AUS4INNOVATION

Technological change in Vietnam

The contribution of technology to economic growth

Summary report

Australian Aid

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Contents

Foreword

Cooperation on security, economic growth, and knowledge and innovation are the three pillars that underpin the Strategic Partnership between Australia and Vietnam.

Since 2017, Aus4Innovation has helped to drive this knowledge and innovation relationship – strengthening the two countries' cooperation in science and technology and building lasting linkages between our innovation systems.

Delivered cooperatively by the Australian Department of Foreign Affairs and Trade, Australia's National Science Agency (CSIRO) and Vietnam's Ministry of Science and Technology, Aus4Innovation explores technology and digital transformation, trials new models of partnership between the public and private sectors, and enhances Vietnam's capabilities in strategic foresight, scenario planning, commercialisation, and innovation policy development.

Over the past four decades, as Vietnam has experienced rapid industrialisation, modernisation, and international integration, the country has achieved rapid economic growth and transformed into a lower middle-income economy. The pace of Vietnam's continued growth and progress toward high-income status will depend increasingly on science, technology, and innovation.

Lower-middle income countries that have successfully developed high-income economies in a comparatively short period of time have switched their focus from export market development and capital accumulation to increasing productivity across all industries. Rapid economic growth at this stage therefore requires a national focus on productivity improvement and technology development.

This report is the culmination of Technological change in Vietnam – The contribution of technology to economic growth, a project delivered by CSIRO's Data61 in collaboration with the State Agency for Technology Innovation. It will play an important role in shaping policies for Vietnam's technology development in the next phase of growth and provides insights supporting Vietnam's economic development models to 2030, with the vision to 2045.

As a component of Aus4Innovation's Policy Exchange, this work was based on key recommendations from the 2019 report Vietnam's Future Digital Economy toward 2030 and 2045. The foresight scenarios contemplated by the 2019 report, and other key recommendations from that project have been widely cited by experts in Vietnam and international partners including the World Bank, United Nations Industrial Development Organization and the Asian Development Bank.

Innovation projects like this demonstrate the power of science and technology relationships to strengthen the long-term strategic and economic relations between our countries. Together, Australia and Vietnam will continue to collaborate in innovation to overcome shared challenges and realise growth opportunities; contributing to the goals of the Vietnam-Australia Strategic Partnership signed by the two Prime Ministers in March 2018.

On behalf of Vietnam's Ministry of Science and Technology and the Australian Department of Foreign Affairs and Trade, we greatly appreciate the collaborative efforts made by the implementing agencies and pledge to continue promoting science, research and innovation collaboration between our two countries.

H.E. Ms. Robyn Mudie
Department of Foreign Affairs and Trade
Ambassador to Vietnam

H.E. Prof. Dr. Huynh Thanh Dat
Minister of Ministry of Science and Technology

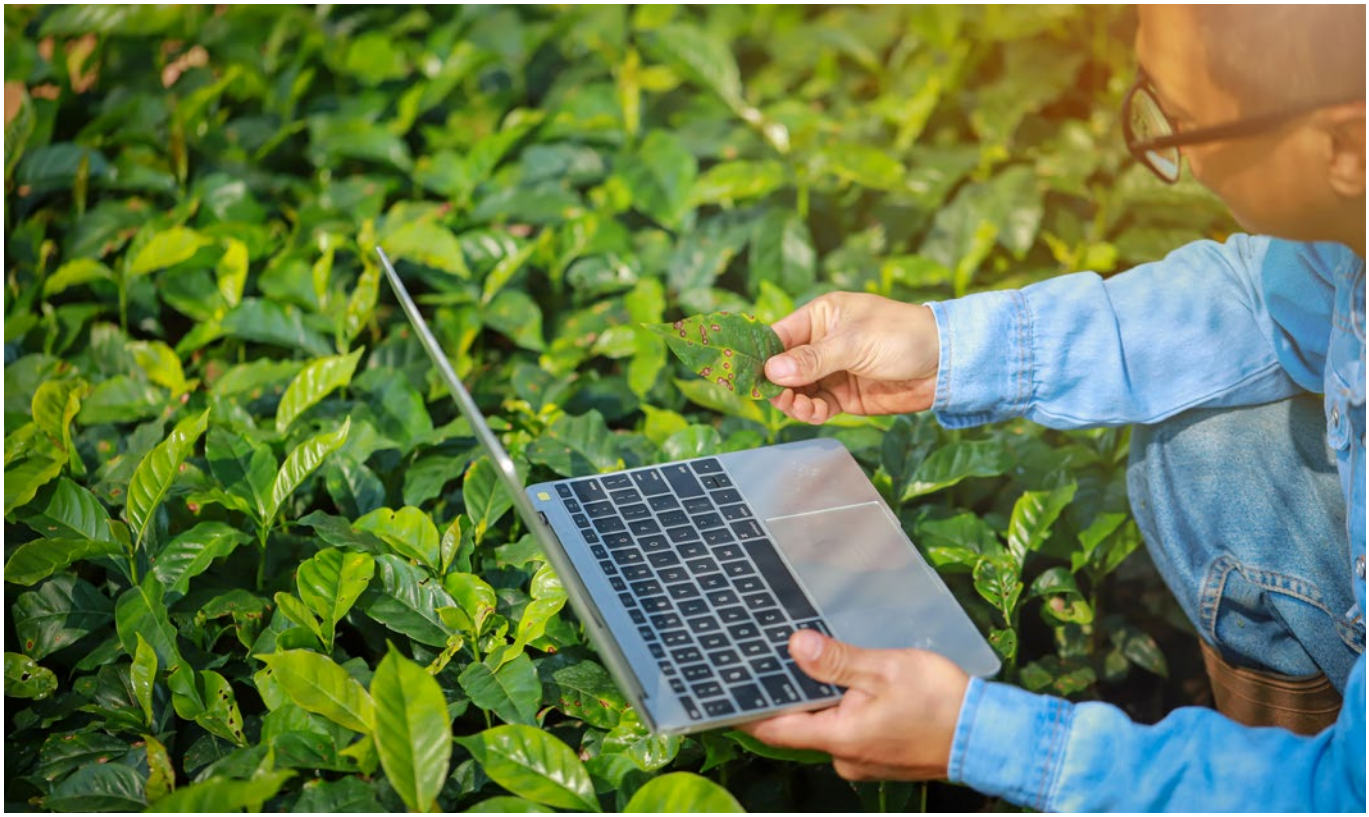
1 Introduction

Vietnam is rapidly growing and advancing economically. The country enjoys high gross domestic product (GDP) growth, averaging over 6.6% per year between 2000 and 2019.[1] This recent phase of economic development starting from 1986 has seen Vietnam open its borders to trade, attract foreign direct investment (FDI) and move quickly into manufacturing. This rapid shift elevated Vietnam from low income status to lower-middle income status by 2015 and has seen over 45 million people lifted out of poverty.

Vietnam is currently entering the next phase of economic development. While the previous phase was based on market development and a shift from reliance on agricultural output to manufacturing, the next phase will need to focus on efficiency gains. Between 2018 and 2019 Vietnam rose 10 places on the Global Competitiveness Index (GCI) published by the World Economic Forum and is now ranked 67th in the world.[2] These are remarkable gains, however, further economic development will require a greater focus on lifting labour productivity through technological change. This change will need to include both technology adoption and technology creation.

Technology development, for long, has been the topic of research, on methods of technology creation, technology diffusion, spillover effect, technology adoption/adaptation to create economic impacts. Many studies also provided evidence on positive impact of technology adoption and creation to productivity growth. In particular, producitivty enhancement can be achived through adopting new technologies to optimise the current resources, reduce costs and satisfy new demand and markets.

This project is a joint venture between Vietnam's Ministry of Science and Technology and CSIRO Data61. The project aims to better understand the current stage of technological development in Vietnam as well as the contribution of different technology creation and adoption activities to technological change and thus to Vietnam's economic growth.



2 Methodology

The diagram below summarises the methodology of the report.

2.1 DATA COLLECTION

Data availability is crucial in evaluating the stage of technological development across industry in Vietnam, as well as the impact of technological development on growth. The project's *Data Report* summarises and describes the database collected by the project team to evaluate technological adoption. This database was used to model the impacts of technology creation and technology adoption on economic growth in Vietnam.

2.2 THE TWO MODELS

The project utilises two economic models to measure technology adoption and creation:

- The **conditional frontier model** was used to assess the impact of technology adoption on economic growth by decomposing the output per worker growth of the economy/ sector into different components:
  - capital deepening
  - the impact of technology frontier lift-up
  - the impact of technology adoption effort
  - the impact of efficiency improvement effort
- The **dynamic stochastic general equilibrium model** was used to assess the impact of R&D investment on economic growth. The model was used to forecast Vietnam's long-term growth, driven by the adoption of new technologies developed by R&D investment. This general equilibrium model assumes that total factor productivity (TFP) does not grow exogenously but is dependent on two factors:
  - the creation of new technologies via R&D
  - the speed at which businesses adopt technologies

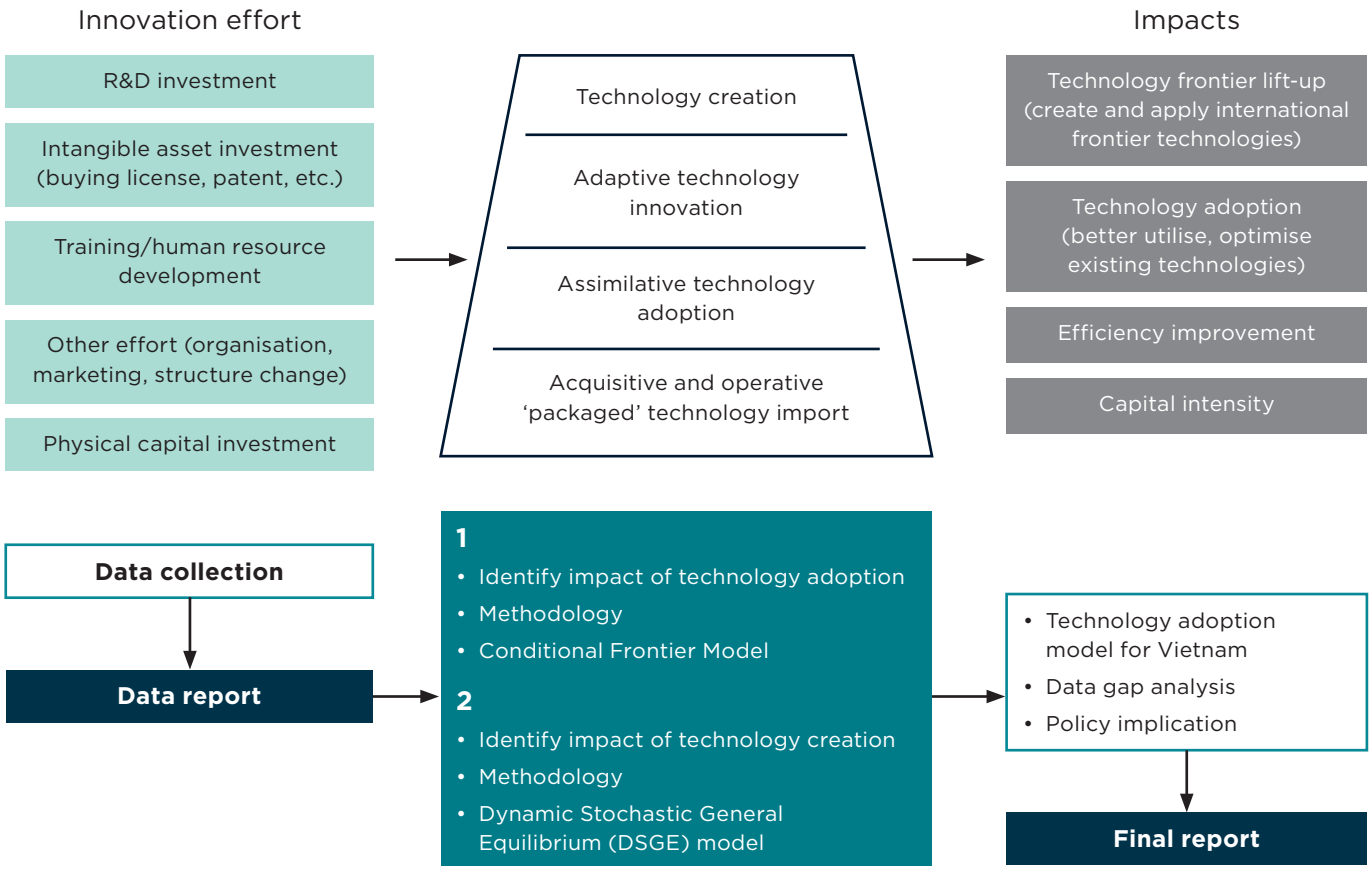


Figure 1. Methodology of the project

Source: Authors' illustration

3 Current stage of technology development in Vietnam

3.1 R&D INVESTMENT IS RELATIVELY LOW AND SCATTERED, HOWEVER VIETNAM RANKS WELL COMPARED TO OTHER NATIONS IN CERTAIN R&D OUTPUTS

International benchmarks indicate that R&D resource allocation in Vietnam remains comparatively low in both regional and global terms, although it has improved in recent years.

There are, however, signals that Vietnamese businesses are actively participating in R&D in terms of localising foreign technologies and through creating incremental innovations to existing systems and technologies.

There is also impressive improvement in R&D outputs in Vietnam. According to the Global Innovation Index 2020, Vietnam scores relatively well in the registrations of trademarks and industrial designs by origin (ranking 20 and 43, respectively), while in registrations of patents by origin it ranks relatively lower, at 65.[3]

3.2 VIETNAMESE FIRMS ARE INCREASINGLY TURNING TO TECHNOLOGY ADOPTION AS A MEANS OF IMPROVING EFFICIENCY AND COMPETITIVENESS

Vietnam's firms are lagging in technology adoption compared to countries at a similar developmental stage. As in many other developing countries, Vietnamese firms acquire and adapt technologies through the importation of capital goods. Another channel of technology transfer in Vietnam has been through labour mobility. Interestingly, Vietnamese firms do not consider technology acquired through backward/forward linkages within the supply chain to be an important channel for the adoption of technologies, particularly for overseas firms transferring knowledge to local companies.

There are also encouraging signs that Vietnam is increasingly adopting digital technologies. A survey on Industry 4.0 readiness in Vietnam showed that in 2018 around 15.1% of firms were applying cloud computing to their business operations, 12.4% were connecting machinery to digital equipment and 9.8% had installed digital sensors in their factories.[4] These levels of adoption, although small, are not much below the levels found in developed countries.

The COVID-19 pandemic has also underscored the importance of technology as businesses have rushed to adopt or develop digital technologies to address both the health and economic effects of the outbreak in Vietnam.

4 Measuring the impacts of technology adoption and creation

4.1 THE CONDITIONAL FRONTIER MODEL SHOWS THAT FROM 2001–2019, TECHNOLOGY ADOPTION HAS BEEN THE MAIN ENGINE OF GROWTH IN VIETNAM

As seen in Figure 2, the average annual growth in output per worker was 5.64% between 2015 and 2019. Also, 55% of the overall growth can be attributed to capital deepening (3.06% of the 5.64% per annum). The remaining 45% (2.58%) came from growth in TFP.

The contribution of TFP to growth in output per worker can be attributed to:

1. The effort of frontier firms in the economy to lift up the potential output that can be produced in the sector
2. The improvement in the efficiency of firms at the average level (laggard firms) in production
3. The impact of technology-adoption-related investment among leading firms to lift up the barriers in technical efficiency change and technology adoption change.

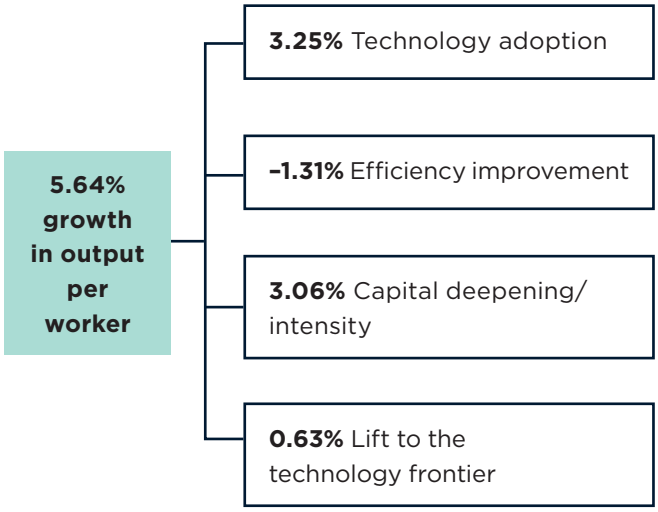


Figure 2. Components of output per worker growth per annum — average between 2015 and 2019

Source: Authors' calculation based on the GSO business survey[17]

The biggest contributor to TFP on average between 2015–2019 was the improvement in the technology adoption capacities of firms in the economy. The modelling results suggest that technology adoption efforts contributed 3.25% to the average growth in annual output per worker (more than 50% of total growth over the analysed period, more contribution to output per worker growth than the capital deepening component).

The efforts of leading firms to lift the potential technology frontier contributed more than 10% to total growth in output per worker over the analysed period (0.63% of the 5.64% annual growth in output per worker). These efforts by leading firms to lift the technology frontier is the second-largest contributor to TFP growth, and the third-largest contributor overall to output per worker improvement.

TFP would have contributed more to the overall growth in output per worker if there was no decline in the technical efficiency among laggard firms. Technical efficiency change represents the proportion of growth in output per worker resulting from the improvement in efficiency among businesses (i.e. improvement though learning-by-doing, organisational change or implementing quality management tools). If laggard firms in the economy managed to improve their efficiency at the same rate as that of improvement in technology adoption investment, then the average annual output per worker growth would be 1.31% higher and reach 6.95% instead of 5.64%.

4.2 THE COMPONENTS OF OUTPUT PER WORKER GROWTH HAVE CHANGED OVER TIME

Over the past two decades technology adoption has overtaken capital deepening as the main driver of growth in output per worker (see Figure 3).

2002–2007: CAPITAL DEEPENING DRIVES OUTPUT PER WORKER GROWTH

In the 2002–2007 period, output per worker growth in Vietnam was approximately 4.47% per year (see Figure 4). In this period, capital deepening played an important role in economic growth. Integration into the international market, together with various measures to stimulate the participation of the private sector and invite FDI, resulted in

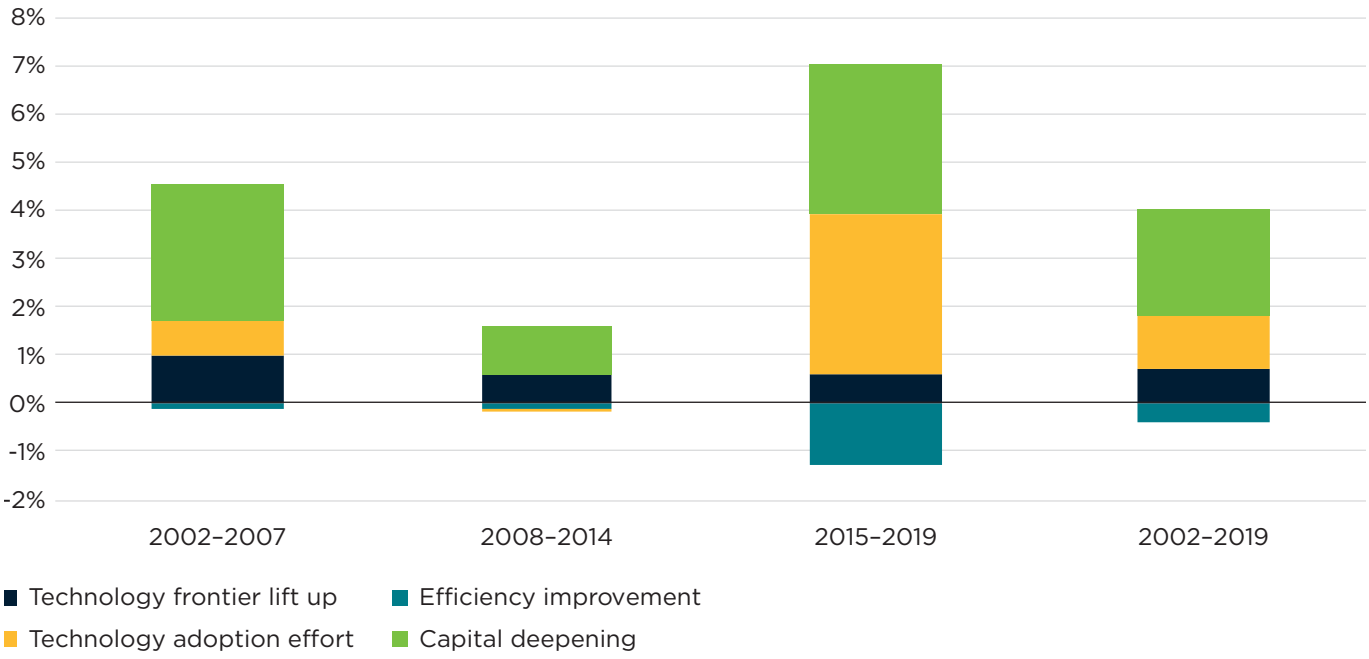


Figure 3. Output per worker growth decomposition across time periods between 2002 and 2019 in Vietnam

Source: Authors' calculation based on the GSO business survey[17]

the increase in both the number and volume of investment projects and thus contributed to the strong rise in the capital to labour ratio in Vietnam's economy. As workers were equipped with more capital, output per worker increased.

In this period, TFP contributed a small portion to output per worker growth. Among TFP's components, the biggest contribution came from frontier to lift up of firms in the economy. Their efforts to reduce technology adoption barriers contributed 1.03% of the 4.47% average output per worker growth per annum, or nearly 22% of total output per worker growth between 2002 and 2007. The efforts of firms to adopt technologies was the second largest contributor of TFP to output per worker growth. This contributed 0.7% of the 4.47% growth per annum, or 15% of total increase in output per worker growth over the analysed period. In this period, the laggard firms were not able to keep up with technology adoption efforts from frontier businesses, as represented by the negative growth rate for the impact of efficiency improvement.

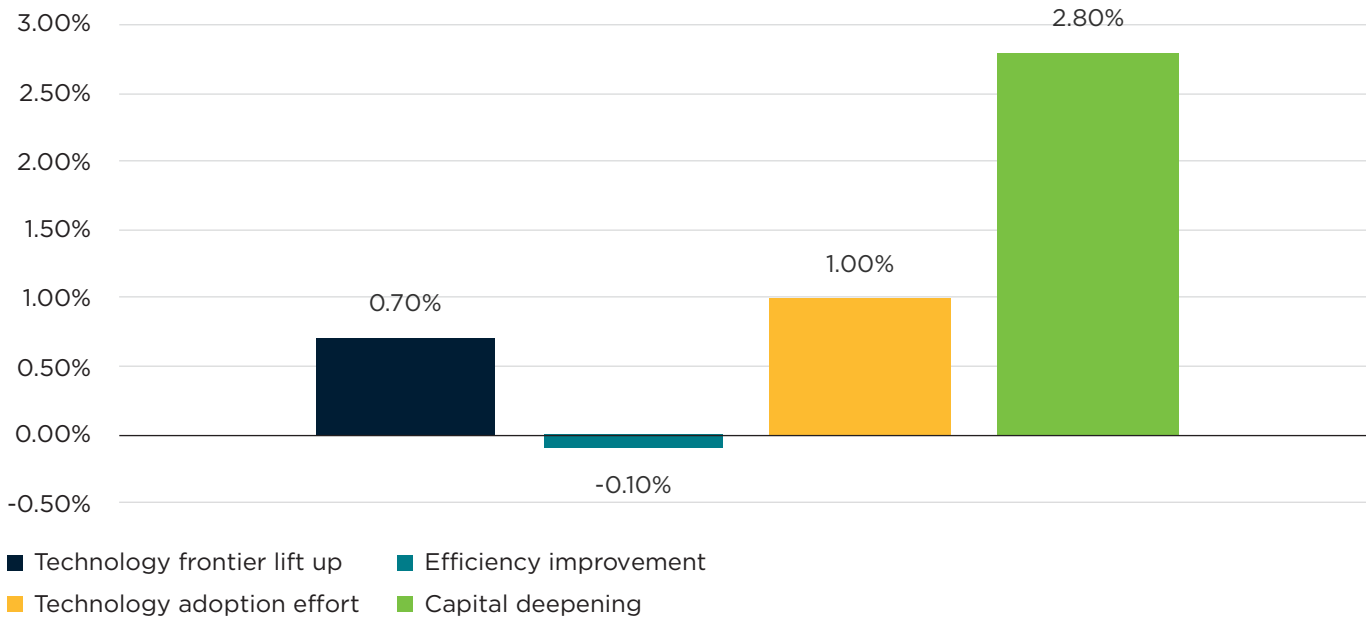


Figure 4. Average output per worker growth decomposition between 2002 and 2007 in Vietnam

Source: Authors' calculation based on the GSO business survey[17]

2008–2014: IMPACTS FROM THE 2008 GLOBAL RECESSION

Following the 2008 global financial crisis, the next period 2008–2014 marked a slow-down in output per worker growth in Vietnam. In this period, a dip in capital investment resulted in a sharp decrease in the role of technology adoption investment in economic growth. The decrease in investment reflects the lagged negative impacts of the global financial crisis on development investment among businesses. Also, a government stimulus package that was counted as an increase in capital stock in 2009–2010 concluded in 2011. This caused a sharp decline in capital stock statistics.

The contribution of capital investment to average annual growth in output per worker fell sharply from 2.79% in 2002–2007 to just 1.0% in 2008–2014. Meanwhile, there was an improvement in the contribution of leading firms lifting the potential technical frontier. Firms at the frontier increased their contribution to total output per worker growth from 22% in 2002–2007 to 43% in 2008–2014 (see Figure 5).

2015–2019: TECHNOLOGY ADOPTION BECOMES THE IMPORTANT DRIVER OF OUTPUT PER WORKER GROWTH

In the most recent period of 2015–2019 the average growth in output per worker per annum accelerated to 5.64%. TFP again became a significant contributor to economic growth, contributing 2.58% of the 5.64% average annual output per worker growth in this period. Interestingly, the impact of technology adoption increased dramatically during this period, overtaking capital deepening to become the largest contributor to output per worker growth (see Figure 6).

In this period, there was a major shift in government policies toward technology adoption (e.g. Resolution 27/QD-CP, Resolution 35/NQ-CP).[5,6] The amendment of the Law on Science and Technology in 2013 and in 2017 incorporated significant improvements to mobilise resources and encourage technology adoption among businesses.[7,8] Since 2013, the National Technology Upgrade program, with public

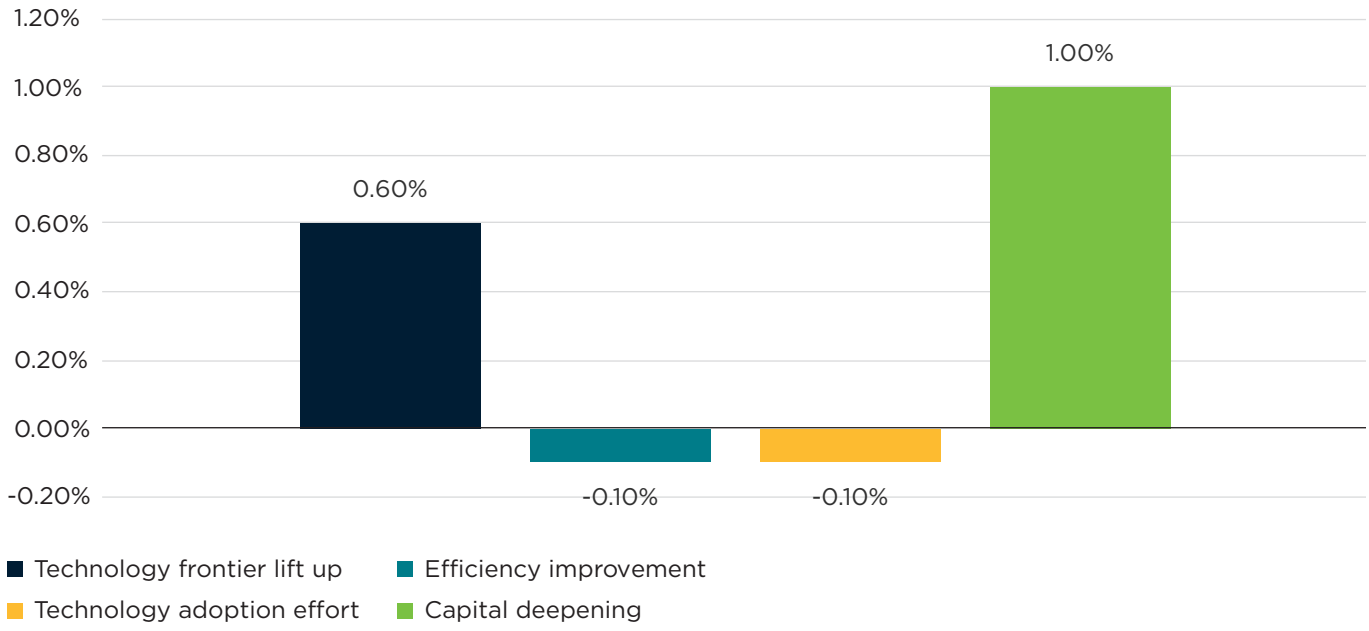


Figure 5. Average output per worker growth decomposition between 2008 and 2014 in Vietnam

Source: Authors' calculation based on the GSO business survey[17]

funding of 889 billion VND, has attracted more than 150 organisations, of which 59% were businesses, contributing more than 4,367 billion VND (about 73% of total investment[a]). The projects were implemented in more than 30 provinces across various sectors and have contributed a significant part in the provincial socio-economic development. In these projects, businesses took the leading role and engaged closely with experts in universities and research institutes to develop commercialised products with the support from the government. These connections have facilitated innovation activities within businesses and accelerated invention commercialisation process.

In 2015, MoST also identified five key measures to promote S&T including:

- significantly and consistently upgrading the organisational structure, management mechanisms and operations of S&T activities
- mobilising resources to implement S&T development orientations
- continuously strengthening national S&T potential
- developing the S&T market, S&T entrepreneurs and S&T-related services
- promoting international integration in S&T.

As a result, during the 2015–2019 period the number of SMEs that had technology-adoption-related activities increased by 23%. Of the top 500 businesses of Vietnam, 85% have upgraded technology, and 81% have invested in R&D. Of those, 41% have focused their R&D expenditure on developing/adapting new technologies/products for the domestic market.

With the increasingly fast rates of technology adoption investment, firms have found it hard to keep up with technological change in terms of organisational restructuring and management changes among other factors. As a result, there was a sharp decrease in firm efficiency between 2015 and 2019. In this period, if firms in the economy had managed to improve their efficiency to keep up with the rate of technology adoption, Vietnam's average annual output per worker growth would have been 6.95% (a 23% increase over the observed level).

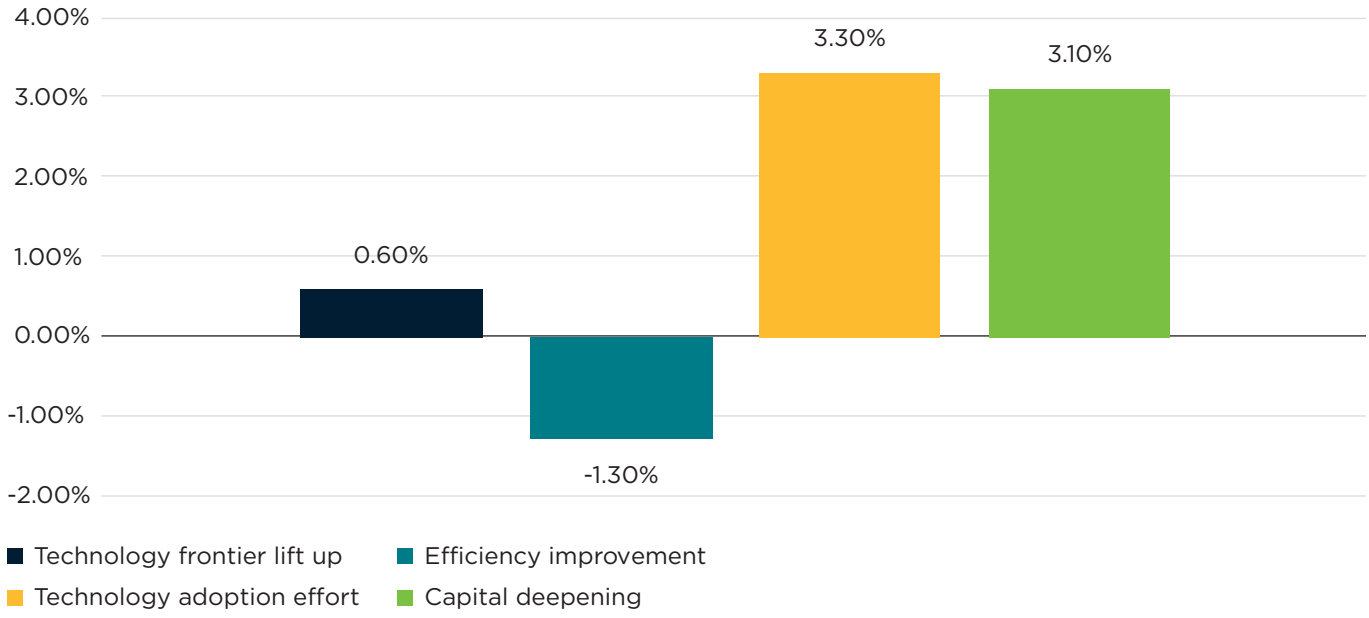


Figure 6. Average output per worker growth decomposition between 2015 and 2019 in Vietnam

Source: Authors' calculation based on the GSO business survey[17]

a This did not include national security and defence projects.

4.3 THE COMPONENTS OF OUTPUT PER WORKER GROWTH ALSO VARY ACROSS SECTORS IN VIETNAM

AGRICULTURE AND SERVICE

Over the last two decades, agriculture, forestry and fisheries were among the industries with the lowest output per worker in absolute levels. Except for fisheries, the average level of output per worker for agriculture and forestry was around 65% of the average level of the country. These sectors, however, enjoyed relatively high rates of economic growth over the period. Capital deepening was the only contributor to growth in agriculture while fisheries businesses were able to rely more on technology adoption to boost their output per worker growth.

Similarly, there was significant difference in the main contributor to growth across service sectors. The main contributor to the growth of the retail, wholesale, accommodation and food sectors was an increase in capital deepening.

Conversely, sectors such as transport, healthcare, and computers and related services not only enjoyed relatively high output per worker growth, but also benefitted significantly from the improvement in technology adoption and efficiency. These sectors also highlight the importance of frontier firms that apply advanced technology to help lift the potential technology frontier of the industry.

Looking more closely at the healthcare sector, TFP contributed 75% to total output per worker growth in the 2015–2019 period with the bulk of growth driven by technology adoption. Technology adoption has been necessary to meet the demand for improved healthcare in Vietnam, which has expanded rapidly with the rise in income per capita, urban populations and the ageing population, as well as new opportunities provided by healthcare insurance schemes. Despite relatively low healthcare spending (6.6% of GDP in 2019), Vietnam has achieved remarkable population health outcomes.[9]

MANUFACTURING

Manufacturing is by far the biggest employer in the economy, employing 20.7% of the total workforce in 2019.[17] The sector also occupies the greatest share of total output (around 16.5%) and plays a vital role in national economic growth and transformation.[17] UNIDO's Competitive Industrial Performance (CIP) Index shows Vietnam's tremendous achievements in manufacturing: between 2006 and 2019, Vietnam overtook 31 countries and improved from 69th to 38th in global ranking, by far the biggest leap among ASEAN countries during that period.[10] Over the past decade, the annual growth rate of manufactured exports from Vietnam has remained at an impressive double-digit level (increasing from US$59.6 billion in 2010 to US$248.6 billion in 2019).[1]

In this report, we follow the OECD and group manufacturing sub-sectors into four groups based on their R&D intensity level (R&D expenditure to turnover).[b]

Overall, low-tech industries play a very important role in employment in Vietnam, similar to that in other countries at a similar stage of development. There has been, however, a tendency for the low-tech industries' share of manufacturing to decline while the share of high-tech industries has increased over time.

Over the last two decades, Vietnam's share of high- and medium-high-technology products has increased considerably. Electronics has had the most prominent expansion, followed by chemicals, non-metallic products and transport equipment. The increasing footprint of the high- and medium-high-tech sectors has been compensated by the decreasing labour share of the low-tech sector. Employment in the low-tech sector decreased from 65% in 2001 to 59% in 2019, although the sector remains the biggest employer in manufacturing (see Figure 7).[17]

b High-technology sectors are those with an R&D intensity or more than 5% and are classed as 'high tech'. Sectors with complex technology with an R&D intensity between 3% and 5% are classed as 'medium-high tech'. Industries which are not research intensive and have an R&D intensity in the range 3%–0.9% and below 0.9% are classed as 'medium-low tech' and 'low tech', respectively.

The four manufacturing sub-sectors also show notable diversification in both the magnitude and source of output per worker growth between 2015 and 2019 (see Figure 8).

The high-tech sector had the highest output per worker among the four groups (124.6 million VND, compared to 108.3 million VND in the medium-high-tech sector, 85.8 million VND in the medium-low-tech sector and 71.1 million VND in the low-tech sector). The high-tech sector also led in the average output per worker growth rate, reaching 7.50% in the 2015–2019 period. This growth rate was comprised maily from: (i) the intense investment in capital resulting in a higher capital over labour ratio, and (ii) the ability of frontier firms to lift the potential technology frontier of the sector.

Firms in the high-tech sector benefitted the most from investing in leading technologies to lift up the technology frontier, which contributed 4.16% out of 7.5% output per worker growth. Investment in technology adoption effort of the sector contributed 0.67% to the output per worker growth of the high-tech manufacturing sector. However, firms in the sector were not able to increase their efficiency to keep up with the change in technology, which resulted in a negative 1.01% contribution to potential output per worker growth.

The medium high-tech sector not only had the second lowest output per worker growth (3.69%) but also relied on increasing capital intensity for growth. Although efforts of leading firms in deploying technologies to lift up the technology frontier of the sector played an important role in productivity improvement, the limited technical efficiency improvement resulted in the limited contribution of TFP to total output per worker growth of the sector. The contribution of TFP or technology and efficiency improvement only comprised 20% of total output per worker growth. Medium high-tech industries mainly include machinery, equipment, chemical (excluding pharmaceutical) and motor vehicle manufacturers.

In recent years, the Vietnamese Government has actively developed domestic manufacturing, attracting many foreign businesses to invest in Vietnam and set up factories. Also, the increasing demand for domestic manufacturing has driven an increase in the general demand for machine tools. However, due to the low technical level of Vietnam's machine-tool industry, Vietnam has been relying on imports for over 70% of the machine tools used. According to the World Machine Tool survey by Gardner, in 2018 Vietnam was the 8th largest importer of machine tools in the world.[11] Increasing the local manufacturing rate of the Vietnamese machinery industry will be one of the keys to increasing Vietnam's footprint in global supply chains.

The medium low-tech sector, though having higher average output per worker growth, compared to the medium-high tech sector (6.86% in the 2015–2019 period) and also depended on capital intensity for growth. These businesses include manufacturers that produce petroleum and coal products, polymer and rubber products, non-metallic minerals, metal products and furniture, and businesses that undertake waste collection and treatment activity. The major issue with the sector was the inability of businesses to keep up with technology-related investment. One possible reason was that businesses in this sector have failed to adjust their organisational and management structures, resulting in a significant potential loss in output per worker growth.

For all three sector groups mentioned above, the main contributor to output per worker growth, beside capital deepening, was the attempt to lift up the technology from leading firms in this sector.

The last manufacturing group, and also the largest group in terms of employment, is the low-tech sector. The sector includes light manufacturing such as food processing, textiles and garments, wood products, paper and printing. These businesses are an important source of employment in Vietnam due to their ability to quickly absorb a large pool of less-skilled workers from agriculture into industry. Although there has been a tendency to shift toward high- and medium-high-tech sectors in Vietnam, the low-tech sector still comprises nearly 60% of total employment in manufacturing.

The low-tech sector, however, had the lowest average output per worker (63.4 million VND) over the time period and also the lowest growth among the four technology groups. The average growth rate for this sector was 2.37% for the 2015–2019 period, much lower than the average output per worker growth rate of the whole economy.

The source of growth for the sector is primarily capital deepening or the increasing capital-labour ratio within the sector. The main contributor to TFP growth in the sector is the increasing investment in technology adoption.

At the other end of the spectrum, Vietnam is home to some world-leading manufacturing businesses who are at the forefront of technology adoption. However, on the whole, advanced technology adoption is more the exception than the rule. Growth in the manufacturing sector mainly comes from sheer increases in the number of micro and small enterprises rather than from a growing number of medium and large firms. Each year, a great many enterprises disappear and as many or more enter the market. Turnover is high as few of these micro and small firms ever reach medium size, creating a 'missing middle' phenomenon that is common in developing countries. The problem with this pattern of growth is that these micro and small enterprises are engaged in low-productivity domestic production activities and have no access to modern technology and knowledge.

Another issue with the low-tech manufacturing sector is that there is a dualism in the sector in Vietnam, whereby low-productivity SMEs with low technology adoption capabilities co-exist with relatively high-productivity large-sized firms. In Vietnam, large, mainly FDI firms, rely on cheap and low-skilled labour, and imports of raw materials and intermediate goods, with few or no links to the domestic market. The domestic market remains dominated by numerous small enterprises using low productivity methods and often outdated technology to supply goods. This has limited the competition pressure and spillover benefits that can stimulate the innovation and growth of domestic producers, as well as help scale-up industrial capacity.

At the 2-digit level, the contribution of different components to output per worker growth also differed significantly across manufacturing sub-sectors. The figures below show the results of some key sub-sectors in manufacturing.

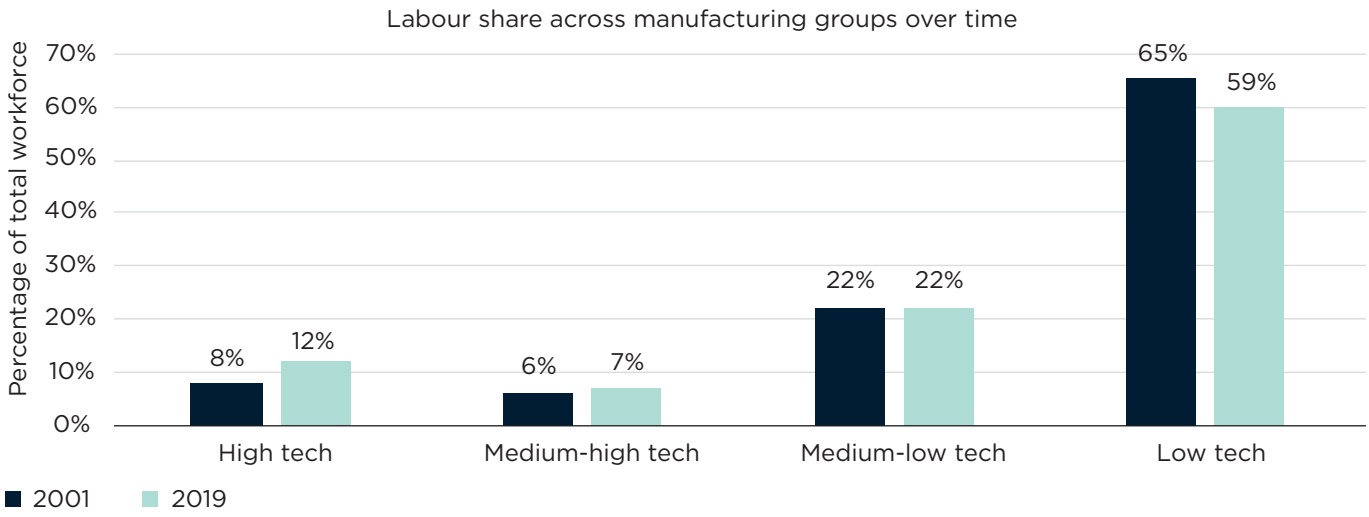


Figure 7. Labour share across manufacturing groups over time

Source: Authors' calculation based on the GSO business survey[17]

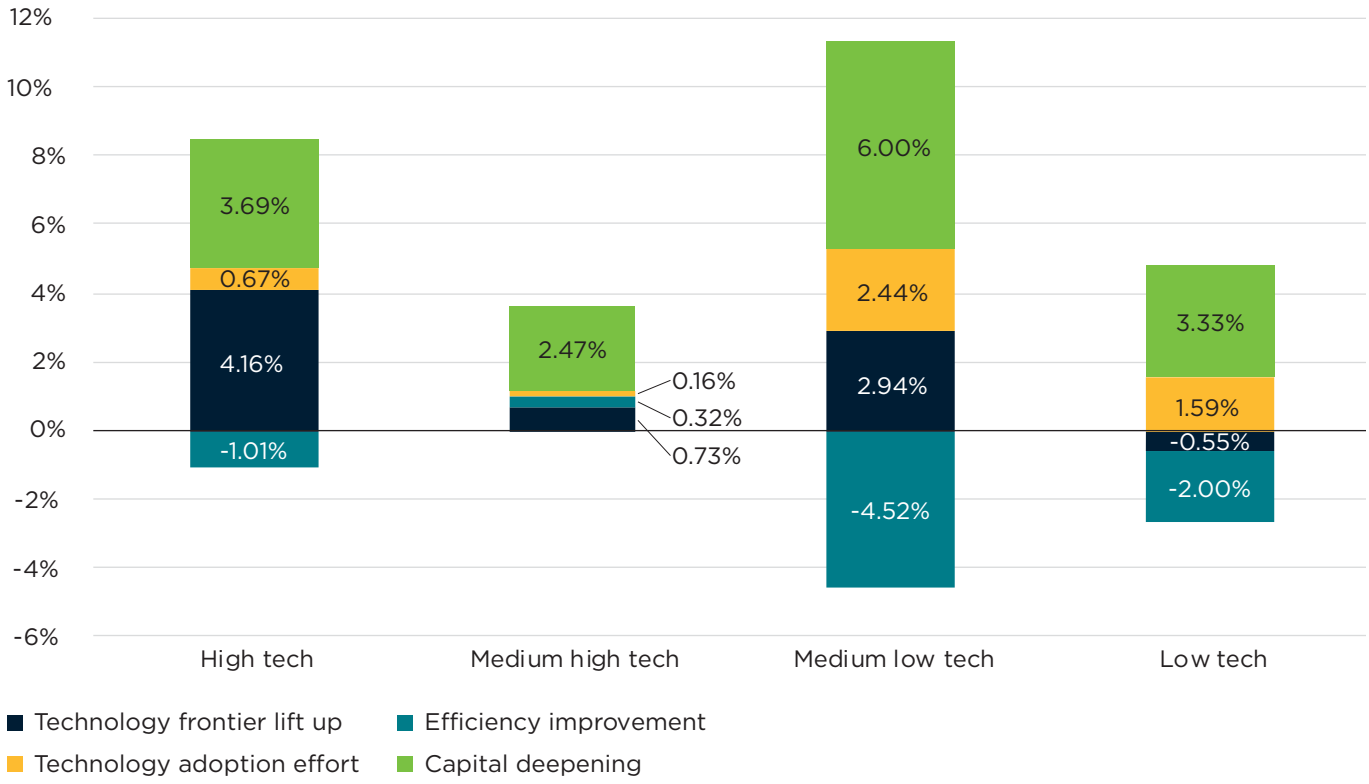
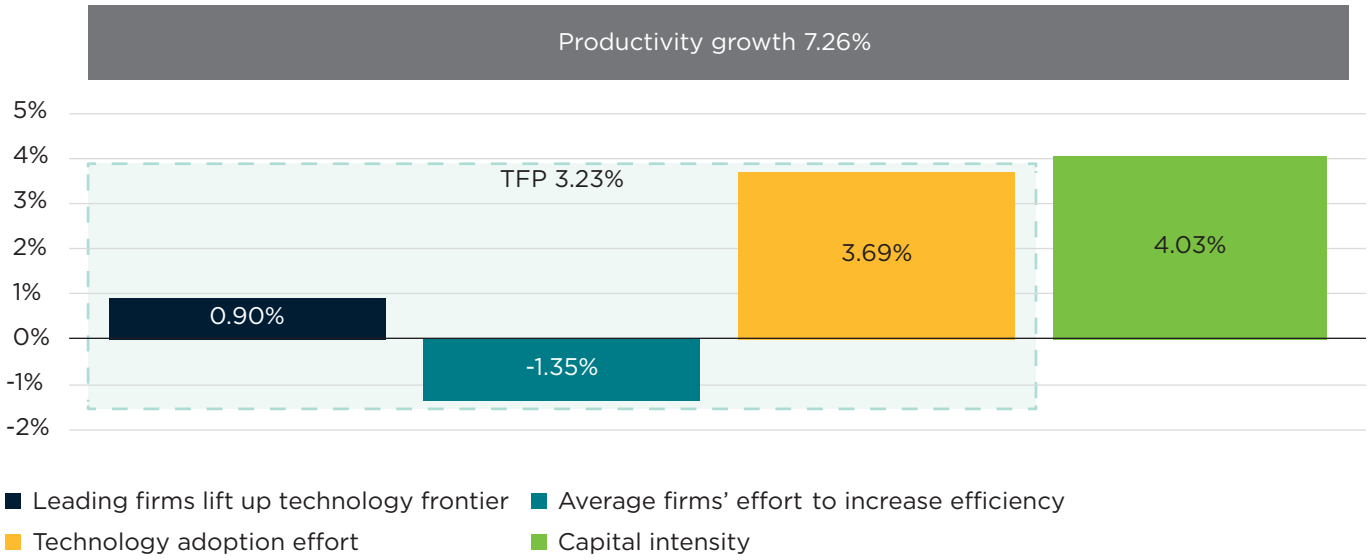


Figure 8. Average output per worker growth decomposition across manufacturing sector groups between 2015 and 2019

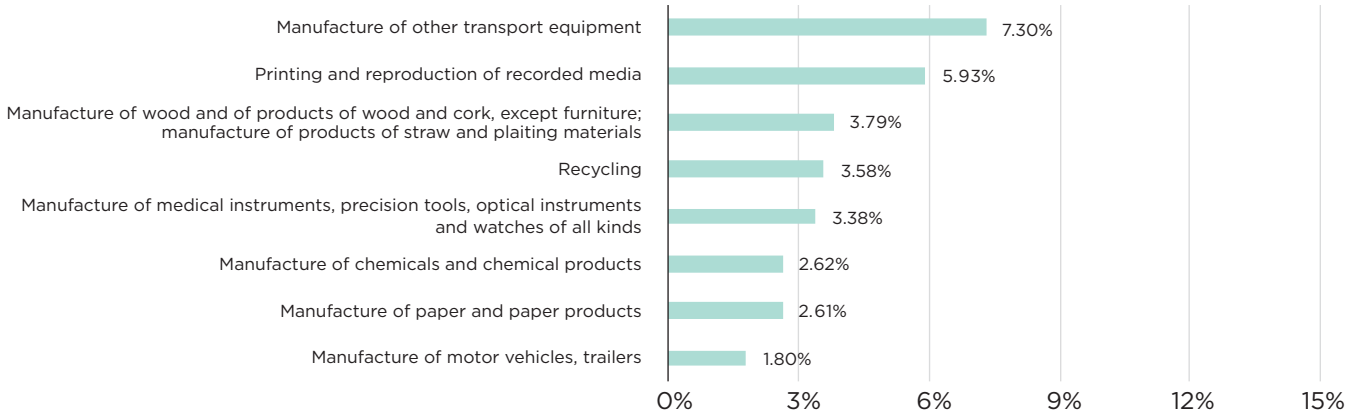
Source: Authors' calculation based on the GSO business survey[17]

MANUFACTURING AT THE 2-DIGIT SECTOR LEVEL, 2015–2019

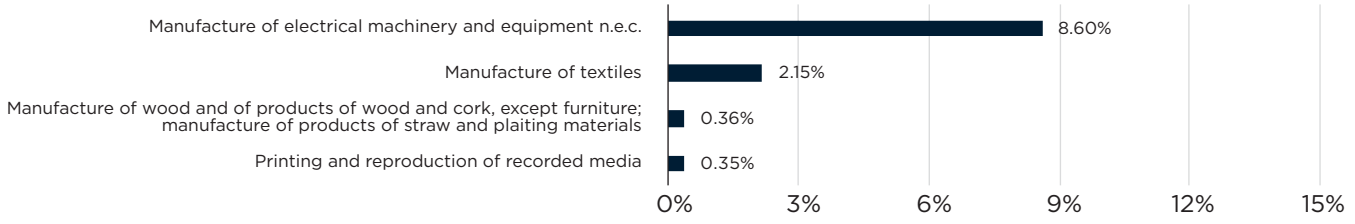


LEADING SUB-SECTORS

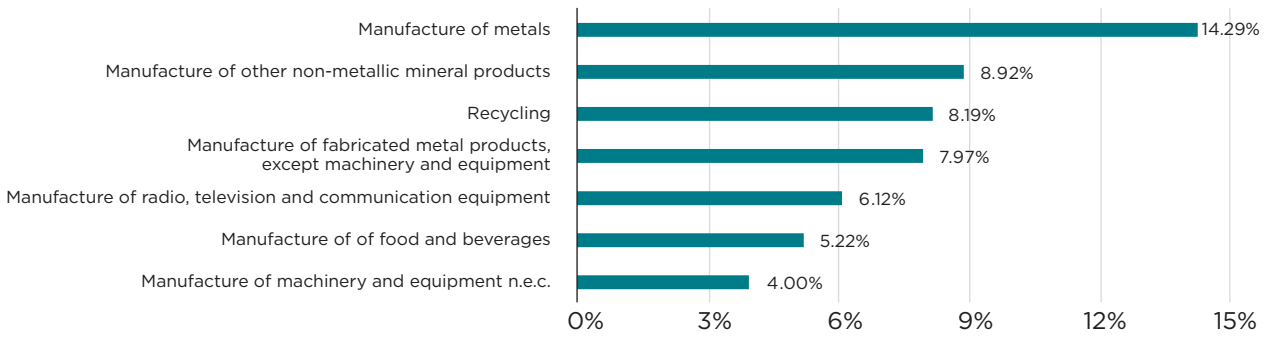
Components of leading firms lifting the technology frontier



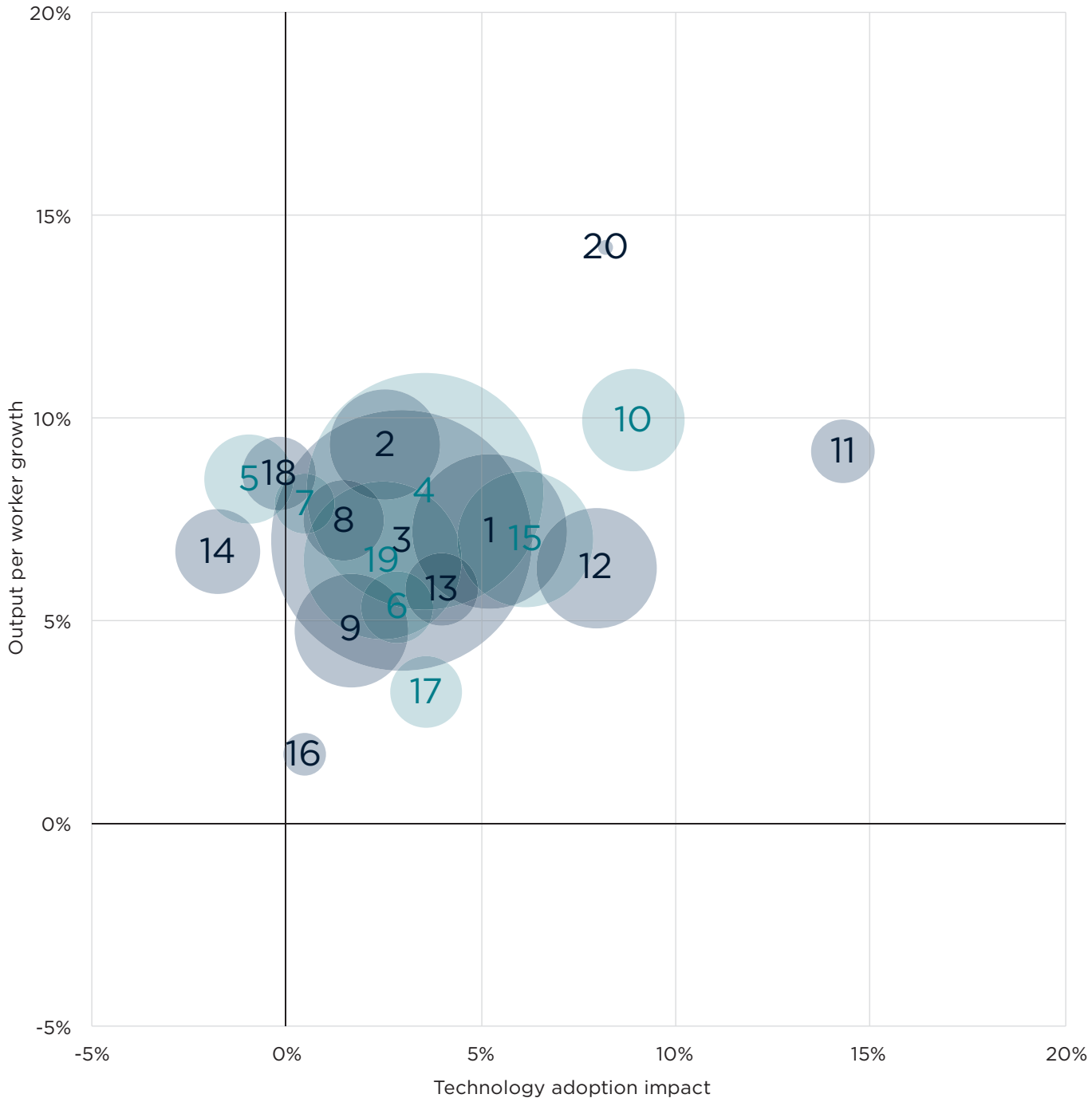
Components of average firms' effort to increase efficiency



Component of technology adoption effort



TFP GROWTH FOR SUB-SECTORS IN MANUFACTURING



1. Manufacture of of food and beverages
2. Manufacture of textiles
3. Manufacture of wearing apparel, tanning and dyeing of fur
4. Tanning and dressing of leather; manufacture of luggage, handbags, saddlery
5. Manufacture of wood and of products of wood and cork, except furniture; manufacture of products of straw and plaiting materials
6. Manufacture of paper and paper products
7. Printing and reproduction of recorded media
8. Manufacture of chemicals and chemical products
9. Manufacture of rubber and plastics products
10. Manufacture of other non-metallic mineral products
11. Manufacture of metals
12. Manufacture of fabricated metal products, except machinery and equipment
13. Manufacture of machinery and equipment n.e.c.
14. Manufacture of electrical machinery and equipment n.e.c.
15. Manufacture of radio, television and communication equipment
16. Manufacture of medical instruments, precision tools, optical instruments and watches of all kinds
17. Manufacture of motor vehicles, trailers
18. Manufacture of other transport equipment
19. Manufacture of beds, wardrobes, tables, chairs; Manufacture of other products n.e.c.
20. Recycling

In this project, we provided the analysis for all 2-digit sectors in Vietnam (using VSIC 1993 sector classification). Sample of the analysis for one sector is presented below. Detailed analysis for all 2-digit industries can be found in the online Appendix.

SECTOR 29: UNCLASSIFIED MACHINES AND DEVICES

For this sector, beside capital deepening, technology adoption effort is the main driver of TFP and a significant contributor to overall output per worker growth.

Over the period 2015–2019, the sector had an average output per worker growth of 5.8% (see **Figure 2**). The level of output per worker of the sector was 98.04mil. VND (constant 2010 price), which was 98.67% higher than the average level of the economy.

Figure 3 shows change in the industry-wide average production level relative to the industry's frontier (the production level groups of most efficient firms in the industry) as well as the movement of the frontier itself of the industry in the last five years.

Over the last two decades, total labour employed in the sector has increased by 97.26%. On the other hand, the proportion of labour engaged in Unclassified machines and devices over total labour of the economy decreased from 1.15% to 0.9%.

Output per worker growth	5.8%
Technology frontier lift up	0.7%
Technology adoption effort	4.0%
Efficiency improvement	-2.9%
Capital deepening	4.0%

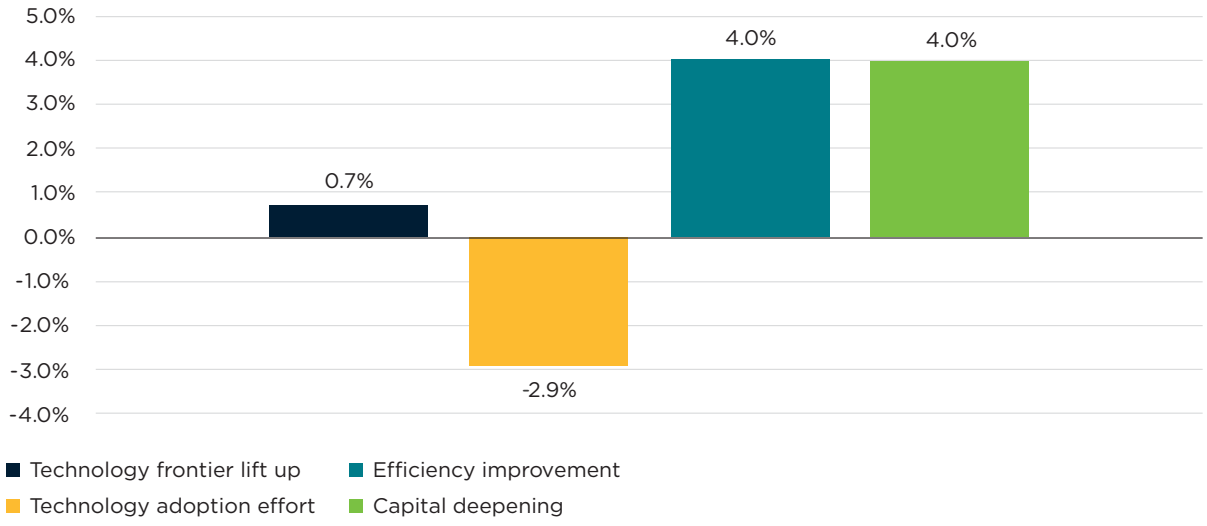


Figure 1. Output per worker decomposition 2015–2019

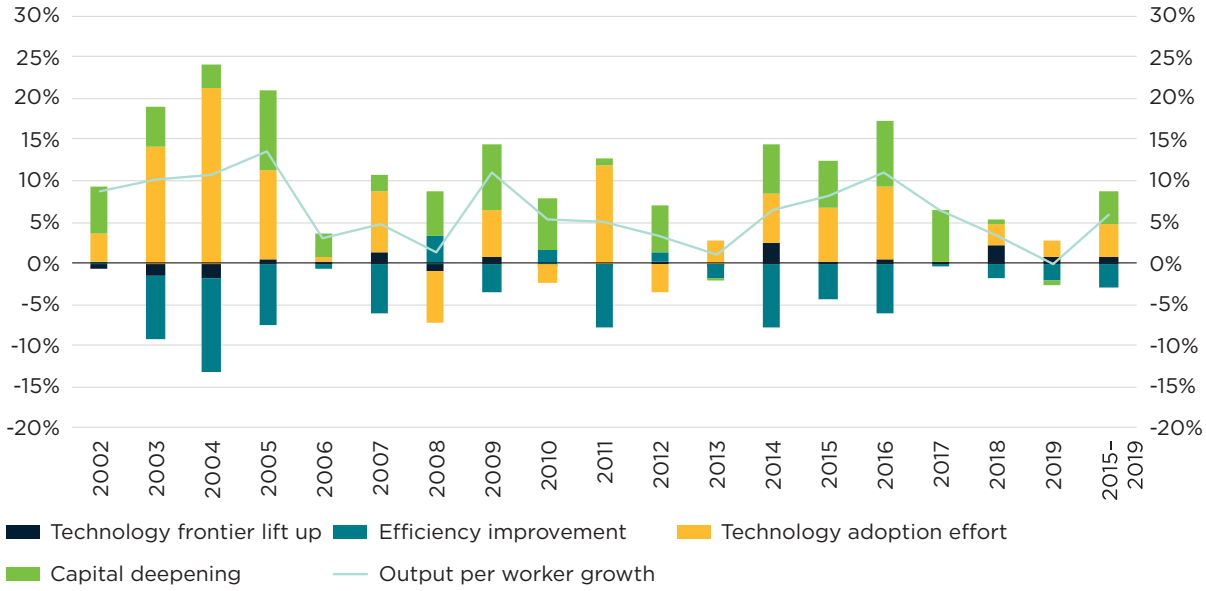


Figure 2. Output per worker decomposition 2002–2019.

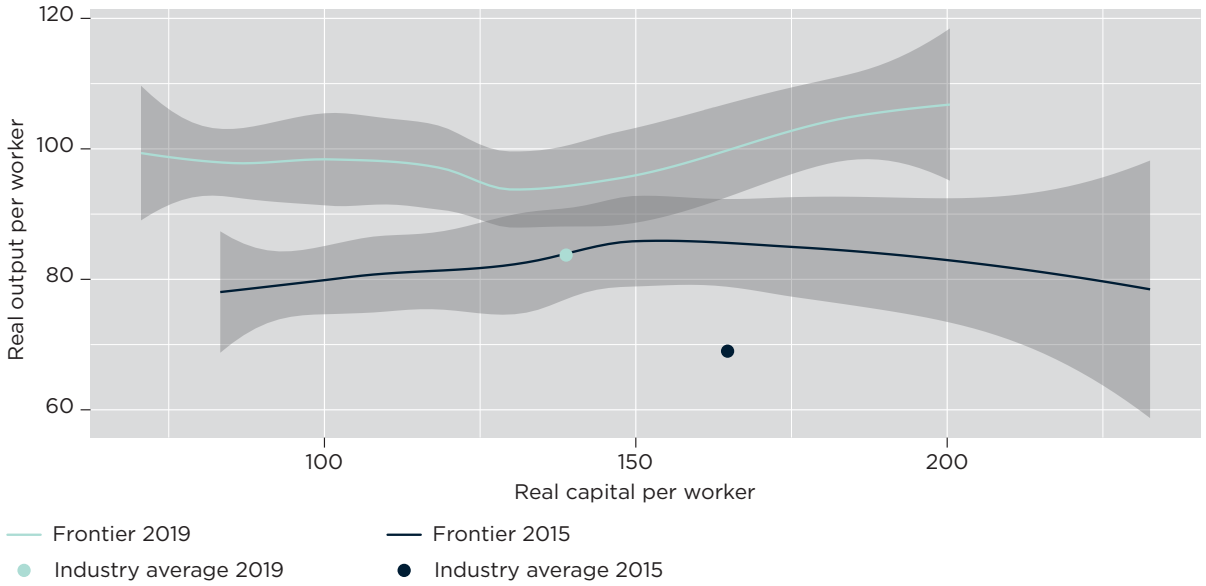


Figure 3. Conditional frontier for the sector 2015–2019.

Figure 4. Labour share of unclassified machines and devices sector in the Vietnamese labour force, 2002–2019.

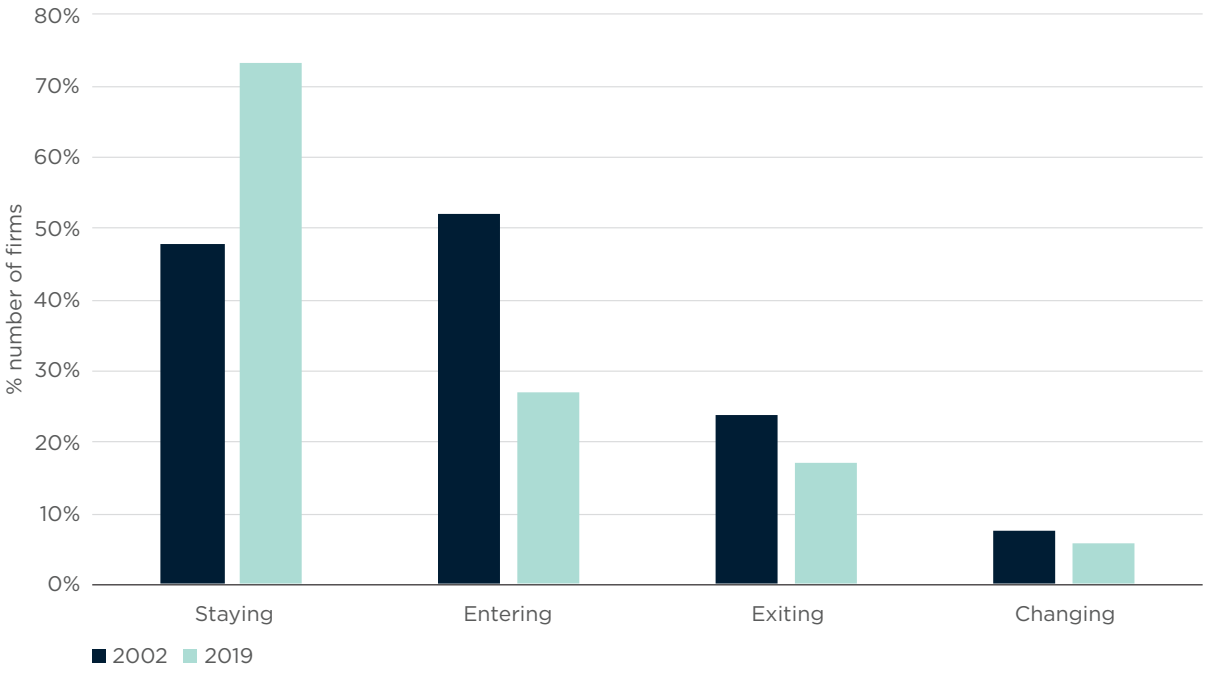


Figure 5. Firm dynamics for unclassified machines and devices in 2002 and 2019

Figure 4 shows that the number of firms in unclassified machines and devices has 12 times. In 2019, the net entry was 10% with the entry rate being 27% and the exit rate being 17%. The proportions of exit and changing firms is calculated over total number of firms in the previous year while the proportion of staying and entering firms are calculated over total number of firms in that year.

The maps below show the distribution of technology adoption effort of businesses across different provinces of Vietnam over time. The technology adoption effort is measured by the business investment per worker in technology-related activities such as buying machine/equipment, training, buying intangible assets like patents, trademarks, etc. As can be seen from the maps, there has been significant dynamic in technology investment intensity across regions/provinces in the sector over the analysed period.

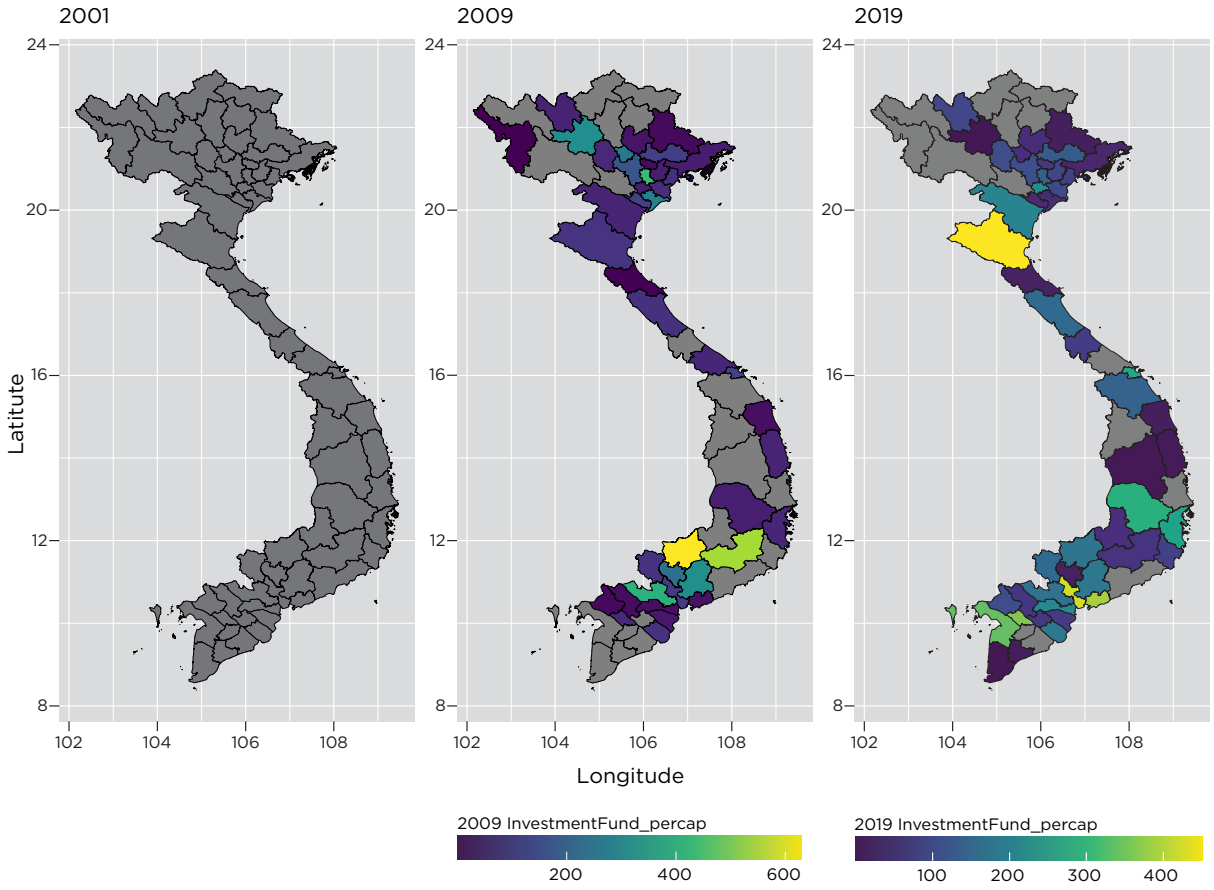


Figure 6. Per worker investment in technology adoption across regions for in 2001, 2009 and 2019

4.4 ACROSS OWNERSHIP

Overall, FDI firms have a higher output per worker compared to private firms. There was, however, a period of stagnancy of output per worker growth among foreign firms in Vietnam in the early 2000s (see Figure 9). In 2002, the real output per worker within FDI firms was nearly double that of private firms, however, the gap decreased significantly to around just 20% in 2009.

FDI FIRMS

There is no doubt that FDI is an important source of growth in Vietnam. In 2019 the FDI sector accounted for 23% of the country's social capital investment (up from 18% in 2000), 13.5% of government revenue and created 4.7 million jobs for Vietnamese workers. Exports, however, are the most significant contribution FDI businesses make in Vietnam. In 2019 FDI businesses accounted for 68% of total export turnover and 57.1% of import turnover. FDI contributed to 100% of telecommunications equipment exports, 95% of computer exports, 89% of machinery and equipment exports, 79% of footwear exports and 60% of apparel exports.[12]

The stagnancy in FDI output per worker growth also partly explains the low growth in manufacturing productivity, especially in the low-tech sector, in recent years given the dominance of FDI firms in the sector. FDI in Vietnam is concentrated in the manufacturing sector, accounting for more than 70% of total FDI into Vietnam (as of December 2009) – the largest proportion of FDI in manufacturing in ASEAN followed by Indonesia and the Philippines.

There was, however, an improvement in the performance of FDI businesses in recent years. In the 2015–2019 period the average output per worker growth rate of FDI businesses was 4.03% – a growth rate close to the average level of the economy.

The majority of FDI flows were concentrated in export-oriented, labour-intensive sectors such as garments, textiles and food processing. Moreover, many of the sectors only engaged in the low value-added activities of the supply chain in Vietnam. These include assembly or other simple production processes, rather than executing upstream or downstream processes that contribute to greater value creation.

Interestingly, beside capital deepening, the efforts of leading firms to lift the technology frontier has been the main source of growth for FDI firms. Over the last decade Vietnam has attracted investment from world-leading multinational corporations like Apple, Samsung and Foxconn, among others. These companies have begun to see Vietnam as a viable destination to expand their R&D activities.

In 2017 Samsung launched a second R&D centre – the Samsung Ho Chi Minh Research & Development Centre (SHRD) and Executive Briefing Centre (EBC)—located at the Saigon Hi-tech Park (SHTP).

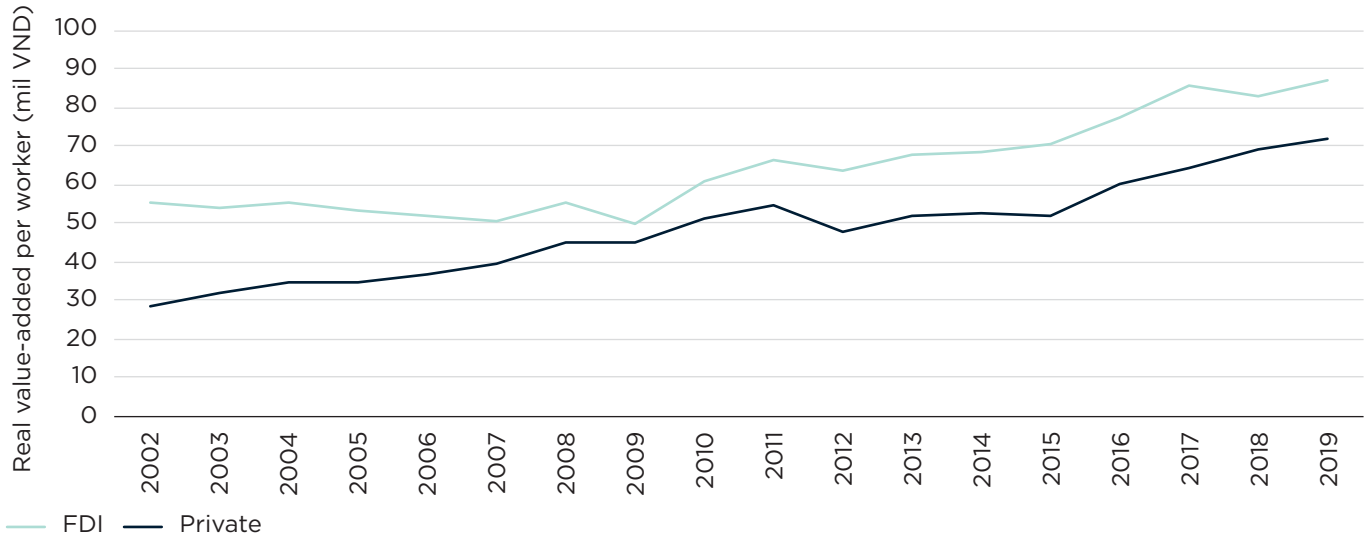


Figure 9. Output per worker of FDI and private firms between 2002 and 2019

Source: Authors' calculation based on the GSO business survey[17]

In 2020, Samsung announced they would build the largest R&D centre in Southeast Asia in Tay Ho Tay New Town, Hanoi. LG electronics, Bosch Vietnam and Intel have also announced the establishment of various R&D centres/offices across Vietnam

There is concern, however, about the strength of links between FDI firms and the rest of the economy. FDI links with domestic firms are particularly weak in high-tech manufacturing (such as electronics and motor vehicles). In this sector most FDI firms focus mainly on assembling (imported) components and packaging final products for export (electronics) or the local market (motor vehicles). FDI in resource-based industries tended to have higher links with domestic firms (backward links in basic metals and chemicals were 96% and 62%, respectively).[13] Weak links between FDI and domestic firms may also be signs of the limited integration of Vietnam's industry with global value chains through FDI channels.

Figure 10. Output per worker growth decomposition in FDI and private businesses between 2002 and 2019

Source: Authors' calculation based on the GSO business survey[17]

PRIVATE FIRMS

Together with FDI, the private sector has been a key contributor to Vietnam's economic growth in recent years. In 2019, the private sector accounted for 42.7% of total GDP, and 15.4% of the state budget. Importantly, women contributed significantly to the growth of the private sector. In 2016, around 25% of private firms in Vietnam were owned or led by women, as compared to the average of 8% in South Asia.[14]

The private sector also enjoys a considerable output per worker growth rate. In the 2015–2019 period, the average annual growth of private businesses was 6.2% (higher than their FDI peers).

Private firms are also found to operate more efficiently than public sector firms. The results of our modelling show that across all sectors, FDI firms operated significantly below the optimal level, compared to private firms (see Figure 11 for 2019 data). The Investment Capital Output Ratio (ICOR) statistics also show that private firms are more efficient at utilising capital and resources compared to FDI firms.

Though our model results show that private firms are more efficient than others, it seems resources have not been allocated to private firms to assist in technology adoption. In absolute values, while the capital stock of the private sector has increased significantly, the proportion of capital stock of private firms has remained relatively unchanged.

There is also evidence of an improvement in the performance of larger private firms. Consolidated data from the top 100 private companies on the stock market in Vietnam show that revenue per worker and profit per worker of these firms grew steadily over the last 10 years. The number of private firms in the top 500 largest Vietnamese enterprise list (VNR500) increased by 2.5 times over the last 10 years, comprising half of the total list.[15] In 2020, five out of the 10 largest listed companies were private enterprises (Vingroup, Vinhomes, Hoa Phat, Techcombank and VPBank). Of the top 1,000 enterprises with the highest payments of corporate income tax to the state budget in 2017, domestic private sector enterprises accounted for 45.8% in terms of number of enterprises (40.4% for FDI firms).[15]

Not only did large firms improve their performance, private-sector giants played a leading role that helped drive the growth of a whole sector or a whole supply chain. Thousands of small businesses have benefitted from the forward and backward links with such leading private companies. These include companies such as TH, VinGroup, Hoa Phat and Vinamilk.

In the last 5 years the main source of output per worker growth for the private sector besides capital deepening was technology adoption improvement. The stagnancy in technical efficiency improvement is the main reason for the limited contribution of TFP to growth amongst private firms. At the same time, the share of domestic businesses contributing to exports has plummeted in recent years (decreasing from 45.8% in 2010 to 32% in 2019), causing the economy to depend heavily on exports generated by foreign firms.[16]

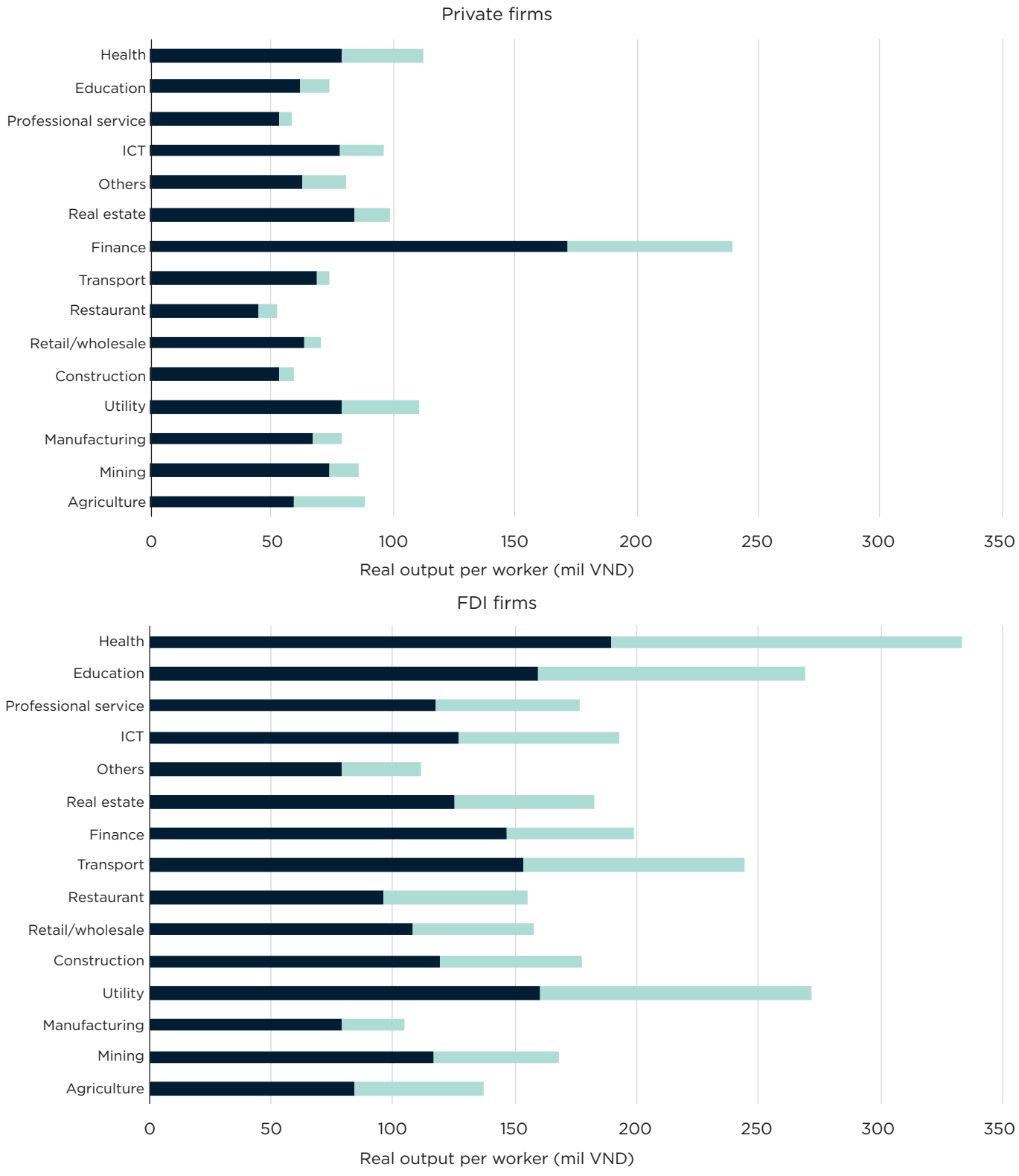


Figure 11. Potential gains if firms operated at the optimal level in 2019

Source: Authors' calculation based on the GSO business survey[17]

4.5 THE IMPACT OF R&D INVESTMENT

The dynamic stochastic general equilibrium model shows that R&D investment has long-term positive impacts on economic growth.

The increase in R&D investment not only directly contributes to GDP growth but also has an indirect impact on stimulating structural change in the economy. The indirect impacts occur through encouraging and upskilling human resources, facilitating technology adoption activities as well as incentivising investment in production across the economy.

Assuming that the R&D expenditure growth rate follows a different pathway depending on different governmental policies and market forces, the model assessed the impact of R&D investment on macro-economic indicators in Vietnam. In particular, we investigated two scenarios:

- **Scenario 1.** By 2030, social investment in R&D activities will comprise 2% of total GDP (meeting the target set by the Vietnamese Ministry of Science and Technology in the Scheme on Mechanism to Attract Social investment to Science, Technology and Innovation)
- **Scenario 2.** The average annual growth rate in R&D expenditure per GDP is assumed to be 24.2% per annum for 10 years till 2030 (i.e. scenario that reflects a growth trajectory for R&D investment in Vietnam similar to South Korea in the period 1981–1991).

In both scenarios, R&D investment initially leads to a crowding-out effect in both social capital investment and investment in technology adoption activities. These investments, however, show significant impact on all macro indicators of Vietnam including GDP, and consumption and investment in the long run. The impact is more apparent after a 10-year period.

The model also shows that improvement in R&D efficiency can result in positive economic outcomes. R&D efficiency can be increased through improving the R&D workforce or links among research institutes. As the R&D sector becomes more efficient, there is a positive impact on real GDP as well as consumption and investment over the longer term. Unlike the impacts arising from the increase in R&D investment, the impacts from R&D efficiency on real GDP are seen much sooner (i.e. five years, instead of 10 years as mentioned in the previous paragraph).

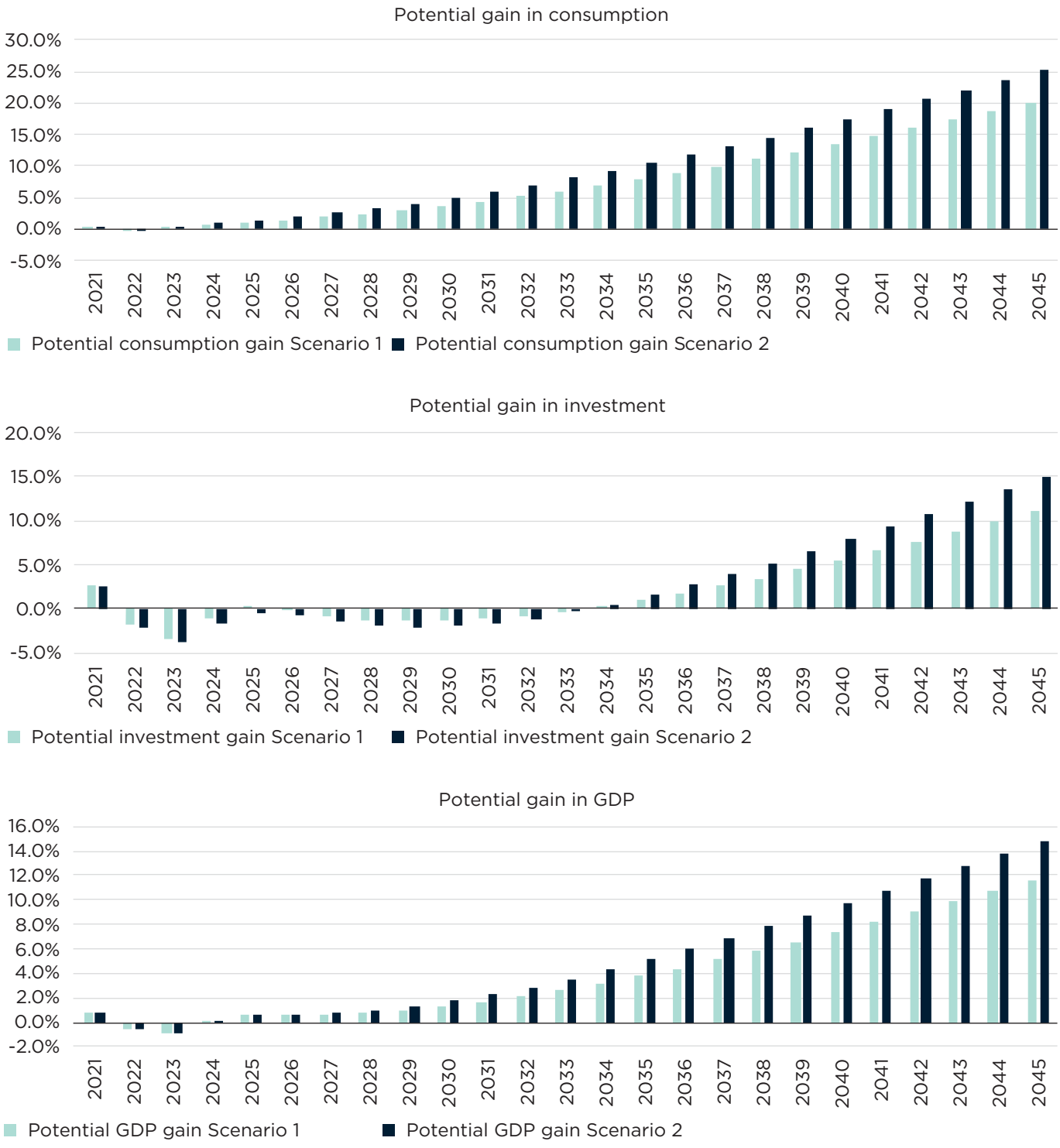


Figure 12. Impact of R&D investment across scenarios by 2045

Source: Authors' calculation based on the GSO business survey[17]

4.6 OBSERVATIONS AND FINDINGS FROM THE MODELLING RESULTS

The analysis demonstrates that technology creation and technology adoption are beneficial to Vietnamese economy. However, a combination of technological capabilities and development strategies and policies will determine what innovation activities will be the most beneficial to the country.

Observations from the modelling results include:

4.6.1 TECHNOLOGY ADOPTION IS THE MAIN DRIVER OF GROWTH IN VIETNAM

Since 2015, the main driver to Vietnam's rapid economic growth has been technology adoption. However, the data show that Vietnam is still slow in technology adoption when compared to other countries at the same income level.

Technology adoption is not an easy process. Technology, in most cases, cannot be sold like physical products in fully embodied forms. Technology transfer usually requires training and skills development, financing and structural or organisational change. The process of technology adoption is generally slow, incremental and path dependent.

In Vietnam the majority of firms adopt simple and basic technologies to improve their businesses, though there are examples of far more complex technologies being taken up. For most firms the innovation process involves the procurement of equipment, training for human resources, learning new technological processes, and implementing production/product design. There are also firms that can reverse-engineer processes, design their own processes and actively purchase technology and equipment for production. They also gradually obtain the capability to improve productivity and product quality as well as deploy new technology. These firms contribute to the technology frontier lift up or removal of technology adoption frontier through increasing investment in equipment, training or intangible assets.

A clear observation from the model result is that there is significant diversification in the intensity and impacts of technology adoption and creation across industries in Vietnam. Technology adoption is the key for output per worker growth for many sectors, especially for high-tech manufacturing sectors or high-tech services. Capital deepening, on the other hand, is critical for traditional sectors such as agriculture, forestry, low- and medium-low tech manufacturing. In a number of sectors such as forestry, the impact of technical improvement is highlighted.

4.6.2 NEW TECHNOLOGY DEVELOPMENT IS STILL A MINOR CONTRIBUTOR TO ECONOMIC GROWTH

Technology frontier lift-up - as a result of new technology development - has only been a minor contributor to economic growth in the most recent phase of development in Vietnam. This is to be expected from a lower-middle income stage of development.

However, there are a small number of leading firms within Vietnam that have developed advanced technological capabilities and skills. These capabilites and skills have come from improving and adapting imported technologies for the Vietnamese context. In some cases firms have improved the technologies themselves through designing and creating more complex technologies that can be sold internationally.

These new, locally developed but world-class technologies have the potential to create new emerging export industries for Vietnam. The companies developing these technologies are normally high-tech and large-scale. They operate at the technology frontier of the region and the world.

Industry 4.0 policies that recognise and support the creation of world-leading technologies can potentially help Vietnamese industry leapfrog technological phases. Vietnamese firms can thus avoid costly investment in increasingly redundant technology and stimulate the development of new technology and more knowledge-intensive industries or emerging sectors.

The most important actors in the development of world-leading technology in Vietnam have to be domestic, although foreign consultants and experts, and foreign knowledge and information are critical.

4.6.3 TECHNICAL EFFICIENCY IMPROVEMENT CAN ACHIEVE THE GREATEST POTENTIAL GAINS FOR OUTPUT PER WORKER GROWTH

Results from the conditional frontier model show the majority of firms in Vietnam were not able to change their organisation's structure, culture and strategies to keep pace with technology investment and adoption. Therefore, implementing changes to organisations to more efficiently use adopted technology will be the key to improving productivity at firm level.

4.6.4 R&D INVESTMENT CREATES LONG-TERM POSITIVE IMPACTS ON ECONOMIC GROWTH

An increase in R&D investment not only directly contributes to GDP growth but it also has an indirect impact by stimulating structural change through improving skills and human capital. Much of the R&D investment in Vietnam is in training and education, and incremental improvements to processes or technologies through adaptations and copying. Over time, however, R&D becomes more important. This is because it is needed for organisations and businesses to better understand, absorb and adapt complex, fast-changing technologies in high-tech industries at a higher level of development.

4.6.5 TECHNOLOGY ADOPTION AND R&D EFFORT ARE CLOSELY LINKED

There is a need to harmonise and co-ordinate policies on technology adoption and R&D promotion, as there is a dependent relationship between them. Strategising and implementing Industry 4.0 is one of the ways to build bridges to connect technology adoption and R&D spending for further economic development.

5 The interlink between the model results and technology capabilities of business and the economy

The results of the two models highlight different impacts of technology adoption and creation in Vietnam's businesses depending on their technology absoption capabilities. In particular, the conditional frontier captures impacts of activities such as adopting/adapting technologies, mastering technologies, which result in improvement in technological efficiency, technology adoption impact and technology frontier lift-up impact. The DSGE model, on the other hand, captures impact of technology creation activities such as R&D. Clearly, businesses enhance their technology capabilities over development time and as a result, they also upgrade their technology development activities to higher levels.

In general, technology deployment and creation activities amongst businesses can be divided into four different levels.

Level 1	Acquisitive and operative 'packaged' technology import
Level 2	Assimilative technology adoption
Level 3	Adaptive technology innovation
Level 4	Technology creation and emerging technologies

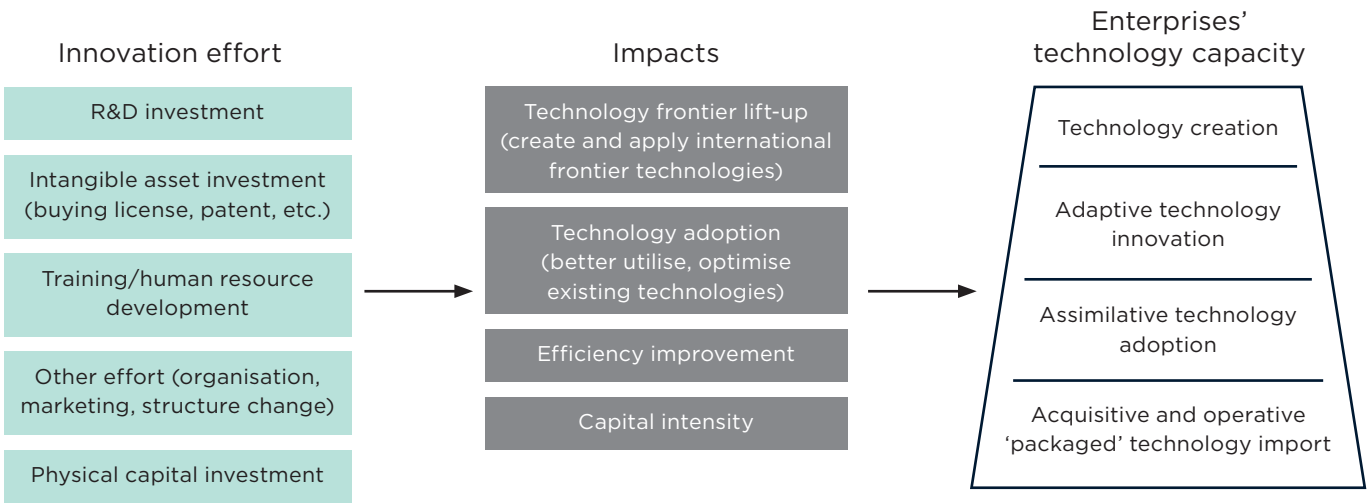


Figure 13. Technology development efforts and business capabilities

Source: Authors' illustration

THE MODEL OF TECHNOLOGY DEVELOPMENT FOR VIETNAM

Within a country, different levels of technological absorptive capabilities are likely to co-exist across sectors or even across firms in one sector due to heterogeneity in the production structure. Firms with different levels of complexity of production technologies exhibit different patterns in technology transfer and local innovation.

The scale of operation also accounts for variations in the behaviour of technological change at the firm level. Generally, large firms are more likely to produce sophisticated products whereas small firms are more likely to produce unsophisticated ones. This may also account for differences in technological behaviour between the two groups of firms. Such diversification supports the co-existence of industries/firms at different levels of technology development in a country at any stage of technology development.

In general, production technology dictates the direction of technological effort and the stage of technology development of a country is determined by the operational level of the bulk of business in the country.

Figure 14 illustrates a common, simplified trajectory for technology development in Vietnam. This framework analyses and integrates the technological trajectories over time.

The focus of the country in terms of technology development is different at various stages of development. For enterprises in the early stage of development, the adoption of technology may be more conducive to their rapid growth. However, with technological advancement and accumulation, enterprises should shift from relying on technology adoption to pursuing independent R&D to achieve sustainable and stable development.

For example, at the technology creation and emerging technologies stage, firms that accumulate sufficient innovation capacity may be able to reach the technology frontier to innovate and create new technologies that can challenge firms in developed countries. These firms may develop core competencies and technology platforms for the country's economy. And when a substantial number of firms reach this level, the country may move to the innovation level where technology creation is the primary source of economic growth and local R&D is the engine of the economy.

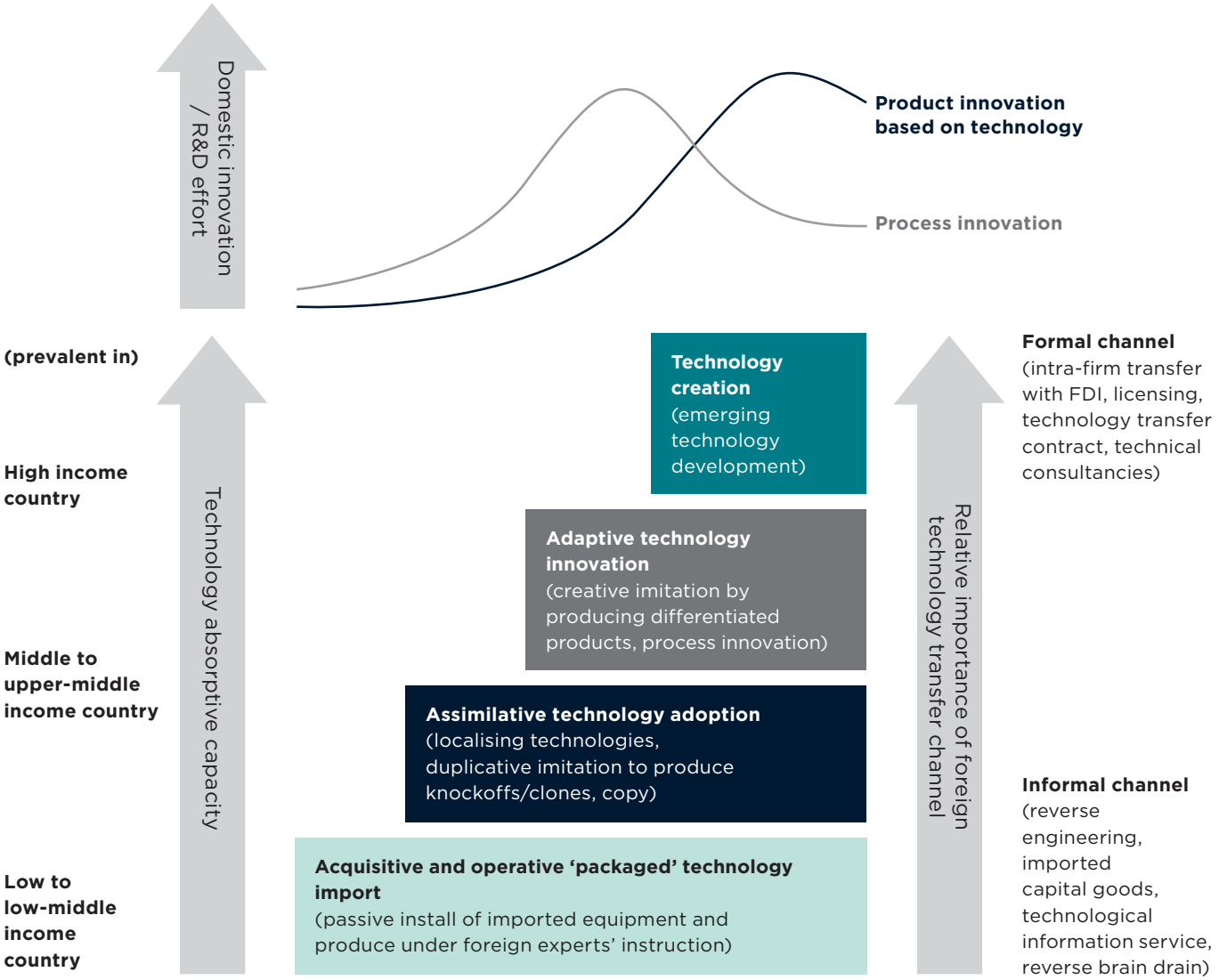


Figure 14. Technology trajectory for industries in developing countries

Source: Authors' illustration

6 Implications for policy

A number of policy implications have been drawn from the analysis. These findings provide insights for future policy directions in the following five areas: (i) improve technology adoption amongst businesses; (ii) improve technical efficiency; (iii) promote R&D and emerging industries to lift up the technology frontier; (iv) human resource development; and (v) develop policy instruments and implementation mechanism to synthesise and stimulate technology development efforts.

The actions listed in this report are designed to provide insights for policy makers and industry leaders in Vietnam around future investment decisions for the next phase of development.

Technology adoption and creation is the key for Vietnam to maintain rapid and sustainable growth and leapfrog through the next phase of development. Strong leadership and institutions will be key for Vietnam to leverage these opportunities and unblock bottlenecks for further economic development.

1

Improve technology adoption among businesses

- Develop sectoral strategies for technology adoption
- Accelerate digital transformation and Industry 4.0 technology adoption
- Improve 'spillover' effects and forward and backward linkages

2

Improve technical efficiency amongst businesses

- Accelerate the implementation of programmes to develop skills and expertise of managers
- Increase the awareness and adoption of efficiency/ productivity enhancement tools for management and business

3

Promote R&D and emerging industries to lift up the technology frontier

- Monitor innovation and technology adoption and identify clusters and emerging industries
- Strengthen IPR protection through increasing IPR consultancy and IPR management
- Select leading technology performers as technology models to showcase and build competitiveness
- Incentivise R&D from the private sector

4

Develop human resources

- Attract foreign researchers/experts, especially Vietnamese experts who are currently living in foreign countries
- Enhance the skills of the S&T labour force

5

Develop policy instruments and implementation mechanisms to synthesise and stimulate technology development efforts

- Undertake foresight exercises
- Develop a database on technology adoption and creation and a systematic methodology to prioritise investment
- Further improve the two models developed in the project using new data available

Figure 15. Policy implications for technology development in Vietnam

Source: Authors' illustration

References

1 Development Data Group (2021). World development indicators. Washington D.C., United States: World Bank.

2 Cornell University, INSEAD and World Intellectual Property Organiwation, (2020). Global innovation index 2020: Who will finance innovation? Ithaca, Fontainebleau and Geneva: CU, INSEAD and WIPO.

3 UNESCO Institute for Statistics (2021). UIS. Stat. Montreal, Canada: UNESCO UIS.

4 Intellectual Property Office of Vietnam (2020). Intellectual property activities: Annual report 2019. Hanoi, Vietnam: IP Vietnam.

5 Vietnam Government (2017). Resolution 27/NQ-CP-2017. The government's action program for implementing the resolution No. 05-NQ/TW dated November 01, 2016 of the fourth Plenum of the twelfth Communist Party's Central Committee on major policies for rennovation of growth models and improvement of growth quality, economic productivity and competitiveness and the Resolution No. 24/2016/QH14 dated November 08,2016 of the National Assembly on economic restructuring plan during 2016-2020. Hanoi, Vietnam: Vietnam Government.

6 Vietnam Government (2016). Resolution 35/NQ-CP on enterprise development policy to 2020. Hanoi, Vietnam: Vietnam Government.

7 Vietnam Government (2013). Law No.29/2013/QH13 on Science and Technology. Hanoi, Vietnam: Vietnam Government.

8 Vietnam Government (2013). Law No.07/2017/QH14 on Technology transfer. Hanoi, Vietnam: Vietnam Government.

9 YCP Solidiance (2020). A look forward: How digitalization is transforming Vietnam's healthcare system. YCP Solidiance.

10 UNIDO (2006-2019). UNIDO's Competitive Industrial Performance Index 2020.

11 Gardner Research (2016). World machine tool survey. Cincinnati, United States: Gardner.

12 General Statistics Office of Vietnam (2020). Investment at current prices by kinds of economic activity. GSO.

13 Vietnam Academy of Social Sciences, Ministry of Planning and Investment, United Nations Development Programme (2019). Productivity and competitiveness of Viet Nam's enterprises - Volume 1: Manufacturing. Hanoi, Vietnam

14 Greene W (2017). Female founders take charge in Vietnam. 14 August, TechCrunch.

15 Viet Nam News (2018). Private firms grow well: Viet Nam report. 20 January 2018, Viet Nam News.

16 Economica (2018). Vietnam private sector: Productivity and prosperity. Hanoi, Vietnam: Economica.

17 General Statistics Office of Vietnam (2019). Enterprise survey 2001-2019. Vietnam: GSO

18 Anzoategui, D., Comin, D., Gertler, M., and Martinez, J. (2019). Endogenous technology adoption and R&D as sources of business cycle persistence. American Economic Journal: Macroeconomics, 11(3):67–110.

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