POLICY PAPER

Using Micro-Data to Understand the Interactions within National Research and Innovation System: The Case of Ethiopia

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Abstract

Interactions among academia, industry, government, public research institutions, development partners and international institutions are important for the performance of national research and innovation systems. To understand the diversity and efficiency research and innovation performance among such entities, the need to use relevant microdata is important. However, the robustness of indicators required to measure performance of research and innovation largely relies on good quality micro-level data sources (for example administrative data collected by a passive system) at the micro- and macro-levels of the strategic economic sectors. Micro-data provide detailed information on the characteristics of the smallest unit of enquiry within a system, particularly the diversity of R&D and innovation management systems. In this paper, we provide an analysis of the performance of the national research and innovation system in Ethiopia using the micro-level data produced by the Technology Innovation Institute. Such analysis demonstrates the need for SGCs to establish good data systems that produced well described and analytics-ready micro-level STI datasets to understand the impact of research and innovation on the economic performance of strategic sectors.

1. Introduction

To generate informed policy debates on science, technology and innovation, the need to use relevant data is key. However, robust indicators require reliable and good quality data sources at both the micro- and macro-levels of national economic activities. *Micro-data* provide detailed information on the characteristics of the smallest unit of enquiry within a system. For Science Granting Councils (SGCs) to effectively manage promotion of R&D activities, micro-level indicators are essential for measuring and understanding the status of R&D performance.

Micro-level STI data analysis provides insights on the enablers and drivers of R&D activities and projects in different country settings. However, the analysis of micro-level data for R&D and Innovation indicators by SGCs is affected by limited access to quality data[1]. There are challenges namely; the collection and analysis of R&D

[1] *Thompson, Kristi Anne. "Data in development: An overview of microdata on developing countries." IASSIST Quarterly 33.4 (2009): 25.*

statistics are usually not housed within SGCs[2], and the quality and completeness R&D and Innovation datasets within STI institutions of Member States is not good. Some SGCs such as the Uganda National Council for Science and Technology (UNCST) and Technology Innovation Institute (TECH-IN) in Ethiopia already have elaborate systems for collecting and analysing R&D and Innovation statistics. Given the importance of data in SGCs playing an intermediary role within national research and innovation systems, SGCs need to invest in developing clear R&D and Innovation statistics capabilities.

SGCs are national agencies with national mandates and functions to deliver on STI. Therefore, using micro-level STI indicators to design R&D and innovation programmes should recognize that SGCs are at different of development and they operate within different contexts. The extent to which SGCs fulfil their functions is also different. The national mandates of most SGCs require that they advocate for *(1) increased R&D investments for projects and programmes managed by themselves* and *(2) increased R&D investments across all economic sectors*. The STI data requirements for the two functions, although related, the levels at which SGCs should operate to fulfil the two functions are different.

In order to deliver on the first function (i.e., effectively managing and advocating for increased investments for R&D programmes), SGCs need a good understanding of the strategic economic sectors where the R&D and Innovation programmes should be performed. The rationale for selecting particular economic sectors to perform R&D and innovation programmes should be strategic and evidence based. Are the choices based on the contribution the sector to GDP, to overall employment growth, or the potential contribution economic growth? SGCs should be able to articulate the importance of these relationships. The design and implementation of R&D and Innovation programmes require micro-level data to reflect on supportive or inhibitory policies, institutions, regulations, funding, research personnel, activities, outputs and societal impacts. Therefore, clear data management and analytics strategies are needed to derive maximum returns from the *research and innovation processes*.

[2] *Mouton, Johann, Jacques Gaillard, and Milandré van Lill. "Functions of science granting councils in Sub-Saharan Africa." Knowledge production and contradictory functions in African higher education 1 (2015): 148.*

To deliver on the second function (i.e., to advocate for increased R&D and innovation investment across national economies), SGCs should have a good understanding of macro-level indicators for R&D performance in terms of total expenditure on R&D, total R&D personnel and R&D outputs. For instance the Gross Domestic Expenditure on R&D (GERD[3,4]) is the intramural R&D expenditure across all sectors of the economy captured as the Business Expenditure on Research and Experimental Development (BERD), Government Expenditure on Research and Experimental Development (GOVERD), Higher Education Expenditure on Research and Experimental Development (HERD) and Private Non-Profit Expenditure on Research and Experimental Development (PNPERD). These macro level indicators are more appropriate for international comparisons and benchmarking. For SGCs to effectively support and manage R&D and innovation projects, in terms of selection and budget allocations, a deeper understanding of the R&D objectives, how the R&D is performed, where the R&D takes place, who performs the R&D activities, and the results of R&D is a precondition.

The SGCs are most familiar with R&D and innovation statistics at the national level. However they must also support R&D and innovation activities at the subnational levels. For example, GOVERD is a macro-level indicator that informs SGCs about the performance of R&D activities and projects at institutions supported by the SGC. Therefore, for SGCs to effectively support and manage their R&D portfolios, in terms of project selection and budget allocation, a deeper understanding of why (objectives) the R&D is conducted, how the R&D is conducted, where the R&D takes place, who is involved in the R&D activities, and what are the results of R&D is required. To achieve the desired level of effectiveness in managing the performance of the R&D portfolio in line with the national development priorities, R&D data should be collected throughout the R&D value chain (Figure 1). The data on objectives, outputs and outcomes as well as the performance status of R&D projects should be captured using appropriately designed instruments. This paper demonstrate that such micro and macro level information can be used by SGCs to, among many responses, effectively

[3] *Gaillard, J. (2010). Measuring research and development in developing countries: main characteristics and implications for the Frascati manual. Science, Technology and Society, 15(1), 77-111.*

[4] *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, oeCd publishing, paris.*

plan, allocate resources (finance, human and materials), track progress and assess the effectiveness of the interventions.

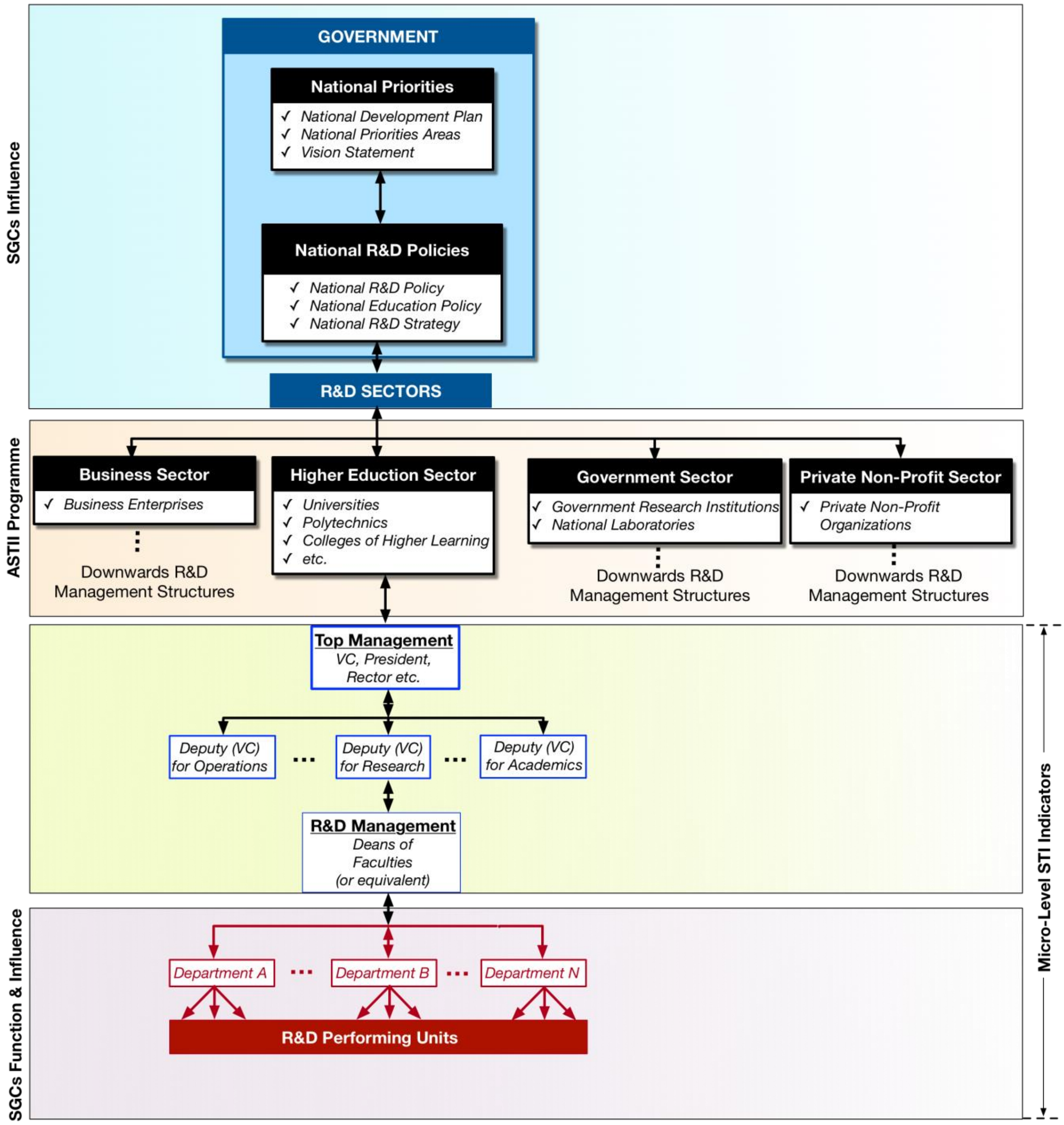

Figure 1: An outline of R&D Management Structures and SGCs Areas of Influence and Functions

2. National Research and Innovation System of Ethiopia

The Ethiopian national research and innovation system consist of the (1) the base that provides the education, knowledge and cultural identity to technologies and innovations, (2) the institutions, firms and interlinkages that produces technologies, innovations and products, (3) the Ministry of Innovation and Technology and other S&T related ministries that provide the coordination needed for executing the mission and goals of the national STI Policy (STIP) and priorities and (4) the top level leadership and strategic direction at the Prime Minister's Office. The policy direction of on STI are specified in the STIP of Ethiopia. The innovation support and research system entities consist of universities, governmental agencies, other international institutions' offices providing innovators with access to locally based, high quality technology information and related services, helping them to exploit their innovation potential and to create innovative products.

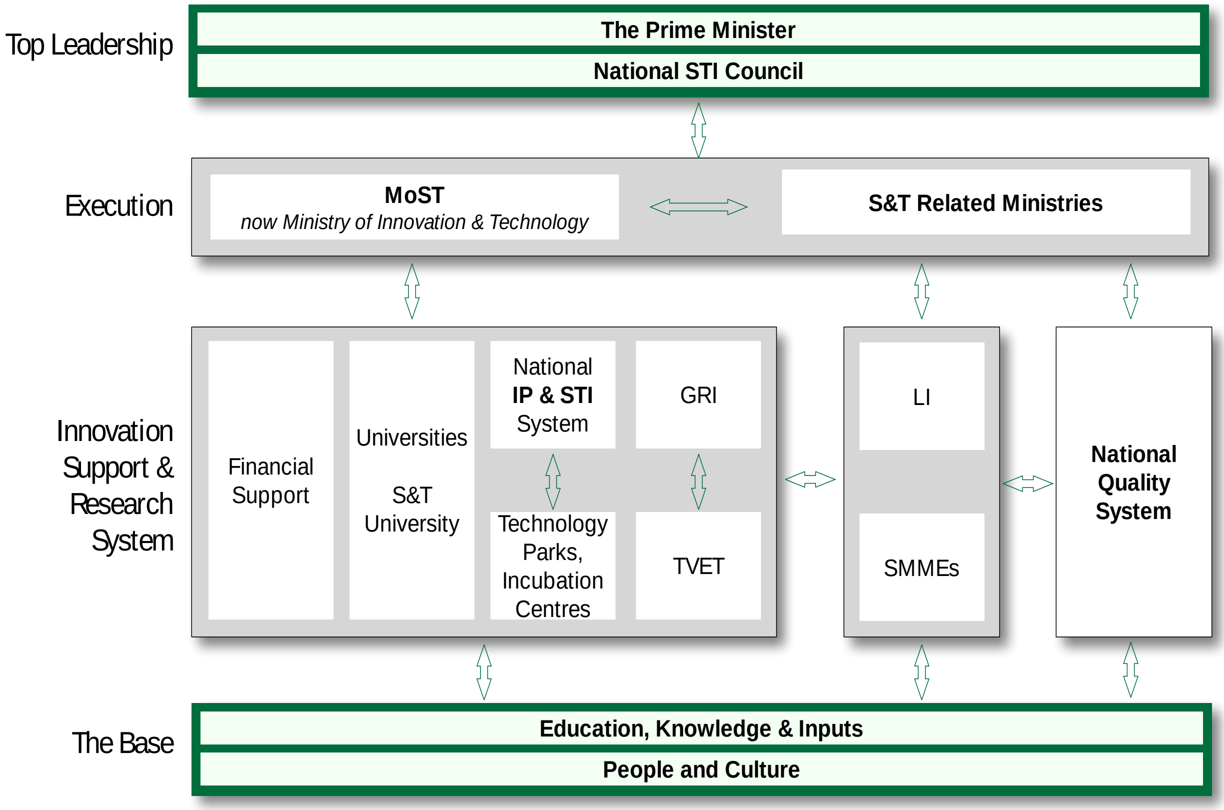

Figure 2: The National Research and Innovation System of Ethiopia

The links among the presented actors and innovation support and research system entities in Figure 2 are strongly dependent on the presence and actions of the government through its policies and strategic directions. However such policies must be informed by evidence underlined by good quality data systems. Such evidence will provide the motivation for the supporting entities to frequently act as facilitators of the relationships and the interactions. Other supporting institutions like innovation support centres, incubators and accelerators contribute to reduce the existing gap in entrepreneurial skills development and in access to technological infrastructures. It also enhances the knowledge between demand necessity from businesses and from other sector ministries such as Ministry of Environment, Forestry and Climate Change (MEFCC), the Ministry of Industry (MoI), the Ministry of Finance and Economic Cooperation (MoFEC) and the Ethiopian Investment Commission (EIC).

3. R&D Performance in Ethiopia

This section outlines and discusses the results of the 2014 R&D survey results of Ethiopia. An important and central indicator of R&D performance for given country, the Gross domestic expenditure on R&D (GERD), measures all the expenditures on R&D performed within the national borders and excludes expenditures on R&D performed outside the country even if the activities are domestically funded. The ratio of GERD as a percentage of GDP is referred to as *R&D intensity*. The pattern and distribution of GERD as well as the financial flows for R&D helps to answer questions like:

- How much is allocated to R&D by different sectors and by who?;
- Where were most of the funds on R&D spent?;
- Who perform R&D activities?;
- What types of R&D activities are performed?;
- What is the purpose for R&D activities?;
- What are the characteristics of R&D personnel?; and
- Indirectly, what are the levels of domestic and international interactions and collaborations across and among sectors and fields of R&D?

3.1. R&D Expenditure Performance

The answers to the questions above provide useful information on resources (e.g. funding, labour, R&D infrastructure, consumables, electricity, etc.) allocated by different actors for R&D activities performed in the four sectors (i.e., Business enterprise, Government, Higher education and Private non-profit sectors) of the economy. In line with the African Union R&D intensity target of 1%, African countries have made a political commitment to invest 1% of GERD to GDP in order to advance STI on the continent. The GERD for Ethiopia was $780.05 million with an R&D intensity of 0.62% and an R&D intensity gap of -0.38% (Figures 3 and A.1 in the Appendix). When compared to the 2010 data, Ethiopia narrowed down the R&D intensity gap by almost half. In 2010, a GERD of $208.74 million and an R&D intensity of 0.24% were reported, representing an R&D intensity gap of -0.76% short of the AU R&D intensity target of 1% (see Figure A.1 in the Appendix).

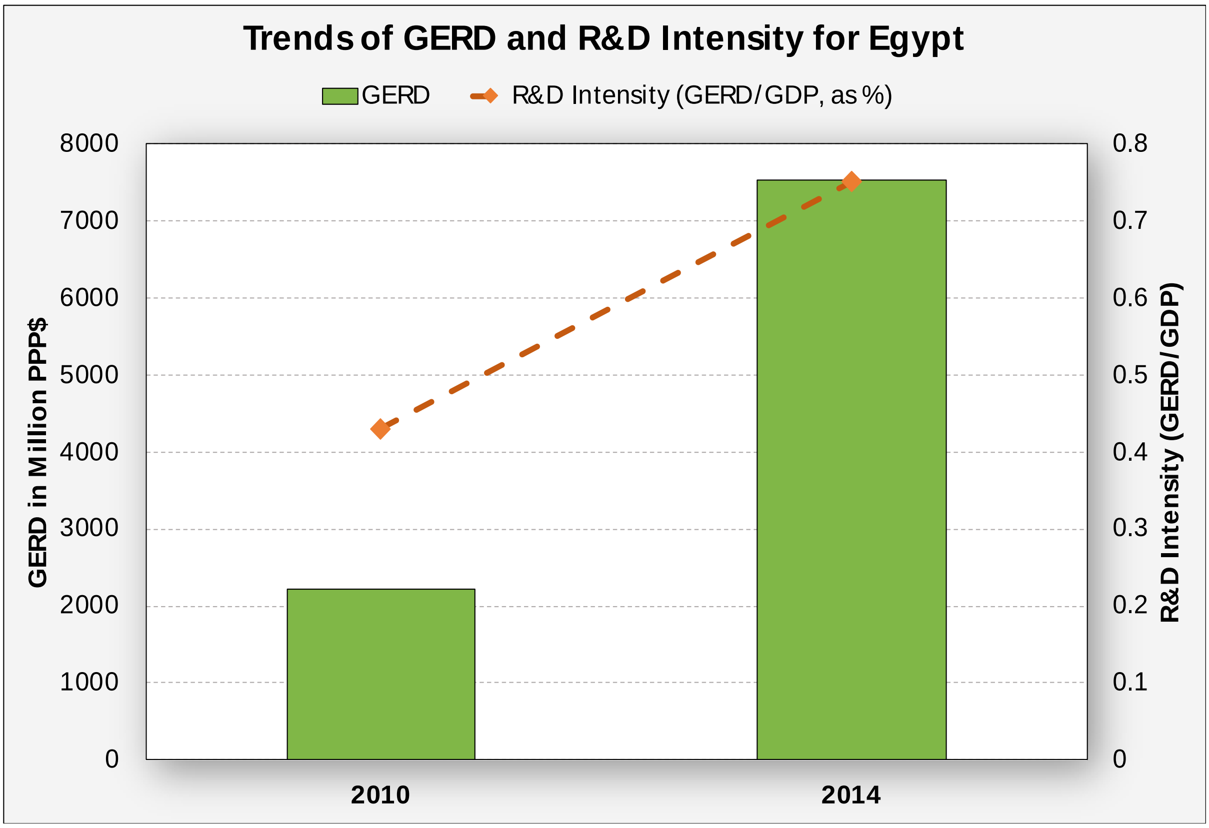

Figure 3: Trends of GERD and R&D Intensity for Ethiopia as reported using data from surveys conducted in 2010 and 2014

The source of $780.05 GERD was comprised of: $8.44 million (or 1% of GERD) from the business enterprise, $754.86 million (or 97% of GERD) from government, $16.75 million (2% of GERD) from the Rest of the World (see Figure A1 in Appendix). The higher education and private non-profit sectors did not contribute to GERD. The Rest of the World was the second major source of R&D funding with $16.75 million (or 2% of GERD) allocated as $13.91 million to the government sector, $2.79 million to the higher education sector and a paltry $0.05 million to the private non-profit sector. The business enterprise sector was the smallest source of R&D funding with investments totaling $8.44 million (1% of GERD). This investment pattern probably represented low institutional sector interactions. As observed in the R&D financial flows of Ethiopia, it is a common pattern in Africa that the government is a major funder of R&D activities in the higher education and government institutions.

The higher education sector spent $546.46 million on capital costs for R&D allocated by type of R&D. Out of this amount, 13% went to basic research, 37% to applied research, and 50% to experimental development. A major share of HERD for capital costs for R&D was spent on experimental development. As shown in Table 1, Ethiopia spent $273.21 million on capital costs for experimental development, $202 million on capital costs for applied research, $71.05 million on basic research. In addition, Ethiopia spent $23.86 million on labour costs and $7.09 million on other current costs. The government sector, on the other hand, spent $88.72 million (46.5% of GOVERD) on capital costs for applied research, $22.17 million (11.6% of GOVERD) on capital costs for experimental development research and $7.39 million (3.9% of GOVERD) on capital costs for basic research. What do the targeted expenditures on applied research and experimental development mean for Ethiopia? *These expenditures may signal Ethiopia's institutional preparations for a growing manufacturing sector*.

Distribution of Current and Capital Costs by Type of R&D Activity (in Million PPP$)

	Basic Research		Applied Research		Experimental Development		Total
Sectors	Current R&D Costs	Capital R&D Costs	Current R&D Costs	Capital R&D Costs	Current R&D Costs	Capital R&D Costs	
Business Enterprise	0.71	0.59	2.02	1.68	2.73	2.27	10.01
Government*	4.06	7.39	48.75	88.72	12.31	22.17	190.83
Higher Education	4.03	71.05	11.46	202.20	15.46	273.21	577.40
Private Non-Profit	0.00	0.00	0.15	0.31	0.42	0.94	1.81
TOTAL	8.80	79.03	62.38	292.91	30.92	298.59	780.05
Percentage (%)	1.13	10.13	8.00	37.55	3.96	38.28	100.00

*The total amount for the Government sector includes R&D Cost of 7.44 million PPP$ for "Not Elsewhere Classified (NEC)"

Table 1: Distribution of GERD by Sector of R&D Performance, by Type of Cost and by Type of R&D Activity for Ethiopia

Distribution of Current and Capital Cost in Million PPP$					
	Current R&D Costs		Capital R&D Costs		
Sectors	Labour costs	Other current costs	Vehicles, Lands, & Buildings	Instruments, equipment, & Software	Total
Business Enterprise	1.78	3.69	0.30	4.24	10.01
Government	22.21	45.41	64.95	58.26	190.83
Higher Education	23.86	7.09	540.38	6.08	577.41
Private Non-Profit	0.27	0.30	0.64	0.61	1.81
TOTAL	48.11	56.49	606.27	69.19	780.05
Percentage (%)	6.17	7.24	77.72	8.87	100.00

Table 2: Distribution of GERD by Sector of R&D Performance and Type of Costs for Ethiopia

The current costs of $67.62 million (35.4% of GOVERD) for the government sector comprised of labour costs of $22.21 million (12% of GOVERD) and other current costs of $45.41 million (24% of GOVERD). The current costs for higher education at $30.95 million made up of labour costs of $23.86 million and other current costs of $7.09 million were lower than the current R&D costs in the government sector which amounted to $67.62 million (see Table 2). The total labour costs across the four sectors was $48.11 million (6% of GERD), the majority of the costs totalling $46.07 million (5.9% of GERD) were for labour in the government and higher education sectors.

3.2. R&D Personnel for Ethiopia

Ethiopia employed 18 435 R&D personnel to perform R&D functions at a total labour cost of $48.11 million (or 6% of GERD). Among the R&D personnel were 8 218 (44.6%) researchers, 4 672 (25.3%) technicians and 5 545 (30.1%) support staff who, all, worked for a full-time-equivalent of 10 502.4 people or 57% intensity of work on R&D activities shared as 62% male and 38% female work effort. The government sector spent $22.21 million on labour costs for 9 141 R&D personnel who performed work equivalent to 7 298.3 FTEs shared as 80% male and 20% work effort (see Figure A.2 in Appendix). The R&D personnel aggregated by R&D function were comprised as: (1) 2 555 *researchers* who performed work equivalent to 2 116.5 FTEs (or 83% intensity of work on R&D activities) shared as 86% of male and 14% female work effort; (2) 2 650 *technicians* who worked an equivalent of 2 043.5 FTEs (or 77% intensity of work on R&D activities) shared as 69% male and 31% female work effort; and (3) 3 936 *support staff* who performed work equivalent to 3 138.3 FTEs or (80%

intensity of work on R&D activities) shared as 65% male and 35% female work effort. The ratio of male to female work effort, across all R&D functions, were 6.1:1 for researchers, 2.2:1 for technicians and 1.9:1 for support staff. The key R&D function of researchers showed a remarkable male biased distribution. *The government needs to put in place policies that encourage gender balanced employment in all sectors of the economy whose R&D activities are directly funded by the government*. In Ethiopia, the higher education is the second largest employer of R&D personnel after the government (see Figure A.2 in the Appendix).

The three top level fields of R&D personnel disaggregated by field of R&D, across all sectors of the economy in Ethiopia, were: (1) *Agriculture and veterinary sciences* employed 2 545 researchers who worked for 1 831.1 FTEs (or 72% intensity of work on R&D activities) shared as 85% male and 15% female work effort; (2) *Medicine and health sciences* employed 1 514 researchers who worked for 769.4 FTEs (or 51% intensity of work on R&D activities) shared as 88% male and 12% female work effort; and (3) *Social sciences* employed 1 380 researchers who worked for 429 FTEs (or 31% intensity of work on R&D activities) shared as 83% male and 17% female work effort (see Figure A.3 in Appendix). For the government sector, the top three fields of R&D where the majority of R&D personnel were employed are: (1) Agriculture and veterinary sciences (total headcount: 1550), (2) Social sciences (total headcount: 187) and (3) Natural sciences (total headcount: 182). However, for higher education sector, the top three fields of R&D where the majority of R&D personnel were employed are (1) Medicine and health sciences (headcount: 1192), (2) Social sciences (headcount: 967) and Natural sciences (headcount: 880). *This information is particularly important for SGCs in strengthening capacities in fields of R&D that aligns with national development plans and directions of their countries.*

4. Assessing the Interactions within the National Research and Innovation Systems

There are mainly two levels of assessing the performance a national research and innovation system. The first is by innovation rate of the system and second is by assessing the level and intensity of interactions within the national research and innovation system. The *innovation rate* is the proportion of innovative firms[5] (or institutions) expressed as a percentage of the total number of firms in the sample[6]. This refers[7] to the total number of firms (or institutions) that introduced new a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process). However for the survey data used in this the innovation rate was computed as the total number of firms that introduced new or significantly improved product or a new or significantly improved process, organisation or marketing method. The innovation rate for Ethiopia for the period 2012 to 2014 is 59.4%. For Ethiopia, the innovation rate for large and medium firms was higher than the overall rate of 59%. This rate increased with an increase in the size of the firm: 57% for small, 63% for medium and 79% for large firms (Figure 4). Large firms may have a long-term strategy for investments in the innovation process (explaining the high levels of overlaps) while the smaller firms may opt for a short-term strategy due to limited resources or age. This may also explain why small and medium-sized firms reported lower levels of abandoned innovation activities (4-5%) compared to 14% for large firms. The smaller firms may be pursuing innovations that take a shorter run to the market and are less risky. *More research is needed to get a full understanding of the observed differences.*

The survey data for Ethiopia covered four main sectors namely; Mining, Manufacturing, Construction and Service. The contribution by type of industry to the innovation rate of Ethiopia is shown Figure 5. The individual innovation rates for the mining (52%), construction (51%) and service (51%) sectors were below the overall innovation rate of 59.4% for Ethiopia while that for the manufacturing sector (68%) was above the national average. The manufacturing sector was the main driver of the higher innovation rate of Ethiopia while the construction sector contributed the least.

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[5] *Organization for Economic co-operation and Development and Statistical office of the European Communities (2005). Oslo Manual; Paragraph 152: Guidelines for Collecting and Interpreting Data, 3rd edition, OECD, Paris. The Oslo Manual is available at http://www.oecd.org*

[6] *This is a statistical sample that is suitably weighted to provide population estimates*

[7] https://www.oecd-ilibrary.org/docserver/9789264304604-en.pdf?expires=1550139196&id=id&accname=guest&checksum=FBD847C82AC32AFC025D13D7D5D4BDA1

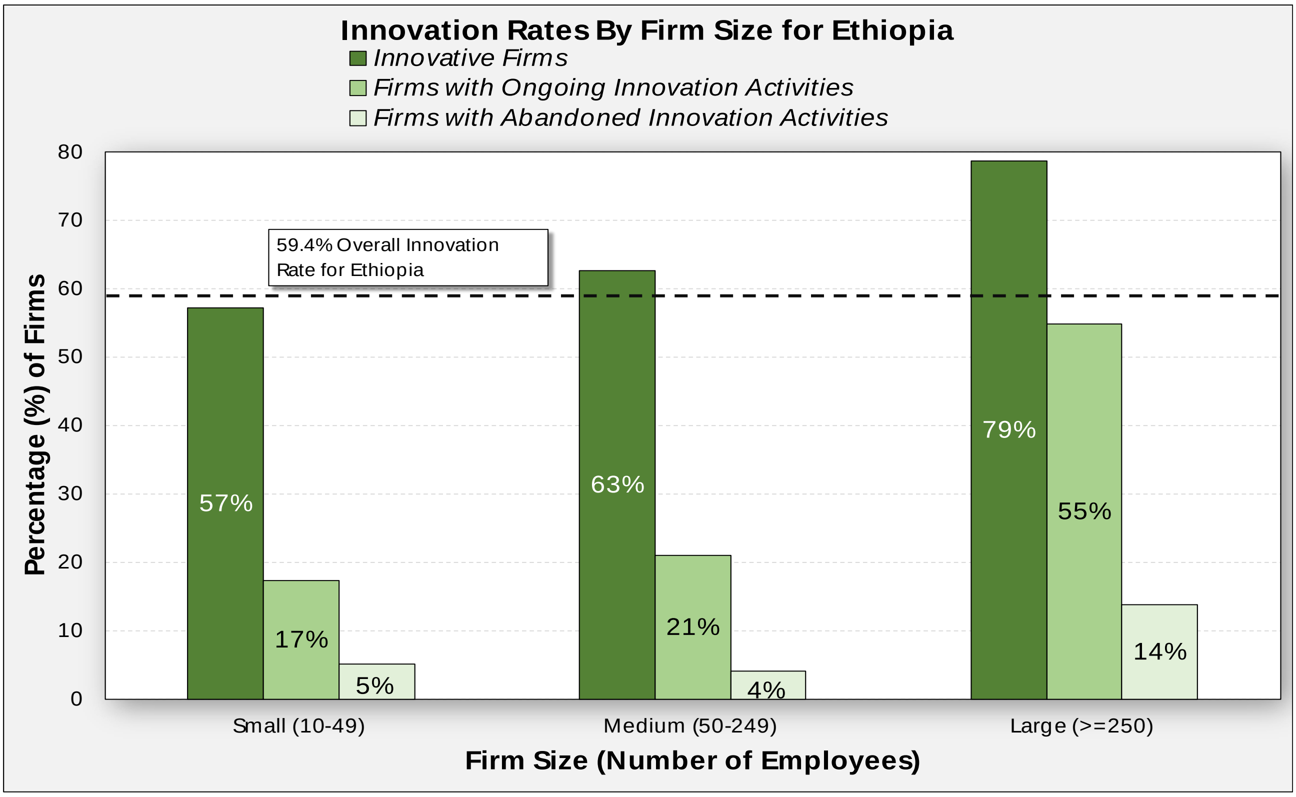

Figure 4: Innovation Rates by Main Firm Size Groups for Ethiopia

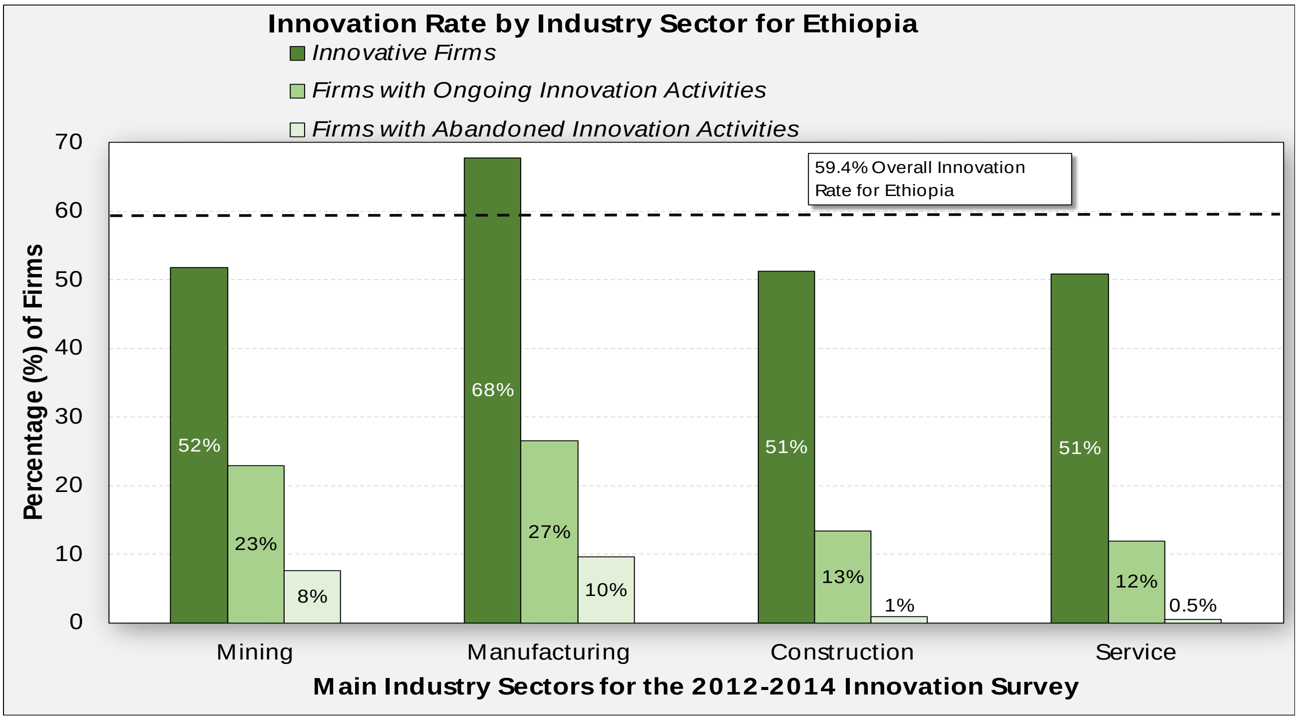

Figure 5: Innovation Rate by Industry Sector for Ethiopia

The research process that leads to innovations varies by organization and within organizations, and also varies by product, sector and segment. Firms and entrepreneurs, in general, continuously seek new ways to drive allocative efficiency and productivity growth[8]. One proxy indicator for accessing the performance of the interactions within national research and innovation systems is the sources of information and knowledge for the innovation processes in firms (and institutions). Data from ten countries on innovation indicate that majority of the innovative firms relied on internal sources of information; that is sources within the firm itself, to come up with innovations (see Table 3). Countries such as Lesotho (63%), Uganda (45%), Kenya (44%), Angola (41.5%) and Eswatini (34.2%) stand out in using sources of information that are internal to the firms. This is probably because the information is freely accessible and some of it may be part of tacit knowledge among employees.

Under the external sources of information, a significant number of firms reported utilizing information they get from suppliers of equipment. This is sometimes part of bulky purchasing of equipment for diagnostic laboratories or some equivalent setup that comes with training as a procurement package. No country had 50% or more of the firms rating universities or technical colleges, and Public Research Institutions (PRIs) as important sources of information for their innovation. Universities and government public research institutions are particularly rated low by firms from all the ten countries. In Ethiopia for instance, only 1.8% and 2.5% of the firms surveyed rated the information from universities and PRIs respectively as important for their innovation process. *This is an important result for the much talked about university-industry linkages and the increased investment in R&D*. In addition such weak linkages among universities, PRIs and firms has negative effects on novelty and quality of innovations produced by the system. Overall, firms in the countries presented in Table 3 were innovative without engaging in R&D activities to support the innovation. In Ethiopia for instance, 91.1% of innovative firms introduced innovations without R&D activities.

[8] *David M. Gann, 2010. Journal of Construction Management and Economics; 21(6): Special Issue on Innovation in the Built Environment. Guest editorial: innovation in the built environment, Gann pgs 553-555 | Published online: 13 May 2010*

		Source of Information for Innovation																			
	Total Number of Firms	**Internal Source**		**External Sources (Market)**								**External Sources (Institutional)**				**External Sources (Other)**					
		Sources within Firm		Suppliers of equipment		Clients/Customers		Competitors		Consultants		Universities/ Tech		Government/ PRI		Conferences		Sci Journals		Professional associations	
Country	**(*n*)**	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Angola	41	17	41.5	12	29.3	11	26.8	4	9.8	3	7.3	1	2.4	4	9.8	6	14.6	3	7.3	2	4.9
Cape Verde	3067	16	0.5	11	0.4	10	0.3	7	0.2	1	0.0	1	0.0	1	0.0	2	0.1	3	0.1	1	0.0
Egypt	2985	736	24.7	411	13.8	324	10.9	199	6.7	59	2.0	27	0.9	25	0.8	159	5.3	113	3.8	38	1.3
Ethiopia	10740	3 038	28.3	1 330	12.4	2 465	23.0	1 133	10.5	222	2.1	198	1.8	268	2.5	833	7.8	331	3.1	198	1.8
Kenya	376	169	44.9	108	28.7	134	35.6	77	20.5	45	12.0	36	9.6	48	12.8	73	19.4	41	10.9	58	15.4
Lesotho	36	23	63.9	20	55.6	25	69.4	19	52.8	13	36.1	12	33.3	16	44.4	18	50.0	19	52.8	18	50.0
Namibia	68	21	30.9	17	25.0	12	17.6	8	11.8	9	13.2	3	4.4	1	1.5	5	7.4	4	5.9	6	8.8
Seychelles	15	5	33.3	6	40.0	8	53.3	2	13.3	3	20.0	0	0.0	1	6.7	4	26.7	3	20.0	3	20.0
Eswatini	149	51	34.2	36	24.2	36	24.2	27	18.1	25	16.8	13	8.7	17	11.4	12	8.1	7	4.7	15	10.1
Uganda	6475	2921	45.1	1451	22.4	1 243	19.2	1 492	23.0	758	11.7	519	8.0	500	7.7	850	13.1	608	9.4	730	11.3

Table 3: Source of Information for Innovation by Firms

5. Factors Hampering Innovation in Ethiopia

Innovation is affected by myriad of factors from lack of funds within the enterprise for financing innovation activities to limitations of science and technology public policies. In total, sixteen factors were considered (see Figure 7). When a few factors hampering innovation are considered and disaggregated by firm size (Figure 6), lack of funds within an enterprise is more prominent within the small to medium firms than in large firms. However, these results ignore the contribution of firms who felt otherwise (only considered the respondents who highly rated the factor). When all the categories (e.g. cost, knowledge, market, reasons for not innovating and others) of the sixteen factors hampering innovation are considered, the picture is clearer (Figure 7).

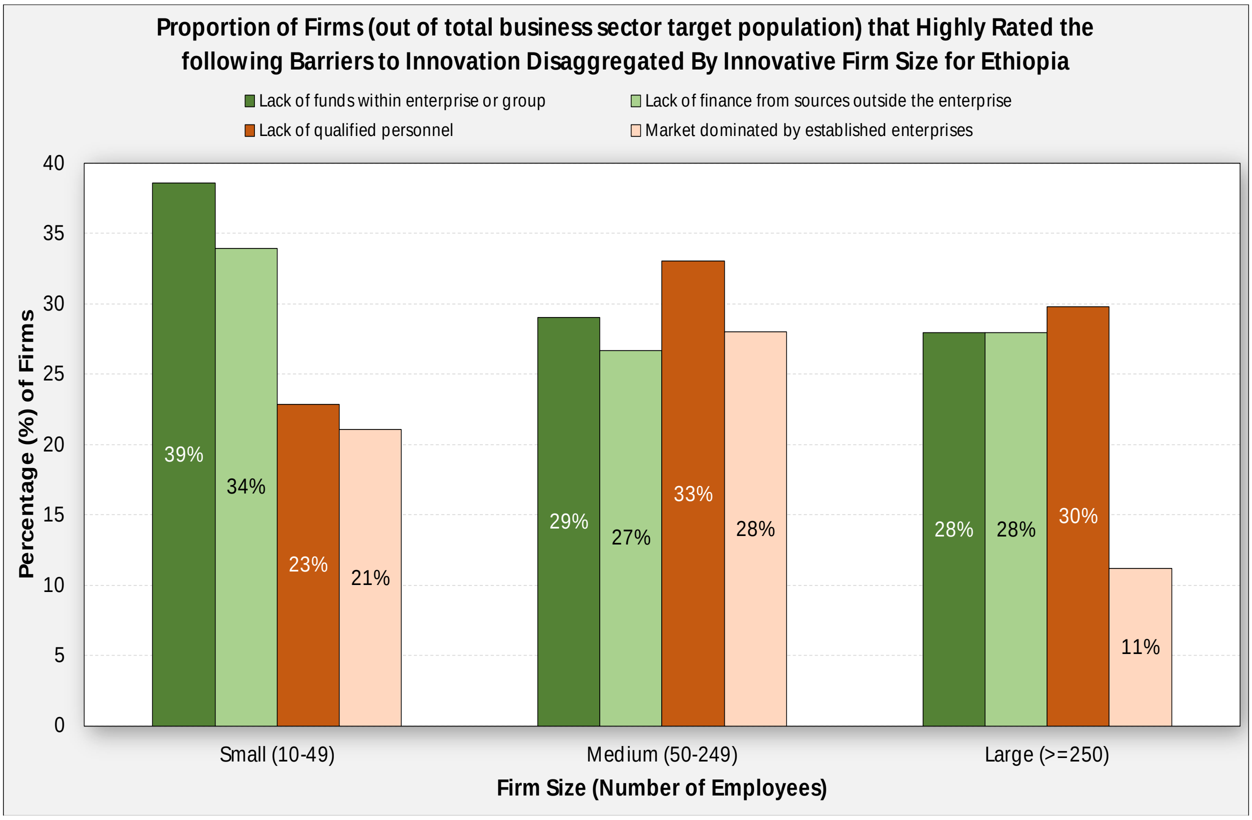

Figure 6: Proportion of Firms (out of total business sector target population) that Highly Rated the selected Barriers to Innovation Disaggregated by Innovative Firm Size for Ethiopia

When all the sixteen factors hampering innovation are presented regardless of the size of the firms; the high costs for innovation, lack of funds within the enterprise, lack of finance from sources outside the enterprises are prominent within the cost category (Figure 7). Within the knowledge category, lack of technology, followed by lack of qualified personnel and lack of information on market are most important barriers to innovation. Another important category that stands out is the market where factors such as domination of the market by established enterprises, followed by uncertain demand for innovative goods or services are critical. The other two categories do not come up prominently. *There should therefore be targeted policy measures to support SMMEs and start-ups in their growth and accessing markets.*

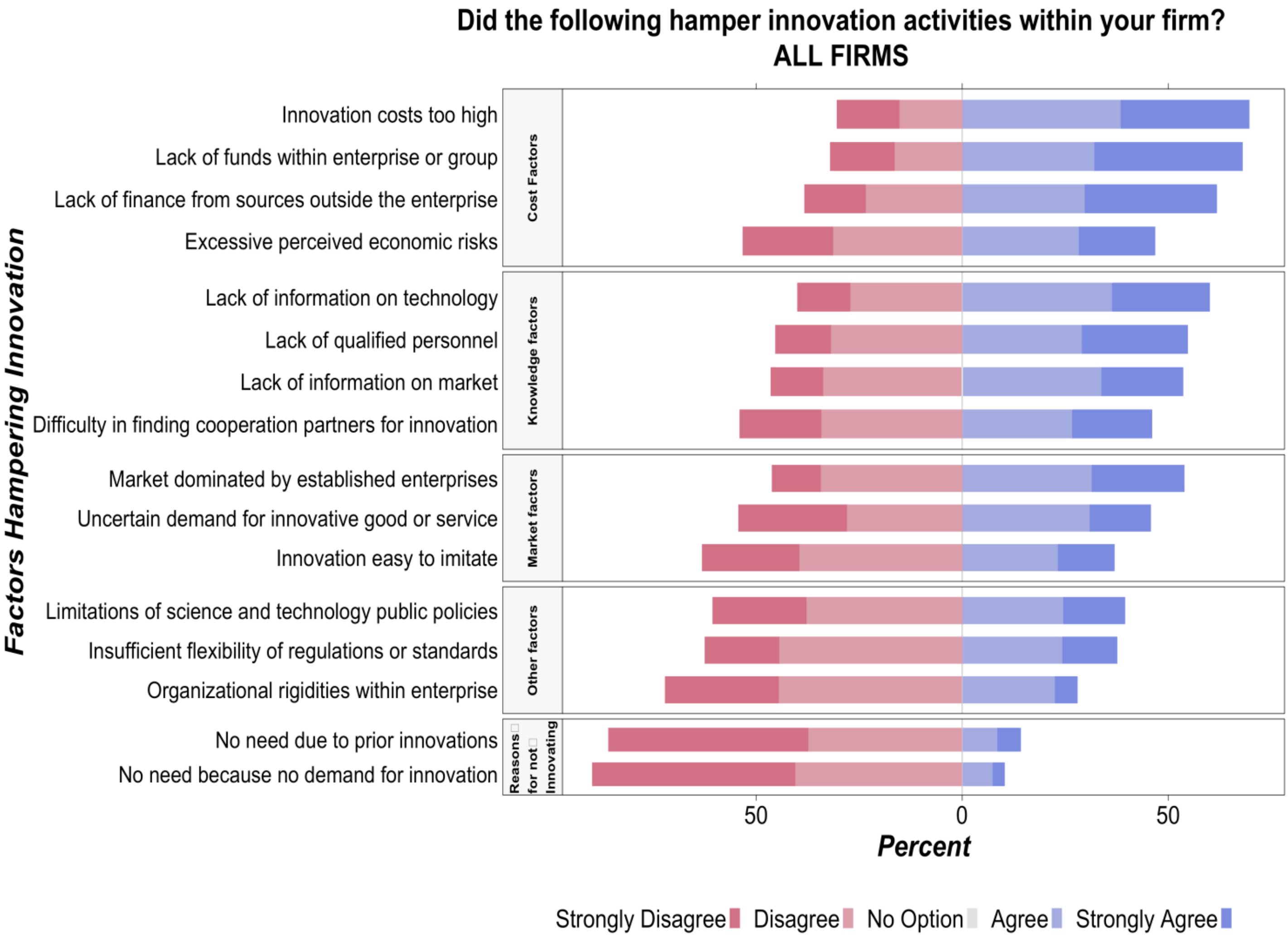

Figure 7: Factors Hampering Innovation for Firms in Ethiopia: ALL FIRMS

6. Policy Recommendations and Conclusion

The majority of SGCs in Africa have not set the target contributions to R&D intensity for government and the business sectors, clearly described the role of the national government and business in achieving the AU 1% target, and have not well articulated the potential pathways to growth (e.g. national programmes and funding mechanisms) for R&D and innovation to drive increased economic growth. To help achieve the AU target of 1%, SGCs may need to: (1) Clearly break down the target into realistic percentage contributions by the government and the business sectors; (2) Focus more on financing mechanisms for R&D and the potential pathways for achieving results (e.g. funding instruments, national programmes and outputs); (3) Link the target to innovation and entrepreneurship (i.e. going beyond R&D); (4) Relate the target to the framework conditions (e.g. partnerships, collaborations, financing, regulatory, trade, competition, etc.) important for the national context within which R&D, innovation and entrepreneurship take place; and (5) Formulate country-specific programmes or projects that promote basic research, applied research and commercialization of research results.

The analysis provided in this paper indicate that there is more work that needs to be done to answer the some of the outstanding questions raised in Section 3 for Ethiopia. We therefore provide the following recommendations:

- A comprehensive capacity development programme on research and innovation data management should be designed to target more officials from different government entities such as the Ministry of Environment, Forestry and Climate Change (MEFCC), the Ministry of Industry (MoI), the Ministry of Finance and Economic Cooperation (MoFEC) and the Ethiopian Investment Commission (EIC). The training programme can build on the work Science Granting Councils Initiative to provide in-depth understanding of national development plans, policies and framework conditions for R&D and innovation.
- Create a culture of collecting and analysing R&D and innovation survey data and continuously improve the questionnaires used to collect data. This will help in bridging the gaps in passive data collection systems particularly for R&D.
- Set up Communities of Practice to encourage dialogue among countries on good practices as a strategic learning process.

7. Acknowledgment

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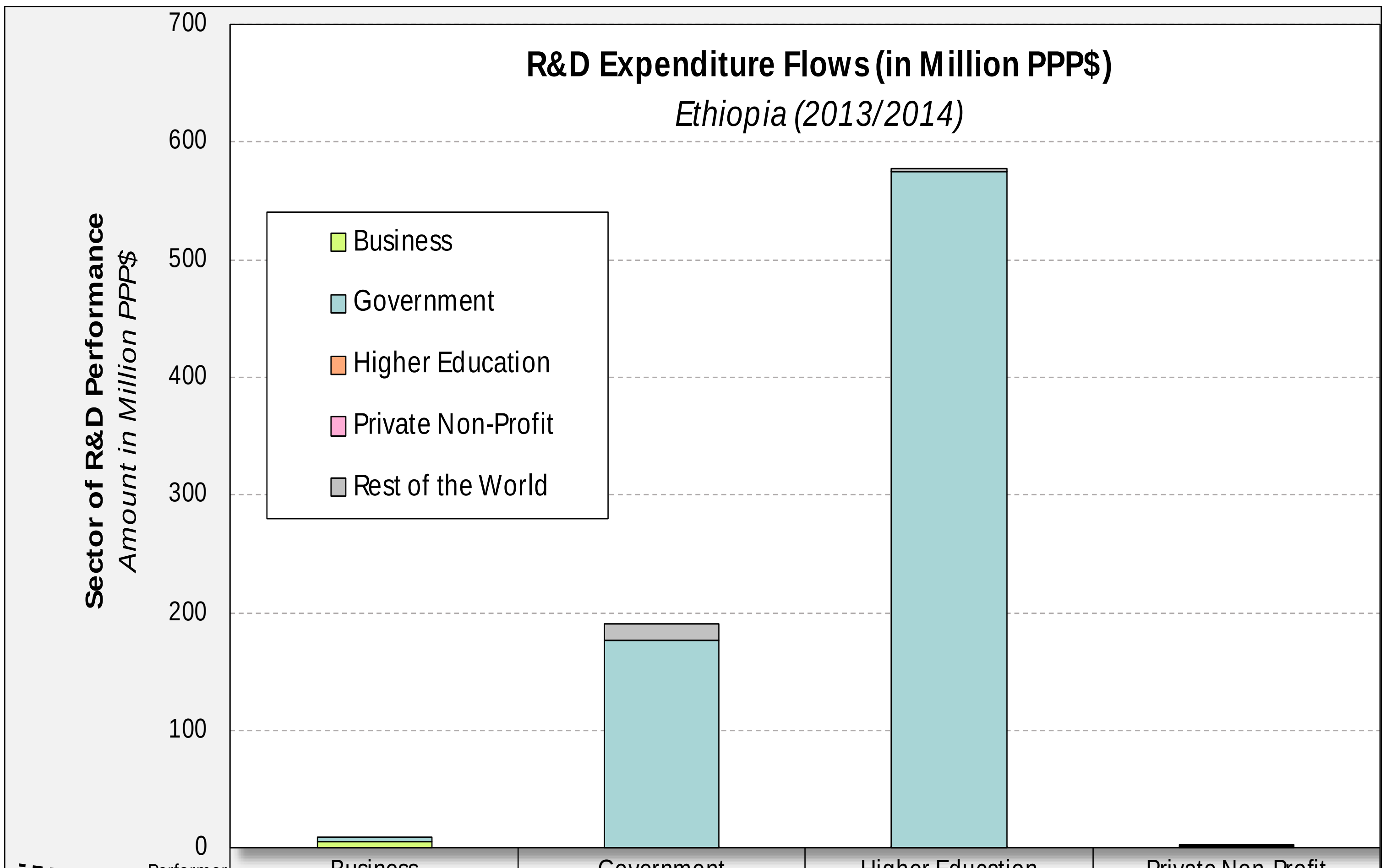
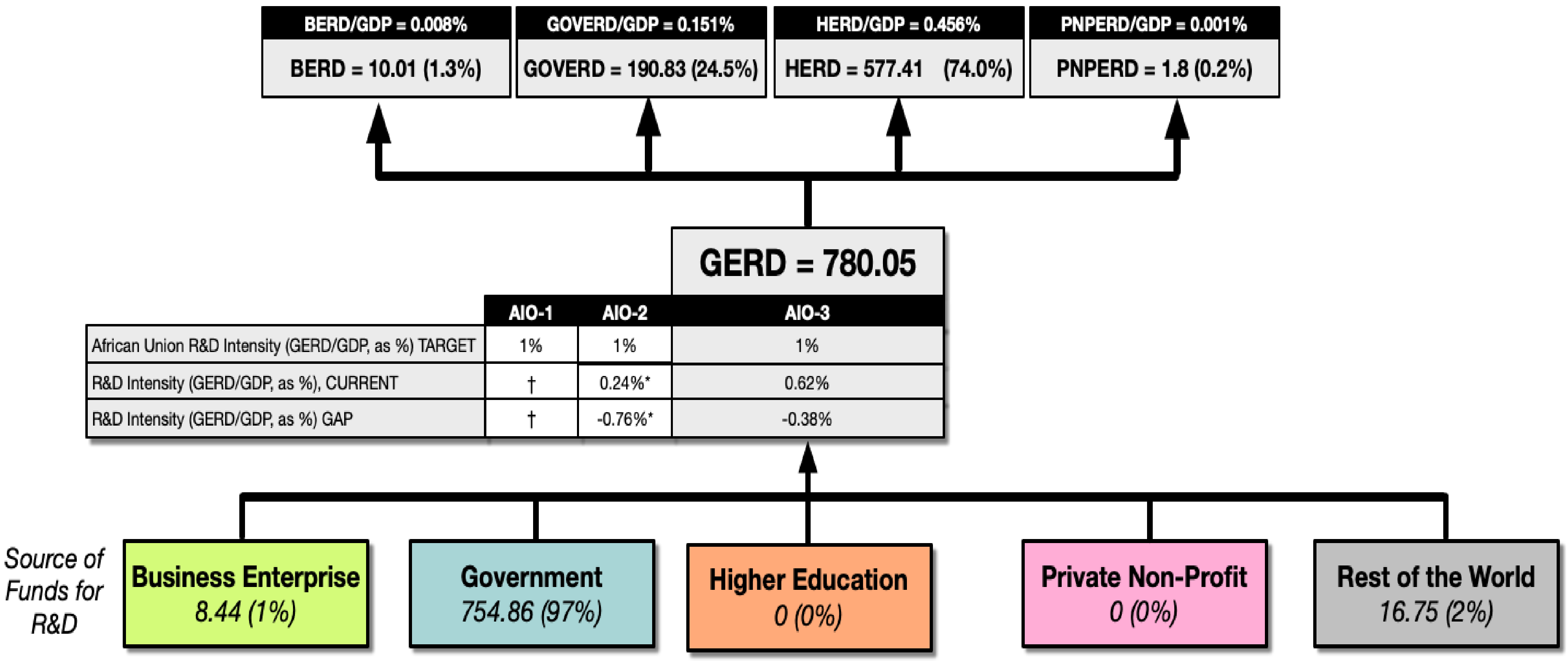
Appendix

A.1: R&D Expenditure Flows for Ethiopia

Summary of indicators: GERD, Sources of R&D funding, African Union R&D Intensity TARGET, R&D Intensity, R&D Intensity GAP, and the Distribution of GERD by Sectors of R&D Performance for Ethiopia in 2014



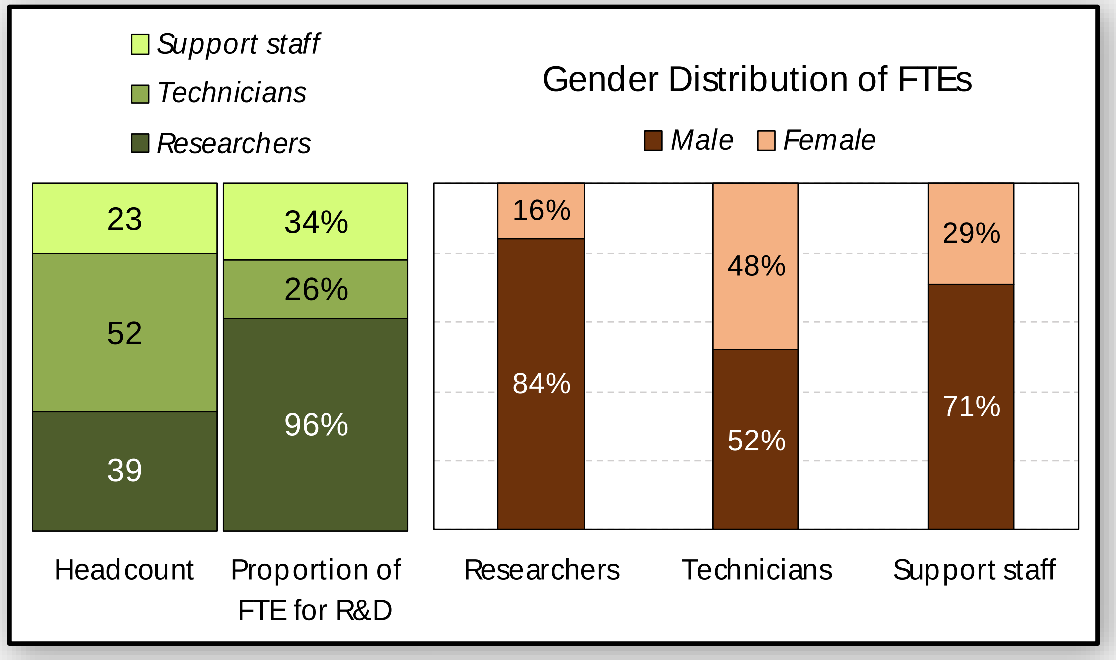
Source \ Performer	Business	Government	Higher Education	Private Non-Profit
Rest of the World	0	13.91	2.79	0.05
Private Non-Profit	0	0	0	0
Higher Education	0	0	0	0
Government	3.86	176.54	574.46	0
Business	6.15	0.38	0.16	1.75



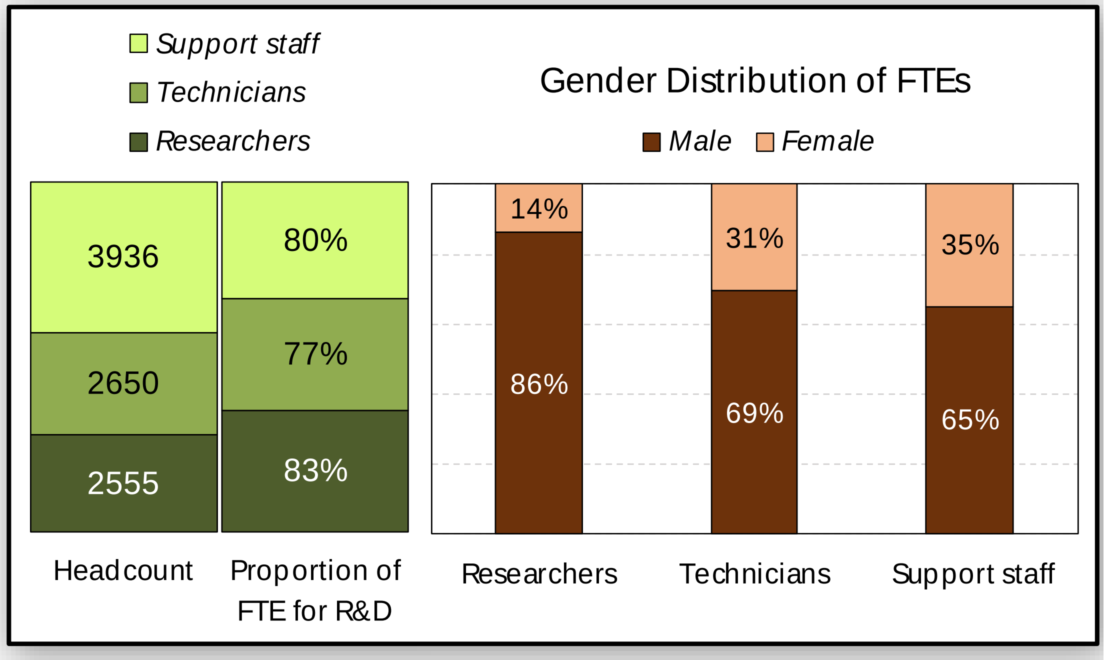
	AIO-1	AIO-2	AIO-3
African Union R&D Intensity (GERD/GDP, as %) TARGET	1%	1%	1%
R&D Intensity (GERD/GDP, as %), CURRENT	†	0.24%*	0.62%
R&D Intensity (GERD/GDP, as %) GAP	†	-0.76%*	-0.38%

A.2: Distribution of R&D Personnel for each Sector by Function and Gender for Ethiopia

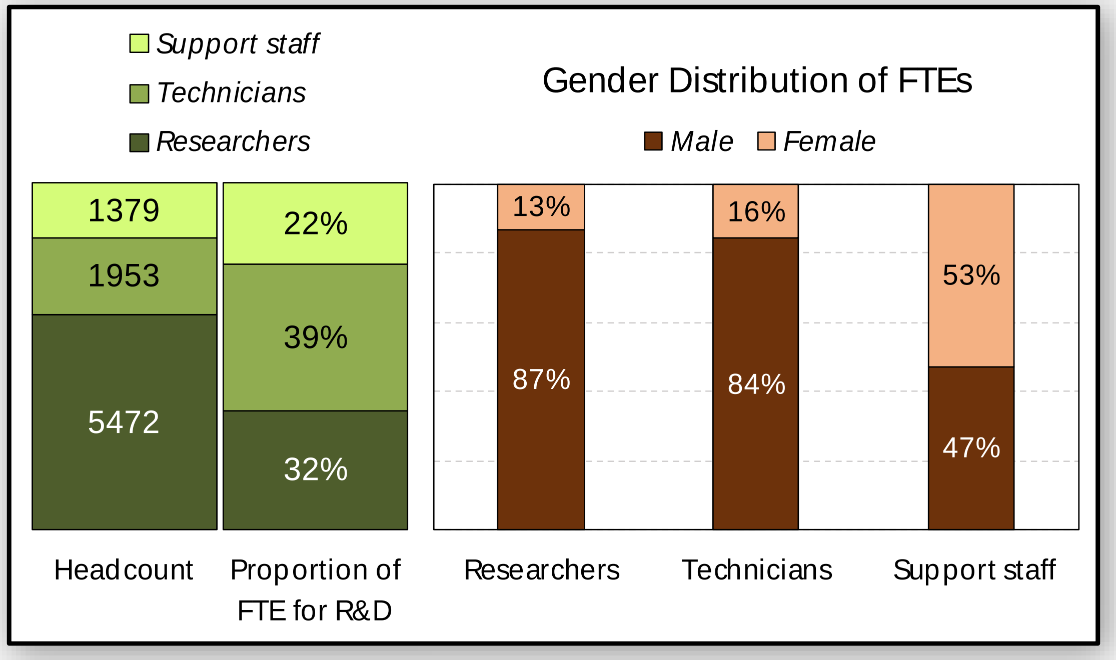
Business: R&D Personnel by Function



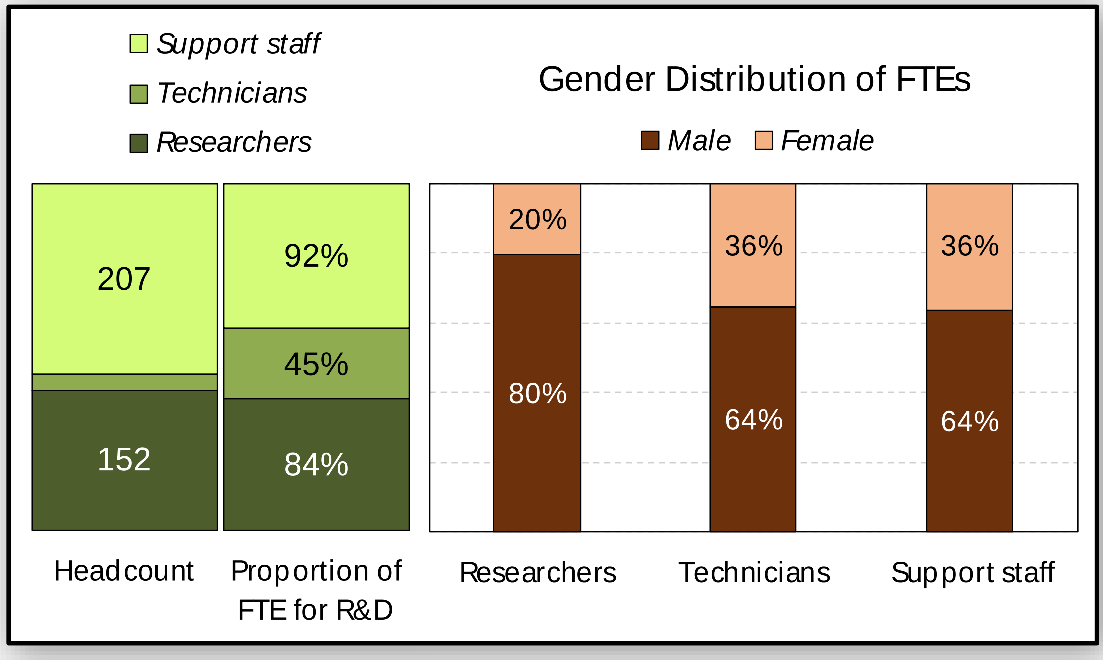
Government: R&D Personnel by Function



Higher Education: R&D Personnel by Function

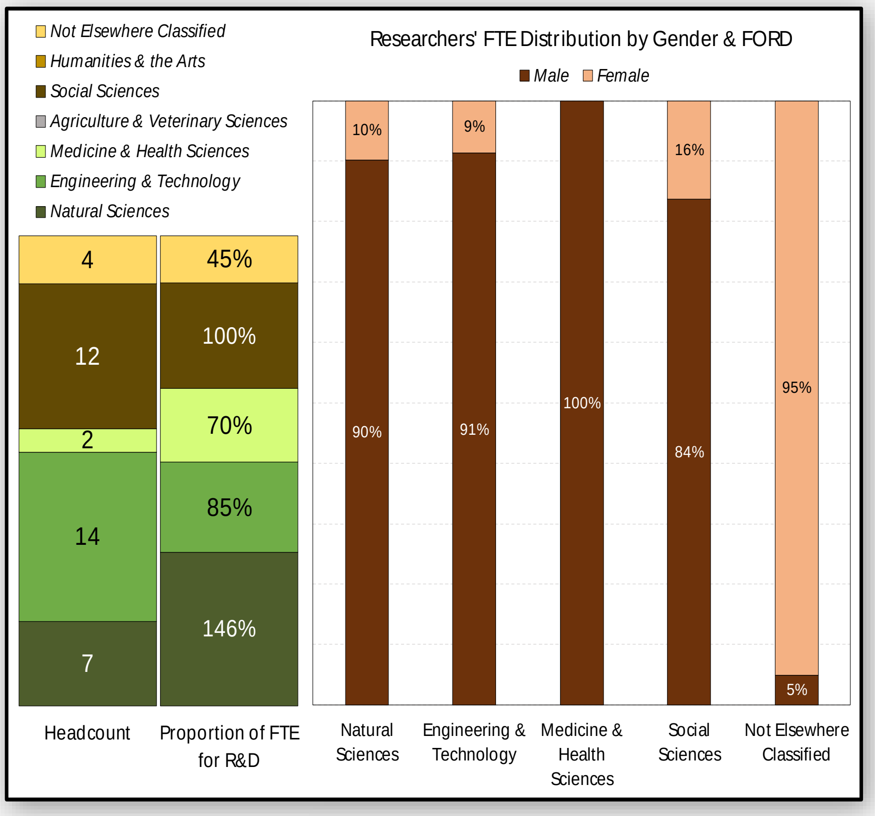


PNP: R&D Personnel by Function

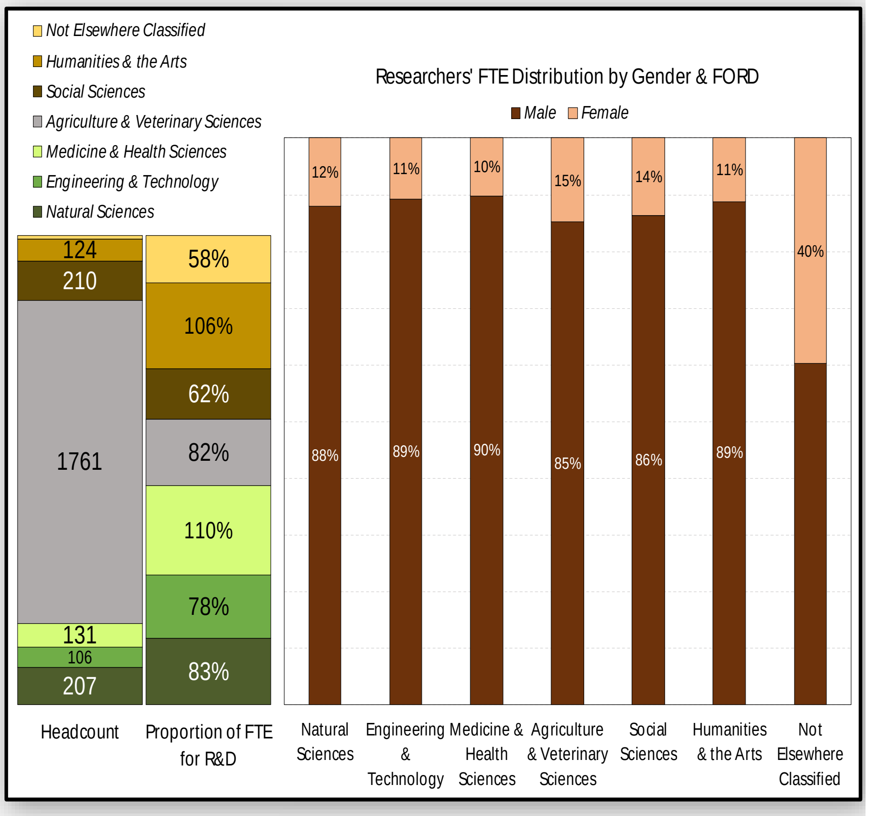


A.3: Distribution of Researchers FTE for each Sector by Field of R&D (FORD) and Gender for Ethiopia

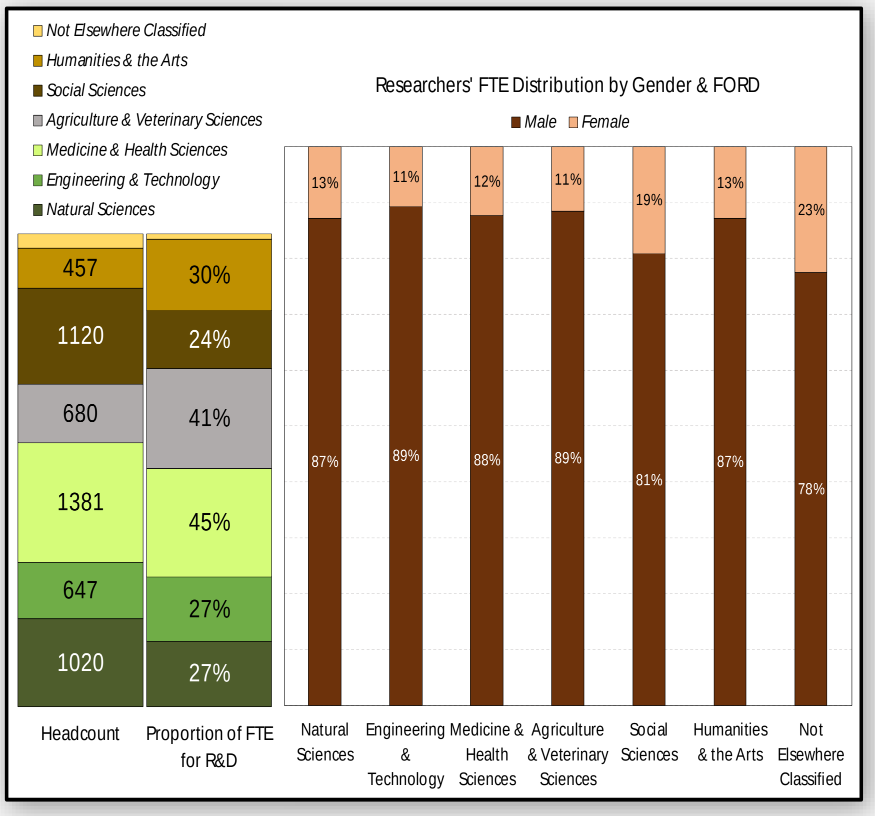
Business: Researchers by Field of R&D



Government: Researchers by Field of R&D



Higher Education: Researchers by Field of R&D



PNP: Researchers by Field of R&D