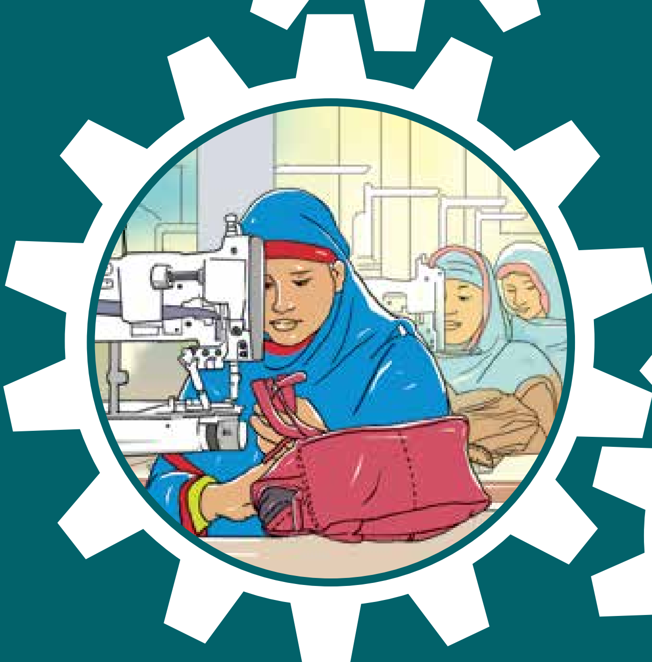
Gearing Up for the Future of Manufacturing in Bangladesh



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Foreword

At a time when many developing economies are experiencing premature deindustrialization, Bangladesh is being touted for an export-led manufacturing miracle. Bangladesh's exports of ready-made garments (RMG), now second only to China, helped propel the country to lower middle-income status in 2015. However, change is coming to the industry and Bangladesh will need to adapt. Fortunately, wages for workers are rising as Bangladesh consolidates its middle-income status but new lower-cost locations have emerged as competitors. At the same time, automation in high-income countries and shifting consumer preferences are raising the bar for countries to be a globally competitive production location. As manufacturers in Bangladesh make the transition from competing on wages to competing on productivity, the rich analysis in this report can help inform policy priorities.

Improving the productivity of firms is central to preparing for the future of manufacturing as Bangladesh seeks to diversify its export base, move up the value chain, and create better-paying jobs. Continuing with regulatory reforms that reduce the cost of doing business and spur market entry remains important but enabling innovation will also be critical to a dynamic manufacturing sector in Bangladesh. The Government of Bangladesh's "Seventh Five-Year Plan: 2016–2021" and "National Industrial Policy 2016" emphasize improving firms' productivity and include technology upgrades in its key targets. The lack of data on technology use at the firm level, though, hinders the extent to which evidence-based practice can guide policy choices.

This report makes an important contribution to building the evidence base through a new Firm-level Adoption of Technology (FAT) Survey—a part of the World Bank's global FAT project—that collects data on technology use among firms in Bangladesh. Although robots, 3D printing and the Internet of Things (IoT) capture media headlines, most Bangladeshi firms still use basic or near-basic technologies. Around half the firms in Bangladesh's manufacturing sector still use handwritten processes for business management; around one-third of firms do not monitor any key performance indicators (KPIs); and most firms still use fully manual or powered but manually operated basic machinery across production stages. Firms need to be enabled to climb the technology ladder.

So how can policy makers accelerate the adoption of better technologies? This report identifies three enabling pillars: capabilities of managers and workers, connectivity to international markets, and complementary markets and institutions. All three of these pillars will be critical as firms try to emerge from the COVID-19 pandemic stronger. Firms have an opportunity to build back better by using more advanced technologies and new digital platforms. As a long-term development partner of Bangladesh, the World Bank Group looks forward to partnering with the country in its quest to build on the export-led manufacturing model that has benefited Bangladesh in recent years. This report is an important next step in pursuing well-informed, evidence-based policy priorities.

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Acronyms And Abbreviations

AI	Artificial Intelligence
API	Active Pharmaceutical Ingredients
BGMEA	Bangladesh Garment Manufacturers and Exporters Association
CRM	Customer Relationship Management
EFP	Effective Rates of Protection
ERP	Enterprise Resource Planning
FAT	Firm-level Adoption of Technology Survey
FDI	Foreign Direct Investment
G2B	Government-to-Business
GPT	General-Purpose Technologies
GTF	Green Transformation Fund
GVC	Global Value Chain
HIC	High-Income Country
ILET	Institute of Leather Engineering and Technology
IoT	Internet of Things
KPI	Key Performance Indicator
LDC	Least-Developed Country
LMIC	Low- and Middle-Income Country
MBA	Master of Business Administration
MNE	Multinational Enterprise
NDP	National Drug Policy
NPL	Non-Performing Loan
NSS	National Saving Scheme
NTB	Non-Tariff Barrier
OECD	Organisation of Economic Co-operation and Development
OSS	One-Stop Shop
PPCG	Partial Portfolio Credit Guarantee
PPP	Public-Private Participation
R&D	Research and Development
RCT	Randomized Control Trial
RMG	Ready-Made Garments
SBW	Special Bonded Warehouse
SEZ	Special Economic Zone
SME	Small and Medium Enterprise
STEM	Science, Technology, Engineering, Mathematics
FAT	Firm-level Adoption of Technology
TC	Technology Center
TES	Technology Extension Services
TRIPS	Trade-Related Aspects of International Property Rights
WBG	World Bank Group
WMS	World Management Survey
WTO	World Trade Organization

Executive Summary

The ready-made garments industry has transformed Bangladesh's economy, but the creation of more sustainable jobs in the manufacturing sector now needs the upgradation of firms' capabilities and technology adoption.

Labor-intensive, export-oriented manufacturing driven by the ready-made garments (RMG) industry has propelled Bangladesh's recent economic transformation, but this growth engine will face many challenges in the near future. The export-led manufacturing growth model will remain central to Bangladesh's sustained growth and job creation, but continued reliance on low labor costs to maintain the competitive edge is increasingly untenable as the country consolidates its middle-income status and its wage costs rise. Simultaneously, major global trends—the growing use of labor-saving technologies, shifting trade patterns, and the increasing use of services inputs in production—are reducing the importance of wage costs in determining international competitiveness. In this changing manufacturing landscape, Bangladesh risks becoming uncompetitive on both the wage and non-wage dimensions of productivity as it seeks to diversify its export basket and move up the value chain.

Strengthening firms' capabilities for innovation and technology adoption will be increasingly critical to productivity growth. If low wages are no longer sufficient for competing internationally, Bangladesh's emphasis must shift to broader considerations of efficiency and productivity upgrading. Promoting the reallocation of resources to more productive firms through structural reforms that reduce unnecessary costs of doing business remains important: in the global "ease of doing business rankings" for 2020, Bangladesh moved up only eight places from 2019 and is now ranked 168th. However, recent international evidence demonstrates that, while reducing allocative inefficiency is important, improving firms' capabilities to enable innovation and technology adoption is a relatively more significant source of aggregate productivity growth (Cusolito and Maloney 2019). By one estimate, differences in technology adoption account for up to 75 percent of the income gap between advanced and developing economies (Comin and Mestieri 2018). The evidence suggests that sustained productivity growth in the manufacturing sector can be achieved only by increasing firms' capabilities for innovation and technology adoption.

Improving firm-level technology will be an integral element of the strategy to create good jobs in a sustained manner. While some technologies might make it feasible for machines to replace labor in specific tasks, others improve input efficiency or product quality without necessarily replacing labor (Hallward-Driemeier and Nayyar 2017). Even when labor-saving technologies are adopted, the resulting increase in efficiency also increases the demand for labor in complementary tasks, and the net effect on employment can be positive. Most importantly, technology upgradation is becoming central to increasing the productivity of the manufacturing sector- a precondition for sustainably generating well-paid jobs.

Upgrading firms' capabilities for technology adoption will also help them to recover from the COVID-19 shock. Addressing the immediate challenges to the survival of firms created by the COVID-19 crisis is an urgent policy imperative. In May 2020 - during the first wave of the pandemic - survey data revealed that about three-quarters of firms were expecting to fall into arrears in the next six months. Looking ahead, policy makers also need to think about how to support firms to recover from the crisis and adapt to the post-COVID-19 world. New technologies and business practices can help. For example, e-commerce platforms can enable firms to maintain access to inputs and a distribution network for their products. Similarly, video-conferencing platforms can enable home-based work where face-to-face interactions are otherwise important. Better management can enable a resumption of industrial production, whereby updated organizational practices could incorporate all the relevant precautions with respect to hygiene and physical distancing. Moreover, the COVID-19 crisis may accelerate the global trend toward automation, adding to the urgency of upgrading Bangladesh's manufacturing firms.

Although promoting better technologies in firms is an official policy objective, its achievement has been hampered by the scant evidence on firm-level technology use in Bangladesh. The country's manufacturing sector policy, as discussed in the "Seventh Five-Year Plan: 2016–2021" and the related "National Industrial Policy 2016", stresses the importance of improving the productivity of firms, and includes firm-level technology upgradation in its key targets. The thrust of the policy is on supporting R&D and start-up activities in high-tech industries. More evidence on the exact nature of the technological gaps and constraints in the manufacturing sector is needed to assess whether these are the right technology-related policy priorities for Bangladesh.

Even incremental technology diffusion can transform Bangladesh's manufacturing sector.

The main technology challenge facing Bangladesh's manufacturing sector is not that advanced technologies have not arrived in the country, but that even incrementally better technologies need to be diffused much more widely. The key data source for this report, the Bangladesh Firm-level Adoption of Technology (FAT) Survey—a part of the World Bank's global FAT project—collects novel and detailed information on technology use in firms. The survey reveals that, while several advanced technologies are already in use among select firms, most firms still use basic or near-basic technologies.

Digital technologies: Most firms use rudimentary information technologies for business processes, although some firms are at an advanced technological level. For example, 47 percent of firms still use handwritten processes for business management and 72 percent of them practice manual quality inspections. While firms have started using digital technologies for sales and payments, the use of cash and traditional sales methods are still predominant.

Industrial technologies: Most firms in Bangladesh still use basic machinery (that is, fully manual or powered but manually operated) in most production stages. Even in the RMG subsector, most firms use basic machinery in most production stages, except for sewing. Eighty percent of RMG firms use semi-automated technology in the sewing stage, and another 9 percent use automated sewing methods.

Management techniques: Many firms do not even use basic management practices for setting targets, providing incentives to workers, and monitoring performance. For example, 32 percent of firms do not monitor any key performance indicators (KPIs). Almost no firms use industrial management techniques such as Total Quality Management, Lean Production, Just-in-time, Kaizen and Six Sigma.

Firms with higher technology levels have better performance. After accounting for differences in key attributes of firms, such as size, physical capital and age, there is a statistically significant correlation between technology levels and firms' performance. For example, a 25 percent increase in the overall technology level is associated with a statistically significant 3 percent increase in profits per worker. These findings accord with global evidence on the positive impact of technology adoption on firms' performance.

Underlining the potential of technology diffusion, differences in technology account for a large share of the overall variation in firms' performance in Bangladesh. Eighteen percent of the total variation in the performance of manufacturing firms (as measured by indicators such as profits per worker) can be accounted for just by their observed differences in technology. This is comparable to the share of the variation in firms' performance that is explained jointly by other key attributes, such as firms' size, capital, age, sector and location.

A comparison with Vietnam also underlines the potential gains from incremental technology diffusion in Bangladesh. Vietnam, similar to Bangladesh, is a fast-growing lower middle-income country with a similarly sized manufacturing sector (as a share of GDP), successful in the global apparel market, and in transition from a labor-intensive growth model to a more productivity-led growth model. Comparable survey data show that firms in Bangladesh are lagging behind those in Vietnam in many general-purpose technologies, but can narrow this gap substantially through incremental improvements.

Firms in Bangladesh need stronger basic capabilities to absorb better technologies

Technical and managerial human capital in firms aids technology adoption in Bangladesh. After accounting for differences in other key attributes, firms with greater technical and managerial expertise levels have significantly higher technology levels. For example, a firm's digital information technology level is 9 percent higher if its manager has a college degree. Similarly, firms with a higher share of employees with a technical degree have sizably higher informational technology levels. These findings are broadly in line with the global evidence base on the role of internal human capital in technology upgradation in firms.

Underlining the complementarity between technology and human capital, firms that use more advanced technologies are more likely to invest in technical expertise and skills. The likelihood that a "technology leader"—a firm in the top 25 percent of the technology score distribution—has tried to hire a technology consultant or technical staff in the past three years is nearly twice that of the average firm. Technology leaders are also more likely than the average firm to train existing workers or hire skilled workers when acquiring new machinery or software.

Nonetheless, technical and managerial expertise levels are low in most Bangladeshi firms. More than 75 percent of firms do not have any workers with a college degree in engineering or applied science. The mean percentage of the workforce with an MBA or master's level degree is only 2.4 percent. More than 75 percent of firms have no dedicated R&D workers. Furthermore, 55 percent of firms are managed by a person without a college degree.

Informational market failures constrain firms from investing in technical and managerial capabilities. In part, firms underinvest in technical and managerial capabilities because of limited awareness of their true value. According to the survey, firms with lower technology levels in Bangladesh have more inflated beliefs about their technology level relative to other firms; that is, they systematically underestimate the extent to which they are behind other firms. Moreover, 84 percent of firms do not believe that they need external advice for technology. Relatedly, missing or under-developed markets for technological and management expertise and advice also present a problem. Even if they are convinced of the need for investing in business advice, most manufacturing firms can only afford the services of local consulting firms, which may lack access to the latest global know-how. Establishing business relationships with leading global firms through either trade or foreign direct investment (FDI) can facilitate such knowledge transfer.

There is room to better leverage international connectivity for technology diffusion

In Bangladesh, connectivity to international markets directly contributes to technology diffusion and improves firms' incentives to innovate. After accounting for differences in other key attributes, firms in Bangladesh with a business relationship with multinational enterprises (MNEs), on average, are characterized by higher levels of technology adoption. Firms that most often used information from foreign buyers or suppliers to make decisions about adopting general-purpose technologies,

on average, used mobile apps to complete tasks related to business administration, human resources, inventory management and production planning compared with other firms that, on average, used handwritten processes or standard computer packages. Similarly, firms that most often used information from foreign buyers or suppliers to make decisions about adopting sector-specific technologies, on average, used semi-automated production processes compared with other firms that, on average, used manually operated machinery. These findings are in line with the global evidence that international trade and business relationships in global value chains (GVCs) are an important channel of technology diffusion. Trade—through its effect on technology transfers, scale of production, and competition—can also improve local firms' incentives to innovate. In Bangladesh, among large firms where exporters are concentrated, competition in the external market is cited as the top reason for the acquisition of new hardware or software by the largest share of firms.

The extent to which connectivity to international markets can be a conduit for technology transfer in Bangladesh also varies fundamentally by sector. Not surprisingly, the RMG subsector is the most well-connected to international markets. In 2018, more than 50 percent of RMG firms exported directly to world markets, directly imported material inputs, machinery and equipment, and had business relationships with an MNE. Exporting and establishing linkages with MNEs can similarly bring the benefits of technology diffusion to firms in Bangladesh's leather goods and footwear industry. However, in 2018, fewer than 20 percent of firms exported directly, imported material inputs, machinery, or equipment and had a business relationship with an MNE. In the pharmaceutical subsector, the scope for technology transfer through international connectivity is currently limited to the import of intermediates in Bangladesh, where 92 percent of firms directly imported material inputs, machinery and equipment in 2018. A highly protected domestic market, coupled with the lack of sophisticated buyers among export destinations, inhibits technology transfer through exporting and FDI in the pharmaceutical subsector. The scope for technology transfer through international connectivity is more fundamentally limited in the food processing industry, which is less amenable to production in GVCs and where Bangladesh's exports target a niche market comprising the South Asia diaspora.

Gaps in complementary markets and institutions also constrain firm-level technology adoption.

Difficulty in access to finance, especially among small and medium enterprises, is a major constraint for technology adoption in Bangladesh. Around 35 percent of firms and 50 percent of small and medium enterprises (SMEs) report difficulties in access to finance as the top obstacle to adopting new equipment, machinery, software or processes. Meanwhile, firms that have successfully obtained a loan for purchasing equipment are characterized by better technology levels. The weak capacity of the banking sector and the gaps in financial sector infrastructure make it difficult for firms, particularly SMEs, to secure long-term loans for technology adoption. In addition, the lack of capital-market and risk-capital financing also makes entrepreneurs more conservative in technology adoption.

The uncertainty and extra costs generated by excessive regulatory complexity and discretion are a key constraint for technology adoption among large firms. Among surveyed firms, large firms are twice as likely as SMEs to select the high costs of complying with regulation as the top obstacle to adopting new equipment, machinery and software. Regulatory gaps (the absence of laws that clarify the rules of the game, and the weak enforcement of existing rules) and regulatory uncertainty (conflicting definitions and interpretations of regulations) are prevalent. These regulatory gaps and uncertainties weaken property rights and contract enforcement, disincentivizing technology adoption that involves sizable upfront investment

Policies to strengthen the basic capabilities of firms are critical

Policymakers must devise a policy mix appropriate to the basic capability-building needs of Bangladeshi firms. This report shows that most Bangladeshi manufacturing firms are on the lowest level of the "capabilities escalator" and are mainly in need of foundational capabilities. Only firms in select subsectors (mainly pharma) and market segments (primarily exporters) are at a higher stage of the capabilities escalator and can absorb more advanced technologies.

Building foundational technological and organizational capabilities is more important than focusing on high-tech research and development. On the supply side, reforms to improve the quality of foundational skills, and science, technology, engineering and mathematics (STEM) skills are important. But supply-side measures alone will not be enough given the evidence, discussed earlier, that the demand for technical and managerial expertise in firms is constrained by informational market failures. The direct provision of business advisory services to firms has been demonstrated to be effective at transmitting better practices and improving firms' performance in contexts similar to Bangladesh's manufacturing sector. This approach needs to be the centerpiece of direct firm-level public support to firms' capabilities, but it will be critical to implement it through cost-effective programs suited to the local context, such as group-based consulting and "tiered" programs that provide basic advisory services widely, while being more selective in providing intensive advisory services. They are best implemented by private providers in competitive markets, with the government providing financial and regulatory support to develop the market and help firms access high-quality advisory services.

Bangladesh needs to gradually scale up a technology extension system to support up gradation in more advanced firms and sectors. Exporters and firms in subsectors such as pharma would benefit from more advanced capability support—including help in acquiring appropriate sector-specific technologies—while still needing support on organizational capabilities. Technology extension services (TES) should be selectively targeted to such firms. They should be carefully evaluated, and gradually scaled up as more firms ascend the capabilities escalator, minimizing the risk of using scarce resources to encourage technological shifts in firms that are not ready and able to make those shifts. Strengthening basic technology infrastructure, such as quality standards and testing facilities, is also important.

There is also a need to strengthen government capabilities to better target direct support for innovation and technology adoption. There is a significant gap between firms' needs to unlock the technology potential and the current provision of government support. Even though uncertainty of demand, unclear economic benefits of new technology, a lack of information on what is available, and a lack of knowledge on how to acquire it are all among the top self-reported obstacles that firms face to adopt new technology, more than 70 percent of government support takes the form of tax incentives—an instrument that does not address informational issues. Furthermore, many firms lack information about relevant government support programs. The agencies that share the mandate to support the upgradation of SMEs, such as the Small and Medium Enterprise Foundation and the Bangladesh Industrial Technical Assistance Centre, need stronger capacity and better coordination.

Reforms to leverage international connectivity and strengthen complementary markets are also critical

Reducing trade and FDI restrictions will encourage technology adoption by enhancing firms 'connectivity to international markets outside the RMG industry. Trade restrictions that continue to weigh on input competitiveness can be addressed through tariff modernization and making the duty-free import of raw materials through duty drawback schemes and special bonded warehouse (SBW) facilities more accessible to firms outside the RMG industry. Raising FDI by removing foreign equity caps, approval pre-requisites, and uncertainty with regard to financial incentives, while strengthening the contract enforcement framework, targeting investment promotion, and continuing with the special economic zone (SEZ) reforms, can also play a central role in enhancing firms' connectivity to international markets.

Policies to leverage international connectivity for technology adoption must also consider differences in the magnitude and nature of Bangladesh's participation across different sectors.

Ready-made garments. The RMG industry, although well-connected to export markets, could benefit from stronger linkages with MNEs. A new FDI policy framework that removes arbitrary caps on technology transfer transactions, addresses the lack of incentives on research and development (R&D) expenses, and relaxes tight controls on expatriate skilled workers, can harness this potential. There is also a role for supplier development programs that, in collaboration with MNEs, help domestic suppliers upgrade their quality and productivity.

Leather goods and footwear. The leather goods and footwear industry would similarly experience greater technology diffusion from exporting and establishing linkages with MNEs in supply chains. However, unlike the RMG subsector, which has well-established global market linkages, the priority here is to increase Bangladesh's participation in global markets through reducing trade and FDI restrictions, as described earlier. There is also a role for policy measures that increase the capacity of potential suppliers to meet price, quality, and timeliness targets. Government support to firms for product marketing and global market access, including through trade fairs both inside and outside of Bangladesh, is a case in point. Evolving standards of global brands mean that firms must also adopt enhanced environmental safeguards to improve export competitiveness. The Government of Bangladesh should prioritize making the central effluent treatment plant at Savar fully functional, providing technical assistance to obtain the internationally accepted certification, and increasing allocations in the Green Transformation Fund (GTF) for non-RMG exporters.

Pharmaceuticals. While low tariffs on active pharmaceutical ingredients (APIs) facilitate the import of necessary inputs, tariff escalation at the last stage of processing has resulted in high effective rates of protection (ERPs), which is indicative of latent inefficiencies in domestic producers of finished pharmaceutical products. A gradual reduction in this protection is needed to spur the competitiveness of firms to expand beyond the export of generic drugs to unregulated markets, largely in neighboring Asian countries. Partnerships with MNEs through FDI, contract manufacturing, joint ventures and strategic partnerships can also enhance technology transfer to domestic firms. Contract manufacturing for exporting to regulated markets in advanced economies also brings the additional benefits of learning from sophisticated buyers.

Food processing. The potential of technology transfer through international trade and investment links is limited because intermediate inputs, such as crops, livestock, and fish, are typically sourced locally and exports serve niche markets in countries with a large Bangladeshi and South Asian diaspora. Connectivity to international markets can improve the incentives for firms to innovate to the extent that trade is associated with scale economies that improve the returns to innovation. Exporting by SMEs can benefit from logistics support, better post-harvest warehousing capacity, and more internationally accredited testing laboratories.

To support technology adoption, reforms in complementary markets and institutions should prioritize: (i) better allocation of credit through more efficient and deep credit markets; and (ii) a reduction in regulatory gaps and uncertainty. Improving access to finance requires enhancement in the capacity of the banking sector to serve SMEs and improvements in financial sector infrastructure in the short term, while gradually developing capital-market and risk-capital financing in the medium to long term. Removing regulatory gaps and regulatory uncertainty requires close public-private coordination to review and update existing regulations, as well as strengthen the enforcement of current regulations. Special economic zones (SEZs), while providing more reliability in access to uninterrupted electricity supply and land, could also be used as a testing ground for removing regulatory red tape.

Chapter 1: # Manufacturing-led Development In Bangladesh: A Second Wind?

Labor-intensive, export-oriented manufacturing driven by the ready-made garments (RMG) industry has been the cornerstone of Bangladesh's recent economic growth. The COVID-19 pandemic creates immediate challenges for the survival of firms in Bangladesh's manufacturing sector, including in RMG. At the same time, the export basket remains highly concentrated, key products are not climbing up the quality ladder, and firms' productivity remains low. Competing on productivity will therefore be increasingly important, especially as automation, changing trade patterns, and servicification are further reducing the importance of wage costs globally. If low wages are no longer sufficient given these trends, which intensify international competition and may even accelerate with the COVID-19 pandemic, the notion of competitiveness must shift to broader considerations of efficiency. Firms can improve their performance while producing with older technologies if structural reforms reduce the cost of doing business and improve market access. Over time, however, strengthening firms' capabilities to enable innovation and technology adoption will be key to improving efficiency and productivity. International evidence suggests that differences in technology adoption account for up to 75 percent of the income gap between advanced and developing economies. Technology adoption can also help firms to better adjust to the COVID-19 shock.

1.1 From competing on wages to competing on productivity

Labor-intensive, export-oriented manufacturing driven by the RMG industry has been the cornerstone of Bangladesh's recent economic growth. While the export-led manufacturing growth model will undoubtedly remain critical, continued reliance on low labor costs is unlikely to yield dividends if Bangladesh aspires to accelerate its progress toward higher incomes, as laid out in the Government's "Vision 2021" document. Sustained progress toward better jobs is not possible without a broad-based rise in real wages, eventually running into a contradiction with a reliance on low wages for maintaining competitiveness. The diffusion of labor-saving technologies associated with Industry 4.0 and shifting trade patterns are also reducing the importance of low wages in determining competitiveness.

Improving the productivity of firms will therefore become increasingly important for Bangladesh to preserve its global competitiveness, move up the value chain, and create better-paying jobs. While regulatory reform that reduces the cost of doing business can facilitate the reallocation of resources from low- to high-productivity firms, as well as spur market entry, new international evidence emphasizes the importance of productivity growth within existing firms. Upgrading firms' capabilities to better enable innovation and technology adoption will therefore be central in raising the productivity and performance of Bangladesh's manufacturing sector.

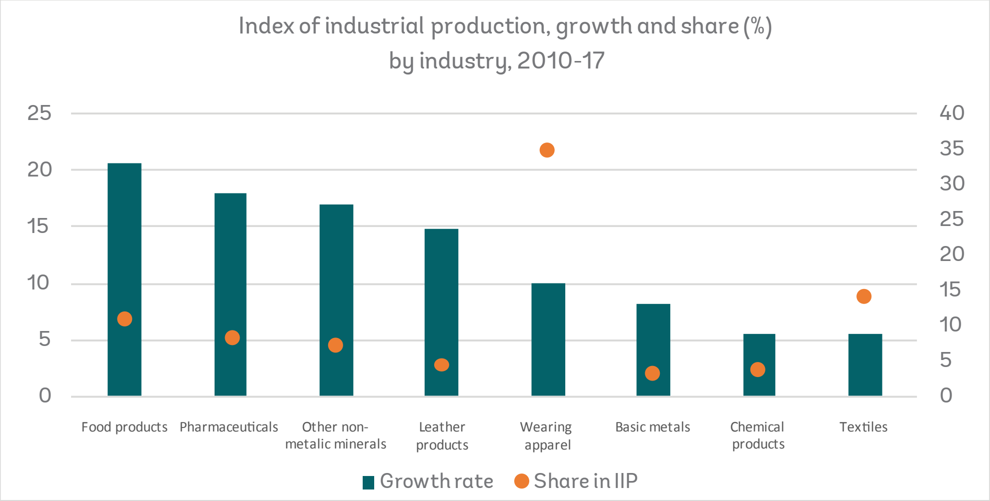
Bangladesh's "National Industrial Policy 2016", which builds on the "Seventh Five-Year Plan 2016–2020", recognizes not only the importance of firms' productivity and technology adoption, but also continues to emphasize the importance of labor-intensive SMEs. The role of improving productivity is discussed, but there is little elaboration on links with technology adoption and few guidelines on policy directions. The role of "industrial technology" is similarly discussed, but this discussion has few updates from the "National Industrial Policy 2010". Furthermore, much of the discussion on innovation relates to support for high-tech industries, tax benefits for R&D expenditure, and the development of incubators to support tech start-ups. There is little focus on upgrading firms' capabilities and basic technology adoption across a large cross-section of firms, including in traditional industries (Khan 2019). Finally, there is limited evidence on the progress made in implementing policy targets related to technology upgrading, such as the establishment of "technology incubation centers," or their impact.

1.2 Labor-intensive export-led manufacturing has helped drive Bangladesh's growth, but faces growing challenges as the future global manufacturing landscape evolves

Annual GDP growth in Bangladesh averaged about 7 percent between 2007 and 2019. Much of this was attributable to the manufacturing sector, which grew, on average, at an annual 10.1 percent during this period. Growth in Bangladesh's manufacturing sector has been both labor-intensive and export-oriented. Bangladesh's exports of manufactured goods have surged, doubling their world market share between 1995 and 2012, making it unique among lower-income countries in its high share of manufactured goods in exports. Three-quarters of the new jobs added in Bangladesh between 2002/03 and 2013 were in the non-agricultural sector, with the manufacturing sector accounting for 37 percent (Khan 2019).

The RMG industry has been central to Bangladesh's manufacturing sector growth. Bangladesh's exports of ready-made garments increased from US$13 billion in 2006 to US$34.1 billion in 2019, making it the world's second-largest exporter after China.[1] What is more, the industry directly employs about 4 million workers and contributes indirectly to the creation of around 10 million jobs elsewhere in the economy. The RMG industry, which accounted for around one-third of total industrial production, has experienced an annual average growth rate of 10.5 percent over the past eight years. Other manufacturing subsectors have also experienced rapid growth in recent years, albeit starting from a low base (Khan 2019). The index of industrial production for medium and large-scale manufacturing enterprises has grown at a double-digit rate, on average, over the past eight years in food products (19.6 percent), pharmaceuticals (19.7 percent), other non-metallic minerals (16.9 percent) and leather products (15.3 percent) (Figure 1-1).

Figure 1-1: RMG is Bangladesh's largest manufacturing industry, but others have grown rapidly too in recent years



Source: Calculations based on Bangladesh Bureau of Statistics.

Note: The combined weight of the eight industries presented in the table account for 86.3 percent of the Index of Industrial Production. The growth rate is measured on the left-hand side axis and the share is measured on the right-hand side axis.

[1] In the first eight months of FY2020 (June 2019 to February 2020), even before the outbreak of the COVID-19 pandemic, Bangladesh's RMG exports dropped by 5.5 percent.

Low wages have helped Bangladeshi RMG exporters remain competitive since the inception of the industry. But this is now changing; average monthly incomes in Bangladesh's manufacturing sector were 3.1 percent higher in 2018 compared with 2013, and wages are expected to rise further as the country consolidates its middle-income status. Furthermore, while average earnings in the RMG industry were estimated at US$0.51 per hour in Bangladesh compared with, respectively, US$1.06 and US$0.51 per hour in India and China,[2] countries such as Ethiopia, Myanmar and Cambodia have recently emerged as lower cost locations.[3]

The COVID-19 pandemic has created immediate challenges for firms' survival in the manufacturing sector, including the RMG industry

The COVID-19 pandemic has quickly evolved from a health emergency into a full-blown economic crisis, spreading rapidly across the globe. In May 2020 - during the first wave of the pandemic - business pulse survey data revealed that about three-quarters of manufacturing firms in Bangladesh were temporarily closed due to the government-mandated lockdown. Furthermore, while only 2 percent of firms reported layoffs, about half had granted a "temporary leave of absence" to some workers. These temporary closures did not vary significantly by firms' size, industry and location, and firms remained uncertain about when business might resume.

As lockdowns were relaxed, firms continued to face constraints on the supply side, either because of the lack of labor with workers returning to their villages, or difficulties in accessing intermediate inputs as value chains are disrupted. On the demand side, the negative impact of the COVID-19 pandemic on final consumption has been paramount. This was also be transmitted internationally through value chains. Export orders from Europe and the United States declined precipitously, and an estimated US$3.2 billion in ready-made garment orders were cancelled or suspended.[4] The shock to the financial sector has inhibited the ability of firms to manage these supply and demand shocks, particularly SMEs, which are fully reliant on bank funding or commercial lending. Among manufacturing firms that were open in Bangladesh during the first wave of the pandemic in May 2020, the vast majority had experienced a decline in demand, hours worked, and the availability of raw materials. Furthermore, firms faced major financial difficulties, with three-quarters expecting to fall into arrears in the next six months and, on average, expecting their cash to last for only 24 more days. SMEs were significantly more likely than large firms to fall into arrears in the next six months and run out of cash faster.

This has created immediate challenges for "keeping the lights on" even among better performing firms, especially with the second wave of the COVID-19 pandemic in May 2021. At the onset of the COVID-19 crisis, in May 2020, the Government of Bangladesh acted quickly and announced a series of support measures for the private sector. These aimed to leverage bank lending to firms (around 72 percent of the program value) and focused on the retention of workers in the export-oriented manufacturing sector (World Bank 2020b). Support measures will continue to remain important with the second wave of the COVID-19 pandemic intensifying in May 2021. However, in doing so, the government will also need to need to ensure that the support reaches all its intended beneficiaries. In May 2020, during the first wave of the pandemic, business pulse survey data revealed that only 2 percent of firms in Bangladesh's manufacturing sector had received government assistance in response to the COVID-19 pandemic. Most firms attributed this to either limited awareness of government schemes, or difficulties and delays in the process of applying for assistance.

Exports remain highly concentrated, key products are not climbing up the quality ladder, and firms' productivity is low

Bangladesh has been unsuccessful in diversifying its export basket, which continues to be overwhelmingly dominated by ready-made garments. The industry has consistently accounted for at least three-quarters of Bangladesh's total exports over the past two decades having, in fact, increased its share from 75 percent in 2000 to 84 percent in 2019 (Figure 1-2). In 2019, leather and leather products accounted for 2.5 percent of total exports and was the second-largest export-earning

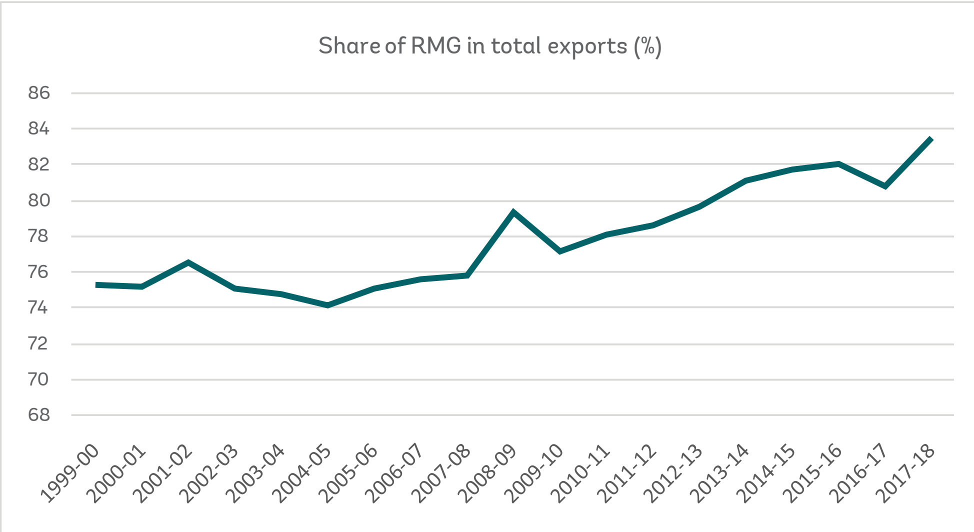
[2] World Bank calculations based on household surveys.

[3] Bangladesh's real effective exchange rate (REER) has also appreciated by around 10 percent over the past two years, while those of Vietnam, China, Cambodia, India, and Pakistan have all depreciated (World Bank 2020a).

[4] Bangladesh Garment Manufacturers and Exporters Association (BGMEA), as of June 1, 2020

source for the country (Khan 2019). Even within the RMG subsector, Bangladesh's exports are concentrated in cotton-based products such as t-shirts, shirts, suits and pants. Globally, however, it is the demand for man-made fiber-based products that continues to rise, accounting for 45 percent of apparel trade worldwide (World Bank 2020a).

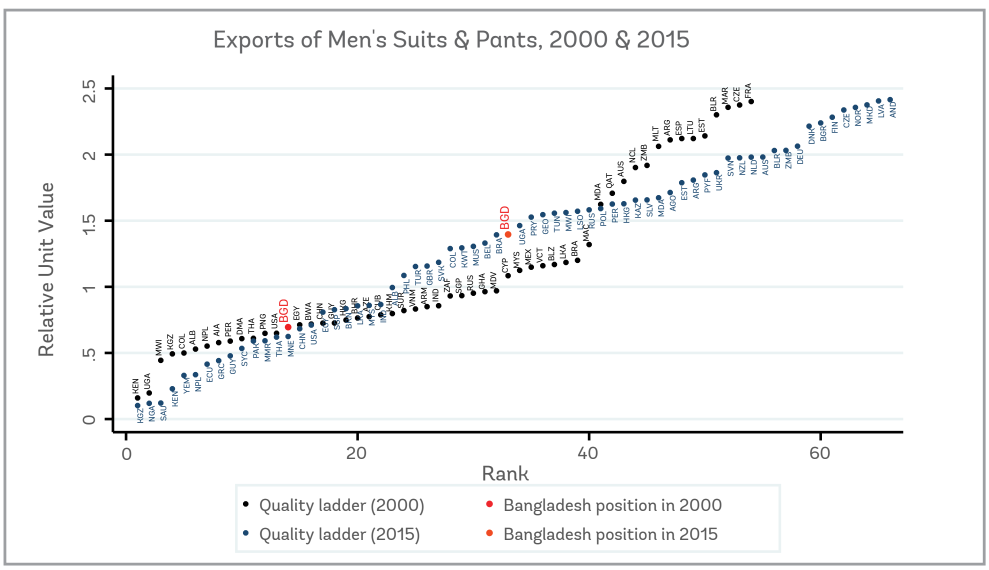
Figure 1-2: Bangladesh has been unsuccessful in diversifying its export basket



Source: Bangladesh Export Promotion Board.

The overall sophistication of Bangladesh's merchandise exports, as measured by the Export Sophistication Index [EXPY] indicator,[5] failed to increase between 2000 and 2014 (Lopez-Acevedo, Medvedev and Palmade 2017). Bangladesh's leading export subsector, ready-made garments, also remains on the lower rungs of the global product quality ladder, despite recent improvements. Take the example of "men's suits and pants", which was Bangladesh's largest export in 2017. Measured by the price that exporters fetch in international markets compared with other producers,[6] Bangladesh's position on the quality ladder moved up by 15 positions between 2000 and 2015, but it remains in the bottom half of the global distribution (Figure 1-3). Other key RMG exports, such as cotton t-shirts, have lost ground on the global quality ladder, moving down six positions between 2000 and 2013 (Lopez-Acevedo, Medvedev and Palmade 2017).

Figure 1-3: Bangladesh's key RMG exports continue to lag on the global quality ladder



Source: Calculations based on UN COMTRADE database.

Growth in value-added among large and medium-size firms in Bangladesh's manufacturing sector has outpaced the sector's overall growth every year since 2007 (Khan 2019). This is not surprising given that large firms are typically more productive than smaller ones owing to a range of factors, including economies of scale, easier access to finance, better employees, and stronger management practices (De Mel, McKenzie and Woodruff 2008; Cohen and Klepper 1996; Ayyagari, Demirgüç-Kunt and Maksimovic 2007; Bloom et al. 2013). Despite this, small firms are not widespread in Bangladesh, with only limited movement in resources from less to more productive firms.[7] This disproportionately high number of small, unproductive firms in Bangladesh's manufacturing sector also neither grow nor exit the market. Firms aged 25 years or more are only around 50 percent larger than firms aged less than five years. In contrast, older firms in Vietnam, Indonesia and China are, on average, 4.5, 4.8, and 2.4 times the size of younger firms, respectively (Lopez-Acevedo, Medvedev and Pal made 2017).

New technologies, shifting trade patterns, and the servicification of production are changing the future manufacturing landscape by reducing the importance of wage costs globally

Low- and middle-income countries (LMICs), including Bangladesh, have traditionally competed based on lower-cost labor. But new labor-saving technologies, such as robotics, the Internet-of-Things (IoT) and 3-D printing, are reducing the importance of low wages in determining competitiveness. Trade patterns are changing too. For one, there is the global economy that has been growing at its slowest pace since the global financial crisis of 2007/08. Moreover, with shifting consumer preferences for speed and customization that emphasize shorter, tailored production runs, countries near major markets in Europe and the United States might be at an advantage. Furthermore, while shifts in sourcing orders from China to other developing countries due to the US-China trade dispute create new opportunities, competition among other potential exporting countries is intensifying. In fact, least-developed countries (LDCs) such as Myanmar and Cambodia receive duty-free quota-free market access to the European Union,[8] which Bangladesh will cease to benefit from once it graduates from LDC status. The increasing "servicification" of manufacturing, especially the rise of professional, scientific and technical services as a necessary complement to the success of manufacturing, is also raising the bar to be globally competitive.

> *"New labor-saving technologies, such as robotics, the Internet-of-Things (IoT) and 3-D printing, are reducing the importance of low wages in determining competitiveness."*

There is some early international evidence suggesting that industrial automation in high-income countries (HICs) might change trade and offshoring patterns in the future. Artuc, Bastos and Rijkers (2019) show that a 10-percentage-point increase in robot density in developed countries is associated with a 6.1-percentage-point increase in their imports from less developed countries, and a 11.8-percentage-point increase in their exports to these countries, such that net imports from within the same sector decline by 5.7 percentage points.[9] Hallward-Driemeier and Nayyar (2019) find that, past a threshold level, the increasing intensity of robot use in HICs is negatively associated with the growth rate of outbound FDI from HICs to LMICs. However, only about one-third of the sample exceeds the threshold level of robots per 1,000 employees, beyond which further automation results in a decline or deceleration in FDI growth. Among a set of 35 products that are increasingly being 3-D printed, Freund et al. (2019) find some evidence of a reversal of comparative advantage whereby the technology may be used to produce closer to consumers for products with high transport costs.

5 In the EXPY indicator, each export good is assigned the value of the average per capita income of other countries exporting that good; the country's EXPY is the average of these values, weighted by the good's share of total exports (Hausmann, Hwang, and Rodrik 2006). The EXPY indicator must be interpreted with caution, because it reflects the final product exported rather than the task carried out locally.

6 The unit values secured by exporters are used here as a proxy because true product quality is unobserved. Differences in unit value may also reflect differences in manufacturing costs observed across firms or even across countries (Khandelwal 2010).

7 Among firms with 10 or more employees, less than 60 percent employ more than 24 people. The RMG subsector is an exception, with 90 percent of the "non-micro firms" employing more than 24 people (Khan 2019).

8 Under "Everything But Arms" (EBA).

9 The positive impact of robotization in developed countries on imports from the less developed countries is mainly driven by exchanges of parts and components.

The extent to which automation technologies, shifting trade patterns and the servicification of production are changing the global manufacturing landscape varies by industry. Among industries that have experienced high rates of growth in Bangladesh over the past decade, pharmaceutical products combine relatively high automation, export concentration and professional services intensity.[10] In contrast, international competition is likely to increase least in a range of commodity-based manufactures that are less affected by these three trends. Food processing is relatively more intensive in the use of professional services, but global competition will likely intensify to a lesser degree because the industry is less traded internationally (Hallward-Driemeier and Nayyar 2017).

The apparel, leather goods and footwear subsector has been slowest to automate in HICs, even in China where wages continue to rise. Adidas' "Speedfactories" in Ansbach, Germany and Atlanta, which use computerized knitting, robotic cutting, and 3-D printing to produce athletic footwear, were heralded as evidence of how automation would lead to wide-scale reshoring. In late 2019, however, the company announced that these automated production lines would instead be moved to China and Vietnam, where 90 percent of Adidas' suppliers are currently located. However, the subsector must contend with retail sales in major markets that have not recovered since the 2007/08 global financial crisis.[11] Furthermore, "fast fashion" places an emphasis on goods that are design-intensive, typically produced in small batches on short cycles, and benefit from proximity to consumer markets. Morocco and Turkey have, in fact, found renewed vigor due to their proximity with Europe; for example, 50 percent of production for Spanish Inditex, the world's largest fashion group, is located in Morocco (World Bank 2018). This might present a new challenge to apparel exporters in Bangladesh.[12]

These global trends that will intensify international competition in the future may accelerate with the COVID-19 pandemic.

The current COVID-19 pandemic has exposed the vulnerabilities of global value chains (GVCs), which are characterized by high interdependencies between global lead firms and suppliers fragmented across the globe. Many countries have faced supply shortages of medical equipment and other critical intermediate inputs, particularly from China (Baldwin and Tomiura 2020). This creates a case for reducing the concentration of globally fragmented production among firms in China, thereby resulting in new potential export opportunities for Bangladesh. This shift in sourcing patterns away from China reinforces a trend initiated by the US-China trade wars. In a recent survey of the United States Fashion Industry Association conducted before the COVID-19 pandemic, 84 percent of buyers expected a decline in sourcing from China in the next two years. Bangladesh can potentially step in but will need to compete with other developing countries, such as Vietnam and Mexico, that have already benefited from such trade diversion (Nicita 2019).

At the same time, the external conditions for global competition may also become more difficult to the extent that the current crisis spurs further automation and reshoring in GVCs to higher-wage economies. There might also be greater automation if robots can enable factories to adapt to post-COVID workplace arrangements by emphasizing physical spacing between employees on assembly lines. For example, a highly automated chip company in Wuhan, China, kept operating throughout the lockdown (The Economist, April 8, 2020). From a lead-firm perspective, labor-saving technologies associated with Industry 4.0 potentially reduce reliance on low-skill, low-cost labor in manufacturing. Automation, as a result, can consolidate various steps of the value chain, moving production closer to key final consumer markets in China, Japan, Europe and the United States (Seric and Winkler 2020). This automation and reshoring allow for more flexible adjustment, thereby mitigating firms' risks in the event of demand or supply shocks.

10 Other manufacturing industries that similarly combine relatively high automation, export concentration, and professional services intensity include electronics, computers, and optical instruments; transportation equipment; other machinery and equipment; and electrical machinery and apparatus.

11 Sales of RMG products in the United States dropped by 2.8 percent in October 2019. Similarly, sales of textiles, clothing and footwear in the euro area has dropped by 0.8 percent in October 2019 compared with the previous month (World Bank 2020a).

12 Negative growth in Bangladesh's RMG exports between June 2019 and February 2020 (even before the COVID-19 shock) perhaps reflects a range of these changing demand patterns, and near-shoring.

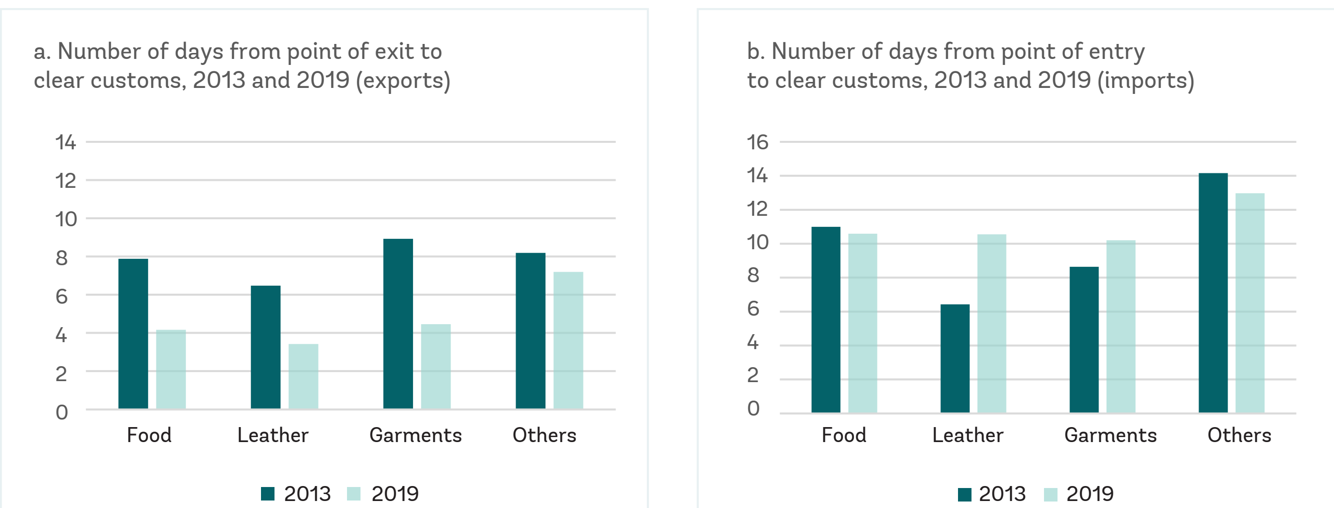
1.3 Bangladesh's competitiveness will increasingly depend on raising productivity, which can benefit from lower costs of doing business and better market access

If low wages are no longer sufficient to stay competitive given the trends that intensify international competition, other countries that are more embedded in GVCs might emerge with a better wage-productivity combination. Evidence suggests that RMG firms in Bangladesh fare less well than competitors in South and East Asia on quality, lead times, and reliability (Lopez-Acevedo and Robertson 2016). Improving productivity with rising wages will therefore become increasingly important for Bangladeshi firms to preserve their competitiveness in RMG, where the pressures of global competition are likely to intensify despite lower exposure to automation compared with other industries. The same holds true for diversification into the leather goods and footwear industry.

The broader considerations of efficiency include more demanding ecosystem requirements in terms of infrastructure, logistics and other backbone services, skills, regulatory requirements, supplier base, and so on. Similarly, there is the consideration of expanding access to markets through tariff reductions, low non-tariff barriers (NTBs), and efficient logistics.

Bangladesh has made progress in reducing the cost of doing business and improving market access. The number of days it takes, on average, for goods to clear customs from the time these goods arrive at their main point of exit (e.g., port, airport) halved from eight days in 2013 to four in 2019 for firms in the RMG industry. The corresponding reduction for firms in the leather goods and footwear subsector was six to three days between 2013 and 2019 (Figure 1-4a). The progress is less apparent on the import side. The number of days it takes, on average, for goods to clear customs from the time these goods arrived at their main point of entry did not decline for either RMG firms or leather goods and footwear importers between 2013 and 2019 (Figure 1-4b).[13]

Figure 1-4: Bangladesh has improved its logistics performance, but it remains a constraint



Source: Bangladesh FAT Survey and World Bank Enterprise Survey 2013.

However, benchmarking with other countries in the region reveals considerable room for improvement. In the global "ease of doing business rankings" for 2020, Bangladesh moved up eight places on its position in 2019 and still ranked 168th. The overall score of 45 in 2020, while a slight improvement from 42.5 in 2019, still lags India (71.0), Pakistan (61.0), Sri Lanka (61.8) Vietnam (69.8), the Philippines (62.8), Malaysia (81.5) and Cambodia (53.8).

13 The actual increase in the number of days between 2013 and 2019 is not statistically significant and is driven by the small number of firms covered in the surveys among these industry groups.

Bangladesh ranks similarly poorly on the World Bank's Logistics Performance Index (LPI), including relative to comparator countries such as India, Pakistan, Vietnam, and the Philippines (Figure 1-5). These constraints on the ease of doing business and logistics performance are also reflected in changing firms' perceptions. The share of firms that report transport as a major or very severe obstacle to their operations did not decline between 2013 and 2019 in either RMG or leather goods and footwear. In fact, the share of firms reporting customs and trade regulations as a major or very severe obstacle to their operations increased between 2013 and 2019, from 10 to 15 percent in the leather goods and footwear subsector, and from 7 to 15 percent in the RMG subsector.[14]

Figure 1-5: There is considerable room for Bangladesh to reduce the cost of doing business

Source: World Development Indicators.

Note: 2016 and 2018 are the latest available years for the Logistics Performance Index. Only countries where all data points are available are included.

While structural reforms that reduce the cost of doing business and improve market access promote the reallocation of resources toward more productive firms, they do little for upgrading firms' capabilities and improving entrepreneurship dynamics. The right sets of skills for managers and workers in firms are increasingly central to increasing productivity, especially to enable innovation in contexts where knowing that a new technology exists, or even buying a license to use it, is not sufficient to being able to adopt it in practice.

1.4 Strengthening firms' capabilities to enable innovation and technology adoption is becoming increasingly central to jobs and economic transformation

New evidence, based on firm-level data in the manufacturing sector across several developing countries, shows that increases in productivity within existing firms (the "within" -component) are relatively more important than the reallocation of resources from low-productivity firms to high-productivity firms (the "between" component), and the

> *While structural reforms that reduce the cost of doing business and improve market access promote the reallocation of resources toward more productive firms, upgrading firms' capabilities is increasingly central to increasing productivity*

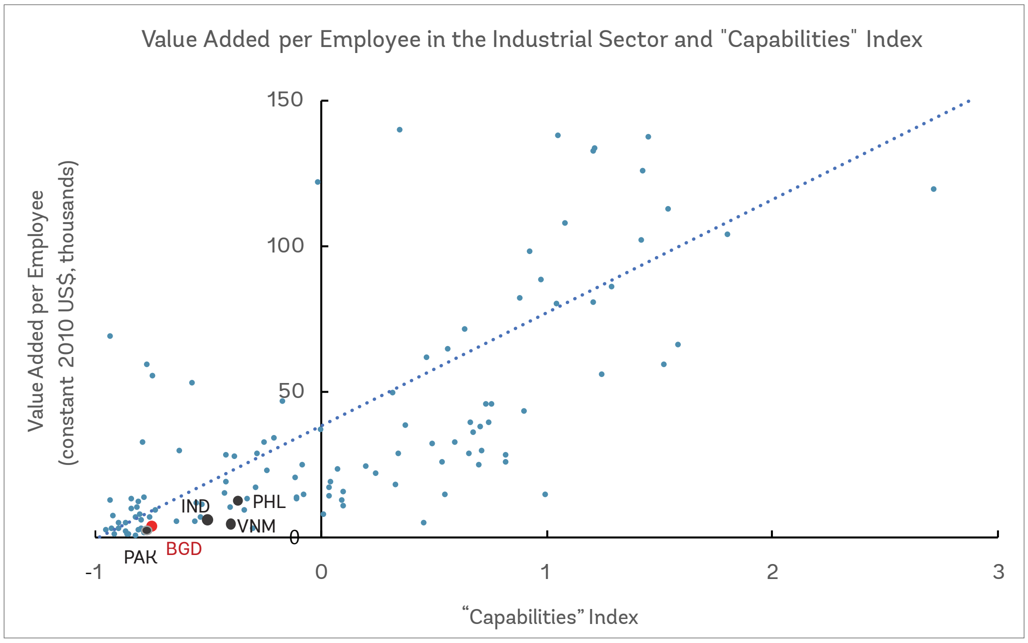
[14] Calculations based on World Bank Enterprise Survey 2013 and Bangladesh FAT Survey 2019.

[15] Caselli and Coleman 2001; Comin and Hobijn 2004; Foster and Rosenzweig 2010.

entry of high-productivity and exit of low-productivity firms (the "selection" component), accounting for between about one-quarter and one-half of productivity growth (Cusolito and Maloney 2018).

Innovation and technology adoption are emphasized as an important reason for productivity gaps between firms (Syverson 2011). These include both "hard" technologies embedded in infrastructure, machinery and raw material, and "soft" technologies where knowledge is derived from human capital, managerial practices and firm organization (Bloom and Van Reenen 2007; Bloom et al. 2010, 2014). Technological differences also account for major differences in per-capita income and the wages of workers with similar skills across countries. Comin and Mestieri (2018), for example, estimate that differences in technology adoption account for up to 75 percent of the income gap between advanced economies and developing economies. Developing the capabilities to maximize growth opportunities that result from technological change will require the right mix of worker skills, management practices and supporting infrastructure. Innovation capabilities across countries are positively correlated with higher levels of labor productivity and Bangladesh does worse than almost all comparator countries (Figure 1-6).

Figure 1-6: "Capabilities" are positively associated with labor productivity, 2015



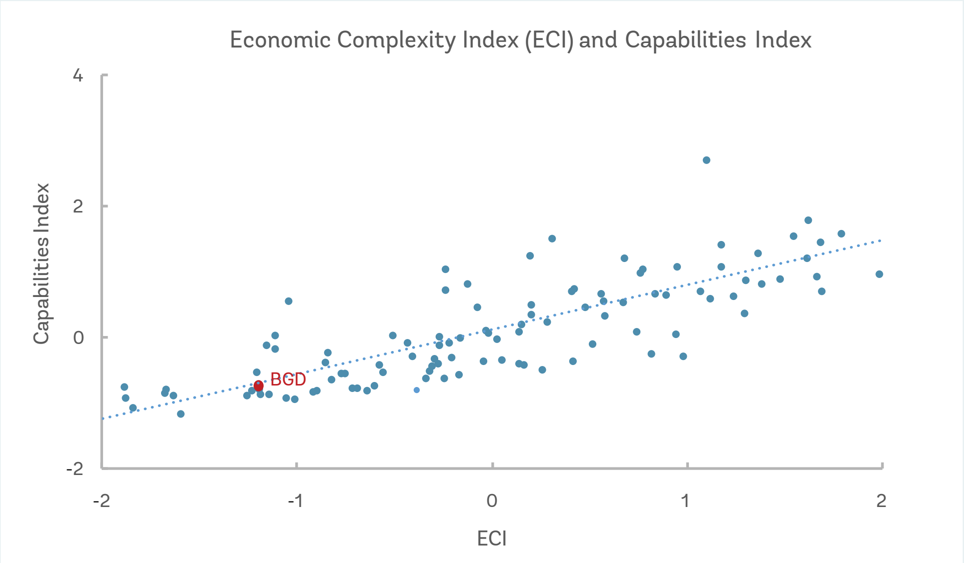
Source: Calculations based on World Development Indicators; Hallward-Driemeier and Nayyar 2017.

Note: The industrial sector includes mining, manufacturing, construction, and utilities. The "capability" index comprises ICT use, tertiary school enrollment rates, and the share of royalty payments and receipts in trade. The three indicators and converted to z-scores to normalize their scales and then averaged.

Over the medium to long term, Bangladesh's capabilities to innovate and adopt new technologies will also be important in moving up the value chain. Innovation capabilities across countries are positively correlated with levels of export sophistication[16] and Bangladesh does worse than almost all comparator countries (Figure 1-7). It is also possible that automated processes standardize a higher quality of production. For example, Ford Motor Company's highly automated sprawling 460-acre facility in Gujarat, India, which churns out 240,000 vehicles and 270,000 engines a year, greatly resembles what one would see in North America or Europe. If using older technologies renders firms in Bangladesh uncompetitive, particularly if higher-quality goods can be produced at lower prices with new technologies, they may need to adopt the latter to stay in business.

[16] Measured here by the Economic Complexity Index from MIT's Atlas of Economic Complexity.

Figure 1-7: "Capabilities" are positively associated with export sophistication, 2017



Source: Authors' calculations based on World Development Indicators, MIT Atlas of Complexity, and Hallward-Driemeier and Nayyar 2017.

Technologies are spreading faster between countries than ever before. In a comparison of 25 general-purpose technologies (GPTs) in the past 200 years, Comin and Mastieri (2018) find that newer technologies, such as the personal computer and the internet, are arriving faster in developing countries than older ones, such as the telegraph and the tractor. Yet, the gap between developing and advanced economies in the intensity of the use of these technologies across firms and workers within countries is increasing. Today, the differences in the intensity of technology use within countries account for a larger share of cross-country income differences than the adoption lags between countries do. This suggests that most firms in lower-income countries such as Bangladesh need to catch up to just the national technology frontier, let alone the global technology frontier.

Technology adoption is vital for the sustained creation of good jobs

Long-term increases in earnings in the manufacturing sector—the source of livelihoods for many of the poor in Bangladesh—can be achieved only by increasing labor productivity (Cusolito and Maloney 2019). Being central to raising productivity, technology adoption is therefore pivotal to generating good jobs. In the short run, technologies make it feasible for machines to replace labor, but their effect on aggregate employment is a function of the technology per se, how their use varies across industries, and the extent to which resulting efficiency gains increase the demand for labor in complementary tasks.

Technologies vary in their underlying source of efficiency gains and thereby imply different degrees of labor substitution (Hallward-Driemeier et al. 2020). E-commerce and other digital platforms better match sellers and buyers to facilitate market transactions. Informational technologies, such as business management software and cloud computing, exploit the exponential growth of data to reduce the cost of computing. These technologies, much like computerization, make it feasible for machines to replace labor in routine tasks that can be easily codified. Yet, unlike the resulting hollowing out of middle-skill jobs such as bookkeeping, clerical work, and repetitive production in the United States (Autor and Dorn 2013), there is limited evidence of labor market polarization in LMICs so far (Maloney and Molina 2016). Industrial technologies, such as robots and 3-D printing, combine data with physical automation to reduce labor costs. In many cases, however, these technologies save material costs, such as through energy-efficient machines, without replacing labor.

Furthermore, even among industrial technologies that directly replace labor, there are differences in the magnitude of use across manufacturing industries. The transportation equipment industry is where the use of industrial robots is most widespread, followed by the manufacture of rubber and plastic products, metals and metal products, industrial machinery, and electronics. The transportation industry stands out, having experienced the largest increase in the use of industrial robots among HICs in Europe and the United States between 1993 and 2016. At the same time, the use of industrial robots in the manufacture of apparel, footwear and leather products—where Bangladesh is strong or has significant potential—remained negligible over the same period (Hallward-Driemeier and Nayyar 2017).[17] 3-D printing has a considerable presence or significant potential in only a handful of industries, such as medical equipment, engine and motor parts, and components for motor vehicles (Arvis et al. 2017).

Last but not least, international evidence shows that automation does not necessarily reduce aggregate employment. The substitution of cheaper machines for human labor boosts productivity which, in turn, can increase the demand for labor in non-automated tasks. Recent estimates, which combine the negative displacement and positive productivity effects of industrial robots on local labor markets, range from a mildly negative to a positive impact. Acemoglu and Restrepo (2017) find that the use of one more robot per 1,000 workers reduced the aggregate employment-to-population ratio by about 0.34 of a percentage point from 1990 to 2007 in the United States. This amounts to one new robot reducing employment by 5.6 workers. However, for a broader sample of countries that also includes those in Western Europe, Australia, Japan, and the Republic of Korea, Autor and Salomons (2018) find that automation-induced job losses in some industries were more than offset by employment gains in other industries.

Importantly, what is automatable may not necessarily be automated owing to considerations of commercial viability. The lower magnitude of automation in developing economies might be explained in large part by lower labor costs. However, if labor-saving technologies that raise efficiency are necessary for firms in Bangladesh to remain globally competitive—in the apparel industry, for instance—then not adopting them could lead to closures and job losses. Similarly, there are additional "potential jobs" that could be lost by never being created. For example, because HICs are adopting new technologies and reducing their labor-cost disadvantage, the product cycle and jobs in the transportation equipment or electronics subsectors might not migrate to Bangladesh as it attempts to diversify its export basket.

Technology adoption can be a useful complement to government support in helping firms mitigate the COVID-19 shock, but the uncertainty might hinder investment

As the Government responds to the COVID-19 pandemic with a range of financial support programs, the use of digital technologies can be a useful complement in enabling firms to better adjust to the COVID-19 shock. E-commerce platforms can enable firms to maintain access to necessary intermediate inputs and a distribution network for their products. Similarly, online fintech platforms can facilitate supply-chain finance to SMEs by reverse-factoring transactions. Better management can also better address any disruption of industrial production whereby updated organizational practices incorporate all relevant precautions with respect to hygiene and physical distancing in factories. Automation too can help labor-intensive manufacturing facilities adapt to post-COVID-19 workplace arrangements by emphasizing physical spacing between employees on assembly lines.

Despite this, the uncertainty surrounding the length and breadth of the pandemic will likely lower investments, and the appetite for risk associated with innovation and entrepreneurship. In May 2020, during the first wave of the COVID-19 pandemic, business pulse survey data showed that most manufacturing firms in Bangladesh were pessimistic and uncertain about their future sales. Furthermore, these expectations varied considerably across firms, which implies a high level of uncertainty.[18]

17 The use of direct injection machines for automating the molding of shoes soles is an exception to the norm, including in Bangladesh where each such machine has replaced about 80 workers among footwear manufacturers.

18 The average variance of expected sales as a percentage of pre-crisis levels is about 1,000. To place it in perspective, the variance of expected sales is only 267 in a hypothetical case where a firm expects sales to go up by 20 percent, stay the same or fall by 20 percent with equal likelihoods. Firms were asked to describe three possible scenarios for their sales in the next six months—pessimistic, optimistic and "regular". Using this information, we estimated the expected sales (relative to pre-crisis levels) in the next six months and its variance (uncertainty) for each firm.

Given the high levels of uncertainty about market conditions, it is not surprising that firms are holding off on investing in new technologies and business practices in response to the COVID-19 pandemic. In May 2020, during the first wave of the COVID-19 pandemic, the survey data revealed that only 6 percent of the firms increased their use of the internet and digital platforms; only 3 percent invested in new equipment or software; and only 3 percent introduced a new product. In order to reduce this uncertainty and help productive firms recover, especially as the second wave of the COVID-19 pandemic has intensified in May 2021, financial support should therefore be complemented by policies that provide regulatory guidance, strengthen the regulatory framework for insolvency and debt resolution, and simplify tax and customs administration (World Bank 2020b).

1.5 The structure and analytical framework of this report

Chapter 2 assesses the extent of technology adoption, and how it relates to the productivity and economic performance of firms in Bangladesh's manufacturing sector using data from a new survey- the Bangladesh Firm-level Adoption of Technology (FAT) Survey. In doing so, this report organizes technologies into three types based on the underlying source of efficiency gains (Hallward-Driemeier et al. 2020). Transactional technologies reduce information asymmetries and thereby facilitate market transactions that might otherwise not happen. Examples include digital e-commerce platforms and digital payment systems. Informational technologies exploit the exponential growth of data to reduce the cost of computing. Examples include business management software. Both transactional and informational technologies are general-purpose technologies. Industrial technologies, in contrast, combine data with automation to reduce costs including labor, materials and, in many cases, energy in production stages that are often industry specific. Examples include robots and 3-D printing. Management practices related to setting targets, incentivizing employees and monitoring performance are also considered as an additional technology type.

Chapters 3, 4, and 5 then examine the factors that determine technology adoption in firms in order to identify ways for policies to better leverage these factors to upgrade firms' performance. This report categorizes these factors into three types depending on their channels of influence and the primary level of intervention (Figure 1-8). Capabilities are the accumulated human and organizational capital of firms that determine their ability to absorb new technologies and practices. Connectivity to GVCs, multinationals and international knowledge flows influence technology adoption through information and market pressure. As discussed in this report, Bangladesh's connectivity to international markets differs across sectors in its nature and magnitude, and hence the policies to leverage connectivity must be designed with sector-specific needs in mind. Complementary markets and institutions, such as contractual institutions and financial markets, influence the costs and benefits of technologies through several channels. Although complementary markets and institutions vary across firms and sectors, they are primarily economy-wide factors. Chapter 6 provides recommendations under each of these three policy levers.

Figure 1-8: The three policy levers available to upgrade firms' technologies and business practices

Chapter 2: The State Of Technology Adoption In Bangladesh's Manufacturing Industries

The technology level of Bangladeshi manufacturing firms is characterized by a low average and high variance. Some firms are near the global technology frontier, but most use basic technologies in production, business processes, management and transactions. Many firms still use rudimentary technologies such as handwritten processes for business administration, cash for payments, and manually powered and operated machinery. Comparable data from Vietnam indicate that Bangladesh is one step behind the former in several technology dimensions. The low level of technology adoption is puzzling because there is a strong positive association between technology levels and firms' performance (as measured by revenue and profits per worker). Eighteen percent of the total variation in firms' performance in the sample can be accounted for just by their differences in technology. This is comparable to the share of the variation in firms' performance that is jointly accounted for by other key attributes, including firms' size, age, sector, location, physical and human capital. The positive association between technology and firms' performance is driven by general-purpose informational technologies and managerial practices, not sector-specific industrial technology. However, more advanced industrial technology is associated positively with exporting. Technology diffusion is therefore a powerful and largely untapped policy lever for raising growth rates and improving export performance.

2.1 The diffusion of technology is a powerful but little understood lever for growth

Productivity growth, improvements in product quality, and other forms of innovation within firms are major drivers of aggregate productivity growth (Syverson 2011; Hseih and Klenow 2014; Collard-Wexler and De Loecker 2014; Restuccia 2016). For example, in the United States, most recent innovation has come from existing firms improving their products (Hseih and Klenow 2018). Accelerating the pace of such internal improvement in firms will be increasingly critical for Bangladesh's growth model as labor costs rise and international competition grows.

Firm-level productivity in low- and middle-income countries (LMICs) is low on average, but also variable, with a "long tail" of firms with very low productivity levels (Tybout 2000; Hseih and Klenow 2009; Hseih and Olken 2014). Even firms making the same product vary substantially in their efficiency. For example, in a small group of Bangladeshi t-shirt manufacturers, the most efficient firm was found to be 50 percent more efficient than the least efficient firm (Chaudhry et al. 2016). When three Pakistani firms—a large-scale exporter, a medium-sized exporter and a small firm—were asked

to stitch, finish and wash an identical pair of jeans, the large-scale exporter finished the task in two-thirds the time taken by the medium exporter, and in about half the time taken by the small firm (Chaudhuri and Faran 2016).

Technology—whether embodied in advanced machinery or an intangible such as software—is a major factor behind these differences in firms' performance (Syverson 2011). It matters even in industries that are not considered to be technology-driven. Consider the evidence from a recent study of carpentry firms in Uganda. In this setting, firms at the 75th percentile of the distribution of profits per worker earn over five times more profits per worker than firms at the 25th percentile of the distribution. There are many different types of machine than can be used together in carpentry, and firms vary significantly with regard to how many of these machines they use. This variation in the usage of machines accounts for a large part of their variation in profits per worker, even more so than other important firm attributes such as size (Bassi et al. 2019).

Management practices adopted by firms also matter. Firm-level data on managerial practices collected by the World Management Surveys show that the average management quality of firms in middle-income countries (MICs) such as India and China is notably low compared with high-income countries (HICs) such as the United States (Bloom and Van Reenen 2010). It is also highly variable: while a few firms are near the global frontier for management quality, most are poorly managed (Bloom and Van Reenen 2010). Even firms that are otherwise very similar can be very different in terms of their business practices (McKenzie and Woodruff 2017). This is surprising because adopting better management practices can improve firms' performance significantly (Bloom et al. 2013 and 2020; Bruhn et al. 2018; Iacovone et al. 2018).

Systematic and objective information on the patterns, impacts and drivers of technology use in Bangladeshi firms is critical for designing effective policies to upgrade firms' performance, particularly since the existing evidence is based on small samples and specific contexts (mostly, the ready-made garments subsector). The rest of this chapter describes technology adoption in Bangladesh's manufacturing sector using unique new data from the 2019-20 Bangladesh Firm-level Adoption of Technology (FAT) survey. It also analyzes the association between technology and firms' performance.

2.2 Technology adoption in manufacturing: Most firms are far from the technology frontier

Firm-level technology has many dimensions

A unique feature of this report is the quality and detail of its firm-level technology adoption data. These data are from the 2019-20 Bangladesh FAT Survey, a part of the global FAT project of the World Bank (Cirera et al. 2020). The FAT surveys are distinguished by a detailed set of questions on technology adoption. Rather than asking a generic question on the adoption of a "new production method/process," each technology question refers to a very specific production stage/process, including industry-specific technologies. The Annex provides more information on the survey, including basic summary statistics (Annex Table A1).

Before discussing specific types of technologies, it is worth noting that the prevalence of basic "technology-enabling" infrastructure among firms is varied (Annex Table A2). Although all the firms surveyed have an electricity connection, 77 percent also have a private generator. A strikingly high share (56 percent) does not have a connection to the main water supply. Cell phones are ubiquitous, but only about 60 percent of the firms have computers, and about 65 percent have an internet connection (mobile or fixed).

A typology of technology

The technologies used by firms can be broadly categorized as **industrial technologies** and **general-purpose technologies.**

Industrial technologies, often sector-specific, improve quality and/or save labor. Examples of such technologies include:

i. Fully manual machines, such as manual sewing machines in the garment and leather goods industries;
ii. Motorized machines operated by a person, such as motorized sewing machines;
iii. Motorized semi-automated machines, such as sewing machines in which some functions are computerized;
iv. Automated machines, or robots; and
v. Other advanced machines such as 3-D printers.

Global technological advances in processes for assembling, producing and packaging products potentially have wide-ranging economic implications, from reducing the role of unskilled labor (through greater automation) to making economies of scale in production less relevant (through 3-D printing). The future potential of some of the most recently developed industrial technologies to drastically alter the nature of production has even caused them to be referred to as "disruptive" technologies (see Box 2-1).

> *Global technological advances in processes for assembling, producing and packaging products potentially have wide-ranging economic implications.*

General-purpose technologies (GPTs) can be sub-categorized into the following:

A. Informational technologies, which use software to reduce the cost of computing in business process. Examples range from basic, generic spreadsheets to more specialized software, such as enterprise resource planning (ERP) software, supplier relationship management software and customer relationship management software.

B. Transactional technologies, which match buyers and sellers, and enable firms to access markets more efficiently. Examples range from the use of email for sales and wire transfer for payments to e-commerce platforms, online and mobile digital payment platforms.

This categorization of technologies into industrial, informational and transactional follows Hallward-Driemeier et al. (2020). In addition, this report also considers management practices as a dimension of technology. Good management practices aim to improve efficiency, quality and innovativeness. Examples include the use of incentive payments to improve employee performance, employee performance monitoring, planning and target-setting.

Technology indices

As discussed, the technology adoption questions in the FAT surveys each correspond to a particular production stage or business process. These questions are used to construct four indices that summarize the adoption level in each technology category. Each index combines the information from all the technology questions relevant to its category on a scale of 1 to 5, with higher numbers indicating more advanced technology levels.[19] The four category-wise technology indices are also combined into an "Overall Technology Index".

[19] For example, suppose there are three questions on informational technologies. A firm's response on each question is first coded on a five-point scale, with higher numbers corresponding to more advanced technologies. The firm's informational index value is the simple average of these three scores.

Box 2-1: The potential of "disruptive technologies"

The term "disruptive technologies" in the manufacturing sector refers to certain advanced technologies that could significantly alter the nature of the production process, and enable manufacturers to increase their competitiveness through changes in costs, efficiency, speed and product quality. Given the trend of convergence in digital and physical manufacturing across industries, these advanced technologies will become increasingly important for maintaining competitiveness in the global economy. They could also help meet sustainable development goals by improving resource efficiency and enabling more sustainable business models. Thus far, though, these technologies have primarily been concentrated in advanced economies and in certain industries, including the automotive, electronics, and aerospace industries, among others.

Focusing on the potential of these technologies in the Bangladeshi context, a few industries are quick to come to mind. First, the combination of additive manufacturing (i.e., 3-D printing) and use of collaborative robots, as well as augmented artificial intelligence (AI), can help reach higher efficiency in the garments subsector. As an example, AI could be used for image recognition purposes, working to detect fabric distortions. Another industry whose landscape could substantially be altered is agriculture, in which the use of "agri-tech" technology can be implemented. Examples of such technologies include data-connected devices using Internet-of-Things (IoT), AI in agricultural biochemistry and biotechnology, as well as farm robotics and automation. Finally, Bangladesh's pharmaceutical industry could gain from adopting disruptive technologies in the drug manufacturing process.

The devising of such advanced, disruptive technologies is contributing to a dramatic shift in the manufacturing world. In time, the adoption and implementation of these technologies will play a major role in helping countries remain (or become) competitive players in global value chains.

Source: Based on inputs from two forthcoming World Bank reports: "Bangladesh Disruptive Technologies Assessment" and Mittal and Raunak, forthcoming, "Bangladesh: The Future of Jobs." Washington, DC: World Bank.

Technology levels vary across firms, but most of them use basic technologies

How far away are the leading Bangladeshi firms from the global technological frontier? How much do technologies vary within the same sector? Are Bangladeshi firms more advanced in terms of some technologies than others? This section explores these questions.

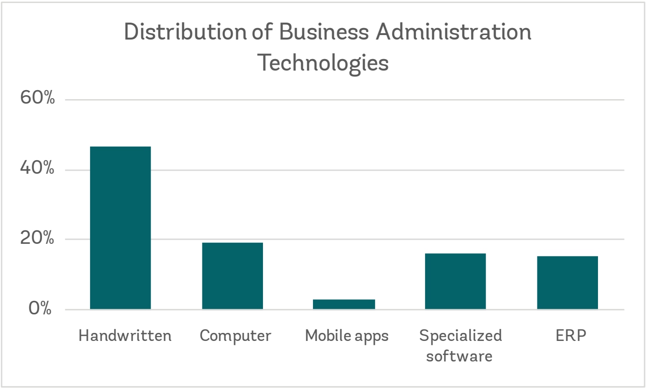
Informational technology: Rudimentary technologies are prevalent, but some firms are advanced

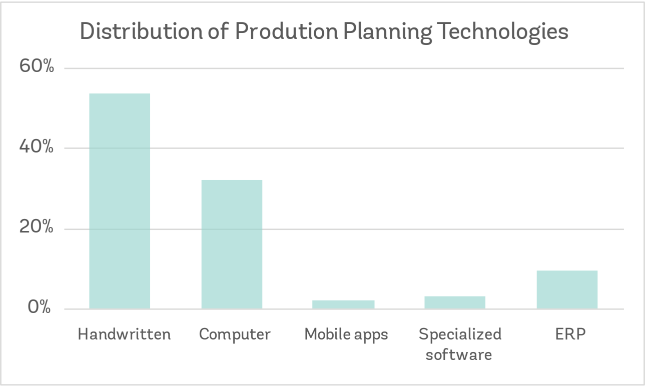
The majority of firms use the most rudimentary versions of informational technologies.[20] Consider two business processes—business administration and production planning. The former refers to the processes for managing finance, accounting and human resources, while the latter is used for forecasting demand, and planning production and services operations accordingly. Forty-seven percent (respectively, 53 percent) of firms are still using handwritten processes for business administration (respectively, production planning) (Figure 2-1). Nineteen percent (respectively, 32 percent) use computers for business administration (respectively, production planning). Note that this refers to the use of general spreadsheet programs such as Excel, and not specialized business software. The adoption rate of more advanced technologies such as specialized software, mobile apps and enterprise resource planning (ERP)—an integrated

[20] In the technology level distributions discussed in this chapter, the sum of the shares of the different technologies used in a given production stage can exceed 100 because some firms use multiple technologies for the same process. The findings are similar if only the technology that is most intensively used by a firm is considered when estimating these distributions.

management system that is the global frontier technology—is much lower, though not negligible. In particular, 15 percent (respectively, 10 percent) of firms report using ERP for business administration (respectively, production planning). Thus, while most firms are at basic levels of technology, some firms are at the global frontier.

Figure 2-1: The distributions of production planning and business administration technologies



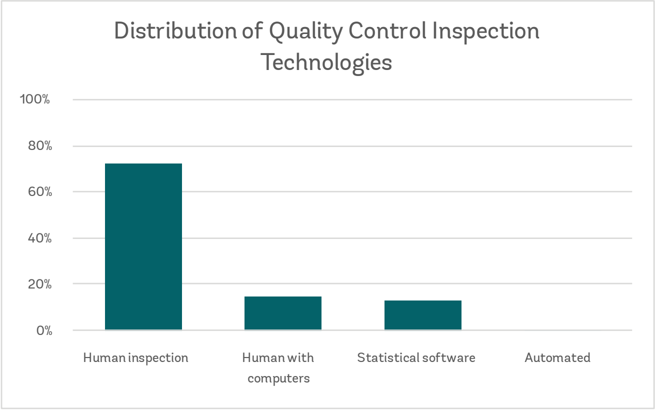


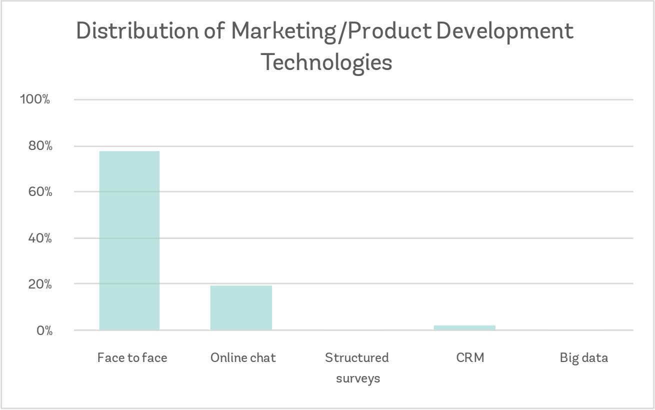
Source: Bangladesh FAT Survey.

Next, consider quality control inspections (Figure 2-2, left panel). Here, too, most firms are using the most traditional method: human inspectors unaided by computers. Seventy-two percent of firms use human inspectors not equipped with computers, while only 13 percent use statistical quality control software. The share of firms using automated quality control methods is negligible.

Similarly, in marketing and product development—defined as the process of collecting and analyzing information from customers for marketing purposes or product development—the traditional method of face-to-face customer interaction is still prevalent (Figure 2-2, right panel). Twenty percent of firms have reached the next technological stage, namely online chats. Almost no firms use advanced techniques such as structured surveys, customer relationship management (CRM) software and big data analytics.

Figure 2-2: The distributions of marketing, product development and quality control technologies





Source: Bangladesh FAT Survey.

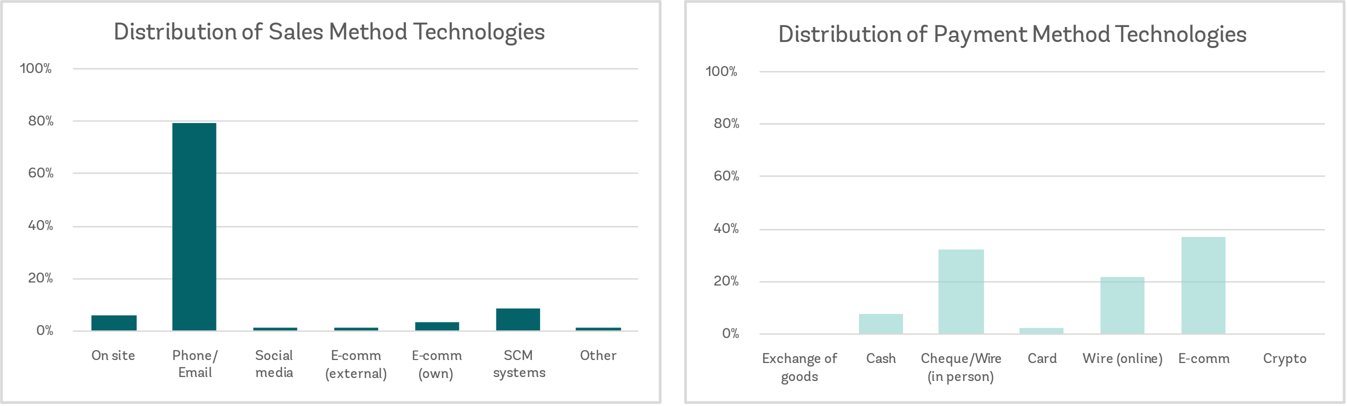
Transactional technology: While firms have started using digital payment platforms, cash and traditional sales methods still dominate

Access to digital technologies that match buyers and sellers could help Bangladeshi manufacturing firms improve their performance by reducing transactions costs, such as costs related to market search and reputation building (Goldfarb and Tucker 2020). For example, a food products firm could sell niche items catering to narrow regional tastes through an e-commerce website. Firms could also use the product rating systems of e-commerce websites to build a reputation for quality. In China, entire villages specialize in making a single product in small enterprises and selling it on the "Taobao" e-commerce platform (see, for example, Qi et al. 2019).

Surprisingly, e-commerce is not used much in the studied subsectors. Among the surveyed firms that report selling their products directly to consumers, only 14 percent use advanced digital sales technologies such as social media, e-commerce platforms, or supply chain management systems (Figure 2-3, left panel). Most firms use phones or emails.

Digital payments technology is more widespread, although not used intensively. Thirty-seven percent of firms use e-commerce (that is, mobile phone-based payment apps) as a means of payment (Figure 2-3, right panel). Nonetheless, when asked which payment method accounts for the largest share of sales, most firms (about 85 percent) still name traditional methods, i.e., cash or check.

Figure 2-3: The distributions of sales and payment technologies

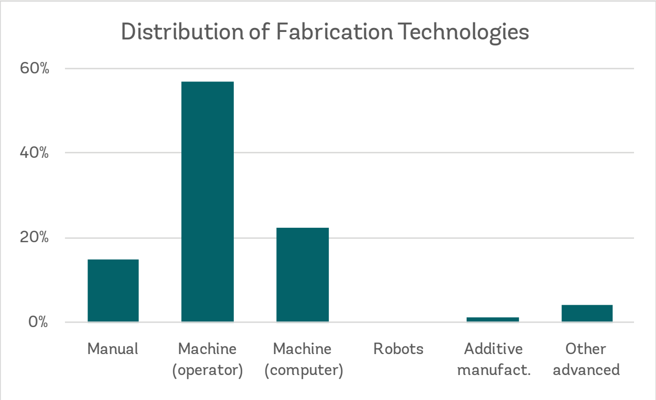


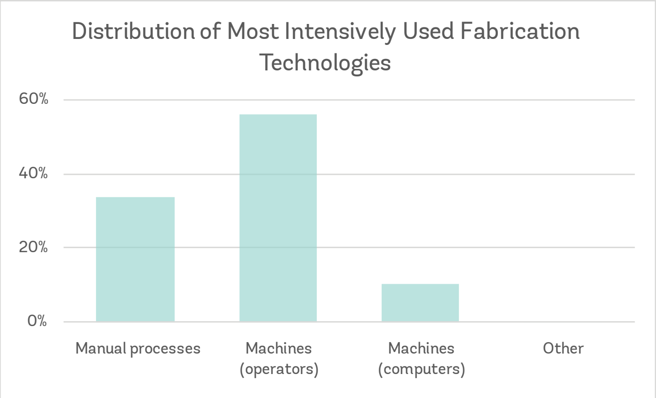
Source: Bangladesh FAT Survey.

Industrial technology: Some firms are approaching the global frontier, but most are at basic and intermediate levels

When it comes to industrial technology adoption in Bangladesh, a small number of firms close to the global technology frontier coexist with a large mass of firms that still use basic technologies. Considering the overall industrial fabrication process (which is composed of several sector-specific production stages), 15 percent of firms in the studied sectors use the most basic of fabrication technologies imaginable: manually operated equipment (Figure 2-4, left panel). Meanwhile, more than half (57 percent) of them use powered machinery with manual operators. A sizable share (22 percent) is at the next stage of industrial technology: semi-automated machinery controlled by computers. Finally, a very small percentage (5 percent) of firms use frontier technologies such as fully automated machinery (robots) and additive methods (such as 3-D printers, laser, plasma "sputtering", and "micromachining"). Even these frontier firms are not intensive users of advanced technologies; indeed, there is no firm for which fully automated or additive technology is the most intensively used fabrication technique (Figure 2-4, right panel).

Figure 2-4: The distributions of fabrication technologies





Source: Bangladesh FAT Survey.

The findings of the survey are consistent with the anecdotal evidence gathered from interim consultations with factory owners and managers conducted during the preparation of this report. Most of the firms that were consulted do not report using advanced industry specific technologies. The most commonly cited examples of technology adoption involve the replacement of manual processes with machinery, such as, for example, the replacement of manual "edge painting" of leather goods by edge-painting machines in some firms in the leather goods subsector. However, large export-oriented firms, particularly those in the garments subsector, are aware of the latest technological advances in their industry, and a few of them have even acquired automated machinery on a trial basis. But these firms are not yet using automated machinery intensively.

Drilling down to the sector-specific production stages, it is still the case that "basic" technologies prevail.[21] For example, 70 percent or more of garment and leather firms use basic technologies in the design, cutting and finishing stages (Figure 2-5). But there is variation between and within subsectors. Eighty-nine percent of garment firms use a non-basic technology in the sewing stage, in contrast to the other sector-specific production stages in which technology levels are mostly basic. In food processing, as many as 84 percent of firms use a non-basic technology in the mixing/blending/cooking stages, whereas technology levels in the other stages are mostly basic.

Looking across subsectors, technology levels are generally the most advanced in pharmaceuticals, where 85 to 90 percent of firms use non-basic technologies in all but one sector-specific production stage. This sectoral variation in industrial technologies is not surprising given the sector specificity in production processes and their inherent technological possibilities. For example, the garments subsector is among the least automated subsectors globally, even in countries such as China where labor costs have been rising (Hallward-Driemeier and Nayyar 2017). Some production stages, such as sewing, are inherently difficult to automate. The pharmaceuticals subsector, in contrast, uses semi-automated and automated technologies world-wide.

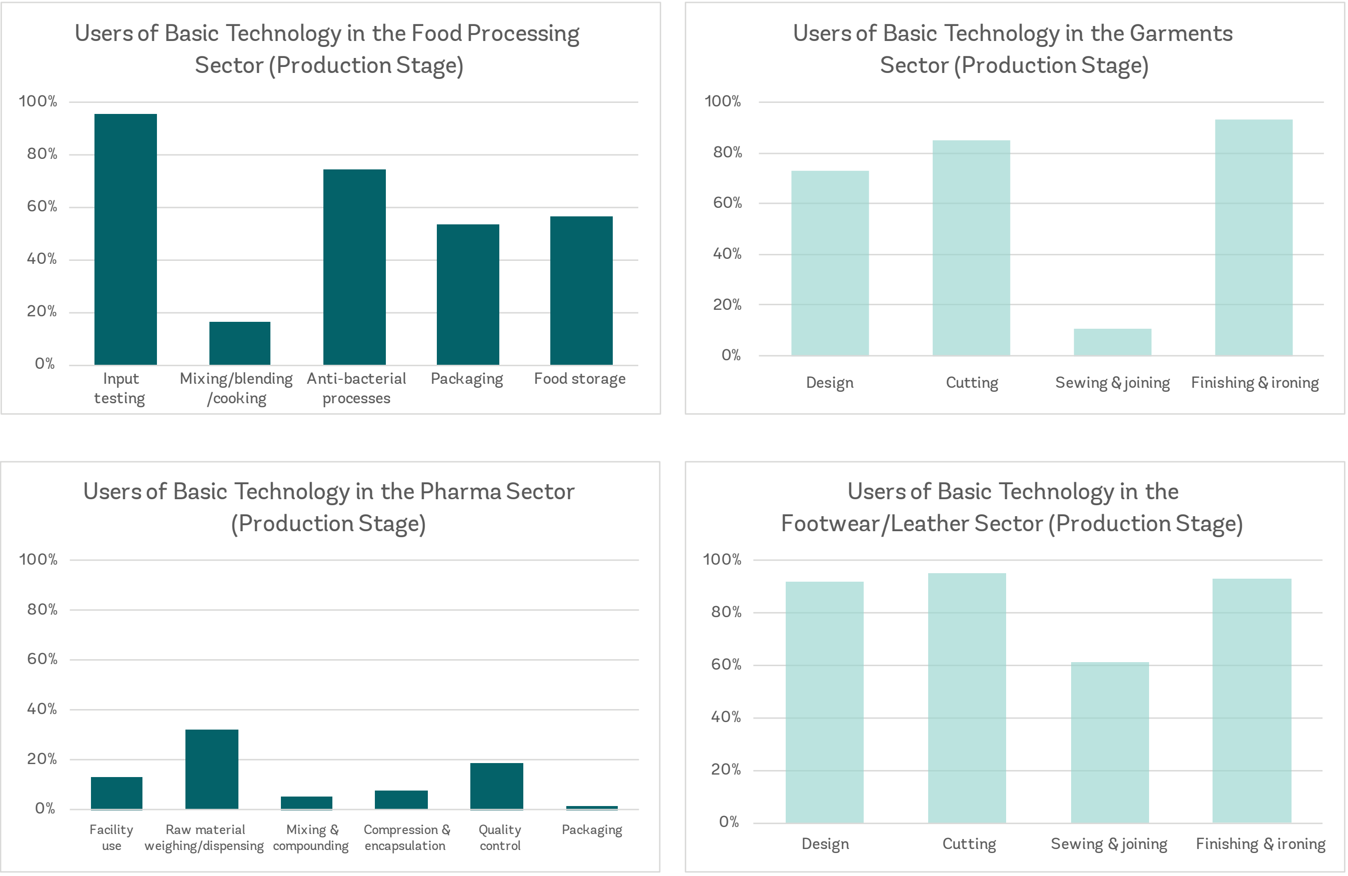
Nonetheless, the inherent technological limits of production processes alone do not determine adoption levels. This is illustrated by the marked differences in non-basic sewing technology adoption between two technologically similar subsectors: garments, and leather goods and footwear firms.[22] In contrast with nearly 90 percent of garment firms, less than 40 percent of leather goods firms use a non-basic technology in their sewing stage.

21 Here, "basic" refers to non-mechanized or mechanized but manually controlled methods. For example, a basic sewing technology in a garment firm is either a manual sewing machine or a motorized machine that is fully controlled by a human operator. Semi-automated (computerized) sewing machines, fully automated sewing machines and 3-D printers are categorized as non-basic.

22 Most leather goods and footwear products involve the cutting and stitching of a material such as leather, just as most garment products involve the cutting and stitching of cloth. Sports footwear, which can use molded injection of synthetic material, is an exception.

Note that firms using a non-basic technology are not necessarily using an advanced automated technology. In fact, most of the non-basic technologies being used in Bangladesh's manufacturing sector are semi-automated processes—a step below fully automated methods on the technology ladder. In the garments subsector, for example, the median firm uses a semi-automated sewing machine, and automated sewing technology is used only by the top 10 percent of firms. In the leather goods subsector, fewer than 10 percent of firms use automated sewing technology.

Figure 2-5: Percentage of firms using "basic" technologies in each sector-specific production stage



Source: Bangladesh FAT Survey.

Management practices: Many firms do not even use basic management practices

Based on the World Management Survey (WMS) framework, management quality in a firm can be characterized along three dimensions: (i) monitoring—how well do companies monitor what goes on inside their firms and use this information for continuous improvement; (ii) targets—how well do companies set targets, track outcomes, and take appropriate action if the two are inconsistent; and (iii) incentives—the extent to which promotions and rewards to employees are based on performance, and hiring is based on merit (Bloom and Van Reenen 2010).

Many Bangladeshi manufacturing firms do not even use the most basic practices for monitoring, targeting and setting incentives (Figure 2-6). Thirty-eight percent of firms do not offer any incentives to workers, 32 percent do not monitor any key performance indicators (KPIs), and 37 percent have only short-run targets with a horizon of less than one year.

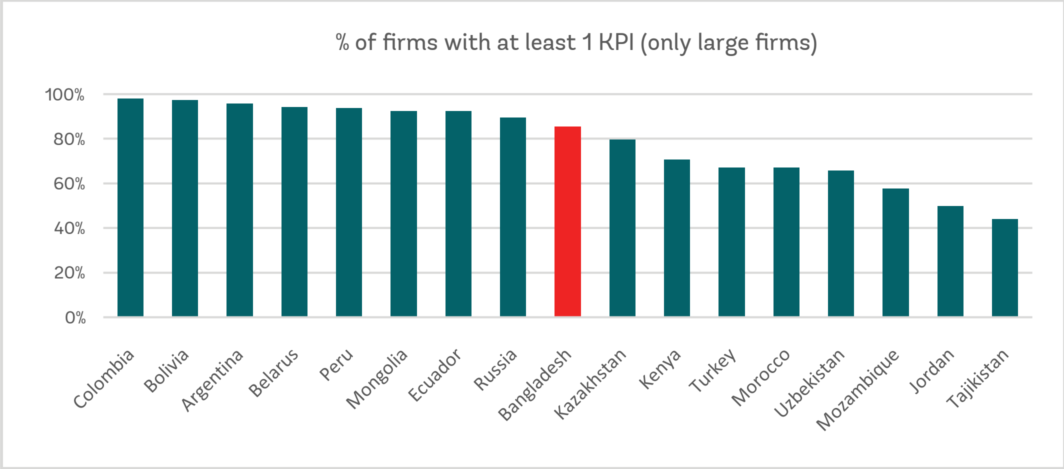
Figure 2-6: Many firms do not employ even basic management practices

Source: Bangladesh FAT Survey.

Among LMICs, weak management practices are not unique to Bangladesh. For example, Bangladesh is on the intermediate rung in terms of its share of large firms monitoring at least one KPI (Figure 2-7).[23] Business practices among small Bangladeshi firms too are similar to most LMICs, in terms of their low average and high variance of management quality (McKenzie and Woodruff 2016).

The adoption rate of advanced management techniques is very low (Figure 2-8). Almost no firm in Bangladesh uses common management techniques, such as Total Quality Management, Lean Production, Just-in-time, Kaizen and Six Sigma. Only 18 percent have achieved the international business certification of ISO 9000 or its equivalent.

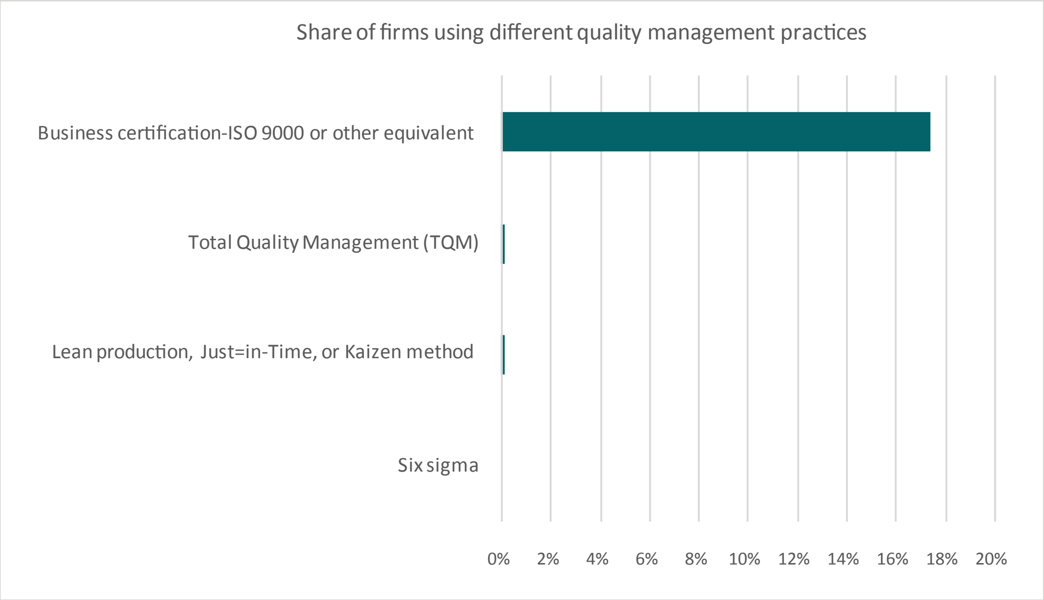
Figure 2-7: A cross-country comparison of a basic management practice (monitoring a KPI)



Source: World Bank Enterprise Surveys and Bangladesh FAT Survey.

23 This comparison is feasible because recent waves of the World Bank Enterprise Surveys, which focused on Latin America, Eastern Europe and Central Asia, included a question on the use of KPIs that is comparable to that asked in the Bangladesh FAT Survey.

Figure 2-8 : Adoption rates of advanced management techniques are abysmal



Source: Bangladesh FAT Survey.

Heterogeneity in technology adoption: Firms' size is the main differentiator

Large firms use significantly more advanced technologies than SMEs.[24] For example, on a scale from 1 to 5, the mean value of the industrial technology index is 2.8 among large firms (those with more than 100 employees), as opposed to 1.7 in medium firms (those with 20 to 99 employees) and 1.6 in small firms (Figure 2-9). The differences are statistically significant. However, there are no statistically significant differences in the mean value of the technology indices between small and medium firms.

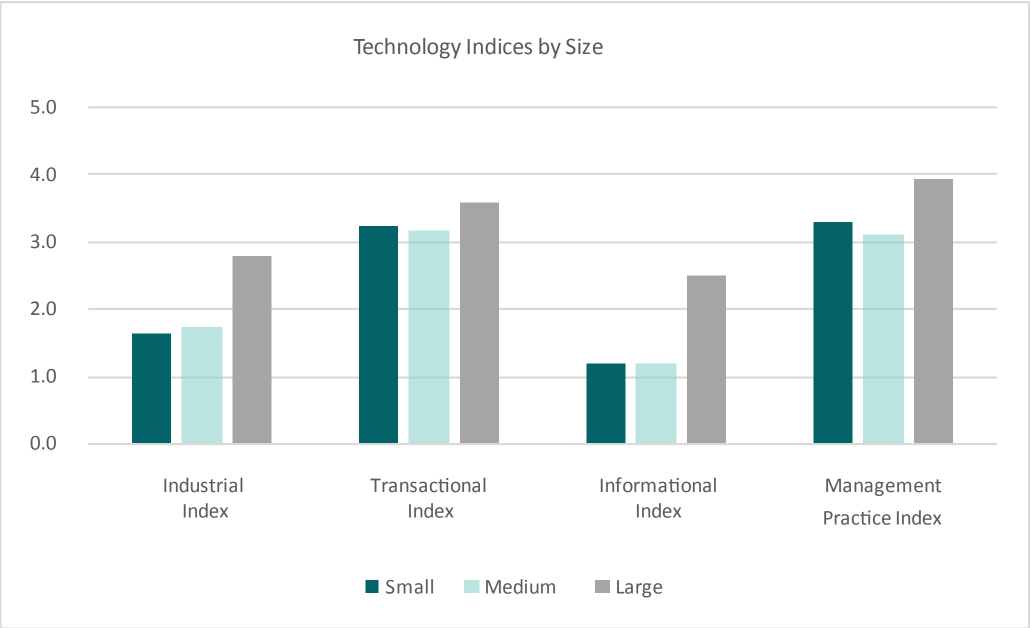
While evidence on the determinants of technology adoption by firms is discussed in later chapters, it is worth noting at this juncture that the positive relationship between firms' size and technology levels could be due to the fact that many advanced technologies involve economies of scale. Advanced machinery is often large and indivisible, and it may not make economic sense for a small firm to purchase such expensive machinery if it would remain underutilized. This scale-dependence of many advanced machines was noted by several of the firms interviewed for this study, across many sectors.

At the same time, scale economies cannot fully explain the relationship between firms' size and technology adoption. Not all advanced machinery is large and indivisible. For example, advanced sewing machines are no larger than basic ones, and so the decision to adopt them should not depend on the scale of production. Small firms could also temporarily rent machinery if scale were the only issue (and such rental markets exist in developing countries; see Bassi et al. 2019). Lastly, many digital technologies do not involve obvious economies of scale, and yet we observe a positive relationship between firms' size and the adoption of informational technology. Therefore, the positive association between firms' size and technology could also reflect other potential mechanisms, such as larger firms having easier access to complementary markets (such as the market for finance) or possessing stronger technological capabilities.

> *"Large firms use significantly more advanced technology than SMEs."*

[24] These size-based differences are robust to controlling for other firm attributes such as sector, location and age. See Annex Table A3.

Figure 2-9: Average value of technology indices by firms' size group



Source: Bangladesh FAT Survey.

Technology levels also differ by sector and location, although not to the same extent as they do by size.[25] Given size, age and location, pharmaceutical firms have significantly higher levels of industrial, informational and management technology than firms in other subsectors.[26] Notably, garments firms do not have significantly higher technology levels once we adjust for size; indeed, the level of automation and informational technology is significantly higher among food processing and pharma firms.

Controlling for size, sector and age, firms located in Dhaka have superior technologies compared with those in Chittagong, Rajshahi and Khulna. This could be due to agglomeration effects in the diffusion of technology, or it could reflect unobserved differences in firms' attributes and the business environment between Dhaka and other areas. Interestingly, firms' age is not significantly correlated with technology levels given firms' size.

Is Bangladesh at par with international peers in firm-level technology?

Where does Bangladesh stand relative to key international comparators with regard to technology use in the manufacturing sector? A comparison with Vietnam is apt because they are both fast-growing lower middle-income countries with similarly sized manufacturing sectors (as a share of GDP), major competitors in the global apparel market, and in transition from a labor-intensive growth model to a more productivity-led growth model (World Bank 2016). Comparable firm-level technology adoption data from the Vietnam FAT Survey (Cirera et al. 2021) and the Bangladesh FAT Survey suggest that firms in Vietnam are more advanced than those in Bangladesh in the adoption of both general-purpose informational technologies and sector-specific production technologies in most manufacturing subsectors. These gaps, however, are not extreme and Vietnam is typically just one technology level ahead of Bangladesh. The gaps are also smaller in sector-specific technology levels where firms in the garments industry are, in fact, roughly at par while Bangladesh is more advanced than Vietnam in the pharmaceuticals industry (see Box 2-2). This suggests that incremental improvements in technology could bring Bangladesh on a par with its peers in manufacturing.

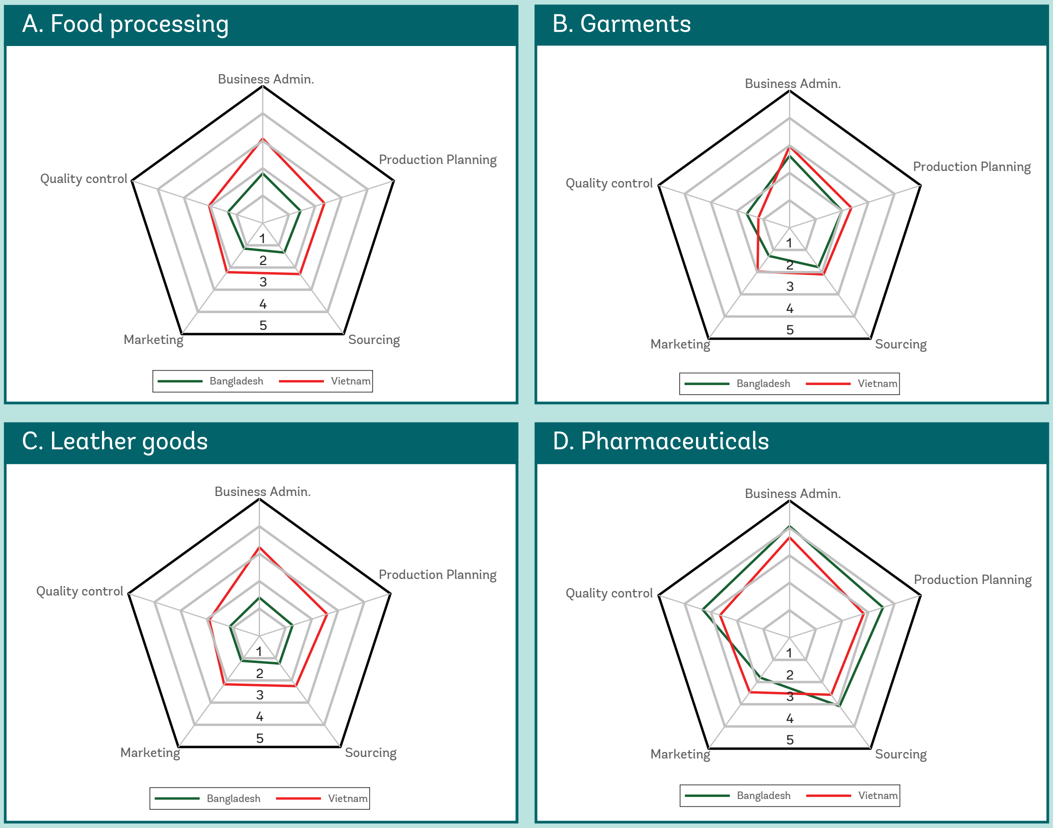
[25] Based on regressions of technology indices on core firm attributes such as sector, size, age and location, shown in Annex Table A3.

[26] The omitted sector dummy (the reference category) is the "other manufacturing" sector, so the values of the sector dummies are to be interpreted as measuring the level of technology relative to other manufacturing.

Box 2-2: Competing on technology: A case study of firm-level technology use in Bangladesh and Vietnam

Comparable firm-level technology adoption data from the Vietnam FAT survey (Cirera et al. 2021) and the Bangladesh FAT Survey reveal some clear differences in general-purpose technologies (GPTs) in the manufacturing sectors of these two countries. For every general-purpose business function in the FAT surveys—business administration, production planning, sourcing, marketing and quality control—a firm's technology level is quantified on a scale of 1 to 5, with 1 representing the most basic (that is, handwritten or manual) level and 5 representing the global frontier. The score is then averaged across all the firms in a sector. In the food processing and leather goods subsectors, Vietnam's average technology scores are about 1 point higher than that of Bangladesh in all five functional dimensions (Figure B1, panels A and C). Vietnam leads in garments, too, though the gaps are smaller (and negligible in the case of quality control methods) (Figure B1, panel B). Pharmaceuticals is an exception, with Bangladesh ahead of Vietnam in all dimensions except for marketing (Figure B1, panel D).

Figure B1 : Vietnam is generally more advanced than Bangladesh in the use of general purpose technologies in manufacturing firms



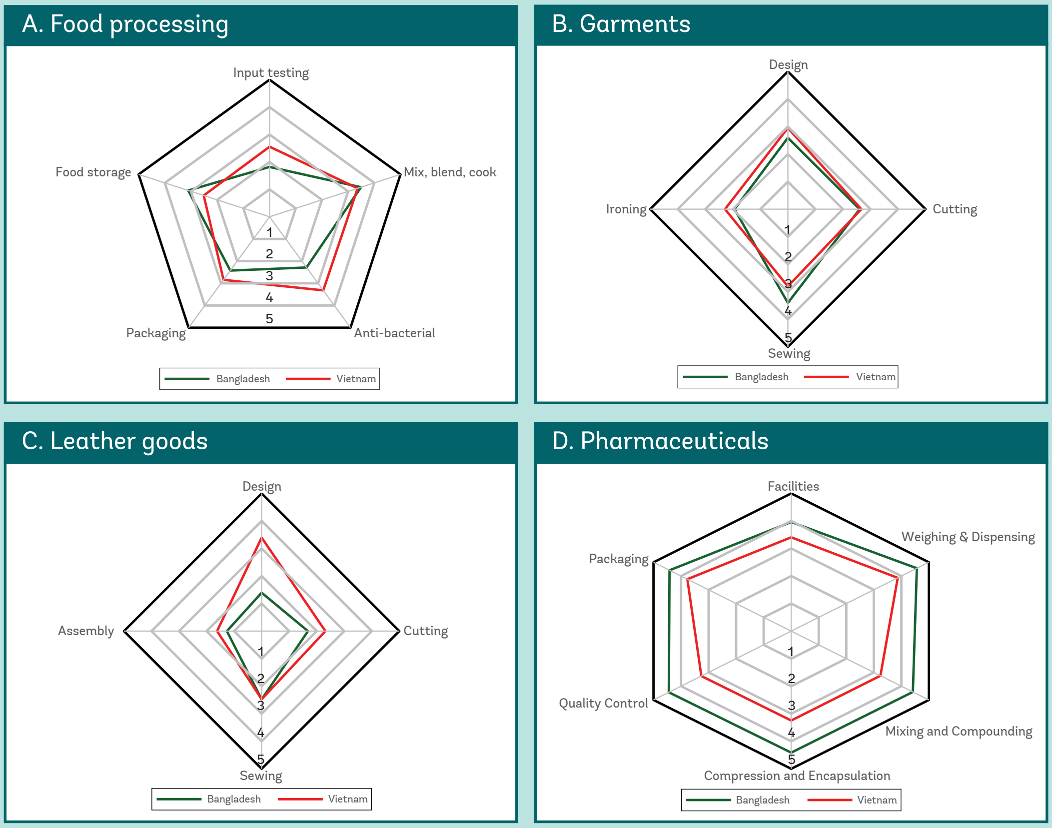
Source: Staff calculations based on Bangladesh FAT Survey and Vietnam FAT Survey (Cirera et al.2020).

Vietnam is also generally more advanced than Bangladesh in sector-specific technologies, but the gaps are not as large as in GPTs, and are more pronounced in Bangladesh's nascent sectors and in the more skill-intensive (or "soft") production functions. The two countries are nearly on a par in the functions of mixing, blending and cooking in the food processing industry, and of sewing in the garments and leather goods industries (Figure B2, panels A, B and C). However, Bangladesh tends to lag in the relatively "soft" production stages, such as design in the case of leather goods, and input testing and anti-bacterial processes in food processing.

In the garments industry, the two countries have similar sector-specific technology levels (Figure B2, Panel B). Thus, Vietnam's technological edge over Bangladesh in this subsector is driven by GPTs. Yet, even this edge could become increasingly pivotal given the global trend toward servicification in manufacturing.

As is the case with GPTs, Bangladesh leads Vietnam in terms of sector-specific technologies in the pharmaceutical subsector. Pharmaceuticals is a technological outlier among manufacturing industries in Bangladesh. This may be related to a unique trade policy regime and related developments in this subsector, which is discussed later in this report.

Figure B2 : Bangladesh lags Vietnams in sector-specific technologies in its more nascent sectors



Source: Staff calculations based on Bangladesh FAT Survey and Vietnam FAT Survey (Cirera et al. 2021).

The technological gaps between Vietnam and Bangladesh are not extreme: barring some exceptions, Vietnam is essentially just one level ahead of Bangladesh. The use of frontier or "Industry 4.0" technologies is rare in both countries. In Vietnam, about 6.1 percent of manufacturing firms use additive manufacturing and other advanced fabrication technologies (Cirera et al. 2-21), compared with about 5 percent in Bangladesh.

Summing up, these patterns suggest that even small improvements in general purpose technologies across all sectors, and in sector-specific technologies in the more nascent sectors such as leather goods, could increase the global competitiveness of Bangladesh's manufacturing sector. Given that the gap between Vietnam and Bangladesh is generally larger in the more skill-intensive business functions, complementary investments in skills could also help.

Sources:Cirera, Xavier; Comin, Diego A.;Cruz, Marcio; Lee, Kyung Min; and Martins Neto, Antonio, 2021."Firm-Level Technology Adoption in Vietnam," Policy Research Working Paper Series 9567, The World Bank.

World Bank; Ministry of Planning and Investment of Vietnam. 2016. "Vietnam 2035: Toward Prosperity, Creativity, Equity, and Democracy. Washington, DC: World Bank."

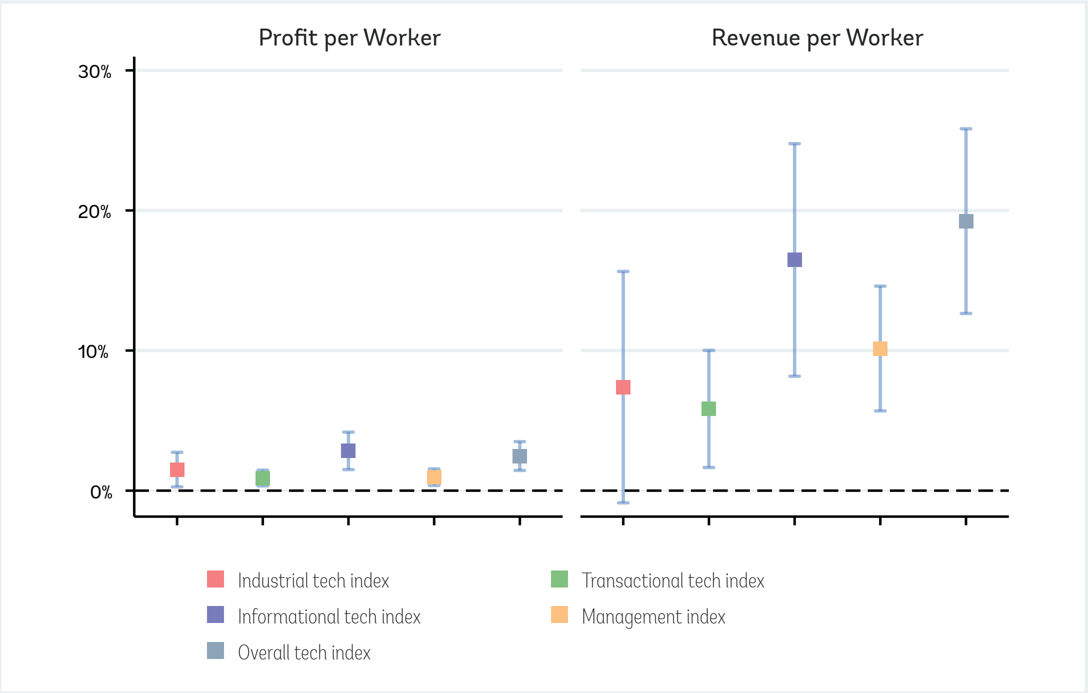
WTO, 2020. "World Trade Statistical Review 2020". World Trade Organization.

2.3 More advanced technology is associated with better firms' performance

Firms with more advanced general-purpose technologies and management practices earn higher profits and revenues per worker

Regression analysis shows that, given firms' size, sector, location and age, there is a statistically significant and positive correlation between technology levels and measures of firm performance (profits and revenues per worker).[27] Consider profits per workers: a 1.0-standard-deviation increase in the overall technology level is associated with 3 percent higher profits per worker (Figure 2-10).[28]

Figure 2-10 : The relationship between technology and firms' performance



Source: Estimates based on Bangladesh FAT Survey.

Note: Based on regressions of firm performance measures on technology indices and firm level controls. Each bar depicts the estimated association between a firm performance measure (in percentage terms) and a 1.0-standard-deviation increase in a technology index.

This relationship between profits and technology is driven by GPTs, specifically, by informational technologies and management practices. A 1.0-standard-deviation improvement in informational technology is associated with a 3.0 percent increase in profits per worker, and a 1.0-standard-deviation improvement in management is associated with a 1.0 percent increase in profits per worker. The relationship between industrial technology and profits is also positive, but not statistically significant; the same is true of transactional technologies.

It is important to note that these cross-sectional correlations, which are conditional on the observed attributes of firms, do not necessarily measure the causal impact of technology on firms' performance. It is possible that they also reflect the influence of unobserved drivers of firms' performance, such as entrepreneurial ability, that happen to have higher levels in

[27] The regression results are presented in Annex Table A4 and Annex Table A5.

[28] In this dataset, the standard deviation of the overall technology index is 0.25 (in logarithms).

[29] If such correlation with unobserved determinants of performance exists, then the conditional correlation estimates likely overstate the impact of technology on firm performance.

firms with higher technology adoption levels.[29] In future research, experimental (or quasi-experimental) research designs such as randomized trials could be used to address this problem and estimate the impact of specific technologies on firms' performance more rigorously.

Nor do these conditional correlations necessarily imply that firms, on average, under invest in technology. First, as just discussed, these correlations could be overstating the increase in net profits that is generated by adopting more advanced technology. Second, it could be that the fixed cost of a new technology exceeds the discounted flow on increased profits. Third, it is possible that the net return from a new technology, even if positive on average, is highly variable or uncertain, in which case attitudes toward risk and access to risk-sharing mechanisms would matter.

Firms with more advanced industrial technologies are more likely to export

Given firms' size, sector, location and age, more advanced technologies are also associated with a higher likelihood of exporting.[30] A 1.0-standard-deviation increase in overall technology levels is associated with about a 3-percentage-point increase in the likelihood of exporting. Unlike in the case of profits, it is industrial technology that has a statistically significant positive association with export success. A 1.0-standard-deviation increase in the Industrial Technology Index is associated with a sizably higher (10 percent) probability of being an exporter. This could reflect the rising demand for quality, reliability, and timeliness in export markets, or a reverse causation from exporting to technology (through information flows). Informational technology too is significantly associated with exporting, but to a lesser degree.

Technology can account for a large share of the variation in firms' performance

About 18 percent of the total variation in profits per worker (given firms' size, sector, age and location) can be accounted for by technology and management.[31] It is remarkable that a single dimension—technology—can explain so much of the variation across firms when there are so many others factors that potentially affect firms' performance: workers' skills and experience, unobserved entrepreneurial ability, and any number of firm-level demand and supply shocks, including weather shocks.

By way of comparison, less than 5 percent of the variation in profits per worker is accounted for by two other important dimensions of firms' human capital: the share of workers with secondary school education, and whether the firm's manager has a college degree. Indeed, these measures of human capital and attributes such as firms' size, age, location and sector together explain about as much of the variation in firms' performance as do the technology variables.

Technologically advanced firms also pay higher wages

Technology adoption is also associated with higher returns to labor. Given firms' size, capital levels and other control variables, a 1.0-standard-deviation increase in the Overall Technology Index corresponds to 8 percent higher wages.[32] This relationship is robust when controlling for workers' skills and experience, as well as the occupational breakdown of employment in a firm, implying that comparable workers (of the same observable skill level and occupational type) earn higher wages in more technologically advanced firms.[33] There are two potential explanations for this (which cannot be explored more rigorously here, given data limitations). First, it could be that firms with more advanced technology make complementary firm-specific investments in human capital. Second, it could be that technologically advanced firms hire workers of higher ability. In either case, there is complementarity between technology and human capital.

30 The corresponding regressions are presented in Annex Table A6.

31 This analysis of variance is based on regression presented in Annex Table A8. The regressors include binary indicators corresponding to every possible technology level in every technology question in the survey. This flexible specification extracts the maximum information on technology from the TAS. Furthermore, the joint F-test of significance shows that the technology variables are jointly statistically significant

32 The regressions are presented in Annex Table A7.

33 That is, the share of managers, professionals, technical staff, supervisors and production workers.

2.4 Conclusion

New survey data reveal there is much room for technological improvement and diffusion in Bangladesh's manufacturing sector. A few firms are close to the global technology frontier, but most use basic industrial and GPTs, and have weak managerial practices. Even large export-oriented garment manufacturers in Bangladesh are well behind the global frontier along most technology dimensions.

This low level of technological adoption is puzzling because there is a strong positive association between technology level and firms' performance in Bangladesh. Even after accounting for physical and human capital, firms with superior technology earn more per worker and pay higher wages. Indeed, differences in technology can account for a sizable share of the total variation in firms' performance in Bangladesh.

With most firms still using basic technologies, it is policies that focus on promoting the diffusion of incrementally better technologies that will be widely relevant in Bangladesh's manufacturing sector. In general, this need for incremental improvement exists is apparent in all technology dimensions—whether digital, industrial or managerial—and in all subsectors, but is particularly the case among SMEs.

At the same time, given the significant positive association between more advanced sector-specific industrial technology and exporting, policymakers should also consider how to promote the diffusion of sector-specific industrial technology in export-oriented sectors. Such technology could be relevant to exporting because more automated production methods guarantee better quality and speed in production. International apparel buyers increasingly value non-cost factors such as consistent quality and low "lead times" highly, and do not rate Bangladesh highly on these dimensions (Lopez-Acevedo and Robertson 2016). Unless firms upgrade technology in time, this rising premium on non-cost factors does not bode well for Bangladesh's export competitiveness.

> *This low level of technological adoption is puzzling because there is a strong positive association between technology level and firms' performance in Bangladesh.*

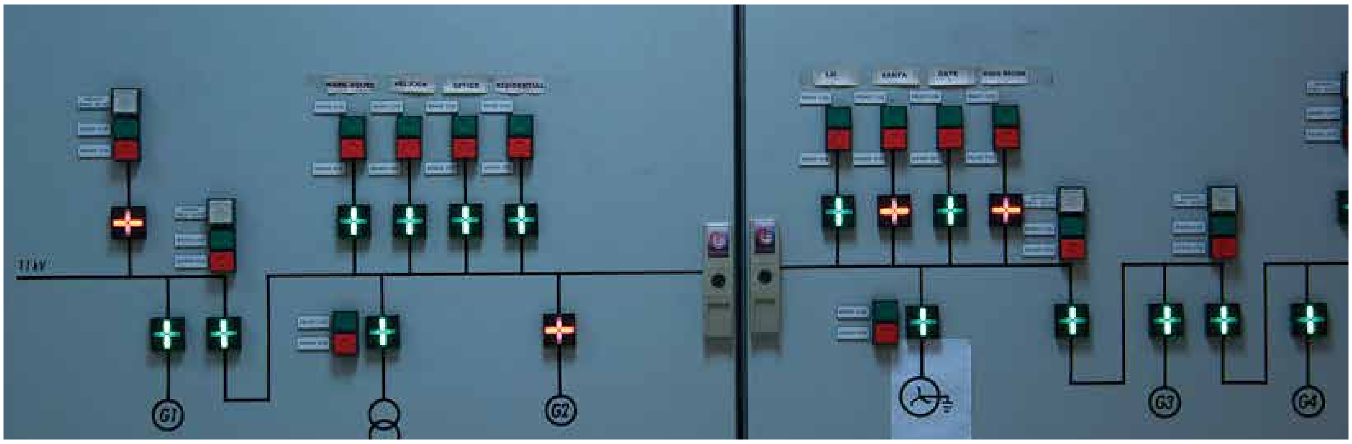
Firms' capabilities for absorbing new technologies and business practices depend on their human capital and organizational structure. In Bangladesh, firms with higher levels of managerial and technical human capital, and a more educated workforce have significantly higher technology levels. However, these capabilities are lacking in most firms. Firms underestimate their capabilities gap and are constrained in accessing private advisory services for building capabilities due to informational market failures.

3.1 Firms need foundational capabilities to absorb better technologies and business practices

While it would be simplistic to single out any one reason for Bangladesh's success in garments exports, foreign-acquired technical and entrepreneurial capabilities have surely played a pivotal role. In 1978, the Republic of Korea's Daewoo conglomerate entered into an agreement with a Bangladeshi firm called Desh Garments in order to bypass the quotas imposed by rich countries on clothing exports from the Rep. of Korea and other rapidly industrializing East Asian countries. Daewoo provided production and marketing training to Desh's supervisors and managers at its Korean plant so that they would be able to produce export-quality apparel in Bangladesh. Within a year, more than one hundred of the original Desh trainees had either set up their own firms or been hired by a new domestic garment firm (Rana and Sorensen 2013).

To succeed, firms need to build a range of "capabilities." According to Sutton (2012), capabilities are those elements of the production process that cannot be bought "off the shelf" like a normal input, and hence must be learned and accumulated by the firm. These capabilities are needed to resolve day-to-day operational problems, as well as for making more long-term decisions, such as those related to the introduction of new business practices, products, and production technologies.

The human capital of owners and managers is a key determinant of firms' capabilities for the adoption of better technologies and business practices. In smaller firms that are often owner-managed, the human capital of the owner is particularly important. In a range of low- and middle-income countries (LMICs) including Bangladesh, McKenzie and Woodruff (2016) find that firms whose owners have more years of schooling, better cognitive and analytical abilities, and a family history of entrepreneurship, demonstrate significantly better business practices. In larger firms, the human capital of managers is also important. For example, firms that have adopted new business practices are more likely to sustain those practices if they have low managerial turnover (Bloom et al. 2020). It is as if business practices are imbibed by individual managers, not the organization.



Cognitive, non-cognitive and technical skills also matter for the adoption of better technologies and business practices. Countries that had a larger share of engineers in the population in the year 1900 have higher income levels and technology adoption rates today (Maloney and Valencia 2017). The growing automation and servicification of manufacturing activities have increased the returns to foundational skills in workers, perhaps because those skills enable them to adapt faster to technological change. The returns to non-cognitive skills such as grit and an aptitude for teamwork have also increased (World Bank 2019; Hallward-Driemeier and Nayyar 2017).

However, increasing the supply of skilled managers and workers is not enough to build strong capabilities in a firm. Knowing which skills to hire, how to screen potential employees, and how to motivate them to perform well are critical. For example, ready-made garments (RMG) firms in Bangladesh know that most workers do not stay for long in the same firm and hence cannot be motivated solely by the promise of higher future wages. So, these firms have devised a system of hiring based on referrals from current workers as a way to ensure that new hires will perform (Heath 2018).

Technological and managerial capabilities are interlinked. On one hand, good management is increasingly dependent on information and communications technology (ICT). On the other hand, the ability to acquire and use new technology effectively is innately tied to organizational form and practices in a firm. Large firms develop organizational hierarchies with layers of "experts" who specialize in solving knowledge-related problems and managing less knowledgeable workers. In Mexico, for example, the returns to research and development (R&D) expenditures are higher in firms with better managerial practices: poorly managed firms are just not able to convert R&D expenditures into tangible outputs such as the introduction of new or superior products (Iacovone and Pereira-López 2017).

Indeed, managerial capability may be a precursor to technological capability. Simply introducing a new technology to a firm is not enough if organizational reforms do not facilitate complementary changes in employee behavior. For example, in the context of Pakistan's leather goods subsector, the adoption of a new technique that cut costs by economizing on intermediate inputs was resisted by workers as their remuneration scheme did not incentivize such economizing (Atkin et al. 2017a).

For Bangladesh, the COVID-19 crisis has added to the urgency of building firms' capabilities for adapting new business practices. Manufacturing firms will not be able to restore operations safely unless they are able to implement certain behavioral and organizational changes effectively. For example, in factories that have re-opened in China after the COVID-19 lockdowns, workers now need to wash their hands frequently, and the machine parts handled by them are regularly disinfected as they pass through the assembly process. Some factories have changed their layouts so that workers are more spread out, sacrificing some speed for the sake of safety.[34] Conversations with factory managers suggest that similar changes are being implemented in Bangladesh. Changes in how global supply chains (GVCs) are shaped and operate could necessitate new logistical process, while the need to avoid physical visits by suppliers and buyers will necessitate the adoption of remote connectivity technology.

Managerial capabilities also matter for the adoption of practices that improve firms' compliance with labor standards—a matter of high priority to Bangladesh's garments industry in the wake of the Rana Plaza tragedy and the ensuing focus on labor safety in the garments industry. In a recent study on enforcing mandates for the introduction of worker-manager safety committees in garments firms, the desired impact (on measures of worker safety and awareness of labor standards) was larger in firms with better management practices (Boudreau 2020).

Finally, government capability to effectively support innovation and technology adoption is also critical. As discussed in this chapter, various market failures, including imperfect information and missing markets, call for direct government investment in a technology extension system. In particular, the design of direct government support needs to be tailored to the country context and the needs of firms in the country (Rodrik 2008).

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[34] See https://www.economist.com/briefing/2020/04/07/how-to-reopen-factories-after-covid-19

Using firm-level data from the Bangladesh FAT Survey, this chapter first analyzes the capabilities in manufacturing firms in Bangladesh, and the association between those capabilities and technology. Then, it examines the barriers to upgrading firms' capabilities in Bangladesh.

3.2 Firms' capabilities in Bangladesh: Critical to technology adoption, yet in short supply

The Bangladesh FAT Survey data reveal a positive association between technical and managerial human capital and technology adoption in Bangladeshi manufacturing firms. Specifically, accounting for differences in firms' size, sector, age and location, there is a positive and statistically significant association between the Overall Technology Index and three measures of technical and managerial capital in the firm: (i) the percentage of workers with an engineering or applied science degree; (ii) the percentage of workers with an MBA, MA or doctoral degree; and (iii) an indicator for whether the manager has experience working in a multinational enterprise (MNE).[35]

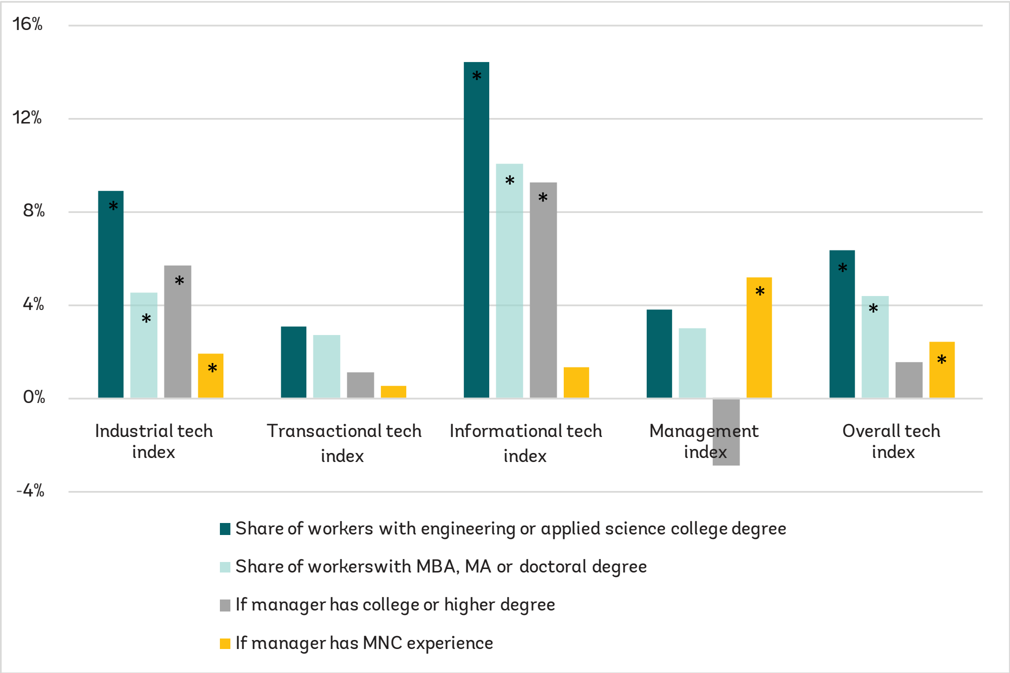
The percentages of workers with engineering or applied science degrees and MBA or doctoral degrees are significantly associated with two subcomponents of the Overall Technology Index: the informational and industrial technology indices (Figure 3-1). A 1.0-standard-deviation increase in the share of workers with a technical degree is associated with a 9 percent (respectively, 14 percent) higher value of the Industrial (respectively, Informational) Technology Index. The education of the manager—as proxied by an indicator for whether the manager has a college degree—also matters to these technology dimensions. On average, a firm managed by a college-educated individual has a 6 and 9 percent, respectively, higher value of the industrial and informational technology indices than one managed by someone whose is not college educated.

While worker skills and manager education are not significantly associated with managerial practices, firms with a manager who has prior MNE experience do have a significantly higher value in the Management Practices Index. Moreover, after accounting for MNE experience, there is no statistically significant association between whether a firm's manager has an MBA degree and the quality of its managerial practices. This suggests that in Bangladesh better managerial practices are acquired through experience in sophisticated firms, not by studying MBA programs.

An important caveat is that this analysis is associational and does not measure causal impact estimates. Furthermore, measures of firms' level of human capital obtained from surveying firms' owners/managers are likely to be noisier than those obtained by interviewing or testing employees directly. As such, this noise would tend to bias estimated associations between human capital and other firms' dimensions such as technology.

[35] Regression results presented in Annex Table A9.

Figure 3-1 : Technical and managerial skills are associated with higher technology levels



Source: Estimates based on Bangladesh FAT Survey.

Note: Based on regressions of technology indices on human capital measures and firm level controls. Each bar depicts the estimated association between a technology measure (in percentage terms) and a 1 standard deviation increase in a measure of human capital.
*: Significance at 10 percent or higher level.

Interestingly, after accounting for technical human capital (as measured by the share of workers with engineering or applied science college degrees), there is no significant association between most technology indices and the general educational level of the workforce (as measured by schooling levels). The exception is informational technology adoption, which is higher in firms with a larger share of workers with secondary school or tertiary education. However, this lack of association could be because the survey does not measure cognitive and non-cognitive skills directly.

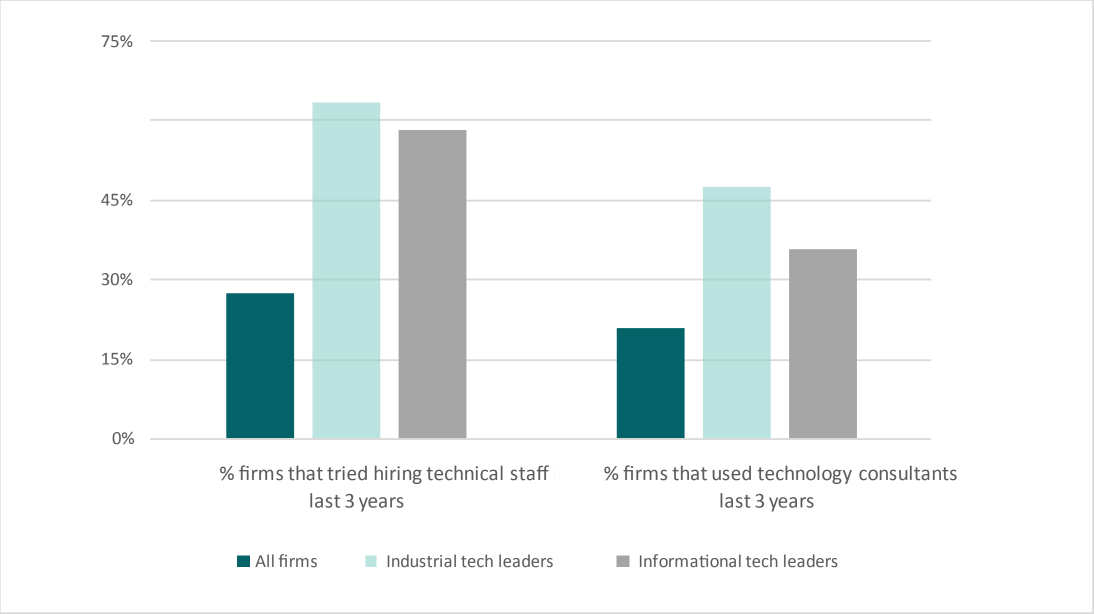
Specialized R&D skills also matter to technology adoption. Specifically, given technical and managerial human capital, a 1.0-standard-deviation increase in the share of specialized R&D workers is associated with a 3.0 percent higher value of the Overall Technology Index.[36]

Underlining the complementarily between technology adoption and technical skills, firms that use more advanced technologies are also more likely to hire technical expertise. Figure 3-2 shows how many firms tried to hire technical personnel or use a technology consultant in the past three years. In each case, the incidence is compared between all firms and “technology leaders”, defined as the top 25 percentile of firms in a particular technology index. On average, 28 percent of the study firms tried to hire technical staff in the past three years. In contrast, as many as 64 (respectively, 58) percent of industrial (respectively, informational) technology leaders tried to hire technical staff during the same period. Compared with 21 percent of all firms, 47 percent of industrial technology leaders and 36 percent of informational technology leaders used a technology consultant.

> *Firms that use more advanced technologies are also more likely to hire technical expertise*

36 Based on regressions shown in Annex Table A10

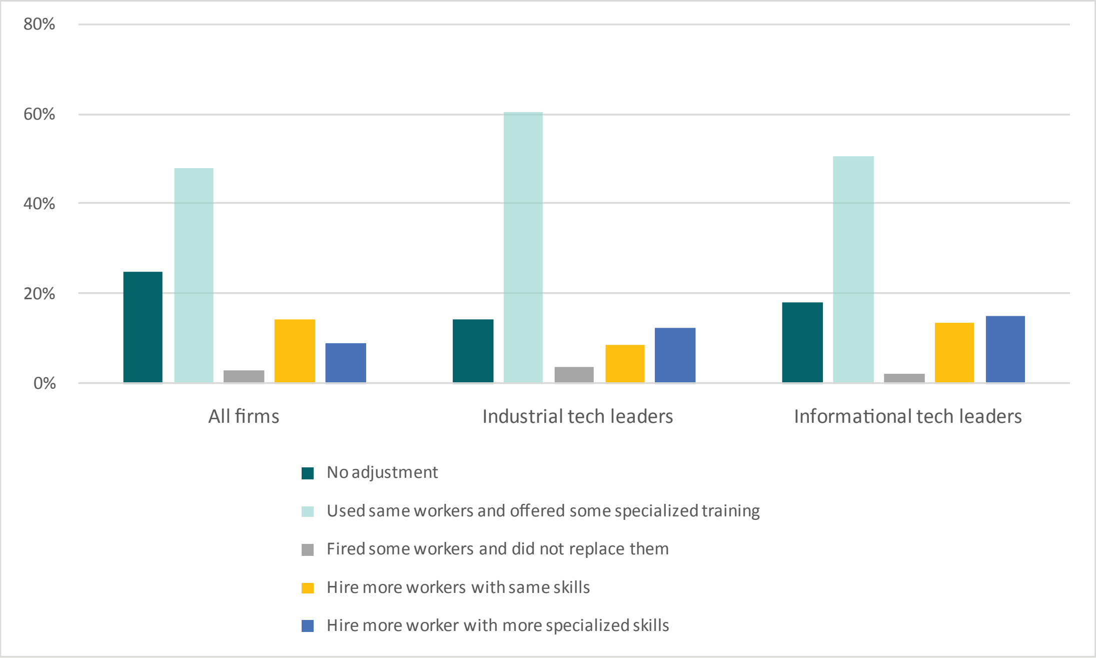
Figure 3-2 Technology adoption and the demand for technical expertise



Source: Bangladesh FAT Survey.

Similarly, training production workers in technology-specific skills matters more to technology leaders. When asked how they adjust their workforce when acquiring new machinery or software, 25 percent of firms said that they undertook no adjustment of the workforce and another 14 percent said that they just hired more workers of the same skill level (Figure 3-3). This suggests that existing workforce skills are adequate for new machinery or software in 39 percent of technology adoption cases. Forty-eight percent of the firms reported training existing workers and 9 percent reported hiring more skilled workers when acquiring new machinery or software: in sum, 57 percent of firms "upskill" workers for new technology. In comparison, 73 percent (respectively, 66 percent) of industrial (respectively, informational) technology leaders upskill their workers when adopting new machinery or software

Figure 3-3: How firms adjust labor when acquiring new machinery or software



Source: Bangladesh FAT Survey.

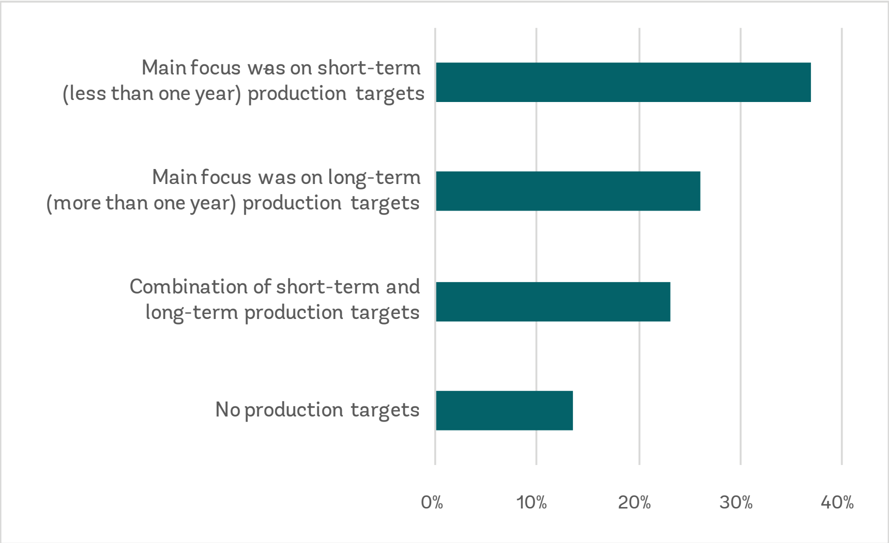
Technical and managerial human capital levels are low and heterogenous in Bangladeshi firms

Given their strong association with technology and managerial practices, the low average levels of technical and managerial human capital in Bangladeshi manufacturing firms are of concern. More than three-quarters of firms do not have any workers with an engineering or applied science college degree (Annex Table A11). The mean percentage of the workforce with an MBA or master's level degree is only 2.4 percent. Unsurprisingly, having workers dedicated to R&D activities too is rare, with more than 75 percent of firms having no R&D workers. Furthermore, 55 percent of firms are managed by a person without a college degree.[37] On the other hand, having a manager with MNE experience is not uncommon (at 45 percent of firms).

Many Bangladeshi firms have limited English communication skills, constraining their capacity to interact directly with foreign buyers and suppliers, and learn from them about new technologies and managerial practices. According to a study of export-oriented SME garments firm owners in Chittagong, only about two-thirds of the firms' owners/managers had the language skills needed to be able to communicate directly in English with foreign counterparts (Rana and Sorensen 2013). Most export-oriented garments SMEs do not interact directly with foreign counterparts.

Because new technologies often entail high risk and long gestation periods, the ability to plan ahead is also an important dimension of a firm's capability to innovate and adopt new technologies (Cirera and Maloney 2017). Unfortunately, many manufacturing firms in Bangladesh lack the inclination or capacity to plan ahead (Figure 3-4). Fourteen percent of firms have no production targets, and 36 percent of them have only short-term production targets (that is, targets defined over a horizon of less than one year).

Figure 3-4: Most firms have short-term production targets



Source: Bangladesh FAT Survey.

3.3 Informational market failures constrain firms from building technological and managerial capabilities

Firms under invest in building capabilities because they are unaware of the value of capabilities and harbor incorrect beliefs about their own capabilities. For example, large textile firms in India do not hire management consultants even though hiring them would be a profitable investment (Bloom et al. 2013). Many of them do not believe that basic management practices, such as the measurement of quality defects, machine downtime, and maintaining inventory, would increase their profits, and are simply not aware of more advanced practices, such as standardized operating procedures and inventory control norms.

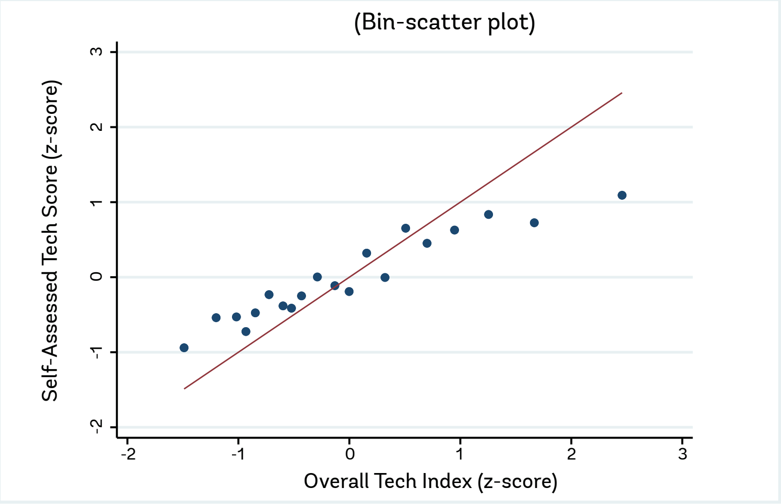
[37] Since most firms are managed by their owner, this also implies a low level of the owner's education. .

The survey data indeed suggest that most firms do not believe that they need consulting services for help with technology adoption, with 84 percent saying that they have no need for such consulting. In fact, firms with the least-advanced technologies in Bangladesh have the most inflated beliefs about their technology levels; that is, they underestimate the extent to which they are behind other firms. Figure 3-5 presents a bin scatter plot of this self-assessed technology score versus the more objective technology index measured from the survey.[38] Firms with below-average values of the objective technology index systematically overestimate their technology level; the lower the objective score, the higher the degree of overestimation (as measured by the vertical gap from the 45-degree line).

Missing or underdeveloped markets for technological and management advice could also be one reason why firms under invest in capabilities. With high-end consulting firms being too expensive for SMEs, they only have recourse to smaller, local consulting firms. In fact, as shown in Figure 3-6 (left panel), 53 percent of the surveyed firms use local consultants and another 12 percent use local business associations for consulting services. It is difficult for SMEs to find suitable and cost-effective local consultants: when asked why they did not use any external consultants for help with technology adoption (Figure 3-6, right panel), 8 percent of the firms attributed this to not being convinced of their cost effectiveness, 3 percent to a lack of trust in their quality, and a further 6 percent to not knowing any such service provider.

In a sense, the missing market for technical advice on new technologies presents a coordination failure between technology adopters and technology providers. For example, a leather goods firm that was interviewed in the course of this study revealed that, while it has invested in a more automated type of leather cutting machine, the machine is not being used due to technical glitches and difficulty in finding local technicians who are able to troubleshoot these new types of machines. The owner of the firm speculated that this is a "chicken and egg problem." Currently, it does not make sense for local technicians to invest in learning about the new cutting machines since there are so few of them in use. In turn, this shortage of technicians may be deterring firms from investing in the new type of cutting machines.

Figure 3-5 : Self-assessment of technology levels versus objective technology score



Source: Bangladesh FAT Survey.

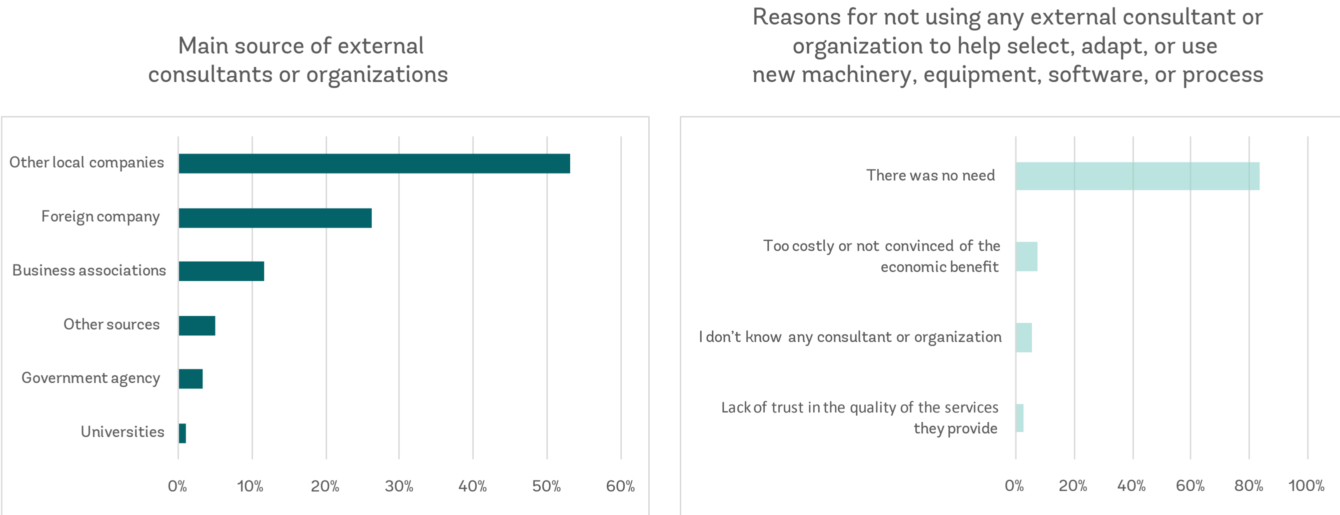
Note: For reasons of comparability, the self-assessed technology level score and the Technology Index have been converted to z-score indices by subtracting the mean value and dividing by the standard deviation across all firms.

Norms and mismatched perceptions also lead to a misallocation of managerial investment in firms. In Bangladesh's garments subsector, women make up a disproportionately high share of production line workers and are underrepresented in supervisory roles. In line with the hypothesis that women are perceived as being less effective than men at management due to limited exposure to women managers, a randomized program that trained female production workers in entry-level

[38] The z-score version of the technology index is the technology index minus its mean value across all firms, divided by its standard deviation across all firms. As such, it is a relative and scale-free measure

managerial task and deployed them to the factory floor improved the perception of female managers over time (Macchiavello et al. 2015). Moreover, since managerial effectiveness relies on employees trusting in, and listening to, their managers, it is not surprising that the effectiveness of the newly trained female managers also improved as their perceived effectiveness improved.

Figure 3-6 : Informational issues in hiring consultants



Source: Bangladesh FAT Survey.

The weak contract enforcement environment could be accentuating the adverse effects of informational asymmetries on firms' capabilities by discouraging the delegation of management to hired experts. One of the most striking features of Bangladesh's manufacturing sector is the prevalence of family-owned and family-managed firms. According to the Bangladesh FAT Survey, 98 percent of the firms are family-owned and 91 percent of them are family-managed. This prevalence of family-run firms could be due in part to the weakness of formal contracting institutions, with Bangladesh ranked 189th out of 190 counties in the Doing Business "Enforcing Contracts" Index (World Bank 2020c). Weak contract enforcement canperpetuate family ownership and management of firms by making it harder to align the incentives of owners and hired managers through formal employment contracts (Bertrand and Scholar 2006).

3.4 Conclusion

International evidence shows that firms need to accumulate technical and managerial capabilities to be able to adopt and effectively use new technologies. Consistently, Bangladeshi manufacturing firms with higher levels of managerial and technical human capital, and a more educated workforce, have significantly higher technology levels. To give a concrete example, the capabilities acquired from a more sophisticated Korean partner firm were central to the early growth story of the RMG industry.

It is therefore of concern that most Bangladeshi firms, even many of those in the RMG industry, still lack basic capabilities. Very few firms have workers with technical degrees, and most of their workforce has had only limited years of schooling. Most firms remain family managed and do not delegate top-level management to professional managers.

The analysis in this chapter suggests that informational failures lead to underinvestment in firms 'capabilities. But these internal, informational constraints to technology adoption in firms are not independent of the more external constraints related to international connectedness and complementary institutions, which are discussed in the next two chapters. A case in point is the contract enforcement environment, which influences the extent to which owners of firms are willing to delegate managerial responsibilities to non-family professionals who possess better managerial capabilities.

Connectivity to international markets plays an important role in the diffusion of new technologies. Trade and FDI can facilitate the transfer of technology through the knowledge embodied in products and people, and improve firms' incentives to innovate. These opportunities for cross-border learning of production methods, production design and market conditions are further intensified through business relationships in GVCs. Evidence from Bangladesh shows that firms that share a business relationship with MNEs, on average, are characterized by higher levels of technology adoption, especially for informational and industrial technologies. However, the extent to which international connectivity can be leveraged for technology adoption varies across sectors.

4.1 Global evidence shows that connectivity to international markets enables technology adoption and innovation

Imports are an important channel of technology diffusion, with the extent of technological spillovers linked to the composition of imports. Technology transfer is potentially higher when imports come from industrial countries that are characterized by a higher embodied technological content than imports from developing countries (Coe and Helpman 1995; Keller 2004). Coe and Helpman (1995), Coe et al. (1997), and Lichtenberg and Pottelsberghe de la Potterie (1998) all provide evidence of how countries whose trading partners invest more in R&D have higher total factor productivity (TFP) levels than other countries.[39] Furthermore, technology spillovers are stronger for imports of capital goods, machinery and information and communications technology (ICT) goods (Coe et al. 1997; Gera et al. 1999; Xu and Wang 1999; Acharya and Keller 2009; Van Meijl and van Tongeren 1998), as well as for intermediate inputs relative to final products (Amiti and Konings 2007).

Exporting to the rest of the world can facilitate knowledge transfers and innovation too. Take the example of the handmade flat-weave carpet cluster in Fowa, Egypt, where firms provided with the opportunity to export experienced 16 to 26 percent higher profits, which reflects, at least in part, the flow of knowledge and information from sophisticated buyers (Atkin, Khandelwal and Osman 2017).

39 Comin and Hobijn (2004), however, find that the effect of trade on TFP may also be through factors other than technology transfer.

Several studies also outline the technology spillovers associated with foreign direct investment (FDI). A meta-review of such studies concluded that a 10 percent increase in foreign presence is associated with a 9 percent increase in the productivity of local suppliers through vertical spillovers—this includes cross-border flows of capital, skills, and technology, as well as more tacit forms of know-how, such as managerial, marketing, and organizational expertise (Havranek and Irsova 2011). Participation in global value chains (GVCs) through international trade and FDI can deepen the transfer of technology.[40] For instance, suppliers in developing countries gain access to better quality intermediate goods (Eaton and Kortum 2002). There is also evidence that workers' mobility, particularly managers with previous experience in multinationals or exporting firms, can facilitate knowledge transfer (Mion and Opromolla 2014). In fact, the experience of domestic producers of apparel inputs in Bangladesh suggests that even those firms that do not export can experience productivity spillovers by learning from the experience of other firms that are part of a shared supplier network (Kee 2005).

Through its effect on technology transfers, scale of production and competition, trade can affect local firms' incentive to innovate. The imitation of advanced technologies, embodied in imported goods and services, can foster research and development (R&D) investments by domestic firms (Helpman 1993). Furthermore, by increasing the size of the market in which a firm operates, international trade increases the payoff from innovation, thereby increasing the incentive to invest in R&D. For example, Bustos (2011) finds that Argentinian firms in sectors with the largest market access gains were more likely to increase technology spending than firms operating in sectors where trade opening was less ambitious. Trade also enhances innovation by increasing competition. When trade barriers are lifted, domestic firms shift from rent-seeking to the more productive innovative activities that are necessary to sustain their international competitiveness. For example, Boer et al. (2001) show that this was the case for Turkish producers in response to trade liberalization.[41]

There is also evidence that greater international competition and growing demand for sophisticated products can increase firms' incentives for upgrading "soft" technologies as reflected in their capabilities. For example, sectors more affected by Chinese competition in Europe have invested more in R&D (Bloom, Draca and Van Reenen 2016). Highlighting the importance of demand, recent experimental studies that randomly "seed" the demand for goods whose production requires specific technologies have shown positive impacts on upgrading of firm capabilities (Hardy and McCasland 2018; Atkin et al. 2017b).

4.2 Connectivity to international markets is associated with technology adoption

Firms in Bangladesh with a business relationship with multinational enterprises (MNEs), on average, are characterized by higher levels of technology adoption. This is most evident in the case of informational technologies, which are relevant for a range of business functions, including business administration, human resources, inventory management and production planning. Firms that most often used information from foreign buyers or suppliers to make decisions about technology acquisition, on average, typically made use of mobile apps to complete these tasks. This is compared with other firms that, on average, ranged between using handwritten processes and standard computer packages. There is a similar pattern for industrial technologies that relate to sector-specific production processes. Firms that most often used information from foreign buyers or suppliers to make decisions about technology acquisition, on average, made use of semi-automated production processes to complete these tasks. This is compared with other firms that, on average, used manually operated machinery (Figure 4-1).

"Firms in Bangladesh with a business relationship with MNEs, on average, are characterized by higher levels of technology adoption"

[40] IMF 2018

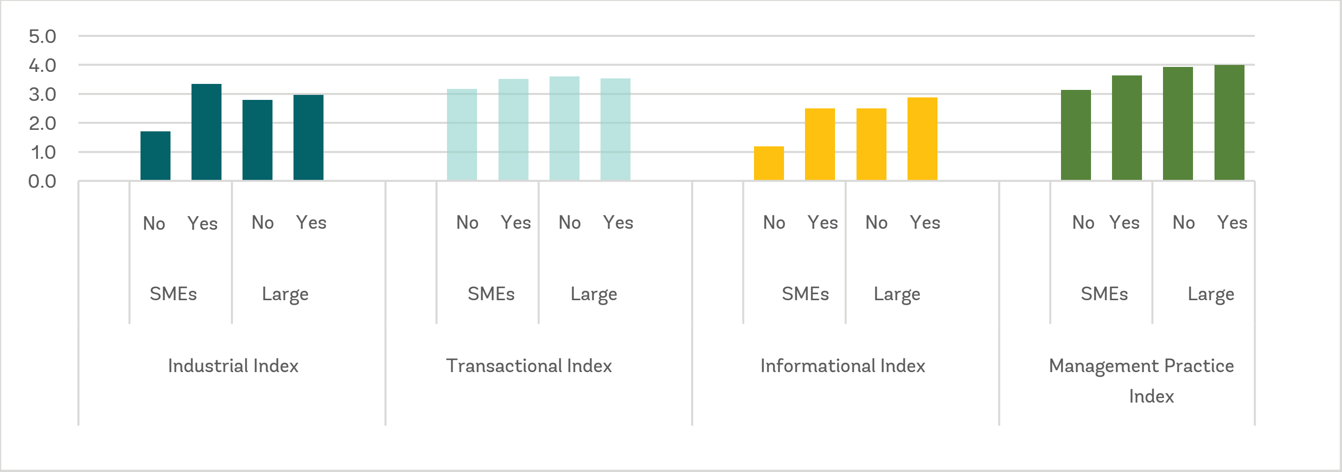
[41] By reducing the monopoly rents associated with innovation, competition may reduce incentives to innovate (Schumpeter 1942).

Figure 4-1: Technology adoption in firms with and without foreign buyers of suppliers as the primary source of information

Source: Bangladesh FAT Survey.

However, using MNEs as the primary source of information for technology acquisition matters less for transactional technologies that apply to sales processes and payment systems. This may be attributable to the fact that information about e-commerce and digital payment platforms is less applicable to firm-specific know-how. Using MNEs as the primary source of information for technology acquisition also matters less for better management practices. Even after accounting for firms' size, age, and sector characteristics, firms that most often used information from foreign buyers or suppliers to make decisions about technology acquisition are characterized by higher levels of technology adoption in the informational and industrial technology categories. This positive association also holds when international connectivity is measured by whether firms shared a business relationship with MNE (Annex Table A12).

Figure 4-2: Technology adoption in firms with and without foreign buyers and suppliers as the primary source of information, by firms' size category

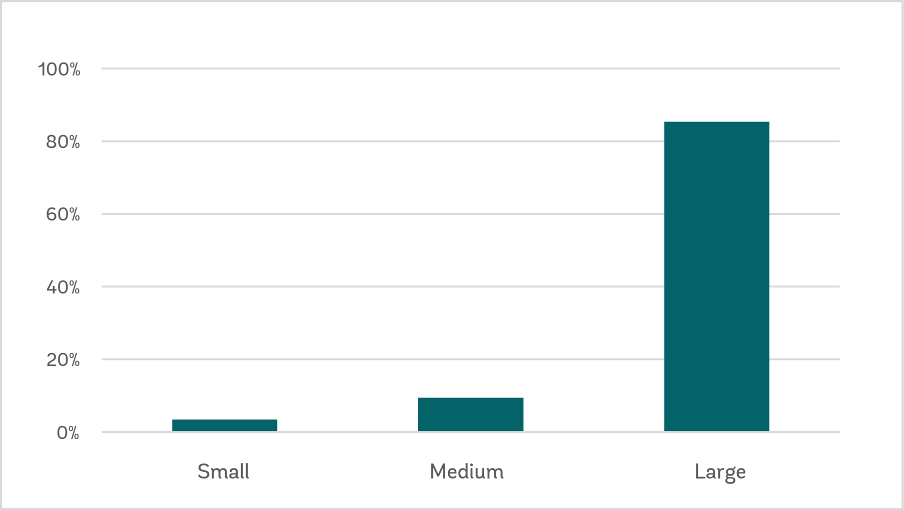


Source: Bangladesh FAT Survey.

Information about new technologies from MNEs is particularly important for small and medium enterprises (SMEs). Among SMEs, those that most often used information from foreign buyers or suppliers to make decisions about technology acquisition, on average, used standard computer packages to complete administrative tasks. This is in contrast to other firms that, on average, used handwritten processes.

Similarly, SMEs that most often used information from foreign buyers or suppliers to make decisions about technology acquisition, on average, made use of semi-automated sector-specific production processes. This is in contrast to other SMEs that, on average, used manually operated machinery (Figure 4-2). Among large firms, there is little difference in technology adoption between firms that mostly rely on information from foreign buyers or suppliers, and those that do not. Large firms likely obtain this information through better managers or learning-by-doing that is enabled by scale economies. However, only 3 percent of small firms and 9 percent of medium-sized firms directly export to the rest of the world, compared with 85 percent of large firms (Figure 4-3).

Figure 4-3 : Share of firms in Bangladesh that export directly (%), by firms' size category, 2018

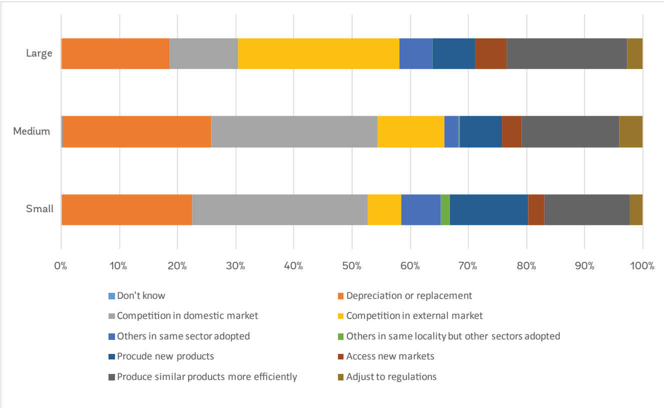


Source: Bangladesh FAT Survey.

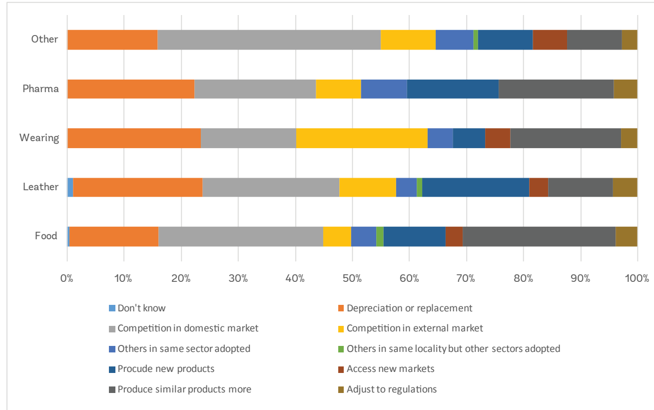
There is also evidence suggesting that competition in international markets has accelerated innovation by firms in Bangladesh to improve their performance. Among large firms where exporting tends to be concentrated, competition in the external market is cited as the top reason for the acquisition of new equipment, machinery or software by the largest share of firms, at 28 percent. This compares with 19 of large firms, that report depreciation of existing equipment and more efficient production processes as the top reasons for the acquisition of new equipment, machinery, or software. Competition in the external market is, not surprisingly, cited as the top reason for the acquisition of new equipment, machinery, or software by a far smaller share of SMEs where competition in the domestic market dominates. Similarly, competition in the external market is cited as the top reason for the acquisition of new equipment, machinery, or software by a larger share of firms in the RMG industry compared with others (Figure 4-4).

Figure 4-4 : Top reason for the acquisition of new equipment, machinery, or software

a. Share of firms by firm size category (%)



b. Share of firms by industry (%)



Source: Bangladesh FAT Survey.

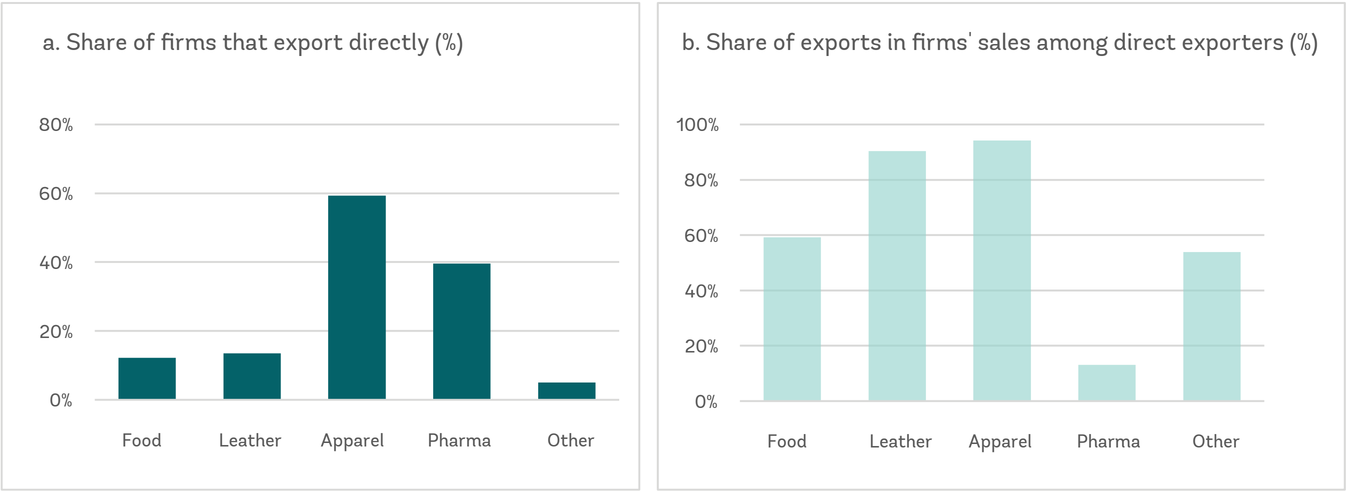
4.3 The extent to which international connectivity can be leveraged for technology adoption varies across sectors

The extent to which connectivity to international markets can be a conduit for technology transfer in Bangladesh also varies fundamentally by sector. As expected, the RMG industry stands out. In 2018, 50 percent of firms directly imported material inputs, machinery, and equipment, and almost half had business relationships with an MNE (Figure 4-5). Furthermore, more than 50 percent of firms exported directly to world markets and the average share of exports in sales was as high as 94 percent among exporters (Figure 4-6). Among exporters in the leather goods and footwear industry, which is also organized in GVCs, the average share of exports in sales was similarly high at 90 percent. However, Bangladesh's participation in export markets for leather goods and footwear remains limited despite duty-free access in 38 countries;[42] only 14 percent of firms in the sector exported directly in 2018 (Figure 4-5). GVC participation was also minimal; fewer than 15 percent of firms directly imported material inputs, machinery, or equipment and fewer than 20 percent had a business relationship with an MNE in 2018 (Figure 4-6).

> ***Fewer than 20 percent of firms in Bangladesh's leather goods and footwear industry had a business relationship with a MNE in 2018***

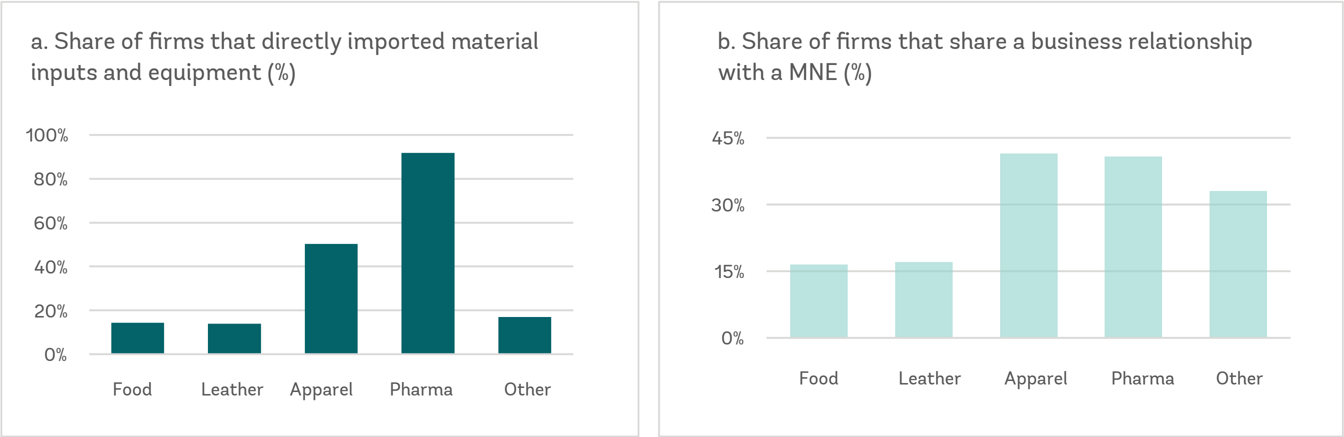
[42] Twenty-eight countries in the European Union, together with Australia, Belarus, Canada, Liechtenstein, Japan, New Zealand, Norway, the Russian Federation, Switzerland and Turkey.

Figure 4-5 : Exports by industry, 2018



Source: Bangladesh FAT Survey.

Figure 4-6 : GVC participation, by industry, 2018



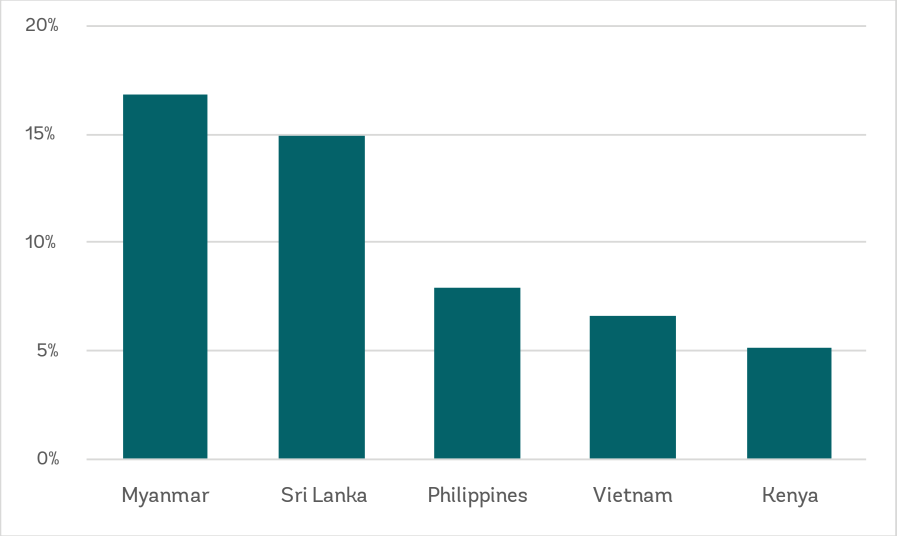
Source: Bangladesh FAT Survey.

Bangladesh's pharmaceutical industry meets 98 percent of local demand, which is indicative of firms operating in a protected market enabled by international and domestic legislation (Khan 2019). The World Trade Organization (WTO) waiver that exempts least-developed countries (LDCs) from obligations under the Agreement on Trade-Related Aspects of International Property Rights (TRIPS) enables firms in Bangladesh to produce generic versions of pharmaceuticals that are under patent protection elsewhere, without any royalty charges or the patent-holder's permission.[43] Furthermore, Bangladesh's Drug Control Ordinance of 1982 outlined a path of import substitution, whereby tariffs restrict imports of pharmaceutical products. Foreign companies are also not allowed to import and sell several listed pharmaceuticals in the local market. The National Drug Policy 2005 expanded this facility to traditional and alternative drugs, and the National Drug Policy 2016 continued these facilities (Khan 2019).

Nonetheless, Bangladesh's pharmaceutical subsector has international links; while 41 percent of firms had business relationships with a MNE, 92 percent of firms directly imported material inputs, machinery and equipment in 2018 (Figure 4-6). The latter reflects the fact that pharmaceutical firms in Bangladesh are primarily concentrated in the final formulation stage and almost 85 percent of the required intermediate inputs are imported (Azam 2016). In fact, imports of active pharmaceutical ingredients (APIs) and other such inputs hold considerable promise for technology transfer because they are associated with high levels of engineering skills and knowledge in chemistry.

There may currently be fewer opportunities for technology transfer through exporting. In 2018, while more than one-third of firms in Bangladesh's pharmaceutical subsector exported directly, the average exports-to-sales ratio among exporters was as low as 13 percent (Figure 4-5). Furthermore, these pharmaceuticals are less likely to be exported to sophisticated buyers because the top destinations are developing country markets (Figure 4-7). This reflects the export of generic versions of patented drugs to LDCs and non-WTO countries that have not implemented product patent protection, or to other developing countries where markets for pharmaceuticals are largely unregulated. These include Bhutan, Pakistan, Sri Lanka, Nepal, Vietnam and Myanmar.[44]

Figure 4-7 : Share of top five destinations in Bangladesh's pharmaceutical exports, 2015



Source: World Bank WITS database.

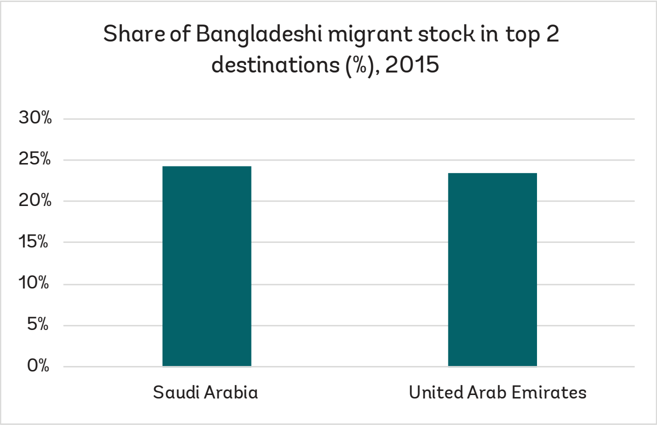
Bangladesh's food processing industry is similarly less integrated with international markets; in 2018, only 12 percent of firms exported directly to world markets (Figure 4-4), fewer than 15 percent of firms directly imported material inputs, machinery, or equipment, and fewer than 20 percent of firms had a business relationship with an MNE (Figure 4-5). This reflects a broader global trend of processed foods, such as spices, dry fruits, tea, fruit juice, biscuits, potato chips, frozen fish, and jam and pickles, which are less amenable to globally fragmented production relative to other manufacturing industries. Imports of intermediate inputs are few and far between because raw materials including crops, livestock, fish, and some forestry products are typically sourced locally. The direct transfer of technology through linkages in GVCs is therefore less relevant here. Furthermore, the transfer of technology embedded in the import of packaged foods from advanced countries is likely to be low because R&D intensities are typically low in the food processing industry. For example, Canada's R&D intensity ranges from as low as 0.5 percent in food products to as high as 37 percent in the radio, television, and communication industry (Acharya and Keller 2009).

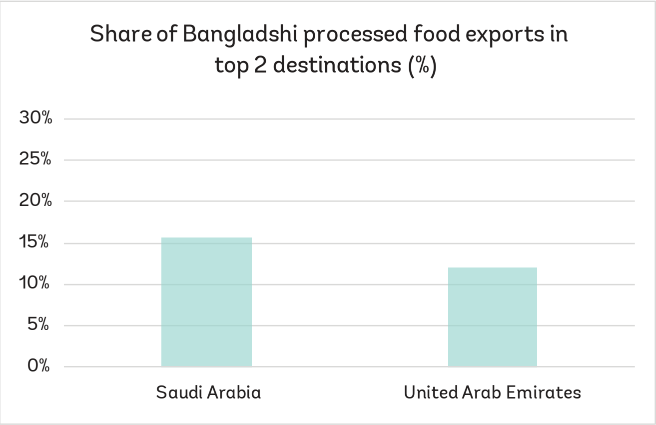
The flow of knowledge from sophisticated buyers associated with exporting is also limited because Bangladesh's food processing industry targets ethnic-food niches in countries with a large Bangladeshi and South Asian Diaspora (Khan 2019). Saudi Arabia, and the United Arab Emirates, which are home to the largest numbers of Bangladeshi migrants, are also the top export destinations for processed foods from Bangladesh (Figure 4-8). Connectivity to international markets can improve the incentives for firms in the food processing industry to innovate to the extent that trade is associated with scale economies that improve the returns to innovation.

[43] This waiver, which was first given in 2001 for 15 years, was later extended until 2033.

[44] Pharmaceutical companies do not file drug patents in all countries, particularly where sales prospects are low or there is no meaningful judicial patent protection. These gaps in patent coverage can therefore be exploited.

Figure 4-8: Bangladesh's exports of processed foods are linked to its diaspora population





Source: United Nations Population Division and the United Nations Comtrade Database.

4.4 Conclusion

The evidence suggests that connectivity to international markets is associated with higher levels of technology use, especially for informational and industrial technologies, in Bangladeshi firms. The extent to which international connectivity can be further leveraged to improve technology adoption varies by sector which, in turn, emphasizes a policy response that takes this heterogeneity into account. Bangladesh is well-integrated into GVCs for ready-made garments. Strengthening linkages with MNEs will therefore be particularly important to diffuse the benefits of technology adoption. Exporting and establishing linkages with MNEs can similarly bring the benefits of technology diffusion to firms in the pharmaceuticals and leather goods and footwear industries. However, greater penetration of export markets and foreign investment are prerequisites for realizing the benefits from knowledge transfer associated with international connectivity. Exports to niche diaspora markets and the lack of amenability to globally fragmented production limit the scope for firms in Bangladesh's food processing industry to leverage international connectivity to boost technology adoption. The relevant policy priorities, differentiated by these sectors, are discussed in Chapter 6.

Chapter 5: Complementary Markets And Institutions

Low rates of investment in technology adoption are also caused by the lack of complementary markets and institutions that are external to the firm. (i) Access to finance is the largest constraint reported by Bangladeshi firms in adopting new technology. (ii) The high cost of compliance with regulations, weak property rights, and poor contract enforcement increase the riskiness of investing in new technologies, especially for large firms. (iii) Access to information about the benefits of technology is lacking. (iv) Gaps in industrial infrastructure, even though not reported by firms as a top constraint for technology adoption, constrain firms' operations and indirectly inhibit technology adoption.

5.1 Evidence around the world shows that complementary markets and institutions are an important enabler for technology adoption and innovation

Information-related market failures, especially those related to the appropriation of knowledge, have typically led to underinvestment in new technology and innovation by the private sector. These market failures, in turn, form the basis for tax incentives, as well as to intellectual property rights (IPR) systems, worldwide. The analysis of Bosch, Lederman and Maloney (2005) suggests that the security of IPR, the quality of research institutions, and the degree of collaboration with the private sector plausibly explain half of the difference in the elasticity of knowledge creation between advanced and follower countries. In Vietnam, the concern of many start-ups about having their ideas compromised during the process of filing for local patents impeded all subsequent mobilization of financing and scaling up.

The accumulation of knowledge capital is also subject to all the same barriers as physical capital—capital markets, business climate, or ability to diversify risk. Hence, low investment in innovation may be due to a variety of investment barriers in these complementary markets and institutions.

Credit constraints are a major reason for underinvestment in innovation and technology adoption (Aghion et al. 2012; Hall and Lerner 2010; Bond, Harhoff and Van Reenen 2003; and Mulkay, Hall and Mairesse 2000). This reflects the fact that technology adoption typically entails investing in fixed capital. Financial frictions induce entrepreneurs in India and Mexico to adopt less-promising ventures than in the United States, despite lower input prices (Cole, Greenwood and Sanchez 2016).[45] Financial constraints also reduce firms' ability to engage in R&D, which is key for firms to enhance productivity and move up the value chain.[46]

The provision of industrial infrastructure also influences firms' ability to invest in technology adoption and innovation by raising production costs. Evidence from Chile suggests that the increase in

firms, Aghion et al. (2012) find that firms in sectors that rely more on external finance have more pro-cyclical R&D, illustrating the impact of financial constraints.

45 Conversely, a deeper local credit market in the Russian Federation increases firms' adoption of new products and technologies (Bircan and De Hass 2019).

46 Subsidies for a small business innovation research program in the United States have large, positive impacts on patenting and revenue, and the effects are larger for financially more constrained firms. In the United Kingdom, there is a significant correlation between cash flow and whether a firm participates in R&D (Hanrhoff and Reenen 2010). Using a sample of French

public infrastructure capital crowded in private investment in production (Albala-Bertrand and Mamatzakis 2004). Moreover, public infrastructure has contributed positively to productivity growth of the manufacturing industries in the United States (Nadiri and Mamuneas 1991), Spain (Pereira and Roca-Sagales 2001) and South Africa (Fedderke and Bogetic 2006) by increasing the productivity of private capital and labor inputs. This positive effect on productivity is also observed to be larger for countries with low initial stocks and inadequate infrastructure services (Agénorand Moreno-Dodson 2006).

The broader institutional environment matters too. Nguyen and Jaramillo (2014) find that lower institutional quality in terms of the rule of law, regulatory quality, or property rights protection lowers the return to innovation for a large sample of firms in developing countries. Other studies have documented the role of corruption (DeWaldemar 2012), or efficient institutions (Amendolagine et al. 2013). Allard, Martinez and Williams (2012) show that political stability plays an important role in the development of public systems to support technology adoption and innovation. More generally, Bloom (2007) and Baker, Bloom and Davis (2016) show how policy uncertainty reduces investment, which is likely to have even more effect on technology upgradation projects with long gestation periods.

5.2 Complementary markets and institutions, in particular difficulty in access to finance, constrain technology adoption by Bangladeshi firms

Access to finance

Difficulty in access to finance is the single largest self-reported constraint to technology upgradation among Bangladeshi firms, and particularly small and medium enterprises (SMEs). When asked about the biggest obstacle faced in adopting new equipment, machinery, software or processes to improve firms' performance, around 35 percent of firms stated the difficulty in obtaining finance (Figure 5-1). Notably, an overwhelming 50 percent of SMEs reported obtaining finance as the biggest obstacle in adopting new technology, compared with a still significant but much lower 17 percent for large firms, suggesting that financial frictions disproportionally affect technology upgrading of SMEs.

Firms that obtained loans for purchasing equipment have better technology levels. Over the period of 2016–18, less than one-third of surveyed firms were able to secure a loan for technology upgradation. Consistent with international evidence, the firms that have successfully obtained a loan for purchasing equipment are characterized by better technology levels (Figure 5-2), and such a result remains robust after controlling for firms' size, age, sector and location (Annex Table A13).

> *Around 35 percent of firms and an overwhelming 50% of SMEs report difficulty in access to finance as the top obstacle for adopting new equipment, machinery, software and processes.*

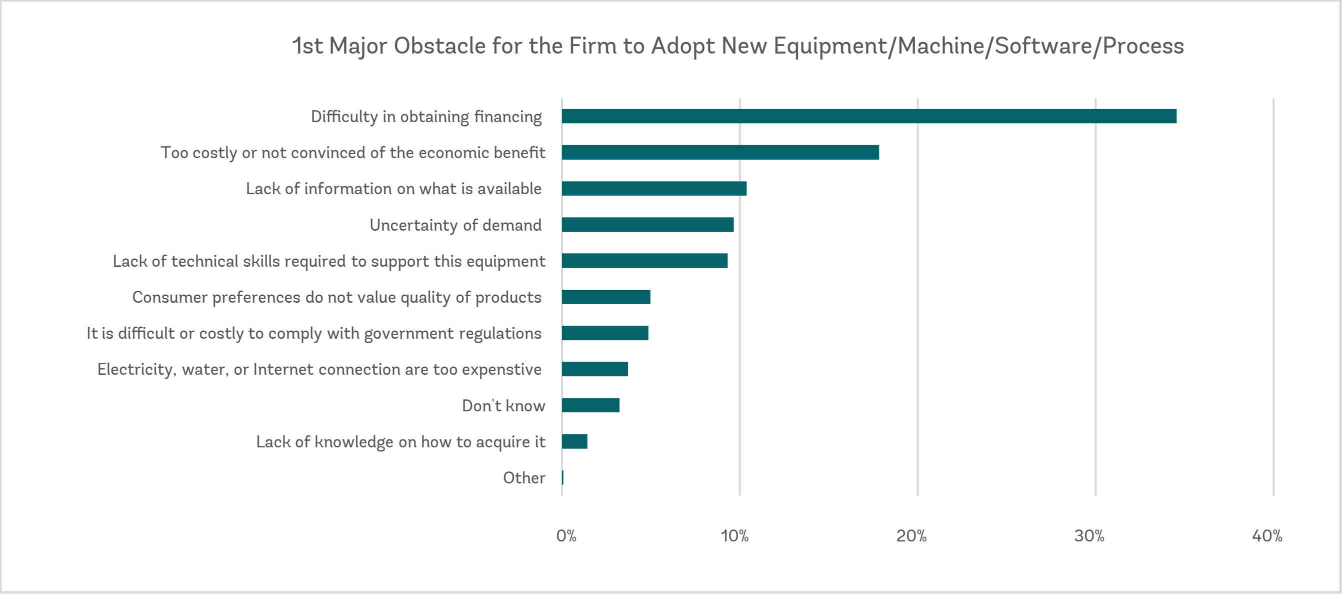
The underdeveloped nature of Bangladesh's financial sector contributes to firms' difficulty in access to finance. The financial sector is bank-dominated,[47] and the banking sector is highly fragmented and plagued by low capacity and weak profitability.[48] As a result, firms and particularly SMEs find it difficult to secure loans, especially long-term ones from banks for investment in technology. The capital market, including venture capital and private equity, is still at early stage of development. The lack of risk-capital financing means the entrepreneurs lack means to share risk with external investors, reducing their incentive for investing in new technology.[49]

[47] The banking sector accounts for around 90 percent of financial sector assets.

[48] The top three banks account for one-quarter of total banking sector assets, lower than in all peer countries. Interest rate margins are low and declining, and profitability is weak. The state-owned banks are particularly weak, operating with high NPL ratios and inadequate capital levels, despite frequent capital injections.

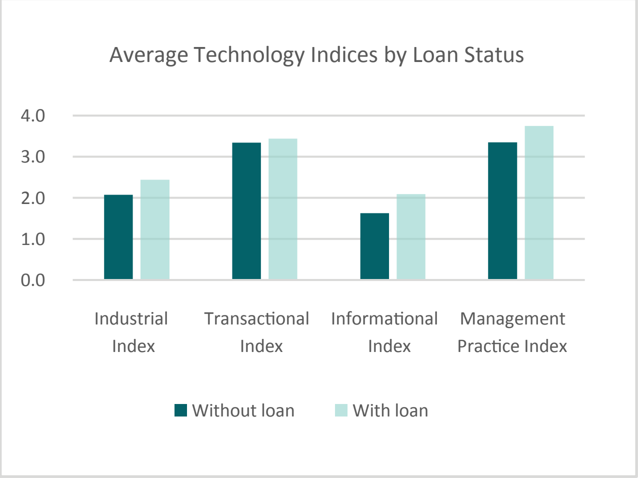
[49] Related to access to finance, uncertainty in economic benefits is cited by a large share of firms as the top constraint for technology adoption. While the uncertainty may come from the fact that some firms are not aware of the benefits of technology (see more discussion in Chapter 3), investment in technology adoption naturally involves uncertainty and risk, and the lack of risk-capital financing may have led entrepreneurs toward more conservative investment options in technology adoption, especially for firms in sectors with more advanced technology, such as pharmaceuticals.

Figure 5-1: Difficulty in obtaining financing is the most significant constraint to technology adoption for Bangladeshi firms



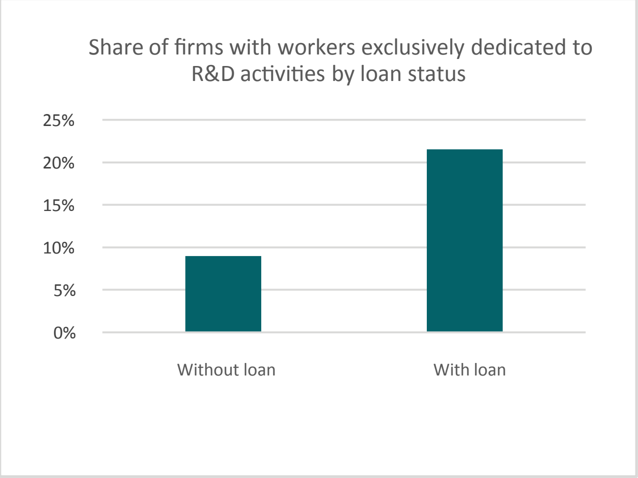
Source: Bangladesh FAT Survey.

Figure 5-2: Firms that have secured a loan for upgrading equipment have more advanced technology levels



Source: Bangladesh FAT Survey.

Figure 5-3: Firms that have secured a loan for upgrading equipment enagage more intensively in R&D



Source: Bangladesh FAT Survey.

Access to information about new technologies

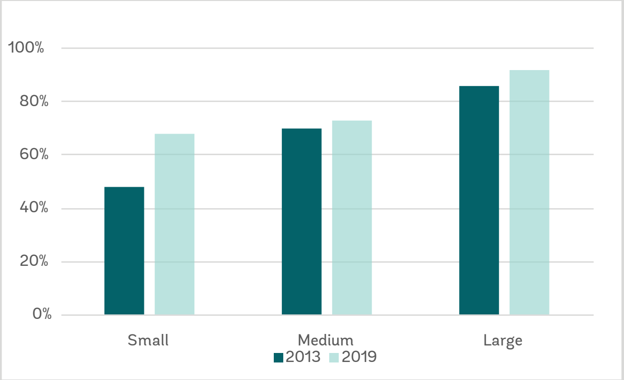
Besides access to finance, many firms in Bangladesh list informational issues as a major obstacle to the adoption of new machinery, equipment, software and processes. These informational issues include uncertainty about demand, a perceived absence of benefits, and a lack of information on what new technologies are available. For example, a perceived absence of benefits is reported by around 18 percent of firms as the top constraint on technology adoption. This indicates a role for public institutions in bridging informational asymmetries in the market for new machinery, equipment, software and processes. The lack of understanding by entrepreneurs about the benefits of technology is also congruent with the evidence for informational market failures in firms' capabilities that was discussed in Chapter 3.

Regulatory Environment

Large firms, in particular, are also constrained in technology adoption by regulatory costs. Among surveyed firms, when asked about the biggest obstacle to adopting new hardware or software, large firms are twice as likely to choose difficulty of regulatory compliance as SMEs. This is reinforced by the fact that the average time senior management spent each week dealing with requirements imposed by government regulations in large firms in 2019 is around double that in SMEs (Figure 5-5). In fact, the share of firms in which senior management has to spend time dealing with requirements imposed by government regulations increased across all firms' size categories between 2013 and 2019, but remained the highest (92 percent) among large firms (Figure 5-4).

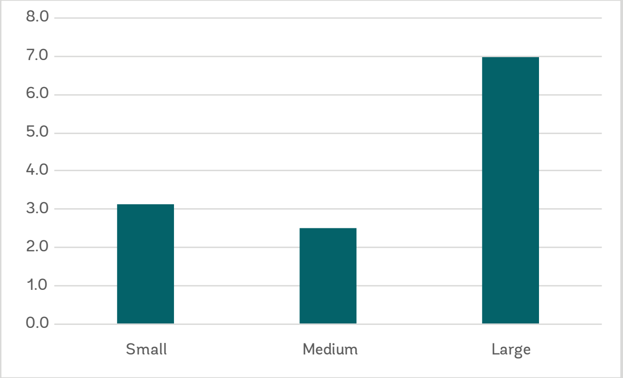
Entrepreneurs in Bangladesh face a high degree of regulatory uncertainty, which can dampen technology adoption requiring large upfront investments. The issues include a paucity of laws that clarify the rules of the game for new activities, weak enforcement of those laws, and conflicting definitions and interpretations of laws.[50] The resulting insecure property rights and weak enforcement of contracts dis-incentivize businesses from making investments in technology by adding to the risk of such investments, as their legality and appropriability are often subject to discretionary interpretation.[51] Businesses seeking to operate in Bangladesh have to contend with multiple reviews and approvals, resulting in difficulties and delays, which could also be preventing the entry of new businesses that use upgraded technologies.[52]

Figure 5-4: The share of firms in which senior management had to spend time dealing with requirements imposed by government regulations has increased since 2013



Source: Bangladesh FAT Survey and World Bank Enterprise Survey 2013.

Figure 5-5: The average time (in hours) of senior management spent each week dealing with requirements imposed by government regulations



Source: Bangladesh FAT Survey and World Bank Enterprise Survey 2013.

Access to industrial infrastructure

Costs of basic infrastructure (such as electricity, water and the internet) are listed by only a small share of firms as the main obstacle in technology adoption (Figure 5-1), as firms circumvent some of these constraints through inefficient alternatives, such as installing private electricity generators. In the case of electricity, which is a fundamental enabler of alternatives. According to our survey, 97 percent of large firms and 55 percent of SMEs have to own, share, or rent generators, which provide on average 17 percent of electricity to their daily production. In addition to the fixed cost of the

[50] Also, the announcement of new rules and regulations is typically done without prior notice, consultation, or impact assessment.

[51] Examples include changes in rules after an investment has been committed or discriminatory and confiscatory taxation.

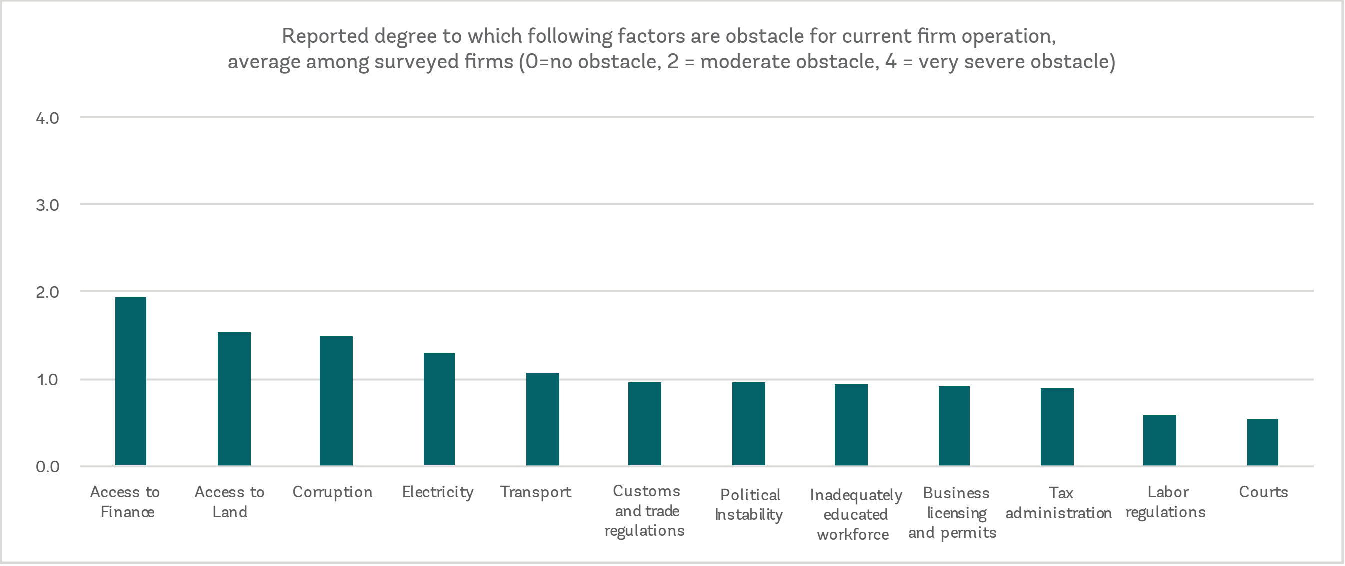
[52] A potential private investor has to navigate more than 150 government services to obtain the necessary approvals to start and operate a business in Bangladesh, and the processes are regulated by over 36 agencies with little inter-agency coordination.

generators, the unit cost of electricity from generators reported by surveyed firms is 55 percent higher than electricity from the public grid, adding an additional financial burden to firms' production and inhibiting firms' potential investment in technologies. In addition, all generators use fuel or gas as the source of energy, imposing environmental costs on the economy.

The installation of private electricity generators appears to be a key determinant for technology adoption. Despite the inefficiency of private electricity generators, they do nonetheless provide a stable electricity supply to firms, and are an indispensable source for firms' production and technology adoption. Among the surveyed firms, those firms that do not install private generators report a significantly lower technology level (Figure 5-7), and this result remains robust after controlling for firms' size, age, sector and location (Annex Table A14).

The inadequacy of basic industrial infrastructure in Bangladesh constrains firms' operation and increases operational costs, indirectly preventing firms' technology adoption. While not reported as a major constraint for technology adoption, difficulty in access to electricity is ranked as one of the top obstacles for firms' operation (Figure 5-6), as electricity generation and transmission has failed to keep up with rapid increases in electricity demand.[53] Besides access to electricity, the lack of access to industrial land is another major obstacle for firms' operation (Figure 5-6), as there is an inefficient land administration system and much of the land is either waterlogged, inaccessible by road, or inhabited. Such lack of industrial infrastructure constrains firms' operation, adding an additional financial burden to firms' production and indirectly inhibiting firms' investment in technology.

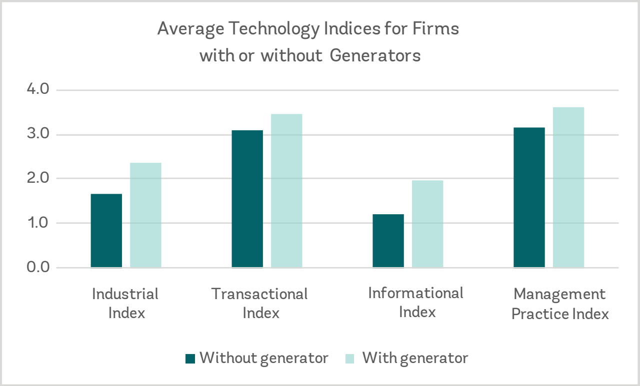
Figure 5-6: Access to basic industrial infrastructure such as electricity and land remains a major obstacle for firms' operation, despite not being reported as a major constraint for technology adoption



Source: Bangladesh FAT Survey.

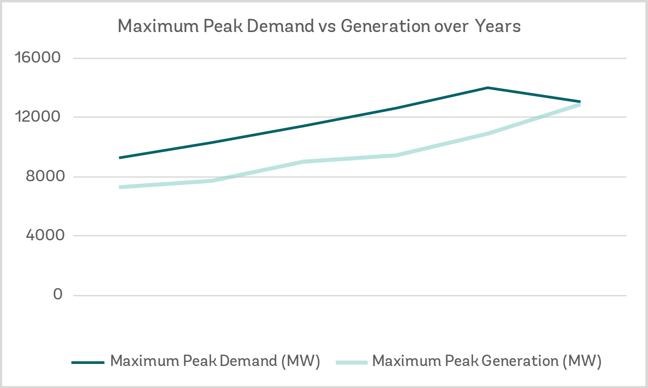
[53] Though the total electricity generation capacity has been improving significantly in recent years, it still fails to meet the rapid increase in demand during the irrigation and summer seasons. Further, while the gap between peak demand and supply appears to have narrowed recently, the narrowing is largely due to an unusual dip in demand in 2018–19 and may not last long (Figure 5-8). Finally, in addition to the insufficient power generation capacity, outdated electricity infrastructure and inefficient transmission and distribution systems also add to the challenges.

Figure 5-7: Firms without private generators are associated with a lower technology adoption level



Source: Bangladesh FAT Survey.

Figure 5-8: Electricity supply has failed to keep up with the increasing demand



Source: Bangladesh Power Development Board, annual report, several years.

5.3 Conclusion

Consistent with the development literature, the new survey data reveal that complementary markets and institutions are associated with technology adoption by firms in Bangladesh. In particular, access to finance stands out as the biggest constraint for firms, and especially SMEs, in adopting new equipment, machinery, software or processes, and firms with access to bank loans are characterized by better technology levels. Informational gaps and the costs of complying with business regulations are also cited by a number of firms (the latter especially by large ones) as a key obstacle in adopting technology. While access to basic infrastructure is not listed by most firms as a major obstacle in technology adoption, the lack of access to industrial infrastructure such as electricity caused firms to use more expensive and less efficient alternatives (such as private generators), which could be deterring firms' ability to invest in technology adoption and innovation by raising production costs.

Chapter 6: Policy Recommendations

Accelerating firm-level technology adoption in Bangladesh's manufacturing sector calls for a holistic policy approach that addresses both internal capabilities gaps in firms, as well as external constraints related to international connectivity, and complementary markets and institutions. Polices to support firms need to focus on the market failures that prevent firms from acquiring basic organizational capabilities. Firms in more advanced subsectors and market segments—whose numbers are low now but will grow in time—will also benefit from more technology-centric support; hence, such support needs to be selective and to be gradually scaled up on a demand-driven basis. A continued emphasis on strengthening foundational skills, STEM and engineering skills, and the basic technology infrastructure is also important. Enhancing firms' connectivity to international markets by reducing trade and FDI restrictions will also be critical to technology adoption. Since the magnitude and nature of Bangladesh's participation across different sectors differ, attention to sector-specific nuance in the design of policies to leverage international connectivity for technology adoption is warranted. Given the high upfront costs and uncertainty involved in adopting potentially profitable technologies, reforms in complementary markets and institutions should prioritize the better allocation of credit through more efficient and deep credit markets, and a reduction in regulatory gaps and uncertainty.

6.1 Recalibrating policies to upgrade firms' capabilities in Bangladesh

Bangladesh's manufacturing firms can achieve substantial gains in productivity and product quality through incremental improvements along several technology dimensions, ranging from industrial technologies to general-purpose digital technologies and business management practices. Technological upgradation, broadly conceived, should therefore be a core element of the productivity agenda. However, in common with other emerging economies, the policy discourse in Bangladesh tends to view firm-level technology adoption through a narrow lens, focusing on the transfer of highly advanced techniques from foreign countries or R&D laboratories to firms in high-tech sectors. This approach risks delinking technology adoption policy from the broader context of firm-level productivity policy.

The analysis in this report points to three factors that are critical to technology upgradation in Bangladesh's manufacturing sector: firm capabilities, international connectivity, and complementary markets and institutions. These channels are interlinked: for example, the dissemination of information on superior technologies is likely to be more effective if firms also have better access to finance for investing in technological improvements. Hence, policies to upgrade technology in Bangladesh's manufacturing sector need to adopt a holistic approach.

Policymakers are encouraged to devise a policy mix appropriate to the capability-building needs of Bangladeshi firms, which depend on where they are situated on the "capabilities escalator" (Cirera and Maloney 2017). With most manufacturing firms still on the lowest rungs of the capabilities escalator, the policy mix in Bangladesh should be focused on building basic organizational capabilities for incremental technology absorption. More technologically-oriented support needs to be selectively targeted at specific sectors and market segments in Bangladesh where firms are at a more advanced stage on the capabilities escalator. Even these firms need support with core organizational capabilities.

6.2 How to build firms' capabilities in Bangladesh

A mix of firm-level interventions, public investment and policy reforms tailored to Bangladesh's position on the capabilities escalator can be effective in building basic organizational and technological capabilities. The levers available to policymakers include firm- or cluster-level interventions involving the direct provision of advisory or financial support to firms, or the promotion of science-industry collaboration, systemic policy reforms, and the provision of "public goods" such as testing facilities and quality standards.

Firm-level interventions in Bangladesh need to be focused on building basic organizational capabilities for incremental technology absorption rather than high-tech R&D and technology transfer. Broader public investment and regulatory reform also need to be about strengthening basic technology infrastructure, research capabilities and skills. Investment in basic technology infrastructure, such as quality standards, equipment piloting, testing facilities and serviced industrial land, will benefit a broad segment of firms.

In subsectors such as leather goods that are seeking to break into more sophisticated export markets, public support for ensuring environmental standards and promoting collaborative research into adapting technologies to the local context is important. Besides science, technology, engineering and math (STEM) skills, these nascent exporting industries also need public support for quality, market-relevant sector-specific technical training. A case in point is the Institute of Leather Engineering and Technology (ILET), which is affiliated to the University of Dhaka. Industry consultations suggest that, while ILET is the major source of technical and managerial personnel for the leather goods industry, the training provided is too theoretical.

The importance of broader public investment and regulatory reform is well illustrated by firms looking to use e-commerce and digital payment platforms as an instrument to facilitate adjustment during the COVID-19 pandemic. The most frequently cited challenges to the adoption of e-commerce in South Asia include concerns about the cost of selling online, uncertainty about the resulting return on investment, and inadequate connectivity and information technology (IT) infrastructure. Regulatory hurdles that firms face when engaging in e-commerce primarily relate to: (i) consumer protection; (ii) data protection and privacy; (iii) e-transactions and e-signatures; (iv) cyber security; and (v) market access and investment-related policy measures (Kathuria et al. 2020).

Building foundational managerial and organizational capabilities is of paramount importance

Business advisory programs can have a major impact, but need to be adapted to the local context

There is evidence from a range of contexts that business advisory and consulting services can spur the adoption of better business practices in firms and improve their performance (see Box 6-1).[54] Such programs typically involve an initial diagnostic stage that is used to develop an "improvement plan," followed by advice on implementing that plan (Cirera et al. 2020). Some business advisory programs target young firms.

For young, small firms that are less innovation-oriented—such as small leather goods firms in Bangladesh—psychology-based, entrepreneurially-oriented training may be more helpful. Recently, a randomized psychology-based personal initiative training program that taught a proactive mindset and focused on entrepreneurial behaviors had a significant impact on the performance and innovation of micro-enterprises in Togo (Campos et al. forthcoming).

[54] See Cirera and Maloney (2017) and Piza et al. (2016) for comprehensive reviews of this evidence base.

Box 6-1: The impact of business advisory services: Evidence from randomized control trials

Randomized controls trials (RCT) are increasingly showing that business advisory services can be effective in improving the organization capabilities and performance of firms. In a seminal randomized study in India, large textile plants (average number of employees 270) that received five months of extensive management consulting from a large international consulting firm showed significant improvement in management practices and performance, with productivity increasing by 17 percent. The positive impacts lasted for several years after the consulting program.

SMEs, and not just large firms, benefit from advisory services. In a randomized program in Mexico, a training institute set up by the Ministry of Labor of the Mexican State of Puebla implemented a business development program to provide participating enterprises with subsidized consulting services. Unlike the Indian case, the training was provided by local consulting firms and given to SMEs (with 14 employees on average). The training led to a marked improvement in business practices, "entrepreneurial spirit" and firms' performance.

Providing intensive business advice to SMEs on an individual basis can be expensive. But there is some good news in this regard: less expensive, group-based business training also works. A recent randomized pilot with small auto-parts firms in Colombia compared the impact of one-on-one consulting with providing consulting to small groups of firms. The group-based approach delivered the same magnitude of improvement in management practices but at about one-third of the cost of the individual approach.

Source: Bloom et al. 2013; Bloom et al. 2020; Bruhn et al. 2018; Iacovone et al. 2019.

Bangladesh should focus on developing evidence-based and cost-effective business training programs suited to its context. While business training can have a strong impact, its cost effectiveness in a new context is not always known in advance. Hence, careful piloting of promising approaches is essential.

Two cost-effective design options—not mutually exclusive—are especially relevant for Bangladesh. The first is a group-based business advisory program design, which has been shown to be cost-effective in a recent pilot from Colombia (see Box 6-1). The second is a tiered approach that provides inexpensive, basic business diagnostics and "funnels" select firms into more intensive support programs. This funnel approach is still untried, although some countries have a menu of business advisory programs that are similar in spirit. For example, Singapore's SPRING program targets SMEs and provides entry-level support for accessing business advice through online toolkits, vouchers to partially cover the cost of core business consultancy projects, and grants for small technical upgradation projects, while the A*STAR program is for more sophisticated firms (Cirera and Maloney 2017).

Such business advisory or training programs can incorporate organizational changes that help managers optimize business practices in a post-COVID-19 world. This may include an emphasis on health-related issues, ranging from periodic hand washing and sanitizing machine parts to reorienting factory layouts that enable physical distancing on assembly lines.

> ***Such business advisory or training programs can incorporate organizational changes that help managers optimize business practices in a post-COVID-19 world.***

Government can play a role in supporting the market for advisory services

Since direct public provision of business advisory services is not scalable, such programs are best implemented by private sector providers in competitive markets, with governments subsidizing their cost for small and medium enterprises (SMEs). Similar to most low- and middle-income countries (LMICs), this market is not well-developed in Bangladesh due to a limited supply of experienced consultants and informational asymmetries, which prevent small firms from assessing the quality of service providers. In turn, limited demand from SMEs could be deterring the entry of service providers and keeping costs high. The Government can help stimulate competition in this market through public quality assessment, regulation, and certification of consulting service providers. Furthermore, given that many firms appear to be unaware of the importance of these services, vouchers and information dissemination on the value of business advisory services and the quality of providers could also stimulate the demand side of the market.

Bangladesh should only gradually build up a technology extension system

Technology extension services (TES) help firms modernize technologies through extension programs and technology centers (TCs) (see Box 6-2). Although they have overlaps with business advisory services, they tend to be more focused on technologies, R&D, and advanced management techniques. They can help address coordination problems and other market failures that prevent technology adoption. However, much of the global experience with technology extension programs is in the context of OECD countries (or that of agriculture) and evidence on their impact from contexts similar to Bangladesh's is limited.

Box 6-2: Technology extension services (TES)

Technology extension services (TES) involve "direct on-site assistance to SMEs through extension staff, field offices, or dispersed technology centers, to foster technological and knowledge-based modernization to improve the competitiveness of firms" (Cirera et al. 2020, p 149). Besides providing expert advice on new technologies and on optimizing the use of existing technologies, TES also help firms with advice on business strategy, quality management and process efficiency (e.g., lean manufacturing), the adoption of environmentally friendly and energy-saving practices, R&D commercialization, accreditation and technical standards.

"Technology centers" (TCs) are government-supported institutions—often sector-specific and involving private sector partnership—that, in broad terms, provide TES to firms. In developing countries, TCs tend to focus on testing, piloting, training and demonstration related to new equipment, rather than R&D activities. TCs can also be used to provide technology-related skills training.

Evidence on the impact of TES on manufacturing firms in countries such as Bangladesh is limited: much of it is either from an agricultural context or based on the manufacturing and services sectors in OECD countries. This evidence is largely positive, although the measured impacts depend on the context and the intensity of services offered, and cost-effectiveness is generally hard to gauge. The quality of technical expertise available to staff TES institutions, government capability for implementing TES, the strength of private sector linkages and the level of firms' capabilities for absorbing TES advice are all critical to the success of TES.

In the case of Bangladesh, TES are relevant largely for firms in more technology-intensive sectors (such as pharma) and market segments (such as exporting) that stand to benefit from acquiring sector-specific technologies to improve quality, reliability and lead times. Most other firms do not have the basic capabilities needed to benefit from such programs. Given the limited evidence base and low average capability levels of most firms, the scale-up of such programs should be gradual, and in sync with how fast firms reach the appropriate stage on the capabilities escalator.

Bangladesh has initiated "technology centers" (TCs) in priority sectors. Lessons from other countries show that successful TES tend to involve strong public-private participation (PPP) and be cluster- or sector-specific, as these features ensure better industry-science and inter-firm coordination (Cirera and Maloney 2017).

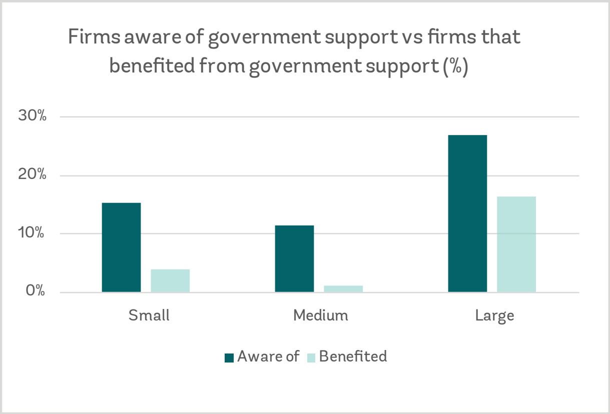
In the COVID-19 context, these TCs can incorporate lessons from other countries to illustrate how industrial machinery can enable better physical distancing on assembly lines in large factories, or how the use of software and other informational technologies can enable some non-production tasks to be carried out remotely.

Many countries use "technology transfer offices" to promote the dissemination of advanced technologies from research institutions to firms through instruments, such as licenses, royalties, and industry-science collaboration arrangements. For Bangladesh, however, improving the quality of research institutes, and basic technology and quality testing infrastructure, should come before such initiatives.

Government capability to directly support technology adoption and innovation needs to be enhanced

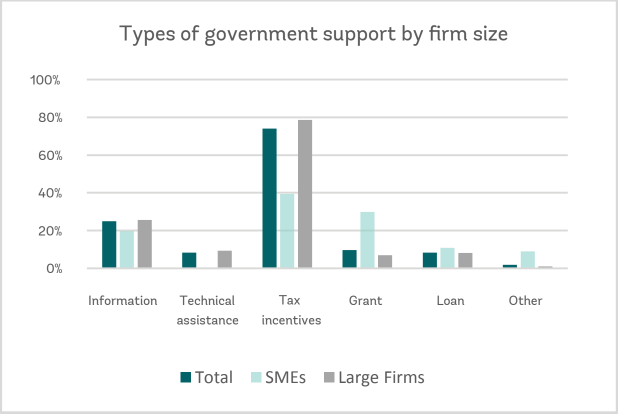
Even though informational constraints are a major barrier to building up firms' capabilities in Bangladesh, more than 70 percent of government support to technology upgradation takes the form of tax incentives. Among firms receiving government support, only 25 percent of them received technical assistance, and support about information and technical assistance in using technology (Figure 6-8). This indicates a significant gap between firms' needs to unlock their technology potential and the current provision of government support.

Figure 6-7: Government support pertinent to technology adoption covers a limited scope of firms



Source: Bangladesh FAT Survey.

Figure 6-8: Government support comes mostly in a fiscal rather than technical form



Source: Bangladesh FAT Survey.

Furthermore, there is a paucity of information about government programs to support technology adoption in firms themselves. Only about 20 percent of surveyed firms were aware of any government support program or subsidy for adopting technologies (Figure 6-7). This limited awareness among firms leaves out potential beneficiaries and undermines the effectiveness of government support programs. There are also substantial differences in such awareness across firms, with close to 30 percent of large firms being aware of government support programs for technology adoption compared with around only 10 percent of SMEs. This barrier for SMEs is also reflected in the actual outreach of such government support in Bangladesh. Government support covers a small portion of firms in the economy. Among those that were aware, only 25 percent of small firms, 9 percent of medium-sized firms, and 60 percent of large firms were able to eventually benefit from support programs. The firms that receive direct government support constitute roughly 10 percent of firms in the entire economy (Figure 6-7).

A systematic, in-depth review of technology and innovation policy, and its alignment with SME development policy, could be a useful starting point for identifying how public support for technology adoption can be better tailored to firms' needs. Bangladesh's firm-level technology adoption agenda, broadly articulated under the National Science and Technology Policy of 2011 and the National Industrial Policy of 2016, falls under the purview of several ministries and agencies given its cross-cutting nature. It is unclear how well the mix of programs and spending aligns with this report's recommended prioritization of incremental technology upgradation in SMEs. There may also be room for a better alignment of science and technology policy with SME development policies (as articulated broadly in the National SME Policy 2019). Furthermore, it will be helpful to assess the capacity-building needs of and coordination between SME agencies, including the Bangladesh Investment Development Authority, the Small & Medium Enterprise Foundation, the Bangladesh Small and Cottage Industry Corporation, the Bangladesh Industrial Technical Assistance Centre, and the Small & Cottage Industries Training Institutes.

6.3 How to leverage international connectivity for technology adoption

Trade restrictions in Bangladesh continue to weigh on input competitiveness. Despite lower customs duties, WTO-consistent export subsidies, tax holidays, and export credit guarantee schemes,[55] there has been a proliferation of levies, such as supplementary duties, regulatory duties, and value-added tax.[56] Furthermore, while exporters across sectors are eligible for duty-free import of raw materials though duty drawback schemes and special bonded warehouse (SBW) facilities, these benefits are less accessible in practice to firms outside the RMG industry. For example, only RMG exporters are exempt from a yearly entitlement process to use bonded warehouse facilities, which allow import orders to be cleared against export orders, based on the production capacity and firm performance in the previous year. Furthermore, the 750 Statutory Rules and Orders (SRO) have been drafted to support the operation of SBWs in RMG firms, and are less favorable when applied to other sectors. Similarly, the duty-free import of inputs is not available equally to non-RMG exporters, which must pay duties on imported inputs upfront and rely on a process of claiming duty drawbacks involving substantial transaction costs.[57] Unlike RMG, exporters in other industries also do not receive back-to-back letters of credit, which facilitate the import of necessary inputs against export orders placed. Therefore, tariff modernization and making access to export incentives less onerous for firms outside the RMG industry can improve Bangladesh's international competitiveness in other manufacturing subsectors.

> ***The benefits of duty drawback schemes and special bonded warehouse (SBW) facilities are less accessible to firms outside the RMG industry***

In addition, foreign equity caps, approval pre-requisites, mandatory public listing on entry, and uncertainty about financial incentives hinder foreign direct investment (FDI) inflows. Policy reforms that remove restrictions in business entry and strengthen the contract enforcement framework to minimize uncertainty for foreign investors, such as through the Companies Act, foreign exchange regulations and investment protection laws, can therefore boost FDI. Furthermore, targeted investment promotion is essential for attracting FDI, along with a strategic engagement with major retailers and brands to enhance the competitiveness of the sector. Special economic zones (SEZs) have some potential to fulfill the demand for serviced industrial land with quality infrastructure and a range of fiscal (e.g., tax holidays, duty-free imports) and non-fiscal incentives (e.g., 100 percent foreign ownership permissible). Nonetheless, they remain plagued by inadequate off-site infrastructure, non-strategic locations, and inadequate linkages with the rest of the economy. Furthermore, existing investment promotion agencies, such as the Bangladesh Investment Development Authority (BIDA), the Bangladesh Economic Zones Authority (BEZA), and the Bangladesh Export Processing Zones Authority (BEPZA), are constrained by weak technical capacity, an inefficient investor service delivery system, and inadequate mechanisms for policy coordination. This indicates a strong case for deeper institutional reforms that better link SEZs with the broader economy and consolidate a targeted investment promotion function for these agencies.

55 Bangladesh Export Policy 2015-18.

56 World Bank 2018a.

57 The process for receiving duty drawbacks is lengthier for exporters outside the RMG sector in the absence of standardized cost estimates, the calculation of which requires industry expertise.

Beyond attracting FDI, SEZs can also directly contribute to technology adoption. The Bangladesh Hi-Tech Park Authority (BHTPA), under the Ministry of Information, Communication and Technology (ICT), is one of two agencies tasked with overseeing the expansion of economic zones, hi-tech parks (HTPs) and software technology parks (STPs) in the country. It is envisaged that specialized private operators of core infrastructure in these economic zones will help leverage technology, innovation, business networks and management expertise of leading international companies. Furthermore, technology centers established under the World Bank's Export Competitiveness for Jobs Project are being located within SEZs and HTPs to encourage technology transfer, product development and productivity-enhancing skill development (World Bank 2019).

Policies to leverage international connectivity for technology adoption must also take heterogeneity across sectors into account

Ready-made garments

Bangladesh is well-integrated into global value chains (GVCs) for ready-made garments, but strengthening linkages with multinational enterprises (MNEs) is important to diffuse the benefits of technology adoption. Increasingly, supplier development programs to raise firms' capabilities involve MNEs that provide an initial diagnostic of management and production functions, and then work with suppliers in upgrading their capabilities with more emphasis on quality and productivity. These programs have proliferated primarily around the automotive and electronics subsectors, and are currently implemented in most high- and middle-income countries.

The Czech Republic was one of the most successful locations in attracting FDI during the 1990s, but MNEs drew few of their inputs from local suppliers. The Czech Government, in collaboration with a dozen MNEs, implemented a pilot National Supplier Development Program (SDP) in 2000–02, to provide needs-based targeted training to 45 SMEs.[58] An evaluation undertaken 18 months after the end of the 2000–02 period showed that 15 companies had gained new business, which they attributed to the program, with these contracts worth US$46 million for the period 2000–03. Four companies had also found new customers abroad, and three companies had obtained contracts for higher value-added content. The share of components sourced from Czech companies by the MNEs participating in the program correspondingly increased, from a rate of 0 to 5 percent at the start to 25 to 30 percent by 2004. Following the success of the pilot SDP in electronics, the program was replicated in three other subsectors (Cirera and Maloney 2017).

Bangladesh's chances of reaping the benefits of technology transfer associated with FDI are also inhibited by arbitrary caps on technology transfer transactions, lack of incentives on R&D expenses, and tight controls on the entry of expatriate skilled workers. A new FDI policy framework that also sheds light on innovation, the transfer of technology and skills is therefore needed.

Leather goods and footwear

Exporting and establishing linkages with MNEs in supply chains can similarly bring the benefits of technology diffusion in the leather goods and footwear industry. However, the necessary first step is to raise the global competitiveness of local firms through reducing trade and FDI restrictions, as described earlier.

There is also a need to develop firms' capabilities that enable potential suppliers to meet price, quality, and timeliness targets. However, developing these capabilities is plagued by information asymmetries. Private firms alone will not undertake research on foreign market information related to consumer preferences, business opportunities, quality and technical requirements, and so on, if competitors can free ride. There are similar externalities to cultivating contacts, establishing distribution

58 The SDP was implemented by Czech Invest, the Czech investment promotion agency. It was designed by the World Bank's Foreign Investment Advisory Services and funded by the European Union pre-accession PHARE Program.

chains, and undertaking other costly investments that can be used by their rivals. Hence, there is a role for policy measures that increase the capacity of local businesses to take advantage of market opportunities. Export promotion policies are a case in point.[59] The Bangladesh Export Policy 2015–2018, which identifies leather goods and footwear as a priority subsector, comprises government support to firms for product marketing and global market access, including through trade fairs both inside and outside Bangladesh.

The adverse environmental effects associated with leather processing in Bangladesh, together with evolving standards of global brands, mean that manufacturers of leather goods must adopt enhanced environmental safeguards to improve export competitiveness. The Government needs to make the central effluent treatment plant at Savar fully functional as soon as possible through financial support for infrastructure improvements, and a framework for its management and operations. The Government also needs to develop an environmental compliance framework and develop the institutional capacity to support firms to implement such a framework. This includes identifying gaps in national product standards and testing parameters as required in international markets, and providing technical assistance to obtain the internationally accepted ISO 14001 certification for leather goods. The industry can also benefit from increased allocations in the Green Transformation Fund (GTF) provided to banks for non-RMG exporters. These policies will help to restore the image of the leather goods industry among foreign investors, and help develop strong backward linkages with environmentally compliant tanneries. The Government is currently finalizing a draft leather policy that will hopefully address these challenges.

Pharmaceuticals

While imports of active pharmaceutical ingredients (APIs) are facilitated by low tariffs, the growing escalation between input and output tariffs has resulted in high effective rates of protection (ERPs) for domestic producers of finished pharmaceutical products. This creates incentives that favor import substitution over exports. In 2012, an ERP of 20 percent for the pharmaceutical industry was indicative of latent inefficiencies in firms, which have tended to perpetuate over time. Therefore, trade policy needs a strategic roadmap for tariff modernization with a gradual reduction in protection to encourage Bangladesh's export competitiveness beyond the export of generic drugs to unregulated markets.[60]

There is also trade policy support for firms to innovate and move up the value chain. In May 2019, the National Board of Revenue (NBR) granted VAT exemptions to imports of raw materials for APIs, as long as the local API producers make at least two molecules every year, conduct a quality audit, maintain good manufacturing practices, and spend at least 1 percent of their annual turnover on R&D.

Furthermore, partnerships with MNEs through FDI, contract manufacturing, joint ventures and strategic partnerships can enhance technology transfer to domestic firms. Pharmaceutical contract manufacturing in developing countries is a large and growing business, as MNCs increasingly seek to reduce production costs. This is a good business opportunity for Bangladeshi firms and, if done well, can enable them to acquire world-class experience in finished dosage manufacturing, APIs or other aspects of pharmaceutical production. Square Pharmaceuticals—one of Bangladesh's largest pharmaceutical firms—attributes much of its success to what it learned by working with a MNC headquartered in the United Kingdom. Contract manufacturing of a product for sale in the domestic market requires the physical presence of the MNE through FDI. Contract manufacturing for exporting to a regulated market, conditional on accreditation, is also consistent with Bangladesh's National Drug Policy (NDP) and brings the additional benefits of learning from sophisticated buyers.

[59] Lederman, Olarreaga and Payton 2010; Lederman, Olarreaga and Zavala 2013; Eaton et al. 2007.

[60] Most drugs on WHO's Model List of "essential drugs" are not patented.

Food processing

Connectivity to international markets is a less important lever for technology adoption in the food processing industry, given the lack of trade in intermediate inputs and exports to a niche Diaspora market. Nonetheless, connectivity to international markets can improve the incentives for firms in the food processing industry to innovate to the extent that trade is associated with scale economies that improve the returns to innovation. While the number of food processing firms in Bangladesh has increased significantly, only a few large firms are able to export. Exporting by SMEs is typically hampered by a lack of logistics support and post-harvest storage capacity. Meeting international food safety standards is also a major constraint. There are limited testing laboratories in Bangladesh that are internationally accredited, while obtaining certification from other countries is both expensive and time consuming.

6.4 Improvements in complementary markets and institutions deserve emphasis

Strengthening credit market institutions

Improving firms' access to finance for technology adoption requires enhancing the capacity of the banking sector to allocate credit efficiently to firms, including SMEs, and developing capital markets over time. Improving banking regulation, enhancing corporate governance of banks, particularly state-owned banks, and creating a level playing field between all banks would allow the banking sector to better serve firms. Enhancement in financial sector infrastructure, including credit information systems and a collateral registry, will make it easier for SMEs to borrow from banks. Over the medium term, capital-market and risk-capital financing could be further developed to support firms' financing needs in technology adoption.

During the COVID-19 crisis, financial institutions scaled back lending to firms, particularly SMEs, amid elevated credit risk. Public interventions in the financial sector are needed to support continued credit flows to the private sector during the COVID-19 crisis. A combination of liquidity injections to private financial institutions and partial credit guarantees to share a significant portion of credit risk with private financial institutions would be effective to incentivize their lending to the private sector.[61] Direct financing or co-financing through state development financial institutions would also be able to deliver financing directly to impacted firms.

Regulatory reform

The regulatory framework needs to be modified to reduce regulatory gaps and uncertainties, in order to incentivize firms' technology adoption. A review and update of the existing legal and regulatory framework, such as the Companies Act and the arbitration framework, are needed. Strengthening public-private dialogue to collect inputs and feedback from private sector stakeholders would also strengthen this process. Furthermore, there is a strong case for simplifying government-to-business (G2B) service delivery by setting up an institutional mechanism to ensure improved inter-agency coordination, such as through a single window model one-stop shop (OSS) for investor services.[62] While these institutional reforms are largely horizontal/cross-cutting, they are particularly important for subsectors outside RMG. The RMG subsector has been effective in advocating for a simpler sector-specific regulatory environment. However, most other subsectors and their representative associations do not have comparable levels of influence and knowledge to identify and effectively advocate for critical regulatory reforms.

[61] Partial credit guarantees with a portfolio approach can be rolled out quickly to cover large number of financial institutions and end-borrowers.

[62] The World Bank's Doing Business 2011 study shows that 72 countries with an established OSS could on average deliver necessary approvals for business registration in less than 20 days, while the average for 111 countries without an OSS was over 40 days.

Infrastructure delivery

While the pursuit of broader economy-wide reforms is necessary to address the challenges of an underdeveloped power sector, a complex land records and titling system, and regulatory red tape, SEZs can be used to deliver better infrastructure and a less uncertain regulatory environment to key clusters of firms. With constraints on government resources and capabilities, two semi-autonomous agencies—the Bangladesh Economic Zones Authority (BEZA) and the Bangladesh Hi-Tech Park Authority (BHTPA)—are expected to play a key role in this process. Unlike the Export Processing Zones (EPZs) that are publicly owned and operated by the Bangladesh Export Processing Zone Authority (BEPZA), BEZA and BHTPA would rely mainly on private capital and expertise to build and operate the new zones but with important government oversight. BEZA aims to develop 100 economic zones by 2025.[63]

6.5 Conclusion

Given the widespread need for incremental technological upgradation in firms and their limited capabilities for doing so on their own, Bangladesh's firm-level productivity policy needs to focus on enabling the basic organizational capabilities for incremental technology absorption. It is important to bridge the gap between "science and technology" policy—which tends to focus on R&D-intensive technologies that are currently of relevance only in limited segments of manufacturing—and SME development programs—which may be of wider relevance, but have not been sufficiently assessed in terms of quality and cost-effectiveness.

The Government can help address financial and informational market failures that restrict firms' demand for managerial and technical advice, while strengthening the supply-side of the market through more effective regulation of quality and competition, and by piloting innovative delivery models such as tiered and group-based approaches in partnership with the private sector. There is also a role for public investment and regulatory reform for strengthening the basic technology infrastructure, such as quality standards and equipment testing facilities.

Trade and FDI restrictions inhibit the potential of Bangladeshi firms to leverage international connectivity for technology adoption. Tariff modernization and making access to export incentives less onerous for firms outside the RMG industry are particularly relevant. The same holds true for targeted foreign investment promotion. At the same time, policies must distinguish between sectors. For RMG firms already engaged in GVCs, strengthening linkages with MNEs and removing arbitrary caps on technology transfer transactions through FDI are central to diffusing the benefits of technology adoption. For the leather goods and footwear industry, removing trade restrictions and supporting export promotion are the first steps toward establishing linkages with MNEs, which in turn can bring the benefits of technology diffusion. Gradually reversing the growing tariff escalation on pharmaceutical products can enable access to more sophisticated buyers by raising the competitiveness of Bangladeshi firms to expand beyond the export of generic drugs to unregulated markets. Partnerships with MNEs through FDI, contract manufacturing, joint ventures and strategic partnerships can also enhance technology transfer to domestic pharmaceutical firms. In the food processing industry, exporting can improve the returns to innovation through scale economies, but remains hampered by the lack of logistics support and warehousing capacity.

Firms also urgently need better access to finance for technology adoption, which would be made possible by improving the efficiency of the banking sector, while gradually developing capital markets. Removing regulatory gaps and uncertainties, through a review and update of existing regulations and the improved enforcement of regulations, would support technology adoption, especially among larger firms. Special economic zones, while providing more reliable industrial infrastructure, could also be used as a testing ground for improving regulations and removing regulatory red tape.

[63] Currently, they have approval to establish 88 of them throughout the country, of which 29 will be private and 59 operated by government.

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Annex

The Bangladesh Firm Level Adoption of Technology (FAT) Survey

The main data source for this report is the Bangladesh Firm-level Adoption of Technology (FAT) Survey, which canvassed about 900 Bangladeshi manufacturing firms between November 2019 and February 2020.[65] The Bangladesh FAT Survey sample is drawn from the 2013 Bangladesh Directory of Establishments and covers registered (formal) firms in five industries (or, subsectors): ready-made garments, leather goods and footwear, food processing, pharmaceuticals, and a residual sector termed "other manufacturing" that includes light manufacturing, plastic products, electrical and electronic goods.[66] It covers four major divisions: Dhaka, Chittagong, Rajshahi and Khulna. These subsectors and locations account for more than 80 percent of the total manufacturing firms in Bangladesh.

The survey was stratified by the five industry groups, by three location groups (Dhaka, Chittagong and Rajshahi-Khulna) and by three firm size groups: small (8 to 19 workers), medium (20 to 99 workers) and large (100 and more workers). The sample size allocated to the strata was designed to ensure that the sample would be representative of the five industry groups (across all location and size groups), the three location groups (across all industries and size groups) and the three size groups (across all industries and locations).[67]

All the summary statistics presented in this report are weighted by the sampling weights—the inverse of the sampling probabilities—to ensure their representativeness of the surveyed population of firms.

The Bangladesh FAT Survey is a part of the global FAT project of the World Bank (Cirera et al. 2020). As such, it includes a module on industry-specific technologies that varies by industry and collects information on the technologies being used in every core production stage of the industry.

As the summary statistics of the survey data presented in the Annex Table A1 show, about 98 percent of formal sector manufacturing firms are private domestically owned. These firms are largely family-owned and managed. About 85 percent of them are owned by their founder and 13 percent by the founder's family. Only 9 percent of the firms are not managed by the founder or the founder's family.

About 47 percent of the firms are categorized as "large."[68] This appears to be at odds with the stylized fact that most firms in low- and middle-income countries are very small (see, for example, Hseih and Olken 2016). One reason for this is that the survey only covers registered firms. That said, it is also the case that Bangladesh's manufacturing sector is dominated by large-scale, labor-intensive garments firms, many of which employ more than 100 workers.[69] In this respect, Bangladesh is an outlier in the South Asia region.

[65] The original sample size was 1,200 firms, but it could not be achieved due to COVID-19-related disruption in field work. Given spatial and sectoral differences in the rollout of the survey, targeted sample firms that could not be surveyed due to the stoppage were disproportionately from outside Dhaka and Chittagong, and in the pharmaceutical sector. Hence, our final sample underrepresents these categories.

[66] The terms 'industry' and 'sector' are used interchangeably in this section.

[67] For example, the sample is representative of the garments subsector, of small firms and of Dhaka firms, but not representative of small garments firms located in Dhaka.

[68] Firms with 8 to 19 workers are categorized as "small" and those with 20 to 99 as "medium".

[69] Specifically, there were about 6,500 large garment firms out of a total of about 15,000 in the sample frame.

Additional tables and charts

Annex Table A1: Key characteristics of surveyed firms

	Mean	Total Observations
Ownership		
% Private domestic	98.4%	903
% Private foreign	1.3%	903
% Private joint venture (domestic & foreign)	0.2%	903
% Government or state	0.0%	903
% Others	0.0%	903
% Owned by founder or family		
% Founder	85.1%	895
% Founder's family	12.9%	895
% No	2.0%	895
% Whose founder or family is also the top manager		
% Founder	83.4%	903
% Founder's family	7.0%	903
% No	9.5%	903
Size		
% small	14.0%	903
% medium	39.3%	903
% large	46.7%	903
Age in years	15.5	902
% whose top manager has graduate or higher degree	53.9%	903
% workers with secondary school or above education	18.4%	897
% workers with graduation or higher	7.4%	897

Annex Table A2: Technology enablers

	Mean	Total Observations
Technology Enablers		
% with electrical connection	100.0%	903
% with generator	77.2%	903
% with water connection to water supply line	55.9%	903
% with telephone landlines	40.4%	903
% with cell phone lines	98.1%	903
% with computers	59.5%	903
% with Internet connection	65.4%	903
% with website	34.9%	903

Source: Bangladesh FAT Survey.

Annex Table A3: The correlation between technology indices and core firm attributes (OLS estimates)

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index
Food	0.394***	-0.125***	0.119*	0.0549
	(12.05)	(-4.28)	(2.49)	(1.57)
Leather	0.0783**	0.0216	-0.0234	-0.00725
	(2.60)	(1.06)	(-0.62)	(-0.23)
Pharma	0.926***	0.0417	0.686***	0.240***
	(28.49)	(1.34)	(11.90)	(5.94)
Garments	0.368***	-0.00874	0.224***	0.0828*
	(12.11)	(-0.37)	(5.14)	(2.49)
Medium	0.0714	-0.0865	0.0726	0.0111
	(1.96)	(-1.56)	(1.77)	(0.13)
Large	1.068***	0.342***	1.277***	0.686***
	(18.96)	(4.85)	(21.00)	(7.01)
Age_New	0.00353	-0.0228	0.00222	0.0275
	(0.09)	(-0.72)	(0.04)	(0.72)
Age_Middle	-0.0485*	-0.0165	-0.0337	-0.0158
	(-2.24)	(-1.00)	(-1.15)	(-0.75)
Dhaka	0.152***	0.0263	0.189***	0.0690*
	(5.64)	(1.07)	(5.02)	(2.32)
Chattagram	0.170***	-0.0214	0.162***	0.105**
	(5.05)	(-0.75)	(3.46)	(2.96)
Observations	903	898	898	903
R-squared	0.387	0.0654	0.173	0.0537

Source: Bangladesh FAT Survey.

Note: Robust standard errors. t-statistics in parentheses* $p<0.05$, ** $p<0.01$ and *** $p<0.001$. Tech indices measured in logs. "Medium" and "Large" are dummies for firm size as measured by 20-99 and more than 100 employees, resp. The omitted (or, the baseline) size dummy is "Small", denoted firms with 8-19 workers. "Age_new" and "Age_middle" are dummies for firm age. "Age_new" refers to new firms started operation after 2015, and "Age_middle" refers to middle-aged firms started operation between 2005 and 2015. The omitted age category dummy corresponds to firms that started operation before 2005. The category "Dhaka" and "Chattagram" are dummies for firm's divisional location, with the omitted location being the combined Khulna-Rajshahi divisions.

Annex Table A4: Impact of Technology on Profit per Worker

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Arcsine Profit per Worker			
Industrial tech index		0.0401*					0.00500
		(2.01)					(0.25)
Transactional tech index			0.0409**				0.0211
			(2.63)				(1.42)
Informational tech index				0.0662***			0.0596**
				(3.50)			(2.89)
Management practice index					0.0309**		0.0280*
					(2.68)		(2.53)
Overall technology index						0.110***	
						(3.96)	
Capital	0.0218***	0.0199***	0.0209***	0.0186***	0.0212***	0.0186***	0.0177***
	(7.62)	(7.00)	(7.37)	(6.52)	(7.44)	(6.56)	(6.18)
Employment	-0.0122***	-0.0160***	-0.0127***	-0.0223***	-0.0138***	-0.0193***	-0.0235***
	(-3.44)	(-4.03)	(-3.58)	(-4.95)	(-3.77)	(-4.85)	(-4.96)
Sector, Age, Location dummies	Y	Y	Y	Y	Y	Y	Y
Observations	789	789	789	789	789	789	789
R-squared	0.174	0.180	0.181	0.200	0.182	0.199	0.208

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * $p<0.05$; ** $p<0.01$ and *** $p<0.001$. The outcome variable is the inverse hyperbolic sine transformation of profits. The inverse hyperbolic sine transformation is similar to the logarithmic transformation and has the same interpretation but can also be applied to zero and negative values. Technology indices, capital and employment measured in logs. Sector dummies include dummy variables for the food, leather, pharma, garment and "other" manufacturing sectors. Firm age dummies include dummy variables for "new" firms (started operation after 2015) "middle-aged" firms (started operation between 2005 and 2015) and "old" firms (started before 2005). Location dummies include dummy variables for firms located in Dhaka, Chattagram and Rajshahi-Khulna.

Annex Table A5: Impact of Technology on Labor Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Log of Revenue per Worker			
Industrial tech index		0.197					-0.0224
		(1.47)					(-0.16)
Transactional tech index			0.265*				0.140
			(2.30)				(1.21)
Informational tech index				0.384**			0.354**
				(3.27)			(2.75)
Management practice index					0.326***		0.310***
					(3.75)		(3.63)
Overall technology index						0.853***	
						(4.81)	
Capital	0.225***	0.216***	0.220***	0.207***	0.219***	0.200***	0.201***
	(10.98)	(10.25)	(10.79)	(9.92)	(10.63)	(9.71)	(9.41)
Employment	-0.113***	-0.132***	-0.116***	-0.172***	-0.130***	-0.168***	-0.183***
	(-4.02)	(-4.30)	(-4.14)	(-5.27)	(-4.56)	(-5.63)	(-5.44)
Sector, Age, Location dummies	Y	Y	Y	Y	Y	Y	Y
Observations	789	789	789	789	789	789	789
R-squared	0.247	0.250	0.252	0.261	0.261	0.272	0.276

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * $p<0.05$; ** $p<0.01$ and *** $p<0.001$. Technology indices, capital and employment measured in logs. Sector dummies include dummy variables for the food, leather, pharma, garment and "other" manufacturing sectors. Firm age dummies include dummy variables for "new" firms (started operation after 2015) "middle-aged" firms (started operation between 2005 and 2015) and "old" firms (started before 2005). Location dummies include dummy variables for firms located in Dhaka, Chattagram and Rajshahi-Khulna.

Annex Table A6: Impact of Technology on Exporter Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Whether firm exports			
Industrial tech index		0.251***					0.190**
		(4.09)					(2.98)
Transactional tech index			0.0404				-0.0228
			(0.82)				(-0.47)
Informational tech index				0.190***			0.136*
				(3.37)			(2.30)
Management practice index					-0.0287		-0.0359
					(-0.77)		(-0.99)
Overall technology index						0.169*	
						(2.05)	
Capital	0.0322***	0.0205*	0.0313**	0.0230*	0.0327***	0.0272**	0.0179
	(3.37)	(2.13)	(3.30)	(2.40)	(3.42)	(2.82)	(1.85)
Employment	0.142***	0.119***	0.142***	0.113***	0.144***	0.131***	0.106***
	(11.16)	(8.22)	(11.10)	(7.50)	(11.05)	(9.29)	(6.62)
Sector, Age, Location dummies	Y	Y	Y	Y	Y	Y	Y
Observations	789	789	789	789	789	789	789
R-squared	0.537	0.550	0.537	0.548	0.537	0.540	0.555

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * p<0.05; ** p<0.01 and *** p<0.001. Technology indices, capital and employment measured in logs. Sector dummies include dummy variables for the food, leather, pharma, garment and "other" manufacturing sectors. Firm age dummies include dummy variables for "new" firms (started operation after 2015) "middle-aged" firms (started operation between 2005 and 2015) and "old" firms (started before 2005). Location dummies include dummy variables for firms located in Dhaka, Chattagram and Rajshahi-Khulna.

Annex Table A7: The relationship between technology and wages (OLS regressions)

	(1)	(2)	(3)
		Wage Rate (in logs)	
Technology Index	0.351***	0.295**	0.266**
	(3.41)	(2.86)	(2.82)
Capital	0.0804***	0.0754***	0.0486***
	(6.70)	(6.17)	(4.58)
Employment	-0.0817***	-0.0955***	-0.0271
	(-4.77)	(-5.04)	(-1.44)
Share of workers with secondary or higher education		0.00165	0.00213*
		(1.60)	(2.07)
Sector, age and location controls	Y	Y	Y
Manager education and experience controls		Y	Y
Occupational composition controls			Y
Additional skills controls			Y
Observations	789	788	788
R-squared	0.111	0.127	0.240

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * $p<0.05$; ** $p<0.01$ and *** $p<0.001$. Technology indices, capital and employment measured in logs. Sector, age and location controls are the same as those described in previous regressions. Manager education and experience controls include dummies for whether manager has graduate degree or above, whether manager has studied abroad, and whether manager has previously worked in a multinational or large domestic firm. Occupational composition controls include variables for the share of workers who are CEO/manager/professionals, share of workers who are manufacturing supervisors or technicians, share of workers who are clerical support workers, share of workers who are line workers, share of workers who are services or sales workers, and share of R&D workers. Additional skill controls include variables for share of workers with engineering or applied science college degree, and share of workers with MBA, MA or doctoral degree.

Annex Table A8: How much of the variation in profits per worker is explained by technology?

	(1)	(2)	(3)	(4)
		Profit per Worker		
Size, Age, Sector Location Controls	Y	Y	Y	Y
Technology Dummies	N	Y	Y	N
Management Dummies	N	Y	Y	N
Worker Skill Controls	N	N	Y	Y
Observations	796	796	795	795
R-squared	0.175	0.357	0.367	0.196
Joint F-Stats for Tech. dummies		20.29		10.61
(P-Value)	0.0000		0.0000	
Joint F-Stats for Management dummies		2.86		2.72
(P-Value)	0.0229		0.0288	

Source: Bangladesh FAT Survey.

Note: Sector, age and location controls include dummies for firm sector, age and location same as above. Technology dummies include dummies for levels of technologies possible in all general and sector-specific production stages. Management dummies include whether the firm has incentives, whether focus on long-term target, the number of KPIs and the frequency of monitoring. Worker skill controls include variables for the share of workers with secondary or higher education, for whether manager has graduate degree or above, whether manager has studied abroad, and whether manager has previously worked in a multinational or large domestic firm.

Annex Table A9: The association between human capital and technology in firms

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index	(5) Overall Technology index
Share of workers with secondary or higher education	0.000647	0.0000178	0.00175**	-0.000916	0.000113
	(1.17)	(0.03)	(2.70)	(-1.30)	(0.30)
Share of workers with engineering or applied science college degree	2.173**	0.752	3.513**	0.927	1.544**
	(3.19)	(0.89)	(3.22)	(0.88)	(2.99)
Share of workers with MBA MA or doctoral	0.662*	0.391	1.463***	0.437	0.638**
	(2.16)	(1.21)	(3.68)	(1.10)	(3.15)
If manager has graduate or higher degree	0.113***	0.0213	0.184***	-0.0584	0.0308
	(4.58)	(0.81)	(5.70)	(-1.78)	(1.70)
If manager has studied abroad	0.0628*	-0.00965	0.0658	0.0152	0.0264
	(2.15)	(-0.29)	(1.58)	(0.41)	(1.25)
If manager has MNC experience	0.0384**	0.0104	0.0258	0.104***	0.0474***
	(2.74)	(0.64)	(1.43)	(4.75)	(4.30)
Capital, Employment, Sector, Age and Location Controls	Y	Y	Y	Y	Y
Observations	788	788	788	788	788
R-squared	0.768	0.128	0.748	0.206	0.626

Note: Robust standard errors with t statistics in parentheses; * $p<0.05$; ** $p<0.01$ and *** $p<0.001$. Sector controls include dummy variables for the food, leather, pharma, garment and "other" manufacturing sectors. Firm age controls include dummy variables for "new" firms (started operation after 2015) "middle-aged" firms (started operation between 2005 and 2015) and "old" firms (started before 2005). Location controls include dummy variables for firms located in Dhaka, Chattagram and Rajshahi-Khulna. Technology indices, capital and employment controls are in logs.

Annex Table A10: The association between human capital and technology in firms (with R&D workers and occupational controls)

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index	(5) Overall Technology index
Share of workers with secondary or higher education	0.000595	0.000142	0.00201**	-0.000675	0.000208
	(1.13)	(0.25)	(3.11)	(-0.98)	(0.58)
Share of workers with engineering or applied science college degree	0.333	-0.0888	0.652	-0.0892	0.147
	(0.93)	(-0.27)	(1.22)	(-0.24)	(0.53)
Share of workers with MBA MA or doctoral	0.228*	0.0114	0.238	-0.0461	0.114
	(2.42)	(0.08)	(1.47)	(-0.17)	(1.23)
If manager has graduate or higher degree	0.112***	0.0232	0.193***	-0.0471	0.0358*
	(4.70)	(0.92)	(6.08)	(-1.47)	(2.02)
If manager has studied abroad	0.0606*	-0.0134	0.0626	0.0203	0.0259
	(2.11)	(-0.41)	(1.55)	(0.55)	(1.27)
If manager has MNC experience	0.0309*	0.0122	0.0234	0.106***	0.0467***
	(2.28)	(0.76)	(1.35)	(4.76)	(4.34)
Share of CEO/manager/professionals	0.397***	0.0244	0.550***	-0.225	0.0974
	(3.52)	(0.18)	(4.59)	(-1.49)	(1.29)
Share of manufacturing supervisors or technicians	0.306***	-0.0253	0.111	0.00240	0.0670
	(3.47)	(-0.25)	(0.58)	(0.01)	(1.02)
Share of clerical support workers	-0.0760	0.291	0.480*	0.325	0.297*
	(-0.38)	(1.30)	(2.22)	(1.01)	(2.00)
Share of line worker	0.00710	-0.0115	0.0121	-0.0265	-0.00787
	(0.32)	(-0.48)	(0.43)	(-0.84)	(-0.54)
Share of service or sales workers	0.0388	0.145*	0.109	0.0219	0.0832
	(0.54)	(2.11)	(1.15)	(0.22)	(1.50)
Share of workers exclusively dedicated to R&D	2.533***	2.185***	3.147***	1.353	2.091***
	(5.29)	(6.18)	(3.95)	(1.62)	(5.97)
Capital, Employment, Sector, Age and Location Controls	Y	Y	Y	Y	Y
Observations	788	788	788	788	788
R-squared	0.780	0.147	0.756	0.211	0.637

Note: Robust standard errors with t statistics in parentheses; * p<0.05; ** p<0.01 and *** p<0.001. Sector controls include dummy variables for the food, leather, pharma, garment and "other" manufacturing sectors. Firm age controls include dummy variables for "new" firms (started operation after 2015) "middle-aged" firms (started operation between 2005 and 2015) and "old" firms (started before 2005). Location controls include dummy variables for firms located in Dhaka, Chattagram and Rajshahi-Khulna. Technology indices, capital and employment controls are in logs.

Annex Table A11: Human capital in Bangladeshi manufacturing firms

	mean	sd	p25	p50	p75
% workers with engineering or applied science college degree	0.42%	2.81%	0.00%	0.00%	0.08%
% workers with MBA, MA or doctoral	1.79%	5.31%	0.00%	0.00%	1.84%
If manager has graduate or higher degree	0.54	0.50	0.00	1.00	1.00
If manager has studied abroad	0.13	0.34	0.00	0.00	0.00
If manager has MNC experience	0.50	0.50	0.00	0.00	1.00
% workers exclusively dedicated to R&D	0.28%	1.57%	0.00%	0.00%	0.00%

Source: Bangladesh FAT Survey.

Annex Table A12: The association between technology adoption and international connectivity

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index	(5) Overall Technology index
Obtain information from a foreign firm	0.0824* (2.36)	0.0612 (1.88)	0.0988* (2.21)	-0.0216 (-0.59)	0.0457* (2.34)
Have business with a multinational firm	0.0607** (3.02)	0.0228 (1.10)	0.121*** (4.52)	0.0988*** (3.96)	0.0687*** (4.91)
CEO or top manager have previous experience working in a multinational or a nati	0.0410** (2.76)	0.0103 (0.62)	0.0289 (1.50)	0.0880*** (4.04)	0.0433*** (3.89)
Capital, Employment, Sector, Age and Location Controls	Y	Y	Y	Y	Y
Observations	789	789	789	789	789
R-squared	0.749	0.128	0.701	0.214	0.624

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * p<0.05; ** p<0.01 and *** p<0.001. Technology indices, capital and employment measured in logs. Sector, age and location controls are the same as those described in previous regressions.

Annex Table A13: The association between technology adoption and access to finance

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index	(5) Overall Technology index
Whether firm has a loan or not	0.0606**	0.0105	0.0551*	0.0607**	0.0462***
	(3.03)	(0.60)	(2.20)	(2.60)	(3.32)
Size, Sector, Age and Location Controls	Y	Y	Y	Y	Y
Observations	785	785	785	785	785
R-squared	0.738	0.126	0.682	0.186	0.599

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * p<0.05; ** p<0.01 and *** p<0.001. Technology indices measured in logs. Size controls include dummy variables for "large" firms, "medium" firms and "small" firms. Sector, age and location controls are the same as those described in previous regressions.

Annex Table A14: The association between technology adoption and access to electricity generator

	(1) Industrial tech index	(2) Transactional tech index	(3) Informational tech index	(4) Management Practice index	(5) Overall Technology index
Whether has a generator or not	0.0779***	0.0530**	0.0969***	0.0746**	0.0730***
	(3.96)	(3.18)	(4.28)	(3.07)	(5.31)
Size, Sector, Age and Location Controls	Y	Y	Y	Y	Y
Observations	789	789	789	789	789
R-squared	0.738	0.125	0.684	0.178	0.598

Source: Bangladesh FAT Survey.

Note: Robust standard errors with t statistics in parentheses; * p<0.05; ** p<0.01 and *** p<0.001. Technology indices measured in logs. Size controls include dummy variables for "large" firms, "medium" firms and "small" firms. Sector, age and location controls are the same as those described in previous regressions.

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