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Background report on science, technology and innovation institutional arrangements and sustainable development

I. Background

1. Science, technology and innovation are critical enablers for accelerated fulfilment of the 2030 Agenda for Sustainable Development and Agenda 2063, The Africa We Want, of the African Union and for meeting national ambitions and international commitments. Scientific and technological advancement have opened up new opportunities for improving the quality of life in a sustainable manner and will continue to do so. Science, technology and innovation have brought new communication tools (such as the telephone and the Internet), agricultural tools (fertilizers and improved seeds), energy solutions (solar cells and batteries) and advanced healthcare services (vaccines), among other assets, that have collectively enhanced the productivity and efficiency of economic activities and significantly improved living standards. Therefore, building scientific, technological and innovation capability is pivotal to accelerating the attainment of development targets.

2. This has clearly been highlighted by the coronavirus disease (COVID-19) pandemic. Science is helping countries to understand, monitor and manage the evolution of the virus, to design appropriate national policies and to assess their impact, among other efforts. Technology has played a key role in keeping the world at work and families connected and in empowering scientists and firms to quickly decode the virus, designing and producing vaccines in record time. Meanwhile, countries, communities, institutions and firms have forged innovative ways of mobilizing resources, supporting those in need and keeping businesses running under challenging conditions. Collectively, countries have relied on science, technology and innovation to meet some of the challenges posed by the COVID-19 pandemic.

3. However, science, technology and innovation capabilities vary widely among countries and communities in the same country. Countries leading the way in this field tend to be those with the top researchers, inventors, innovators and owners of existing, new and emerging technologies. Currently, most of the publications, patents, technologies and firms in such areas as financial technology, educational technology, energy technology and nanotechnology are to be found in developed and emerging countries. The gap in science, technology and innovation systems between developing countries and those developed countries presents both challenges and opportunities for developing countries in general and for Africa in particular.

4. In terms of opportunities, developing countries can make significant gains by adopting emerging technologies and applying them to their own needs. The green revolution in Asia and mobile money in Africa are good examples. While mobile money may only offer a small enhancement to those with access to well-developed financial services, such as bank accounts, credit cards, investment facilities and so

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forth, it does represent a major leap forward for communities that had no access to formal financial services for receiving, paying and saving money. Similarly, the provision of electricity from renewable energy technologies could be transformative for unconnected rural communities, meaning that business can stay open late, perishable food can be preserved, schools and hospitals can offer better services, as in communities that have access to reliable electricity. In general, developing countries can make major gains in economic and social development through the deployment of existing, new and emerging technologies.

5. In addition, developing countries can make concerted efforts to learn and catch up with their leading developed counterparts. History has many examples of countries that successfully learned, caught up with and overtook leading countries in science and technology. In this case, countries have to go beyond learning how to apply, deploy and manage mature technologies but also to understand, upgrade, design and own recognizable branded technology and innovative products. New and emerging technologies often propel countries to quickly catch up with those at the forefront in this field.

6. Institutional arrangements play an important role in technological learning and advancement. As used here, the term "institutions" refers to legal and regulatory arrangements, platforms, agencies and entities that are responsible for the governance, management and support of science, technology and innovation. The institutions may be subnational, national, regional and international in nature; they all play an important role in the coordination, alignment and coherence of actions and mechanisms that enable technological learning and proficiency, promote scientific excellence and encourage firms and other players to innovate. Institutional arrangements play a key role directing and aligning the efforts of academia, government and industry towards certain common goals and targets.

7. For instance, the United States of America launched its National Research Foundation with the stated aim of coordinating scientific research and its application to existing scientific knowledge to improve national health, create firms and jobs and advance national living standards.[1] Comparable functions are performed by national science and technology councils, national research and innovation funds, industrial research centres, national academies of sciences, and so forth. These entities and arrangements are required to coordinate talent generation, and research and industrial development to provide solutions to social challenges.

8. In this regard, science, technology and innovation policies and strategies are among the mechanisms that help countries to govern and coordinate the disparate activities of their countries' numerous agencies and players to successfully harness science, technology and innovation for sustainable development. This was explicitly spelled out in the Addis Ababa Action Agenda, in which countries committed themselves to “adopt science, technology and innovation strategies as integral elements of [their] national sustainable development strategies” (para. 119). Africa went a step further by designating science, technology and innovation policies one of the four pillars of the Science, Technology and Innovation Strategy for Africa 2024 of the African Union. The Strategy specifically calls for strengthened legal and regulatory systems to promote innovation, create and protect intellectual assets, and provide equal career opportunities in science, technology and innovation for all citizens.

II. Objectives and organization of the report

9. The main objective of the present report is to provide an overview of the key issues that will be addressed and discussed during the fourth African Science, Technology and Innovation Forum. The Forum will address strategies and

[1] Vannevar Bush, *Science, the Endless Frontier. A Report to the President* (Washington, D.C., Office of Scientific Research and Development, 1945).

mechanisms to strengthen institutional arrangements for the effective formulation and implementation of science, technology and innovation policy in Africa; for the advancement of technology development and transfer to transform Africa from an adopter and imitator into an innovator; and for the promotion of innovation and entrepreneurship through education with a focus on universities.

10. Besides the above topic, the fourth Forum will also feature a youth and innovation boot camp and undertake a review of progress towards Sustainable Development Goals 4, 5, 14 and 15, in addition to Goal 17, which is reviewed each year. The general assumption is that countries need to take steps to build their national scientific and technology base by strengthening the institutions that support research and development, technology transfer and promote innovation and entrepreneurship. Building a solid foundation could help countries to harness the new and emerging technologies needed to bring new products to market, diversify their exports, create new firms and jobs, and improve the quality of life.

III. Institutional arrangements for effective science, technology and innovation policymaking in Africa

11. All countries have their own governance arrangements that determine when and how public policies are generally designed, adopted and implemented and ensure that such policies are coherent and consistent with national development aspirations and compatible with legal instruments and other social, economic and political considerations. The number of processes that countries may have to undertake in the design and implementation of science, technology and innovation policies may vary widely. The various processes can, however, be summarized into a few key steps. Each of the steps may also involve a number of different processes.

12. Agenda setting is the first phase, which involves the framing and reframing of the problems that the policy is designed to address and to reveal the underlying causes of the problem, so that they can realistically be tackled. Multiple options may be reviewed, analysed and refined to determine the probability and effectiveness of any possible solutions.

13. Policy analysis is carried out in the second phase, consisting in a deep and rigorous diagnosis of the underlying causes of the policy issue at hand and their relations and interactions with other aspects of society. This phase helps to clarify complex issues, weighs the associated risks and considers various ways to minimize them. It also outlines the opportunities and their implications for different stakeholders in the current or future development of the country. Following this process, the policy document is drafted, setting out the priorities, plan of implementation and mechanisms for monitoring and evaluation. In general, these three phases are part of policy formulation.

14. Policy adoption is a distinct phase, in which the policy is formally approved or enacted by the relevant government body or bodies. This phase may include public scrutiny (if, for example, the policy is gazetted), review and approval by the cabinet, the treasury and government legal advisors, and parliamentary processes, depending on the governance arrangements of the country.

15. Policy implementation is activated when all the good intentions need to be translated into actions undertaken to attain the desired outcomes and impacts. This requires a high level of coordination among the various players and their activities, and a set of management skills necessary to maintain a good balance among the interest of different players and to ensure buy-in by those implementing and those benefiting from the policies.

16. Policy monitoring and evaluation furnish an oversight of the activities being undertaken and ensure that corrective steps and changes are undertaken in a timely fashion. This can be achieved through regular reviews that may take place every month or quarter (at the operational level), annually, at the mid-term stage and the end of the term of the policy for high-level oversight.

17. Among the factors influencing the policy formulation, adoption and implementation stages, the following key issues may be identified:

(a) *Science, technology and innovation policymaking*: In Africa, the formulation and implementation of policies on science, technology and innovation are not institutionalized but carried out in an ad hoc and fragmented manner at best. Some countries appear to have no entity or mechanism responsible for continuous policy dialogue, formulation, implementation, review and revision in this area. Key stakeholders are not effectively engaged and coordinated. This is evident from the fact that science, technology and innovation targets, priorities, roles and responsibilities are rarely the subject of presidential, national, parliamentary or cabinet annual or quarterly reviews;

(b) *Policy platforms*: The absence of institutions or platforms for continuous policy research and dialogues may also explain the failure to prioritize areas of science, technology and innovation policy focus. The current approach of setting up temporary task teams to undertake consultations and consolidate inputs is inadequate for the purpose of helping countries to prioritize. Maintaining and expanding the task teams would ensure a continuous learning process that would inform the next stage of policy formulation and implementation and provide the needed oversight during implementation. Such task teams can help to prioritize areas of focus;

(c) *Implementation plans*: The lack of implementation plans poses another key challenge. Implementation plans play various roles in clarifying needs, opportunities, timelines and milestones, roles and responsibilities, contingency actions and mitigation strategies to surmount potential barriers, among other functions. A realistic implementation plan can help to inform such tasks as the preparation of agendas, identification of priorities and resource needs, and anticipation of challenges and project outcomes to enhance chances of success;

(d) *Monitoring and evaluation frameworks*: These two are often missing. Some policies name institutions that, it is hoped, will monitor and evaluate the policies but do not budget for monitoring and evaluation activities. A framework, even with few key targets and indicators, will help in identifying who and what needs to be monitored and the frequency of such monitoring and how the result will be disseminated to ensure the successful execution of activities;

(e) *Resource mobilization and allocation*: While policies may make estimates of funding, they are often silent on the actual sources, the amounts disaggregated by source and time, and the returns from and impacts of such resources. Resources should include the skills, technologies, talent, infrastructure, investment and time, among other elements, that are needed to successfully meet the goals of the policy. The absence of institutional arrangements may make it harder to prepare informed resource estimates and to identify the sources of such resources.

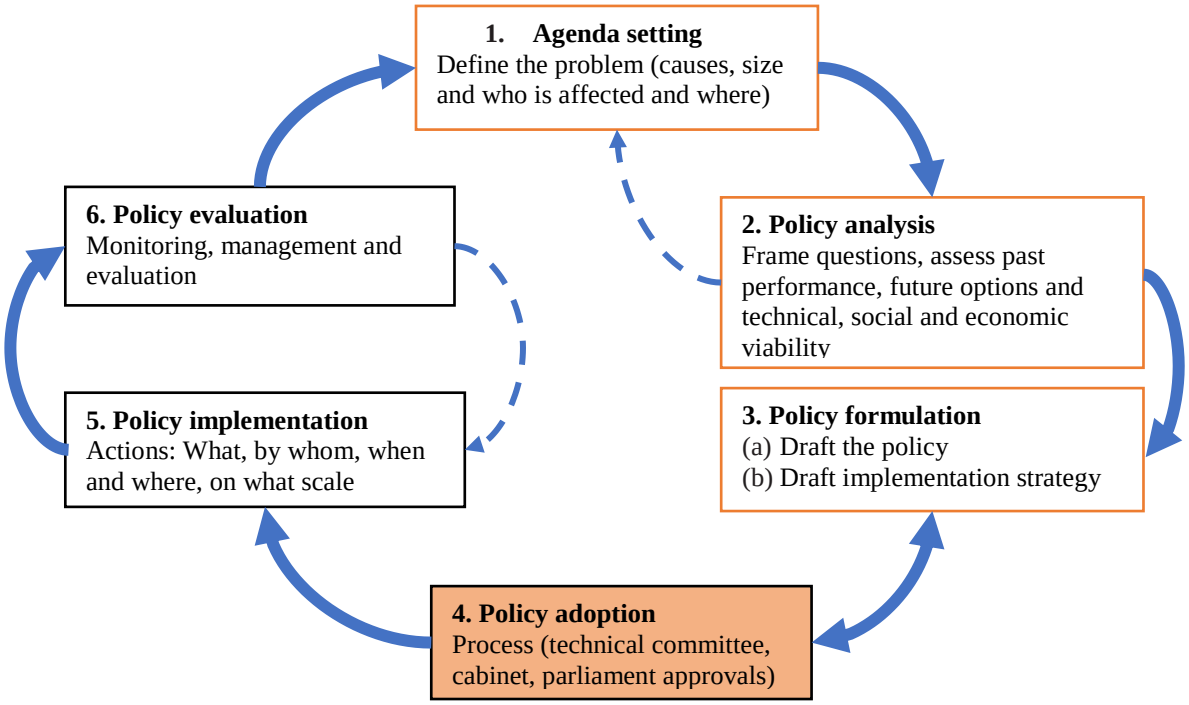
18. It is against this background that ECA has prepared its draft guide on science, technology and innovation policy formulation and implementation, with a view to helping countries to address gaps in policy intention and policy implementation. Noting that policy intentions do not necessarily lead to actions nor does the existence of policy instruments lead to expected results,[2,3] the guide provides detailed

[2] World Bank. “Excellent policies – unintended failures”, South Africa Policy Brief (Washington, D.C., World Bank Group, 2010).

[3] Stephen Bolaji, Jan Gray and Glenda Campbell-Evans, “Why do policies fail in Nigeria?” *Journal of Educational and Social Policy*, vol. 2, No. 5 (November 2015), pp. 57–66.

information on processes and institutional arrangements that can improve the effectiveness of science, technology and innovation policymaking and implementation. It offers a range of examples and tools that a country can use at different stages of policy formulation, implementation and review.

Generalized policymaking process



Source: ECA draft policy guide.

19. As shown in the figure above, there are six distinct phases in policy design and implementation. Of these, three relate to policy formulation: agenda setting, policy analysis and policy formulation, and two phases may be summarized as policy implementation: implementation, and monitoring and evaluation. Policy adoption forms a distinct phase of its own. While policy design may have proceeded smoothly, policy adoption may fail. Several policies could remain in draft form and unadopted for several years.

IV. Technology transfer and transforming Africa into an innovator

20. The 1985 draft international code of conduct on the transfer of technology defined the transfer of technology as the "transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service and does not extend to the transactions involving the mere sale or mere lease of goods".[4] Access to key technologies could lead to improvement in quality of production, generation of new knowledge, improvement in living standards, productivity and efficiency, and diversification and competitiveness of exports, among other benefits.[5] Technology, however, is neither free nor easy to access, acquire, adapt and upgrade.

[4] See also Surendra Patel, Pedro Roffe and Abdulqawi Yusuf, eds. *International Technology Transfer: The Origins and Aftermath of the United Nations Negotiations on a Draft Code of Conduct* (The Hague, Kluwer Law International, 2001).

[5] See Zhou Wei and Adel Ben Youssef, "The productivity impact of international technology transfer in China: empirical investigation on Chinese regions," *Economics Bulletin*, vol. 32, No. 2, pp. 1590–1603 (2012).

21. For instance, the Government of Zambia, private firms, donors and the community at large worked together to acquire new technologies, train personnel in the public and private sector and design new standards and policies for the fortification of sugar with vitamin A. By 1998,[6] Zambia had become the first country in Africa and the second in the world (after Guatemala) to fortify sugar with vitamin A and was part of a national effort to reduce vitamin A deficiency. The policies and standards designed at the time protected both the consumer (with a minimum guarantee of vitamin A per kilogram of sugar) and the firm from suppliers of cheaper unfortified sugar.[7] As this example indicates, technology transfer often has cost implications for firms and consumers, may induce changes in the market and affect more players than just the immediate user of the technology.

22. Technology imports from technology exporting countries are key to building a sound and competitive domestic scientific, technological and industrial base and to initiating the process of catching up. Research suggests that imports of capital goods, for example, have contributed greatly to economic growth in China[8] and, in the United States of America, accounted for 20–30 per cent of growth in output per hour between 1967 and 2008.[9] Similarly, technology imports drove most of the growth of the information and communications technology sector in Africa.

23. For the purposes of this report, only two proxies of technology transfer are used: capital goods imports and payment for intellectual property assets. Often referred to as "knowledge in machines", capital goods embody research and development efforts and knowledge of others and thus serve as a useful proxy for knowledge flows.[10] In this regard, capital goods imports by Africa grew from some $31 billion in 2000 to $145 billion in 2014, before dropping to $107 billion in 2019. Sub-Saharan Africa witnessed the largest fall in imports of capital goods – from $101 billion in 2013 to $83 billion in 2018, while those for North Africa were relatively stable, varying between $42 billion and $47 billion. Countries growing fast witnessed the fastest growth in capital goods. For example, capital goods imports by Ethiopia grew from $363 million in 2000 to $6.6 billion in 2015 and $4.8 billion in 2018.

24. Technology transfer can also be tracked through payments of royalties and licensing fees. Despite data deficiencies, the latest data suggest that payments in sub-Saharan Africa rose from $408 million in 2000 to $2,335 million in 2010 and $2,829 million in 2017,[11] before falling to $1,899 million in 2020. The African share of the world payments for intellectual property was about 0.9 per cent and is more highly concentrated in a few countries than imports of capital goods. The small share of the world's total of royalties and licensing fees held by Africa and their concentration in only a handful of countries suggest that most African countries have few firms – or few firms of sufficient substance – that would need to use new knowledge.[12]

25. Governments play a central role in promoting technology acquisition by their institutions and firms through the provision of incentives to attract technology intensive foreign direct investment in areas of interest; government contracts and investment in technologies in fields of significant importance; industrial alliances or

[6] E.M. Besa, "Sugar fortification in Zambia", *Food and Nutrition Bulletin*, vol. 22, No. 4 (2001),

[7] John Fiedler and others, "Identifying Zambia's industrial fortification options: toward overcoming the food and nutrition information gap-induced impasse", *Food and Nutrition Bulletin*, vol. 34, no. 4 (2013).

[8] Maria Herrerias and Vincent Orts, "Capital goods imports and long-run growth: Is the Chinese experience relevant to developing countries?" *Journal of Policy Modeling*, vol. 35, No. 5, pp. 781–797.

[9] Michele Cavallo and Anthony Landry, "The quantitative role of capital-goods imports in U.S. growth", Working Paper No. 47, Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute (2010), pp. 78–82.

[10] ECA analysis based on UN Comtrade database, rad economic categories (BEC) group 4. Data for BEC 41 are limited to a few countries only.

[11] Based on latest and more complete data as of 2019 in the World Development Indicators database.

[12] Economic Commission for Africa, "A technological resurgence? Africa in the global flows of technology" (New York and Geneva, 2010).

special economic zones; and increased investment in research and development. Countries may offer incentives and support to enable firms to establish new operations and manufacture products to meet a national need.

26. In recent years, Morocco has established itself as a major hub for the aerospace industry, while Ethiopia has emerged as a top producer of cut flowers in Africa. These results have been achieved through concerted efforts to attract technology-intensive firms, easing administrative, trade and licensing procedures, providing financial incentives and forming partnerships with the private sector to train qualified human resources.[13] All these measures helped the countries to acquire the technologies and skills needed and build their industries within a decade or so.

27. While most of the measures are generally well established, the institutional arrangements remain fragmented, weak or altogether lacking. With a few exceptions, national agencies responsible for technology transfer whose core mandates are to identify, acquire, adapt and diffuse desired technologies, or to encourage and support firms and institutions to develop, commercialize or import and use new and emerging technologies remain few in number. Even where they exist, the main focus is placed on regulating technology transfer-related activities such as enforcing or administering incentives, licensing and monitoring payment for technology between domestic and foreign affiliates or partner firms.

28. Yet such agencies could play a pivotal role in creating an environment conducive to technology transfer, assessing the technology readiness of emerging products and innovations, supporting small and medium-sized enterprises and start-ups from academia and research and development institutions in technology commercialization. A good example is the South African Technology and Innovation Agency, which provides support to researchers, start-ups and firms to commercialize their technologies and develop viable technology-based businesses, including training exhibitions and the acquisition of technology. The Nigerian National Office for Technology Acquisition and Promotion (NOTAP) is another example of an agency established to support technology development and commercialization and regulate technology inflow.

29. However, Africa is now home to numerous institutional technology transfer units and offices in universities, research and technology organizations and government agencies. In addition, the continent has a growing base of innovation hubs and technology and innovation-funding agencies that could anchor national technology development and transfer platforms, programmes and agencies where those do not yet exist. Strengthening its institutional arrangements to promote technology transfer and commercialization could help Africa to rapidly develop and meet the targets of the 2030 Agenda and goals of Agenda 2063.

30. To aid in the process, ECA and its partners will launch a regional network of technology development and transfer that could support member States in their endeavour to create the necessary mechanisms and institutions to accelerate technology acquisition, commercialization and trade. It will draw lessons from the Economic and Social Commission for Asia and the Pacific (ESCAP), which established the Asia and the Pacific Centre for Technology Transfer (APCTT) in 1977 with the "overall objective of strengthening the technology transfer capabilities in the Asia-Pacific region and to facilitate import/export of environmentally sound technologies to/from the member countries".[14]

[13] Examples include the specialized aeronautics training centre, Institut Spécialisé des Métiers de l'Aéronautique et la Logistique Aéroportuaire (ISMALA), and aeronautics institute, Institut des Métiers de l'Aéronautique (IMA), in Morocco. See also Nadia Rabbaa, "Morocco matches skills and growth sectors", *The Africa Report*, 20 October 2014.

[14] Further details available at www.apctt.org/general-information.

V. Promoting innovation and entrepreneurship through academia

31. In a 1997 address, the former President of South Africa, Nelson Mandela, stated: “The power of education extends beyond the development of skills we need for economic success. It can contribute to nation-building and reconciliation.”[15] His message underlines the importance of academic institutions empowering their students, researchers and the community in general with skills to generate knowledge of economic relevance, encouraging the rise of the third mission of the university, termed the “entrepreneurial mission”.

32. The term “entrepreneurial university” largely refers to a university’s focus on capitalizing on its massive research outputs and talent, and its exhibition of practices that mirror those of the private sector, such as, among others, the existence of technology transfer offices, intellectual property management units, incubation and enterprise development centres. The case of universities such as the Massachusetts Institute of Technology and Stanford University driving the economic success of their regions has encouraged governments around the world to look at ways of replicating such success.

33. While most of the world debates – and sometimes resists – the need to encourage universities to embrace the entrepreneurial mission, fearing its impact on academic freedom, in Africa the entrepreneurial mission is embraced for two main reasons: high unemployment among youth and resource constraints faced by universities. Countries and universities are seeking ways to empower their students to become more entrepreneurial, so as to create employment for themselves and others, and to enable research units to become semi-autonomous and self-sustaining, so as to take the pressure off university budgets. Lastly, demand for entrepreneurial talent is expected to rise as African firms become more knowledge-driven and digitalization and manufacturing take hold.

34. Institutional arrangements are important in advancing the entrepreneurial mission of universities. It was the enactment of the Patent and Trademark Law Amendments Act of 1980, known as the Bayh–Dole Act, by the United States that truly transformed universities and encouraged them to become entrepreneurial in nature. The Act allowed, for the first time, institutions and firms to own intellectual property generated from publicly funded research. The Biotechnology Innovation Organization (BIO) maintains that the “Bayh-Dole Act has bolstered U.S. economic output by $1.3 trillion, supported 4.2 million jobs, and helped lead to more than 11,000 start-up companies”.[16] This is an admirable result that Africa may wish to emulate and even to surpass if it can strengthen its own institutional arrangements.

35. National policies and laws play an important role. Other institutional arrangements, such as the governance of research and development systems (for example, determining whether universities can own firms, founders take shares in those firms, and universities dispose of or sell firms emanating from their research and innovations); regulations on funding research, innovations and start-ups (enabling entities to offer grants and loans to start-ups interest free or at low interest rates); management of public-private partnerships in research and innovation; independent intellectual property offices and other such facilities are all needed. The majority of these institutions are in place but efforts are needed to foster their involvement in and support for technology ownership, innovation and entrepreneurship.

36. While patenting activities drove most of the changes in the 1980s, the last few decades have seen a stronger focus on innovation. The majority of innovation hubs are linked to universities, industry and government departments, and also to non-governmental organizations and donors. A recent ECA survey of some 20 universities

[15] Available at www.mandela.gov.za/mandela_speeches/1997/971122_educ.htm.

[16] See https://bayhdolecoalition.org/wp-content/uploads/2020/01/bayh-dole.pdf.

in Algeria, Ethiopia, Ghana and South Africa demonstrated the need to strengthen institutional arrangements related to the governance of intellectual property, the commercialization of technology and innovations and the promotion of entrepreneurship in general. In addition, it was noted that the autonomy needed by universities in order to act on entrepreneurial opportunities was limited and that there was a significant level of policy overlaps and overregulation, which discouraged staff, students, partners and communities from exploiting entrepreneurial opportunities. Clearer guidelines and independent technology transfer and enterprise development units could help in this regard.

37. It is against this background that ECA and its partners will be launching the Alliance of Entrepreneurial Universities in Africa. The main aim of the Alliance is to help member States to build their capacity to advance the development of entrepreneurial universities. The expected outcome is that African universities will take their place at the centre of the innovation ecosystems of their countries, by grooming innovators and entrepreneurial talent and fostering the development of firms that create jobs and wealth, drive intra-African trade and attract investment in knowledge-intensive firms.

VI. Conclusion

38. Countries with strong and reliable science, technology and innovation institutional arrangements tend to be more successful in harnessing science and technology to meet their development aspiration. As noted earlier, the existence of formal institutions for policy research in science, technology and innovation, governance of science and technology development and the support and promotion of innovation and entrepreneurship are important steps. However, countries also need platforms and mechanisms for knowledge exchange, policy design and the development and tracking of policy implementation, and for continuous evaluation to ensure a timely response to emerging opportunities and prompt action to mitigate risks. It is these arrangements that enable countries to learn, encourage partnerships and improve interactions and relationships among the various players in the national innovation system.