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Africa's technology futures: three scenarios

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Dirk Swart



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Africa's Technology Futures: Three Scenarios

Dirk Swart

Abstract

Technology has critical impacts on regional and national futures everywhere. It can be particularly important in enabling developing countries and regions to increase efficiencies and develop rapidly. This paper examines two questions using a scenario planning approach: (1) can Sub-Saharan Africa be effective at creating, owning, developing, and harnessing homegrown technology, and (2) can Sub-Saharan Africa adapt non-African technologies into innovation cycles. A set of driving forces, effects, and change triggers that influence technology in Africa are identified and analyzed, looking at both the desired and the expected outcomes. Based on this analysis, three feasible futures are presented and discussed: "Use, don't own," "Pockets of innovation," and "Leapfrogging." The situation today is discussed as a baseline, and the risks of assuming that Africa will take the same trajectory to technological sophistication as the West are noted. The analysis suggests that for Africa to move toward more desirable trajectories, the welfare-generating capabilities of African markets will need to be enhanced, governments will need to be more effective and responsive, and more constructive external intervention will need to replace currently exploitative trends.

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INTRODUCTION

With its fast-growing populations, growth potential, and strategic importance, Sub-Saharan Africa's¹ future is going to have a significant impact on the future of the rest of the world, and vice versa. A look at technology through seven fundamental drivers can help tell the story of what Africa's future might look like over the next 20 to 40 years.

Technology is the means by which human societies interact directly with and adapt to the environment (Moss 2001), the application of science to real-world problems—and right now the situation in Africa is unsettling. In 2000, 3.8 percent of Sub-Saharan Africa's exports were high-technology, compared with a worldwide figure of 22.9 percent (World Bank 2007)². This figure, by far the lowest of any region, represents a lost opportunity for Africa and emphasizes the potential and the amount of work still required if Africans are to elevate this base to world standards. An outlier like this warrants investigation. How will Sub-Saharan technology develop over the long term?

African countries are as diverse in culture as they are differentiated in their political heritage (Juma and Agwara 2006). Nevertheless, they have some significant commonalities. None of them are world powers. The majority will experience dramatic population growth and a demographic youth bulge in this century. A significant portion of the population has been isolated from the ongoing technological revolution. There is no effective trans-continental or, for that matter, regional organization, although the African Union (AU) is trying. This diversity and lack of regional cohesion slows down the propagation of change and stifles competition.

In his 2007 Frederick S. Pardee Distinguished Lecture, Nobel-winning physicist Murray Gell-Mann noted that it is hard for people to envision a future that is dramatically different from the present, and commented that in discussing how to look ahead and plan for the future, we should look

1. This paper deals exclusively with Sub-Saharan Africa. Occasionally "Africa" is used instead of SSA or Sub-Saharan Africa to aid readability.

2. To emphasize how very low this figure is, compare with Latin America at 15.8 percent and the United States at more than 35 percent.

not just at the expected scenario, but also at other, less-likely scenarios that produce the results we would like to see (Gell-Mann 2007). While it is

A role for public policy is to try to increase the chance of these more-desirable scenarios coming to pass and to formulate methods to insulate society against unpredictable shocks.

difficult to attach reliable probabilities about which scenario is more likely with today's initial conditions, we can say which is more desirable, and state which factors we believe to be the most relevant and impactful. A role for public policy is to try to increase

the chance of these more-desirable scenarios coming to pass and to formulate methods to insulate society against unpredictable shocks.

These scenarios address two questions:

1. Can Africa be effective at creating, owning, developing, and harnessing homegrown technology?
2. Can Africa adapt non-African technologies into its innovation cycle?

DRIVING FORCES

Fundamental driving forces reveal underlying commonalities. In addition to their explanatory role, drivers are used to frame key questions: Will Africa's future end up depending on the type and amount of external influence? Is competent governance the fundamentally necessary and sufficient condition? Seven drivers are used to investigate these questions and construct the scenarios.

The seven drivers (Table 1) were selected because they are all basic long-term factors that will significantly affect or even determine Africa's technological future, have rates of change large enough to impact its future trajectory, and are, as far as is possible, independent and seen as the most appropriate for discussing Africa's technological future. Each driver has both positive and negative effects that determine the possible scenarios. Individual drivers dominate if particular triggering events occur. Table 4 (p. 19) links the drivers to the scenarios.

Table 1: Key Drivers of Technological Change in Africa

Driver	Relevance
Demographics	Large populations, particularly if they are concentrated in urban areas, mean large potential markets. They also mean increased stresses on limited resources and introduce stresses from the social change associated with urbanization.
Governance	Governments have a key role to play in nurturing and protecting technology and technological capability. This includes conflict.
Safety and security	Lack of security changes the way people think about the future and reduces the value they give to long-term planning.
Entrepreneurship and the technology multiplier	Opportunity entrepreneurship is an interactive, social activity that requires the right conditions to be successful.
Globalization and external intervention	In addition to trade, globalization affects a country's capability to resist external political and economic intervention, increases technological collaboration, and enables niche players.
Internal continental relations	Good relations with neighbors create convenient trade opportunities, enhance skill and knowledge exchange, encourage a pluralistic approach to security, create economies of scale in knowledge creation, and create growth potential.
Economic and human development	Technological sophistication multiplies economic and human development opportunities, which in turn create opportunities for technological development. Economic and human development move together and are considered together.

Drivers that are experiencing a change in direction or have recently reversed direction are particularly interesting. With all the drivers, a process of steady,

step-by-step progress should generate the best future, allowing factors to build on each other and produce the circumstances most favorable to the developing and harnessing of homegrown technology. Technology itself is a unique driver. Creativity, knowledge, and ways of thinking are applied to many different approaches to create and apply technology. The development of technology to answer the two questions posed above is part of the transformation of knowledge into goods and services via economic participation (Juma and Agwara 2006). One particular technology can drive specific developments, but clearly, as a whole, science and technology are a wrapper for a wide classification of economic endeavors. In our scenario planning, the effects of the application of these economic efforts, conveniently labeled “technology,” are an output (that can feed back into the model) and are discussed as part of the scenarios. Partly for this reason, “Entrepreneurship and the technology multiplier” is used instead.

Finally, some drivers appropriate for a general scenario planning exercise but that were not selected include health, natural resources, and foreign aid. Also, conflict was merged with individual security as “Safety and security,” a measure of how people think about the question, “Can someone else do me harm?”

Demographics

Africa’s population and demographic profile is a significant contributor to any technology scenario. Today there are no African countries ranked in the 10 most populous countries (Table 2). However, by 2050 we can expect three—Nigeria, the Democratic Republic of the Congo, and Ethiopia—to move into the top 10. These are part of an overall trend of rapid population growth throughout Sub-Saharan Africa.

Historically, predictions of population have been fairly reliable. While it is true that the accuracy of past predictions does not imply the same for future predictions, and that it is plausible that the current forecasts are “not necessarily reliable” (World Economic Forum on Africa 2006)³, the shock-free scenarios presented treat population growth as “predictable” and not “variable” (see p. 18). All three scenarios assume the amount and type of

3. See also World Economic Forum Annual Meeting 2007.

growth as put forward by the Population Reference Bureau, including that the developing world will continue to outpace the developed world through 2050 (see also Engelman 2008).

Table 2: Ten Most Populous Countries, 2050

Country	Population (mil)
India	1,628
China	1,437
United States	420
Nigeria	299
Pakistan	295
Indonesia	285
Brazil	260
Bangladesh	231
Dem. Rep. of Congo	183
Ethiopia	145

Source: Population Reference Bureau (prb.org)

The effects are that developing countries will make up the overwhelming bulk of the world’s population by 2050, accounting for 7.8 billion of the 9 billion people on the planet (World Economic Forum Annual Meeting 2007). Africa is also going to continue to have a young population—in 2050, 28 percent of Africa’s population will be under 14 years old, by far the youngest in the world (United Nations 2007). This, plus increasing rates of urbanization are going to mean tremendous potential for the development of large regional and transnational markets (a market effect). Unfortunately it also places increased stresses on limited resources (a resource effect) and challenges political stability and the government’s ability to provide services and monopolize the means of violence (societal effects). While other drivers will determine if they actually develop, the large size of these effects has a significant impact on our scenarios. For example, if large markets do not develop and there is no increase in wealth and no application of technology to offset resource shortages, this could result in increased instability, fewer efficiency gains, and a less-than-ideal future.

Governance

Good governance can be seen as the ability of a government to ensure political transparency, provide efficient and effective public services, promote the health and well-being of its citizens, and provide a favorable climate for economic growth. This includes ensuring that economic rents are reason-

Given the importance of globalization today and our expectation that it will continue to increase, it is clear that both shoddy governance and poor intergovernmental cooperation can be a hindrance to technological advancement.

ably fairly allocated, particularly if most income is from a single source, like oil—arguably the single most important resource on the continent from an outsider’s perspective. Governance has two primary effects on technology: First, the state’s and public service’s contribution to social capital is significant. It has been

extensively discussed (Sagasti 1978; Shaw 1981) and will have a powerful effect on all possible futures for Africa. Given the importance of globalization today and our expectation that it will continue to increase, it is clear that both shoddy governance and poor intergovernmental cooperation can be a hindrance to technological advancement.

Second, and most important, governments are crucial in generating entrepreneurial momentum. They play a key role in nurturing and protecting technology. Khalil-Timamy (2002) has discussed the instruments of technology policy in Africa and noted that there is a lack of capacity to translate relevant knowledge into policy and programs and a need for greater commitment to research scholarship. The idea that there is less innovation in Sub-Saharan Africa as compared to the rest of the world is not supported. Yet policy failures prevent technologies from taking off, or raise the bar that entrepreneurs have to clear. Without effective governance in this capacity, it is more difficult for innovation to succeed. Even worse and more importantly, where innovation does occur it is not protected and the rewards are lost.

Governance has been blamed as a driver for Africa’s difficulties (Fukuyama 2004) and viewed as a consequence of other factors rather than a factor in itself (Sachs, McArthur, et al. 2004). The Institute for Security Studies EU

2025 scenario calls political and economic governance “the crucial factor” for Sub-Saharan Africa. It goes on to state that bad governance hinders economic diversification and development. Without an improvement, Africa will continue to be a “breeding ground for violence” and continue to be poorly equipped to compete in a globalized world (Gnesotto and Grevi 2006). The authors espouse the rather dim but entirely plausible view that the region will continue as it is now. There is certainly supporting evidence for this depressing level of realism: historically it has proven to be correct, and there are at least as many challenges today as there have been in the past 40 years.

Finally, while both good and bad governments use technology extensively, bad governments do not foster the development and adaptation of technology. The inefficiencies brought about by flawed governance, like those of inadequate infrastructure and other factors, are losses to society as a whole.

Safety and Security

When statistics on HIV/AIDS, war, agriculture, food security, and stability are discussed, Africa does not fare well. Fifteen of the 32 conflicts currently occurring worldwide are in Africa, including the Congo war, the highest casualty conflict since World War II. Botswana, Africa’s poster child for peace and stability, has HIV/AIDS rates around 30 percent⁴. Although things are looking up in Southern Sudan and elsewhere, negative safety and security issues continue to reduce productivity and stability.

These factors all contribute to dramatically shortening the average African citizen’s “look-ahead” horizon, causing people to apply a large discount factor to even relatively near-term future events, and discouraging longer-term thinking. Research and the integration of new technologies into innovation are long-term endeavors, so a lack of confidence in the future discourages research and investment.

While it is true that wars can spur innovation and growth, it is not clear that the low-intensity conflicts in Africa have this effect to any marked degree.

4. UNAIDS (unaids.org/en) has previously estimated around 37 percent, but this is now felt to be too high. Avert.org estimates rates of around 24.1 percent.

They also have a more insidious effect, that of reducing the role and influence of women in civil society. This is not to suggest that women have any particular role to play in technology that men don't. It is simply a case of reducing the number of productive economic actors. Finally, it is not clear whether wars attract negative foreign intervention, but they are at least associated with it (Regan 2000)⁵.

Entrepreneurship and the Technology Multiplier

Technology builds best on a fertile base. Entrepreneurship is an essential component in mobilizing the other factors of production and, in the case of technology entrepreneurs, converting science into technology or spreading technologies. Unfortunately, a concise definition of an entrepreneur is difficult. The Global Entrepreneurship Monitor (GEM) considers them to be adults who have taken some action toward creating a business or who are active owner/managers of a new business (Harding and Bosma 2007). They distinguish between entrepreneurship by necessity and entrepreneurship by opportunity, and have identified a “U”-shaped relationship with GDP per capita. Poor countries have high levels of entrepreneurship

by necessity, middle income countries have low levels of both types of entrepreneurship and are relatively non-entrepreneurial, while richer countries have more opportunity entrepreneurship. James Surowiecki (2008) notes that what poor countries need are not more microbusinesses but more small to medium businesses. They employ people and leverage entrepreneurship more effectively. Micro to small enterprises are more likely to be owned/managed by entrepreneurs through necessity. Medium and larger businesses are more likely to be owned/managed by traditional opportunity entrepreneurs.

New technologies are built on top of existing ones through successive elaboration and cooperative idea sharing—and through a combination of skills, access to finance, and access to markets.

5. Regan notes that 64 percent of post-World War II conflicts involved direct third-party intervention, and 34 percent of them occurred in Africa, making Africa by far the most conflict-beset continent.

Importantly, entrepreneurship is a social activity. The idea of the lone innovator working in isolation to produce the next big thing is a myth (Berkun 2007). In reality, new technologies are built on top of existing ones through successive elaboration and cooperative idea sharing—and through a combination of skills, access to finance, and access to markets. This means communications technologies are particularly important and is one reason that phone connectivity is a good leading indicator. I have called this interdependence effect “the technology multiplier”—new technologies and entrepreneurs stimulate investment and build markets, which further encourage innovation and entrepreneurship.

No data is available on technology penetration in Africa. If we instead use metrics such as patents (see “Status Quo” section), industrial technology adoption (for example, Figure 1 on p. 23), how wired each country is, and total energy consumption per capita, we can estimate a representative basket for technology penetration. The conclusion is that technology penetration is low. In at least two countries, energy consumption has declined in the last quarter century⁶.

Globalization and External Intervention

Intervention has two aspects—globalization as a source of general betterment, and foreign external intervention—a comparison many Africans see as tautological.

Global trade is an important pathway for technology diffusion. We are moving to a world without one dominating superpower. The United States is no longer the largest economy, many countries compete for influence (Corsi 2008), and at \$114.8 billion in 2010, China is Africa’s largest trading partner. In this environment we should expect increasing trade and continued pressure for countries to integrate into the international system. It is also highly likely that economic, governmental, and knowledge globalization will continue to increase (Meier and Stiglitz 2001; Najam, Runnall, et al. 2007).

6. We are not suggesting that all technology requires power, but rather that power consumption and technology trend in the same direction at similar rates.

Table 3: Globalization Index

Country*	Index
North America	0.872
World	0.675
Arab Rep. of Egypt	0.460
Kenya	0.352
Nigeria	0.350
South Africa	0.340
Morocco	0.307
Tunisia	0.284
Senegal	0.276
Sub-Saharan Africa	0.270
Zambia	0.266
Algeria	0.247
Libya	0.207
Cote d'Ivoire	0.198
Cameroon	0.186
Mozambique	0.182
Seychelles	0.176
Togo	0.176
Mali	0.175
Gabon	0.174
Mauritius	0.172
Zimbabwe	0.167
Malawi	0.146
Dem. Rep. of Congo	0.135
Sudan	0.120

Source: Centre for the Study of Globalisation and Regionalisation (CSGR)

*All African countries that have an index are reported.

Prediction is tricky. There is no simple formula for predicting or managing national responses to globalization and the associated proliferation of regional and bilateral trade agreements (*The Economist* 2008a). A common element

of the current globalization discourse is the belief that a partial power transfer from the G8 to the G20 or a similar grouping is one inevitable effect (World Economic Forum Annual Meeting 2007). As part of this pressure, the scenarios assume increasing cross-border movement: we cannot have free flow of goods and services without also having free flow of labor, or at least intense pressure for it. Africa has relatively low levels of globalization (Table 3), but this is changing, especially with Chinese and Indian national entrepreneurs moving in. In absolute terms, the globalization of Sub-Saharan countries will increase, but it is not clear whether we will see relative improvements—the rest of the world may globalize even more than Africa.

Stronger and more influential nations are better able to harvest the positive benefits of globalization and resist negative external intervention to better control their own futures. African countries are not very effective at this, and other nations are not necessarily going to help. As former U.S. Secretary of State Condoleezza Rice famously noted on the subject of spreading American values: “To be sure, there is nothing wrong with doing something to benefit all humanity, but that is, in a sense, a second-order effect” (Kaplan 2007).

The ability of Africa’s countries to adapt foreign intervention to their own needs will have a significant impact on their ability to leverage and adapt technology. Indeed, some have shown an adept ability to court several large economies at the same time.

Internal Continental Relations

African states are bedeviled by their inability to project influence beyond their local region. Even the “anchor tenants”—South Africa, Nigeria, and Kenya, each of which has at one time or another demonstrated continent-wide influence—find it difficult to avoid being distracted by whatever internal issues they are dealing with at any particular time. There is no effective continent-wide organization, although the AU is gaining weight and shows promise. The New Partnership for Africa’s Development (NEPAD), an integrated socioeconomic development framework for Africa created in 2001, which was once off to a promising start, is criticized by many—including one of its founders, Senegal’s President Abdoulaye Wade—as having achieved nothing.

Regional organizations do not fare much better. As current evidence of this, the Southern African Development Community (SADC) recently convened a special meeting to discuss the Zimbabwean election crisis and concluded that no such crisis exists. At least one in-depth study has shown that South-South trade agreements do not necessarily increase trade (Mayda and Steinburg 2008). Yet good intra-African relations have the potential for enormous positive effects, and there has been good progress on some fronts. The Southern African Customs Union functions quite well, the COMESA preferential trading area is making good progress, and the AU has shown some muscle: It has overturned coups in Togo and Mauritania, oversees an 8,000-troop body in Somalia and more in Darfur, and has suspended Niger, Madagascar, and Cote d'Ivoire for undemocratic behavior.

One reason for this lack of good relations might be that Sub-Saharan countries are natural competitors with each other. This would explain why efforts that start well and seem beneficial later seem to fall apart. Still, competing neighbors elsewhere in the world can get on well enough. If African countries cannot, it suggests that unless the underlying reasons for competition change, regional arrangements will be biased toward failure. In addition to the safety and security reasons, productive intracontinental relations are essential for the development of African markets, the facilitation of inter-country migration, and the effective leveraging of the increased opportunities that greater integration and communication bring.

Economic and Human Development

When Africa's economic and human development is compared with that of any other region over the last 20 years, the results do not favor Africa. Why has Africa performed at such a low level? Meier and Rauch (2000) provide a good overview, but essentially attribute it to predictable poor quality of a variety of things such as governance, and "structural weakness"—which is another way of saying that yesterday's poor quality is coming back to haunt us today.

Human development is a composite measure of life expectancy, literacy, education, standard of living, and per capita income. All of these factors contribute significantly to the technology multiplier and the technological absorptive

capacity of a nation. They are basic inputs into any longer-term scenario planning exercise. From a technology perspective, economic development and technological sophistication closely overlap human development, especially with respect to technology adoption, markets, ease of business and market development, access to capital and relations—each of which is mentioned below. A key variable in the adoption and spread of local technology is the existence of local, preferably transnational, technology markets and consumers, and the continued building and development of these markets. Education, especially tertiary education, is a major contributor to this process.

THE SCENARIO FRAMEWORK

The technological futures facing Africa have been grouped into one baseline status quo, in which things continue as they are today, and three new scenarios of steadily more optimistic outlooks. They are internally consistent, plausible outcomes based on interpretations of present trends. As such, there is no intention to predict or solve anything. The scenarios are intended as a constructive process in “the gentle art of re-perceiving” (Wack 1985a and 1985b).

Scenarios are usually presented in two ways, either as challenging descriptions of the future, or “a causal line of argument linking an action option with a goal” (Van der Heijden 1996). What is presented here are the former: stories about the future. The scenarios are not intended to be predictions or probabilistic previews but are steps toward a shared conclusion, aimed at grouping and contrasting the large number of possible futures. This allows the development of falsifying tests and data points ahead of time to confirm (or not) the accuracy of predictions. Changes can be recognized as part of a pattern within an ongoing discourse, so that we can more easily see the implications of changes as they are occurring, instead of in hindsight—and perhaps respond more quickly. Within this framework, these scenarios focus mostly on the creation and ownership of technology in Africa (dynamic capabilities, as defined in

The scenarios are not intended to be predictions or probabilistic previews but are steps toward a shared conclusion, aimed at grouping and contrasting the large number of possible futures.

Global Technology Forum 2007) and spend less attention on the unmodified application of technology created in other places and implemented without modification in Africa (core competencies).

Before presenting the new scenarios, it's useful to examine what people some 40-plus years ago were predicting about today—and try to identify patterns and systematic biases. In the 1960s Kahn and Wiener at the Hudson Institute made detailed predictions of population and economic growth out to 2020 for the whole world. Population growth from 1965 to today is pretty close to their predictions⁷. Economic growth has been less than predicted in their “Africa” scenario, is on target for their “Black Africa” scenario, and has outperformed predictions in Asia. They also included detailed comments on science and technology, noting that “technological change itself may contribute to feelings of estrangement . . .”—a feeling present in Africa today (Kahn, Wiener, et al. 1967). It has been noted that “it is important for Africa to come to terms with its cultural dichotomy of western and traditional values” (Gatune 2009).

The first detailed scenario analysis to focus specifically on Africa was Shaw's excellent 1981 book, *Alternative Futures for Africa*. This work adopts an approach of looking at Africa's alternatives within the world system, in this case, intellectual property, innovation development, and protection⁸. His 1981 scenario highlighted the alternatives of dependency versus self-reliance. In many ways that is the situation for African technology today.

Shaw looked at other forecasts as well as at trends like industrialization, population growth, nutrition, depletion of nonrenewable resources, and environmental pollution. Of the seven earlier works he compared, Kahn and Wiener's have proved to be the most accurate predictor of population and economic growth.⁹ Their scenarios were comparatively pessimistic,

7. Kahn predicted a per capita GNP growth rate, from 1965 to 2000 of 2.0 percent for Africa as a whole. Pandya-Lorch uses a GNP per capita from 1965 to 1990 of 0.2 percent, with no or stagnant growth from then on. Ndulu and O'Connell estimate a real GDP growth rate of 3.2 percent from 1965 to 2000, but a real GDP per capita of only 0.56 percent, broadly in line with Pandya-Lorch. These figures are intended to provide an overall comparison, not substitute for a detailed analysis of this topic.

8. On page 95, he presciently notes: “. . . an inheritance of external dependence constitutes the major determinant of Africa's present and future prospects for development and underdevelopment.”

9. The works are: Bariloche, Leontief, Kahn and Wiener (Africa), Hughes and Strauch, Mesarovic and Pestel, UN (Medium), and Kahn and Wiener (Black Africa).

particularly with regard to economic growth, suggesting that most analysts predicted a more optimistic future than was realized (Kahn, Wiener, et al. 1967). HIV/AIDS was not anticipated at the time of analysis, and growth would probably have been higher without it, but it is possible that global climate change presents as grave a threat today as AIDS did in the last century, suggesting a pattern of future scenarios about Sub-Saharan Africa being overly optimistic.

Shaw also predicted an increasing level of intracontinental integration that has not come to pass—even the most optimistic new scenario considers only a limited form of continental integration, transnational markets. Regarding technology and computers, in his discussion of modernization and development Shaw warned that technological development as an effort to “catch up with the West” carries “considerable risk” of dependency, a point worth noting.

Three points related to Shaw’s predictions:

- i) His analysis seems to have been from a hardware/manufacturing perspective rather than a software/knowledge economy approach, which is understandable as he was writing before the personal computer phenomenon.
- ii) Pragmatically we should not only consider whether Africa has improved relatively but also whether its people are better off in absolute quality of life. Computers and smartphones have increased the life choices for Africans. It is reasonable to state that the “Pockets of innovation” scenario would not be possible without information and communications technologies (ICT).
- iii) He is correct that a devotion to merely catching up results in dependency. However, the implication that technological development is automatically an attempt to catch up seems to imply that all technological development must proceed on the same trajectory as it has done in the West. What about a future in which some development is catching up and some proceeds along African adaptations and applications of technology?

Finally, Shaw's analysis of "the computer and the science of anticipation" is highly readable and remains relevant more than a quarter century later. Three trends of modernization included—secularization, technicalization, and future orientation—have all come to pass in a limited way.

Driving Forces

How do these drivers result in the three scenarios? Each driver effect—positive, mixed, or negative—was used to characterize the problem space in terms of input availability, knowledge, the technology multiplier, absorptive capacity, technological wealth, responsiveness, and so on. In addition, specific events were noted as triggers, where a particular driver has a larger-than-usual effect. The three scenarios—"Use, don't own," "Pockets of innovation," and "Leapfrogging"—were then created as plausible answers to the unknowns.

For all three, the drivers are classified as follows:

- Predictables—Vectors with predictable direction, variable but estimable magnitude, and unknown impact
 - Demographics: Increasing population
 - External intervention and the globalization of culture: Increasing globalization, continued external intervention
- Variables—Vectors with variable direction, hard-to-estimate magnitude, and unpredictable impact
 - Governance
 - Safety and security
 - Entrepreneurship
 - Internal continental relations
 - Economic and human development

Many of the challenges facing Africa today are not new, and two scenarios describe a world in which things are not much better, at least for most. This warrants a short sidebar regarding external intervention. Many authors have explained a bleak reality and future for Africa by highlighting intractability of managing external intervention. This paper emphasizes that the onus is

on countries in Africa to work within the existing reality. Where possible, they should work to force the rest of the world to be more cooperative and less exploitative, not expect more powerful nations to suddenly start treating Africa differently. Asante, et al. (2001) sum up the realpolitik approach: “It is only by entering the international market from a strong bargaining stance that the discriminatory treatment meted out . . . can be checked”.

Drivers do not have equal weight across all scenarios. In each scenario a subset of the driving forces dominate the environment, but these may not be immediately discernable. Triggers are introduced as specific things we can watch out for as early warning signs that a particular scenario is gaining momentum. As such, they are first-order effects of underlying drivers that allow the scenarios to develop (Table 4). Using this abstraction, the scenario planning process can be viewed as discovering a representative finite-state machine.

Table 4: Triggers Link Drivers to Scenarios

Trigger	First-Order Driver	Scenario
Contagion	Internal continental relations	Use, Don't Own
Human security	Safety and security	
Slow to change	Governance	
Niche players	Globalization and external intervention	Pockets of Innovation
Stable group of innovators	Safety and security, entrepreneurship	
Slow to change	Governance	
Markets	Internal continental relations, demographics, economic and human development	Leapfrogging
Responsiveness	Governance, entrepreneurship	

For example, if contagion within regions increases substantially, we can best model the future by considering internal continental relations as the first-order driver. This will increase the probability of the “Use, don't own” end state. Likewise, if stable groups of innovators develop, safety and security will become the dominating driver, transitioning Africa from its current

state to “Pockets of innovation.” Each row can be seen as a way in which a scenario can come to pass. So if contagion or human security issues or slowness are present, we should look to “Use, don’t own.” The more of these triggers that are present for a particular scenario, the more likely it is that Africa will transition to that state. In addition, that particular scenario will be expected to have greater geographic and social scope across the continent.

For all three scenarios, the more that Africans are able to develop and localize technology, the more likely that Africa will be able to control the direction and craft a future that benefits those on the continent instead of others.

Status Quo: The Situation Today

A review of the drivers as applied to Africa today reveals a mixed but mostly pessimistic picture.

First, let’s consider market development and capital. Sub-Saharan Africa does not have well-developed markets, and it remains the world’s most difficult region to do business in. Very little local capital is available in Africa. Capital markets are poorly developed, and an astonishing 40 percent of African private wealth is located offshore (Gnesotto and Grevi 2006). This forces businesses to raise capital on the global market, which is both more difficult and more expensive, and thus available to fewer entrepreneurs. It is “far from obvious that developing countries benefit much from opening up to global capital,” and the linkages between economic and human development indicate that countries should pursue human development first, further complicating the issue (*The Economist* 2008b). This is the policy being adopted by Rwanda in its attempt to become a high-tech hub in Africa (Baldauf 2007). In addition, capital goods are more expensive in Africa than the international average, reducing the effectiveness of investment. Still, with the exception of Zimbabwe, in the last year African countries at least did not make it more difficult to conduct business.

Although it is a region of weak market development, and reforms to remedy the difficulties are uneven, there is much to be positive about. There are fewer successful coups, some long-running intractable conflicts have been resolved (e.g., Angola and Congo), and the Mo Ibrahim index for safety and

security has improved slowly between 2000 and 2006¹⁰. Safety and security appear to have strengthened over the past decade. Still, governance remains weak in most countries, contributing to lower levels of technology adoption.

Second, let's quickly overview entrepreneurship and the ownership of its rewards. Entrepreneurship continues, and it is true that some technology is created, but it is not leveraged efficiently into the creation of new, derivative technologies. This is evidenced by how African countries do not generally appear in listings of technology ownership. Patent applications are one such easily accessible metric, and we can look at them as evidence and for some insight. For example, South Africa, by far Africa's most active protector of intellectual property, filed 137 international patents in 2006. Israel, ranked 15th in the world by number of filings, had 1,512 (World Intellectual Property Organization 2007). No African country appears in the top 30 list of patent filings by million inhabitants, the top 30 list of filings per unit of GDP, or the top 20 list of filings per U.S. dollar of R&D expenditure. This does not count the local-only protection of innovations, but figures, where available, are similarly low.

Third, let's consider the maturity of the innovation cycle and the technology multiplier. The extent to which African countries have a mature innovation cycle is not clear, and there are very few re-injections into the international technological community. Some elements, such as access to venture capital, are missing in most places. Africa is not successful at adapting non-African technologies into the innovation cycle. There is one well-known exception: cell phones. These are discussed in more detail later.

Africa is not successful at adapting non-African technologies into the innovation cycle. There is one well-known exception: cell phones.

When considering the technology multiplier, African technology development today still suffers from problems with input availability. Absorptive capacity for new technology is low in many places, and when new technolo-

10. The Mo Ibrahim safety and security index, averaged over all countries, increased from 74.73 to 76.64 between 2000 and 2006. Rotberg and Gisselquist 2008. The full Ibrahim Index is available at www.tinyurl.com/ibrahim-index-08.

gies are introduced, often in an attempt to leapfrog existing technologies, they are often incompletely adopted, inefficiently used, or later abandoned. An example of adopting and later abandoning a single technology can be seen in fertilizer use in Ethiopia. For small farmers the downside risk—having to pay for the fertilizer even if the crop failed—made its use a relatively high-risk activity. Poor farmers are unable to shift this risk to others, so they choose to avoid it, even if that means lowering profit margins. A supportive insurance system would result in fertilizer being more widely used.

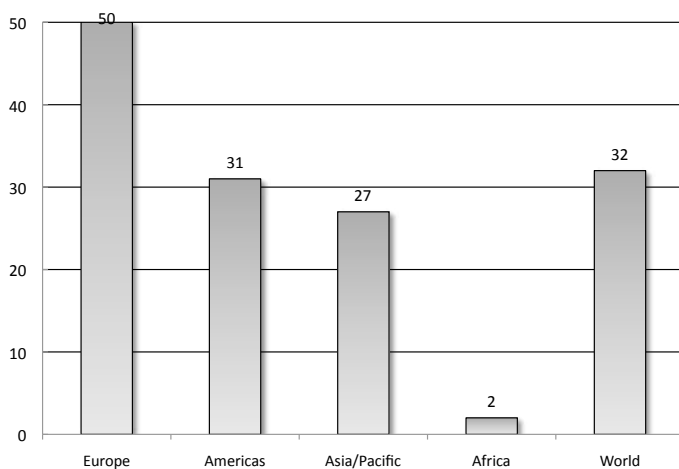
In the context of the technological multiplier and the myth of leapfrogging, this is entirely predictable because new introductions cannot leverage other supporting systems. Technological wealth is relatively low, responsiveness to new technologies is mixed, and there is a persistent brain drain of knowledge workers, and often insufficient attention to education—making it difficult to address any of the above issues, and making it harder for niche players to remain active.

Finally, we consider demographics. The current youth bulge, which is so promising in other places, is a mixed blessing in Africa. A youth bulge has been linked to increased risk of change, especially civil war and violence (Cincotta 2007), suggesting that if Sub-Saharan Africa continues to have a very young population, stability will be hard to achieve. Therefore, one key indicator will be how many power transitions are peaceful.

To paint a minimalistic picture of African technology based on the status quo is wholly uncontentious. Africa is involved in the global exploitation of technology, and there is some limited involvement in global technological collaboration, but African economies are by and large not involved in the global generation or even use of technology. As one example of technology usage in industrial production, consider the diagram of robots in use around the world (Figure 1).

It is not difficult to find reasons for these abysmal technology statistics, at least at the most abstract level of analysis. Worldwide, three factors contributed to the transformation of successful emerging economies (Juma 2006): They invested heavily in basic infrastructure, they nurtured the development of small and medium enterprises, and governments assisted

Figure 1: Industrial Robots per 10,000 Manufacturing Workers by Region



Source: Guizzo 2008 (<http://tinyurl.com/ieee-robots>)

and funded educational institutions. Least-developed countries (LDCs) have only invested weakly in infrastructure, and the education gap between LDCs and the G8 is wider now than it was in 1960. Because of the nature of these weaknesses, any attempt to rectify them must involve the government—and the amount of political will necessary to put Africans on the path of technological development is significant. Any future scenario is heavily influenced by initial conditions and this, the status quo, forms our base case.

Scenario 1: “Use, Don’t Own”

In this most pessimistic scenario, unfavorable effects overwhelm the favorable. A growing population stresses resources, but lack of security, poor governance, and poor internal continental relations prevent market development. These effects, plus weak borders, make it hard for countries to pursue their own course. The result is a weaker continent, dominated by risks of contagion, too-slow change, and lack of security. Each country’s proximity to its neighbors, plus lack of strong political leadership and market pressure, make it essentially impossible for one country to pursue a technological future that is significantly different from that of the bordering countries.

Use, Don't Own: Predictors

- Large youthful populations stimulate civil wars.
- Governments are unable to protect inventions and resist external exploitation.
- Rights of women and minorities are not protected.
- Anchor states, especially South Africa and Nigeria, aren't able to develop local regions where it is easy to do business.
- Fundamentalism increases, democracy decreases.
- African entrepreneurs relocate, then become successful.

The overall lesson is that societal technological progress is by no means a certainty. The future is one where no single country can kick-start markets in technology, so all fail to thrive. The lack of local customers for local goods dampens the technology multiplier, stifles innovation, and results in insufficient base-level technology and disposable income for there to be a reasonable amount of absorptive capacity—which in turn reduces any potential for a market. Lack of a private market and successful business reduces the ability of the private sector to pressure governments to become more business friendly and pursue business collaboration with

neighboring countries. They are drowned out by other lobbies, and, furthermore, neighboring countries are not seen as potential markets. Lack of incentive combines with lack of ability. This slows down the adoption and use of technology, with some countries moving backwards.

Even today, it is relatively easy to find African examples of countries whose citizens are worse off overall now than they were some decades ago, and Africa is the only world region with negative per capita growth during 1980–2000 (Sachs, McArthur, et al. 2004). There are no available figures for technological development, but if we use per capita energy consumption as a course-grained proxy¹¹ of the 15 African countries for which comparative figures are available, two are worse off than 20 years ago, and several have shown pedestrian progress (see Table 5).

The telecommunications and biological revolutions that we are seeing today will continue into the future, but Africa will not be contributing to them

11. Given the low levels of development, we expect there to be a positive relationship between per capita energy use and technology. This relationship would not be expected to hold true past a certain level of development, and indeed the United States's per capita energy consumption from 1980–2003 declined from 8,138 to 7,794 per capita kilograms of oil equivalent (kgoe).

Table 5: Comparing Per Capita Energy Consumption in Kg of Oil Equivalent

Country	1980	2003
Angola	178.5	606.1
Benin	49	301.4
Cameroon	107.8	434.1
Congo	320.6	272.7
Ethiopia	17.5	277.9
Ghana	187.6	400.2
Kenya	145.6	481.2
Mozambique	72.1	435.8
Nigeria	37.8	776.9
Senegal	254.8	233.2
Sudan	70.7	475.9
Tanzania	48.3	464.9
Togo	142.1	445.3
Zambia	513.1	600.6
Zimbabwe	544.6	743.8

Source: International Energy Agency

other than as a consumer. Africa’s high-technology exports will continue at their present low levels but will steadily become proportionally smaller as the rest of the world moves increasingly into high technology.

The results of this scenario: Africa continues much as it is now, but with a larger population and perhaps more resource stresses. Vulnerability to external shocks remains significant. Africa is not effective at creating and owning technology, and only somewhat effective at localizing technology obtained from the rest of the world. The conti-

**Contagion and Security:
The Zimbabwe Example**

Africa lacks an effective security community and transnational leadership. Southern Africa’s limp response to Zimbabwe’s economic misrule has deeply affected all neighboring countries. In South Africa, the muted government response to the refugee influx led directly to xenophobic riots in June 2008 in Johannesburg and Cape Town, impacting businesses both directly and through changing international perceptions of South Africa’s ability to avoid contagion.

ment is technology-dependent and uses technology more or less as provided by the rest of the world. Technologies are not adapted into the innovation cycle because there is no innovation cycle to speak of, and it remains very difficult to protect the rewards of innovation.

The international technological perception continues to be one of seeing Africa as a single entity, and individual countries are not able to resist contagion. Some local innovation continues, but for the most part it involves finding “African” solutions to problems that have already been solved elsewhere using more sophisticated technologies. It is clear that few in Africa want this scenario, but that does not mean it won’t happen.

Scenario 2: “Pockets of Innovation”

“... the future is already here. It’s just not very evenly distributed.”

—William Gibson, National Public Radio interview, 30 November 1999

The drivers have emphasized the importance of a step-by-step approach, where each technological improvement builds on a previously established base and increases the scope and effectiveness of innovation. Partial success will result in the “Pockets of innovation” scenario.

Pockets of Innovation: Predictors

- GDP and Gini coefficients both increase.
- African cell phone-based services extend beyond the continent into the Middle East and Asia.
- Funding for basic research increases.
- International (United States/ Europe) patent filings by African companies increase.
- African entrepreneurs relocate overseas when they become successful.
- Wars decrease in scope and duration.

If contagion can be avoided, and at least some regions have extended stability, then it is possible that an Africa with a few technology performers will emerge. In this future, there will be some countries, or industries within countries, that will compete as niche players and endure in world technology markets in industrialized countries, reaching across their African neighbors to overcome the lack of domestic markets. However, they will be surrounded by their lackluster neighbors, the majority of African nations. These will be countries that for one reason or another are not able to successfully interact with the major world markets and that will continue to

be subject to external attempts to leapfrog their development. The result will be patchy successes and a strong tendency of reversion to the mean. For these lackluster nations, this scenario will look much like the first, as technology ownership passes them by. Every economic change has winners and losers, and there will be a mix of both—but in Africa there will be more technology losers who can't keep up than there will be technology winners.

Malerba and Orsenigo (1995) identify the emergence of stable groups of innovators who innovate consistently, rather than a particular group or industry size, as strongly associated with technological performance. This trigger allows the technology multiplier to work over the longer term. Here the future is one of islands of innovators and technology performance in a sea of mediocrity. This is perhaps the easiest of the three scenarios to envision because it is effectively a national, or more likely a sub-national, “go it alone” approach. Each group of successful innovators succeeds without leveraging local markets, and each group has more ties to international markets and resources than to local ones. Effective idea sharing, which in today's Africa means the continued penetration of cell phones, is a requirement for this scenario.

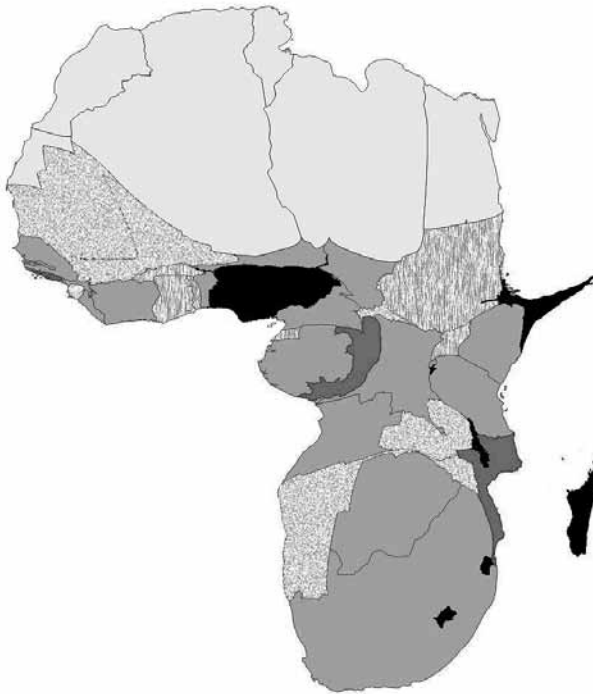
We see that technology adoption and use is aligned to the social order across countries. Within-country adoption varies as much as between-country adoption. There is no requirement for much transnational cooperation within Africa, and there is a reduced expectation from governments—as expressed in the EU 2025 scenario predictions for the region. This is also very similar to Shell's Business Class for Africa, with Connected International Elites scenario (Shell International 2002).

Because South Africa, Nigeria, and Kenya are considered Sub-Saharan Africa's anchor states, in this future we should expect pockets to arise there first (Hanson 2009) and also possibly in Rwanda, which is small and developed. Angola is another candidate because of high oil revenues, although there the development of innovation pockets may be thwarted by low levels of education.

Historically, an environment where national wealth is centralized or from a single source has tended to increase the risk of bad governance because the single source

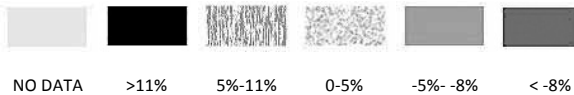
has increased the opportunities for misuse, something Angola is also vulnerable to. This trend puts additional focus on the importance of good governance. Technology and entrepreneurship can assist with distributing wealth more evenly, working against this effect but not overcoming it. Still, it is reasonable to expect that countries with in-demand raw materials will demonstrate good growth, which they can apply to technology and development if they wish.

Figure 2: Comparison Between Mobile Phones and Fixed Line Growth Rates, 2001-2006



Country size is scaled based on mobile phones per 100 people, 2007.

Color indicates fixed line phone CAGR 2001-2006.



Note: There are no countries in the 0 - -5% bracket over this period.

Source: *International Telecommunications Union Data and Statistics*
 (<http://tinyurl.com/ICT-stats-Africa>)

In this world of “pockets of innovation,” technology arises piecemeal through niche players who don’t interact much with their local markets, instead creating solutions for the global market. This isolation from local markets and local innovation opportunities is important because individual technologies work best, and innovation occurs best, in an environment of mutually supporting technologies. Technological development is almost always a set of small steps, built on a matrix of the technologies that preceded it through the technology multiplier.

In the same way, successful technologies are not often brought to market by individuals working alone. Rather, they build on the base of existing technologies that prime consumers for the next innovation. Leapfrogging, in the sense of skipping over something and not doing it at all, does not occur very often if at all.

Because this future deals with some countries rising above others in the context of an “external intervention” driver, oil is worth a short discussion. African oil is generating a lot of attention with several important effects (Klare and Volman 2006). The focus on oil encourages countries to rely on oil-based agendas, instead of seeking a broader-based approach. It aggravates internal political conflict over the allocation of oil revenues, makes it more likely Africa will become a proxy for superpower conflict, and increases the level of inequality within societies. This does not bode well for the achievement of stability.

Africa’s Cell Phone Boom

Cell phones allow information to reach deep into communities and connect the excluded. They also foster services based on data exchange. From 1999 to 2004, Africa was the world’s fastest-growing mobile phone market. Subscribers jumped from 7.5 million to 76.8 million in that period, an annual growth rate of 58 percent. What is interesting about the boom in addition to its magnitude is that cell phone technology has not leapfrogged fixed-line technology throughout Africa, at least not in the usual sense of leapfrogging—skipping over a technology without using it. The boom has changed the technology adoption order, but fixed lines are still vital, and used by cell phone customers.

In some cases, cell phones have acted as a technology multiplier, with fixed-line installations following behind. This makes sense when you consider the high cost of installing land lines, but the low cost of their use. Once a business need is easy to see, the fixed lines follow. From the map in Figure 2, it is clear that fixed-line phones, while not increasing as fast or uniformly as mobiles, are still doing well in many countries.

The results of this scenario are threefold. Most importantly, globalization and technology will allow some countries—and elites within countries—to link themselves to the world and other entrepreneurs, rather than to their local environments. These countries will rise above their neighbors and develop the kind of technology infrastructure required for large-scale technology development, but this development will not be regional in scope.

Second, technology diffusion will occur and will follow the existing wealth and social order, which by and large will remain in place. The dichotomy of tribal-versus-modern thinking present in Africa will mostly remain in place for the foreseeable future. The social order will be mostly but not wholly static, and technology, particularly information and communications technology (ICT), will reduce social movement barriers (Kyem and Kyem 2006).

Third, some new technology will be created and owned by knowledge workers in the innovation pockets. In the absence of inter-African linkages, these external bindings will result in non-African countries having a disproportionate say in the affairs of these successful countries. Being successful at integration with global markets is generally a good thing, and will attract all countries to do business, but there is a risk that poorly governed regimes will prefer partners that don't pursue humanitarian or other non-commercial agendas.

A rising tide—even a small one—lifts all boats. The extremely pessimistic future will not arise, even for the losers, who will benefit from substantial trickle-down effects. Today we are seeing these benefits arriving via the availability of mobile phones, a trend likely to continue for some time to come because of increasing smartphone availability.

Scenario 3: "Leapfrogging"

The most favorable outcome is one where Africa's unique needs, young population, and positive external interests create an opportunity for technology to help bring Africa out of poverty. There will still be inequality, but overall, life will be better on a wide scale. Technology, as part of the engine for solving African problems for the growing population, will facilitate overall growth, increasing the upsides of the drivers and skewing effects toward the positive. Africa will have sufficient positive drivers to

leapfrog over some of its problems and move to a better future¹².

Building on the “Pockets of innovation,” in this scenario adaptability and markets are the keys to prosperity. Countries and individuals in Africa will maneuver through externally imposed attempts at intervention and control¹³, and will, through a steady process, move toward technological success. Governments will be more responsive and proactive both in their own affairs and in their regions, rather than just waiting passively.

Cell phones are an industry example of the technological multiplier working with markets to generate a self-reinforcing benefit. Greater connectivity increases efficiency and generates markets for downstream products as well as the obvious network effects. Cell phones have produced a strong impact—triggered by broad-based adoption to a large market accessible through effective distribution channels—and therefore are a specific instance of the kind of responsiveness and progress needed if this scenario is to come to pass. We are now seeing phone-based services (e.g., Facebook) driving phone adoption. This needs to happen in many more industries and niches—one technology is not enough.

There will be many positive effects from this scenario. There are substantial benefits to countries undertaking joint efforts to strengthen market-boosting

Leapfrogging: Predictors

- Local services based on imported IT.
- Multinational collaborative regions develop and expand, fostering local technology.
- Adaptation of open-source embedded hardware for local problem solving.
- Heavy infrastructure investment.
- Peaceful protests increase, and losers accept defeat peacefully.
- The voice of civil society is louder.
- Governments prioritize the rights of women and minorities.
- African entrepreneurs expand outside the continent.
- Successful entrepreneurs stay home.
- Funding for innovation centers increases.
- Patents increase, technology exported.
- University graduates remain in Africa (decreased brain drain).
- Increasing life choices for the middle class.

12. It should also be noted that leapfrogging in the sense of technological leapfrogging (see sidebar “Africa’s Cell Phone Boom”) is extremely rare and not a necessary condition for this scenario.

13. This is not intended to imply that there is any sort of conspiracy, but simply to suggest that globalization is making it difficult for African states to design and implement their own agendas. Chances of a successful scenario are increased if this can be effectively managed.

technology. First, cooperation increases the potential for markets, which in turn creates a much greater absorptive capacity for technology, allowing success to build on success. Second, local markets are easier to do business in, and technology that is created or adapted to African market demands will be more resistant to external intervention. Third, more marketing alternatives also will allow each country to be less dependent on any one external or developed nation market, and in particular will increase the focus of commercial interests and decrease the leverage of countries that use trade to pursue non-trade-related agendas, such as human rights.

Increasing life choices will create an opportunity to manage the youth bulge, as technology assists with the increased agricultural production required for Africa's population growth. With an increase in basic standards of living, we should expect to see more effort devoted to education. Hopefully this will include the education of Africa's "secret talent pool" of women (World Economic Forum on Africa 2006). While societal change is required for women to be fully economically integrated, technology can lower the barriers to them becoming greater participants in the economy, as has happened with mobile phones. Integration will increase pressure for further economic involvement, and will increase the size of the technology multiplier, benefiting society as a whole. A similar effect can be achieved through encouraging the diaspora population to invest in their home countries. A more dynamic and market-oriented Africa will attract diaspora attention; harvesting it will require careful planning and public policy support, which is not currently in place (Kyem and Kyem 2006).

Some authors (e.g., Sachs, et al. 2004; Kyem and Kyem 2006) see significant government involvement as essential to this process, through all means at their disposal, but most importantly encouraging education and investment. This is true, but governments will also need to become much more responsive to the requirements of innovators than they are at the moment. Government involvement is required at least to help protect the intellectual property created within national boundaries. Poor intellectual property protection is going to haunt Africa for a long time. Perhaps one way to see it is as a checklist rather than one overriding factor. It is obvious that the more driving forces that are moving in a positive direction, the greater the chance

of success. Countries that protect the intellectual property they have, foster education, build technology programs, create and strengthen networks of cooperation, provide security, build markets, and foster stability for innovators will succeed.

This shift in focus and boost in responsiveness will be difficult to bring about—and is not possible without improvements in governance. A further risk in this scenario is that a reduced focus on human rights will increase inequality within Africa, particularly if strong partnerships develop with countries that do not involve themselves with internal human rights issues in trading partners. Success will require societal transformation and adjustment. Large markets will attract new attention from non-African nations and enterprises, and this will bring new pressures to bear. The opportunity costs of peace and strong governance will become increasingly obvious.

CONCLUSIONS: CREATING ACTION POTENTIAL

Regardless of the scenario, Africa's technological future depends on the type of relations that Africans develop among themselves and outside actors. There are real choices to be made about how to drive toward success.

The crux is that Africa's technological future will not depend solely on direct technological development—of course that is important—so much as the conditions for technological innovation and uptake that are created in Africa. Primary determinants of this will be the triad of governance, external influences, and the strength and nature of intra-African market linkages. Efforts that emphasize and create intra-African markets, boost governance, and bring out the best of external influences will be the path to success—efforts like the Mo Ibrahim prize for achievement in African leadership, and the East African Community, which seems to have a new lease on life.

Thirty years ago, Shaw correctly identified governance and policy as critical factors, and African scenarios have been predicting much the same thing for much the same reasons for more than 20 years. At a high level, these usually take the form of optimistic interpretations forecasting rapid growth because there is a great deal of potential, and pessimistic forecasts predicting slow growth because of a belief that the problems facing Africa are intrinsic,

rooted in geography, and dependant on governance. Many of these negatives have remained the same since Shaw's initial analysis, and entrenched problems are depressingly familiar. Nevertheless, we see a different Africa now than the one he saw 20 years ago. Some fundamental problems have been worked through—there is a resurgence of interest in Africa and decreasing contagion risks. Africa is also more integrated, with a greater degree of connection to the world and the knowledge economy in a way no pre-Internet scenario envisioned. A “Pockets of innovation” outcome would not have been possible in the 1980s.

Today, each of the three scenarios is equally likely to occur, and which one comes to pass will depend on the decisions going forward. Previous scenarios have not considered the mix of governance, external intervention, the market effect of internal continental relations, and the technology multiplier—yet it is these that will dominate the future. Three issues are most fundamental to answering the questions posed at the beginning of this paper:

- Will markets for technology products develop in Africa, how geographically large and sophisticated will they be, and how smoothly will they function?
- Can governance be effective generally, in particular can it be effective at boosting social capital?
- Is it possible for the technology multiplier to be effective?

The goal of these scenarios has been to envision plausible futures in order to more easily recognize approaching decision points, which may allow us to nudge things toward a more favorable future. Issues that bear on the three questions above are such decision points, and by looking at them we can more clearly see the technological future. For example, we are seeing cell phones driving new technologies. But are they driving a change in civil society? Are they making markets?

The scenarios have not taken account of two possibly important factors. First, it is possible that within-country social differences will be more important than has been presented. This could encourage national elites instead of a middle class. Second, surprise shocks—unknown unknowns—

could upset the applecart. These are impossible to predict, and their effects typically dwarf the effects of non-shock events, often dominating the future and making forecasting, especially numerical forecasting, very difficult. HIV/AIDS is an example. Prior to the discovery of the disease, no one forecasted it, yet its impact on Africa has been huge. Nassim Taleb (2007) calls this “the scandal of prediction”—we tend to overestimate our ability to predict the future. Gell-Mann considers this the problem of envisioning a dramatically different future.

A robust approach to this reality is not to try to anticipate these events—they are inherently unpredictable. Better to assume that shock events will occur and to build societal resilience to deal with them, whatever they are. In this context, building technology—especially communications technology—is itself a mechanism of building this resilience, enabling Africa to better withstand unexpected large-magnitude shocks.

Choice Points

So how can we steer things in the direction we want? We are keenly aware that high-level scenario plans not only omit shocks but systematically filter out the particularity of detail, and it is the details that count—each person’s activities are situated in the minutiae of his/her environment, and while each individual’s actions are almost always systematic, they are usually not planned with an abstract future scenario in mind (Suchman 1987).

Within the three questions above, one of the easiest choice points to effect positive technological change will be in market development. It is essential to encourage local and regional market development. Market creation is a complex phenomenon, but it starts with governments permitting business to function efficiently. Technologically, cell phones and the Internet have strong market-making potential, so watching the penetration of these technologies is a good indicator.

Secondly, good governance is both the most difficult and the most important factor. This includes a focus on technology programs and rewarding excellence, and does not include the establishment of secretariats and administrations to watch and discuss. Good governance will also require resilience to external intervention. Today Sub-Saharan Africa is more sus-

ceptible to external intervention than other regions. Countries absolutely need to work closely with offshore players and organizations (including the United Nations), but should not rely on them to create action potential or automatically do what is in Africa's best interests. A "we can do it" philosophy is required.

The current globalized playing field will create more pressure to change than has been present in the past, and those wishing to effect change are faced with more complexity and a greater likelihood of being pushed around by the market, making clarity of strategic vision even more important. At the same time, each country has more tools in its toolbox to effect change than in the past, and several countries are trying to woo African markets. Based on this, action potential can be created if: first, we can build on the welfare-generating capabilities of African markets; second, Sub-Saharan Africa can steer in the direction most useful for itself, turning external intervention from an exploitative stance to a constructive one; finally, governments can translate a vision of success into sustained action and encourage ways of thinking that accommodate longer time periods and longer-term thinking.

Technological development and market development go hand-in-hand, mutually benefitting each other. African markets, especially those that can

Technological development and market development go hand-in-hand, mutually benefitting each other. African markets, especially those that can be served by small and medium businesses, will help to foster a middle class and generate a virtuous cycle of technology development.

be served by small and medium businesses, will help to foster a middle class and generate a virtuous cycle of technology development. This will allow places that have markets to generate local, broad-based technological assets. Markets and increasing life choices will help absorb the youth bulge and potential demographic problems. If, in addition

to this, a slow change to the prevailing mindset can be effected, then the pace of this technological change can increase and become more widespread, perhaps creating a bridge from a "Pockets of innovation" world to a more widespread welfare increase.

It is therefore important to examine how to change the mindset:

- If Africa is able to embrace technology as cultural change and exert influence, then people must be motivated to change their attitudes to globalization, a potentially powerful force for human betterment.
- If Africa can leverage the diaspora populations to accomplish change and provide vision, this can work to increase the importance and spread of technology.

A future where Africa can create, develop, and own technology does exist—one in which Africa can effectively adapt and “Africanize” technologies created in other regions for re-export, drawing them into the innovation and adoption cycles.

This scenario exercise made no attempt to forecast or predict which future is more likely. It would be interesting to build a more forecast-oriented scenario study that includes an analysis of these factors, along with a focus on continuous improvement for Africa, and also to look at how many innovations are being performed by Africans who have relocated to developed countries¹⁴. It would be useful to create some metrics—for example, an African entrepreneurship metric—and track these going forward. With an approach based on running forecasts, and comparing them with changes to some metrics gathered on the ground, it might be possible to hone in on some specifics.

It also would be interesting to examine national and regional connectedness with some newer technology-based models. Google’s PageRank algorithm, for example, measures connectedness, and has recently been used to assess biological food webs. Looking outside of traditional sources of information and applying more computational approaches could generate some good results.

Finally, it would be interesting to study the extent to which African countries are natural competitors with each other, and compare this to how development has proceeded in other parts of the world (e.g., the EU). Competition just might be the ticket.

14. These issues are often reported in the news. For example: “Poor state of African roads keeping the continent poor, UN advocate says,” reported by the UN News Centre, 22 February 2008.

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