspect that the transition point is probably closely associated with the global absolute poverty line, but that point is still under investigation. Regardless of where the actual transition appears, it comes along with differences in income distributions such that below the transition point will appear a disproportionate number of women and members of disadvantaged religious and ethnic groups.

Above the transition point, champions can choose among luxury or mass markets for the products they create from the technological opportunity. Basic infrastructure can be taken for granted and champions must compete for the portion of a market created by the variety they offer. Technological choices involve relatively small shifts in costs in relation to income, and consumers have the resources and leisure to shop around.

Below the technological transition point, the product may be irrelevant (open source software for people without electricity let alone computers) or downright dangerous (insulin in an urban slum). If the product reaches poor consumers at all, it is likely to be either in second-hand form (like the hand-me-down mobile phones common in Maputo) or broken down into small lots that cost more per unit (again, the higher rates per minute for pre-paid versus contract mobile phone access illustrate). They thus pay a larger share of their income to have access to the benefit, and the whole issue of benefits becomes more acute because the opportunity costs are relatively higher. The important questions then do not have to do with access per se, but rather with whether access might actually be counter-productive.

Developing Country Experiences

The preceding summary of results tracks the technologies across all eight countries in the study. How do these dynamics look from the viewpoint of the four middle and low income countries we studied? A few summary observations will have to stand in for the fuller analysis that will be available in the country chapters of the book we are preparing. Again, I draw here on the work my colleagues in Resultar and ResIST have reported.[12]

First, it is not true that emerging technologies always emerge in the North. Insulin (at least the traditional kind) was purified in Argentina first, in the 1920s. But the U.S. drug company Lilly moved in quickly and bought out the Argentine interest in the product, then produced it there (close to a good supply of the pig pancreas it was purified from) for many years, until recombinant insulin disrupted this symbiotic business

[11] This is an analogy to a concept in public health of the epidemiological transition: that one set of diseases characterizes countries with incomes up to a certain level, after which certain infrastructural conditions have been met and a different set of diseases emerges against the background of generally good public health. The first set is the "diseases of poverty" and the second set "the diseases of affluence."

[12] We hope the working papers will be available in 4-6 weeks through links at www.tpac.gatech.edu.

relationship by removing the need for the raw material.[13] The story is an even more familiar one today – large multinationals buy out the intellectual property of small firms in the South. It illustrates that the key to taking advantage of emerging technologies is not invention or discovery, but ownership and business opportunity.

Business opportunities. Across the four developing countries, there is significant variation in the extent to which local businesses grow up around the technologies. Argentina makes the strongest showing in this regard, with insulin production still happening there, partly based on the production facility left behind by Lilly but certainly supported by local biomedical expertise. Local seed companies co-exist with huge Monsanto operations around genetically-modified crops, including our case of maize. Outside the life sciences, however, the pattern breaks: mobile phones are entirely imported in Argentina and we could find no business activity in open source software.

In Costa Rica, a country with a similar level of wealth, local business was clearly supported by a significant plant tissue culture operation, in a research facility supported by the banana industry.[14] But this was the only private business activity linked to our five technologies there. The puzzle in Costa Rica is why the significant local software industry does not generate any discernible open source business activity. In general across the countries, a local software industry is a necessary condition for open source businesses to spring up; but apparently it is not a sufficient one.

Another potential business opportunity that did not appear is plant tissue culture in Jamaica. There is an appropriate facility, used in a previous project with the European Union.[15] PTC does not need to be limited to bananas – planting materials for other local vegetatively-propagated crops could be produced and sold. A few hundred miles away, in Florida, a thriving plant tissue culture industry thrives. Why not in Jamaica?

In Mozambique, the technologies provide interesting support to livelihoods at the micro level.[16] While mobile phone companies do not employ very many people, they do provide opportunities for hundreds of street vendors in Maputo to sell recharge cards on every street corner. And tissue cultured planting materials, prepared in a government laboratory and distributed by international aid organizations, provide some help for subsistence farmers, many of them women, with perhaps some movement of the product involved into local markets.

In short, the variable experiences of our low and middle income countries show the business opportunities generated by emerging technologies depend crucially on the technical capabilities that already exist in a local environment, but also on some other set of complementary conditions that we were not able to identify. Low technical capabilities lead to small business opportunities. Higher technical capabilities bring the possibility of larger business opportunities, which innovation policies might be able to target.

Employment. As noted earlier, no major shifts in employment were visible in any of our case studies. The shift that seemed most likely was the substitution of recombinant for porcine-based insulin that affected the production facility in Argentina; but local

[13] Bortagaray, Argentina-insulin case.
[14] Bortagaray, Costa Rica banana case.
[15] Gatchair, Jamaica plant tissue culture case.
[16] Brito, Brouwer, and Falcao, Mozambique cases.

action prevented the plant from closing and a local market maintains it.[17] The contrast with cases in which production of high-technology products has moved to developing countries is striking, and illustrates how limited those other experiences are, and how hard it is to generalize from them to other developing countries.

Benefits and costs. All the technologies we studied were widely accessible in Argentina, Costa Rica, and Jamaica, with some rather specific holes in coverage. The wide availability of recombinant insulin was largely as a result of health insurance and public health services, so where someone did not have access, it was because they were not covered – a situation that characterized a surprising 25% of Argentines and probably the full 40% of Jamaicans who work in the informal economy. Another hole in accessibility, this time of mobile phone hand sets, was caused by the government telecommunications monopoly in Costa Rica, which managed to put a lot of obstacles in the way of acquiring the set – after which, service was cheap. With banana tissue culture material, small farmers were likely not to be able to afford the materials, since they were not produced locally. Larger farmers could import what they needed. Access to a basic level of the technology of course did not imply access to the best version that was available (the different versions of insulin illustrate), but mostly people living in middle income countries are on the positive side of the distributional boundary.

The situation was different in Mozambique.[18] Since there are only 20,000 computers in this country of 20 million, not many would have been able to benefit from open source software. Mobile phones are heavily concentrated among male users in Maputo, according to a telephone survey done by our Mozambican team. And for the estimated 80,000 diabetics in the country, only enough insulin for perhaps 50-100 is imported. (Affluent Mozambicans in the south of the country can drive to South Africa and buy insulin over the counter in drug stores.) Doctors in Mozambique are reluctant to prescribe insulin to people in poor households who will not be able to maintain the necessary regimen. So ironically, while insulin is free through the public health service there, rich people are much more likely to benefit from that policy than poor ones. Likewise, ironically, pre-paid phone plans make mobiles accessible to poor consumers, but they pay more per minute used.

None of these limitations is inevitable, as the story of the tissue-cultured orange flesh sweet potato plantings in Mozambique illustrates. When government and NGOs decide to work together to diffuse a useful technology, they can be successful, especially with a community-based multi-pronged approach involving education and subsidies. Our Mozambican colleagues recommend policies that incorporate these elements for other technologies as well.

Policy Options

Clearly, there is no one-size-fits-all set of recommendations that can be made based on our findings, even among these four "developing" countries. For each country represented in our study, we have prepared an essay pointing to patterns across the technologies and policy options that make sense in that country's context.

[17] Bortagaray, Argentina insulin case.
[18] Brito and Brouwer, Mozambique country essay.

Our Mozambican colleagues have provided a particularly detailed analysis of policy options for using emerging technologies in resource-poor environments for inclusive development.[19] They use concepts from another part of the ResIST project to place the technologies on three dimensions of inequality: structural, representational, and distributional.[20] These generate ideas for multiple approaches to reducing inequalities in the distribution of benefits and costs while building capacity for society and economy.

Let me end with a key feature of their discussion.[21] Emerging technologies do not have to diffuse passively into developing countries. National governments can choose to work on absorbing ones that make a difference locally and hold the potential for increasing the innovative capacity of the country. Such selections need to be surrounded by training, supported with facilities, and stimulated through community participation. If they are, however, then even emerging technologies can contribute to inclusive development.

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[19] Idem.
[20] See Cozzens, Kallerud, and Santos Pereira for a discussion of these and how they may be reflected in different approaches to STI policy.
[21] Brito and Brouwer, Mozambique country essay.