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An analysis of the capacity of Singapore's industry transformation programme (ITP) to meet the transformation expectations: the case study of precision engineering industry

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Executive summary

The slowdown of productivity growth over recent decades is raising concerns that the long-term economic growth and thus further improvement of living standards might be much slower than was evident during the second half of the 20th century. This became particularly pronounced in policy discussion during the recent years, questioning the sustainability of economic recovery taking placing after the global recession of 2008. These concerns, from the policy side, turned into renewed interest in the potential of new generation industrial policies to revive productivity expansion and enhance economic growth over the long-term.

This interest is also linked to the expectations (both positive and negative) put on the technologies belonging to the so-advertised fourth industrial revolution (particularly automation and robotisation processes) and how new industrial policy could facilitate their development and adoption. Furthermore, skills policies also play a prominent role in these discussions, being aimed both at enabling and supporting the revitalisation of productivity growth through those new technologies as well as a reaction to the expected transformation or even the feared destruction of jobs, caused by the spread of those same technologies.

Higher productivity growth is expected to be achieved through mainstreaming new industrial technologies (i.e. robotics, additive manufacturing) enabling the introduction of higher value-added activities and/or upgrading the position of industries and countries within the global value chains. Across countries, different policy interventions are put in place in this regard to support the development and introduction of these new technologies as well as to safeguard and prepare for the job destruction challenge by facilitating the transition of workers from sectors affected by job destruction towards those with a job-creation potential.

Singapore's Industry Transformation Programme (ITM) brings together different policy actions addressing these challenges. Therefore, it was chosen as the focus of this research project, being a practical example of an umbrella policy framework combining a mix of generic as well as sector-specific policy actions aimed to raise productivity, develop relevant skills of the workforce, create high quality jobs, help companies access international markets as well as drive the overall industrial transformation of Singapore's economy.

Moreover, as a specific case study, Precision Engineering Industry Transformation Map has been chosen to inform a more in-depth analysis of the role of sector-specific layer in such a policy framework. Furthermore, this analysis will also enable an assessment of the potential of automation technologies due to the central role that Singapore's Precision Engineering industry plays in developing those technologies and supplying them internationally.

Finally, in terms of outcomes, it is expected that this research project would not only bring about some pragmatic analytical work on the contemporary industrial and skills policies, but, more importantly, would facilitate and contribute to a forward-looking reflection of the value of a combined industrial, innovation, trade and skills policy framework to address the new, post-2015, global economic environment and its challenges.

1. Introduction

The slowdown, since early 2000s but mostly pronounced after the end of the decade, of global productivity growth coupled with population aging has led to the slowdown in overall economic growth. It is therefore considered, that overall economic growth potential for the coming decades will be subdued. The challenge how to sustain economic growth is therefore generating a broad-based interest and calls for an analysis of the factors and policies which could help accelerate productivity growth and increase economic growth potential in the future (OECD, 2015).

However, economic growth in itself is not sufficient to drive economic (and social) wellbeing of individuals. It needs to build upon an increase in labour force productivity (rather than increasing the labour force as such) with equitable distribution of workers income (OECD, 2016a). Furthermore, the distribution of national income (the fruits of economic growth) between returns to capital and labour is also important (ILO-OECD, 2015).

Above mentioned economic developments as a consequence generated renewed interest within the developed economies in the capacity of industrial policy to address these challenges. This resulted in the launch of numerous new policy initiatives and increased public investment to drive industrial transformation (Garcia C. A., & Coulter, S., 2017; Deloitte, 2017, Warwick, K., 2013, IAB 2014, IEG, 2016, European Commission, 2017).

Similar tendencies have also been evident in the economy of Singapore, with negative multi-factor productivity growth since 2012, sluggish overall economic growth and limitations imposed on the import of labour. What is even more notable in Singapore is the broad based public expectation and the reliance of the political promise on the sustained economic growth as the driving force behind improvement in living standard and income growth of individual citizens of Singapore.

Potentially in this same context, the government of Singapore in 2016 initiated the Industry Transformation Programme (ITP) to facilitate innovation, trade as well as creation of more productive and higher quality jobs and ensuring that sufficient amount of qualified local labour force will be readily available to occupy those jobs. It is notable that the initiative in Singapore is very broad - aiming to cover both “secondary” and “tertiary” economic sectors – respectively the manufacturing and the services sectors, including some non-market sectors as well as different policy domains – skills, innovation, trade, productivity and governance.

From the outset it is expected that the success of industry transformation programme will depend more (or be more challenging to achieve) as regards the transformation of services sector. While manufacturing sector was the sector driving global productivity growth, services seemed to be much less influenced by adoption of technology. Structural shifts of global economy from manufacturing to services in terms of labour or value added (i.e. “tertiarisation”) also played a role (Memedovic, O., and Iapadre, L., 2010; Kim, H. J., 2006).

These structural shifts however also come together with increased complexity of the manufacturing sector and its links to services sector. These are evidenced by the segmentation of the supply and production processes – the rise of global value chains and, at the same time, the increasing amount of services in manufacturing process, otherwise also known as “servicification of manufacturing” (Lanz, R., & Maurer, A., 2015).

In addition, the risks and opportunities seen with regard to increasing potential of advanced manufacturing/4th industrial revolution become more pressing issues (OECD, 2017a). The development of technologies for the "next industrial revolution", and in particular automation and robotisation has generated strong interest, in part due to the expected impact on services sector too (Manyika, J., et al., 2017; Arntz, M., T. Gregory and U. Zierahn, 2016; Frey, C. B., & Osborne, M. A., 2013). This adds a further important aspect to the discussion on economic transformation.

Finally, with the aim of this research project being the analysis of the potential of the new generation of industrial policies (and in the case of Singapore – the ITP), the most important critical factor (and primary focus of the forthcoming analysis) will be dedicated to analysing the actions focused on skills and productivity pillars of the ITP. Skills in particular have been lately discussed as a prerequisite for the capacity of countries to penetrate global value chains and specialise in high-value added economic activities/tasks (OECD 2013; OECD 2017b; OECD 2017c) while transformation of jobs would ensure the realisation/utilisation of those skills, leading to the expected economic and social impact.

Linked to all of the above and given that Singapore's Industry Transformation Programme shall cover (through sector-specific transformation maps) 23 different sectors; the focus of this research exercise has been chosen to be precision engineering (PE) manufacturing sector. This sector is at the very centre of the interplay of the different trends and tendencies discussed above. This includes its links to high-growth additive manufacturing and robotics markets; its potential for developing manufacturing services as well as being the technology provider for automation and robotisation solutions targeted at both other manufacturing industries as well as services sector more generally.

Therefore, the ultimate aim of the research project would be, via the analysis of the potential impact of the actions planned as part of Singapore's Industry Transformation Programme in general and the Precision Engineering Industry Transformation Map in particular to get a better understand and insights in the historic tendencies of economic transformation towards services as well as forward looking tendencies (risks and opportunities) of the new generation of industrial and skills policies to facilitate and enable faster introduction of automation/robotic technologies and at the same time address possible negative consequence, caused by the wider adoption of those technologies.

1.1. Main research questions

To satisfactorily address the research topic – analysis of the capacity of Singapore's Industry transformation programme (ITP) to meet the expectations, it was proposed to focus the research on one selected industry (**Precision Engineering**), to be contextualised within:

- The macro-level discourse on falling productivity growth rates in developed economies, the increasing relevance of investment in intangible assets (and more specifically skills) and internationalisation;
- The general industrial policy context in Singapore (notably within the scope of the ITP) and other developed economies;
- The specific industry initiatives for the selected sector in other developed economies;
- The specificities of other industry sectors in Singapore (other ITMs).

Based on all of the above, a (re-)construction of the intervention logic of the reference ITM (within the overall framework of the ITP) would be carried out. It would map all major activities, dedicated resources, expected outcomes and the links between those elements. All the analysis will then be brought together to pursue an impact-capacity analysis, to judge the likelihood that the ITP and

reference ITM would meet the expectations. It will also allow then to conclude what could be potential gaps and opportunities to further increase the impact capacity and how future progress reviews could be designed. Therefore, the **aim** of the project would be to answer these two key research questions:

- *What is the capacity of the selected reference industry transformation roadmap, given the totality of planned actions, the deployed resources, the expected outcomes and the links between actions, resources and outcomes; of reaching those outcomes?*
- *What gaps limit this capacity and what actions could increase it?*

In addition, three aspects would contextualise the analysis, both to set a broader research context as well as enable a comparative analysis of broad industrial policies, including:

- *A literature review of the potential contribution of investment in skills and other intangibles for industrial policy and economic growth;*
- *A review of Singapore's Industrial Transformation programme;*
- *A review of industrial policy developments in other developed economies;*

Furthermore, two additional elements would underpin the comparative analysis of the selected (reference) ITM, notably:

- *A comparison of the selected reference ITM with other industrial policy programmes focused on a selected sector, internationally;*
- *A comparison of the selected reference ITM with other ITMs.*

1.2. Research strategy

The aim of the research project is to assess the capacity of the selected reference ITM to meet the transformation expectations. Analysis would further benefit from the insights of a comparative review of other similar policy interventions around the world as well as comparison of the reference ITM with other ITMs in Singapore.

As it seems that a major component of this policy initiative is focused on skills development, analysis should also to a large extent cover actions aimed at skills development. However, for a holistic assessment of ITM as a policy intervention, all core elements of the policy initiative should be identified and captured in the overall analysis. The **research tasks** would be as following:

1.2.1. Carrying out a **literature review** of key research arguments/success factors as regards the impact of intangible asset investment (skills, R&D, innovation) and international trade (global value chains) on productivity growth, having the purpose of providing theoretical and research background for respective policy initiatives;

1.2.2. Carrying out a focused **comparative review** of Singapore's ITP and broad industrial policy initiatives and their outcomes of other developed economies, to identify similarities and assess the extent to which international experience and achieved outcomes could be applicable in the case of Singapore's ITP and vice-versa;

1.2.3. Carrying out a focused **comparative analysis** of the selected reference ITM (as proposed – precision engineering ITM) with a number of other sector-specific initiatives, assessing the comprehensiveness of precision engineering ITM and identifying the key shared and differing elements, as compared to:

- Other Singapore's ITMs (that cover other industry sectors); and
- Policy interventions in other countries targeting the same industry sector;

1.2.4. An **in-depth analysis** of PE ITM; including:
    - (Re-)Constructing the intervention logic;
    - Mapping the major actions to be undertaken to implement it;
    - Establishing the scope of resources deployed to implement it;
    - Establishing the scope of expected outputs and outcomes of the ITM;
1.2.5. Undertaking an **impact-capacity analysis** (*assessing the likelihood, given the totality of planned actions, the deployed resources and expected outcomes; and earlier experience of similar interventions, of reaching those outcomes*)
1.2.6. Undertaking **gaps-opportunities analysis** of the selected reference ITM, to identify any elements that constrain the possible impact as well as those elements that could enhance the impact of this policy intervention;
1.2.7. **Proposing a template for a future progress review,** applicable for a particular selected ITM or, alternatively, to all ITMs.
1.2.8. **A forward-looking reflection** based on the overall findings of the project, on the potential of combined industrial, innovation, trade and skills policy interventions to contribute to industrial renewal of advanced economies in the current economic environment.

2. Industrial policy – a comparative international review

A number of major world countries and economies, similarly like Singapore, are currently renewing their economic and industrial policy frameworks and strategies. This is driven by a new phase of global economic environment already at a distance from 2007-2009 financial crisis and the rising expectations of new technologies, in particular the new wave of automation and robotisation. They often are related to two similar, but not identical concepts:

- the narrower concept of **"Industry 4.0"** (originating from Germany), mostly linked to changes in manufacturing as regards the expected further digitisation and robotisation as well as the possible re-localisation of manufacturing due to emergence of additive manufacturing (i.e. 3D printing) technologies. This concept has a more positive connotation (from the perspective of developed economies) of increasing employment due to the "re-shoring" of industrial production back to developed economies;
- the broader concept of the expected-to-be **Fourth industrial revolution** (most prominently known from the World Economic Forum), putting more emphasis on technological advances (in particular as regards artificial intelligence) enabling a broader application of automation technologies, including for services sector. This concept has a more negative connotation of automation of a very broad range of tasks (physical, cognitive or social) potentially leading to wide-spread job destruction.

However policy reflection to intervene as regards these new technologies (both for optimistic – i.e. growth enhancing and pessimistic – i.e. job destructing expectations) is not a replication of earlier thinking with regard to industrial policy. Quite the opposite, this new wave of thinking and policy action is termed as a new generation of industrial policy, moving beyond generic/horizontal/direct interventions in product or factor markets (subsidies, taxes, direct ownership) towards more complex composite policies, "that help build systems, create networks, develop institutions and align strategic priorities" (Warwick, K., 2013).

This changing direction of industrial policy emphasises more the importance of intangible factors in pursuit of technological catch-up and economic development, be it promoting research and development activities; developing company networks and clusters; facilitating human capital formation or enhancing access to international trade, including through accessing complex value-added chains in global production networks and upgrading the position companies and industries occupy in them (Warwick, K. and Nolan, A., 2014).

The following sections will provide a concise overview of the latest industrial policy initiatives across major global economies, the growing importance of intangible capital and value chains perspective in generating productivity growth and fostering economic development, a summary of key analytical frameworks available in the literature (particularly as developed by international organisations) to deconstruct, classify and compare industrial, skills and workforce development policies, an overview of debates on industrial policy evaluation and then finally analysing the situation in Singapore from all those perspectives.

2.1. Current industrial policy in major world economies

While a comprehensive overview of the (constantly changing) industrial policies around the world is beyond of the scope of this exercise, some more notable examples come, apart from Singapore's ITP, from Germany, France, United Kingdom and Spain (Garcia C. A., & Coulter, S., 2017), the United States (Deloitte, 2017) and China (Kenderdine, T., 2017). The European Union also launched a new industrial policy strategy in 2017. Furthermore, several recent reviews by international organisations provide more in-depth analysis of national industrial and productive transformation strategies (ILO, 2014; OECD 2017a).

The most recent initiative, which is worth analysing, is the newly adopted European Commission Communication on a renewed EU industrial policy strategy (European Commission, 2017), developed following the requests, earlier in the year, of European Member States through the European Council conclusions (Council of the European Union, 2017a) and European Parliament resolution (European Parliament, 2017). European Union, compared to the major national global economies – US, China, Japan or Germany is a combined supra- and cross-national body, resulting in many legal, administrative and institutional specificities not directly comparable to policies adopted at national level. Still, being a very recent initiative, it represents the latest thinking and priorities both from the perspective from Europe as a continent and integrated economic zone as well as supported by the EU Member States (Council of the European Union, 2017b).

This new industrial policy strategy for Europe identifies six areas to be acted upon, in partnership with the EU Member States, regions, cities and the private sector:

- Empowering companies and individuals by building deeper and fairer single European market, stressing the need and benefits of further integration of business activities within European and global value chains but also "supporting industry, people and communities to adapt to social, environmental and economic change"; particularly through education and training measures;
- Digital transformation of industry, aiming to boost the uptake of digital technologies;
- Building upon industrial leadership in low-carbon and circular economy, with a particular emphasis on the development of automotive industry;
- Promoting investment, particularly investment in intangible capital, where Europe is lagging behind the US and emphasis investment in defence sector;
- Supporting industrial innovation;
- Extending international dimensions, to ensure open but fair and sustainable trade;

As regards initiatives of EU Member States, the state of play can be summarised as following, based on several recent reviews (European Parliament, 2015; Garcia C. A., & Coulter, S., 2017):

- In **Germany**, given strong government capacity and fiscal position almost unscathed by global economic recession as well as broad-based industrial capabilities, a relatively ambitious strategy, with broad strategic goals and mostly horizontal (sector-neutral) approach is pursued in cooperation between federal and state governments in promoting investment in research, education and infrastructure, with 8.4 billion EUR for technology promotion between 2012 and 2015; 7 billion EUR for education between 2011 and 2015 and with planned further 6 billion EUR for education as well as 3 billion EUR for research between 2016 and 2020. Furthermore, 10 billion EUR is also for infrastructure and energy efficiency expenditure between 2016 and 2018. For implementation and coordination with firms, Germany relies on networks of independent Max Plank and Fraunhofen institutes and places particular emphasis on SME's via regional clusters and links between firms, public research bodies and finance

institutions. In the overall subsidy structure tax breaks for companies play the leading role, with only 1/3 of subsidies being actually paid out. The subsidy structure has three "legs": improving access to capital markets; improving access to skills and incentivising R&D.

- In **France**, the aftermath of financial crisis seem to signal a return to a more sector-specific, interventionist industrial policy, following a retreat of industrial policy in 1980s and 1990s, with strong influence by large firms (i.e. "national champions") and addressing specific shortcomings of selected industries/sectors. The government in 2013 announced a 3.5 billion EUR budget to support its industrial strategy but without clarity on further breakdown of the budget. The policy framework in place before 2015 include five core pillars – with the first three - innovation and industrial development; regional development; support for SMEs being horizontal and smaller in scale and the last two – a sectoral pillar (the most ambitious part) and a fifth – regulatory pillar. For sectoral interventions, the selection criteria are stated explicitly and include (1) positive market prospects; (2) existing technological leadership and (3) an established academic, technological, commercial or industrial base.
- In the **United Kingdom**, which has the smallest industrial sector of the three leading EU economies but a strong services sector, the recent industrial policy framework represents more a horizontal approach but with some sector-specific features. Horizontal policy emphasises four cross-cutting themes – access to finance, skills, procurement and technologies with 4.7 billion pounds dedicated for science and research between 2016 and 2020 as well as plans for very ambitious investments plans – 100 billion pounds for infrastructure and 250 billion pounds for nuclear energy research. Support to SMEs and developing coordinating institutions is also addressed in the policy framework.

When moving the attention to the other side of Atlantic Ocean – **the United States**, it becomes more difficult to analyse industrial policy, which is not as pronounced as in other economies. Some authors even call that United States is actually "a developmental state in disguise" – with industrial policy mostly hidden as spending for basic and military research and development (ILO, 2014). During the 1980s a number of programmes have been launched to support basic research and its commercialisation – including for SMEs, high-risk industry research and semiconductors sector, though being modest and of limited scale, in part due to the launch of privately-financed IT revolution (OECD, 2017).

However during the Obama administration, with a likely influence of global financial crisis, some actions to enhance industrial policy have been undertaken, particularly promoting advanced manufacturing concept by establishing advanced manufacturing partnership in 2011 and then the launch of advanced manufacturing institutes, inspired by the German model of Fraunhofer institutes. A key goal of the institutes was to create space for collaboration between industry, universities and government to enable the evolution of advanced manufacturing.

The institutes were given a number of tasks (ibid):

- Create new production technologies, processes and capabilities;
- Provide a testing ground for those new technologies;
- Support efforts to deploy those new technologies;
- Build relevant workforce skills.

The criteria used to selection sectors for support, in order to avoid thematic capture by implementing agencies and ensure alignment with industry needs were (ibid):

- Presence of industry or market pull (demand);
- Cross-cutting, linking multiple sectors and different sized manufacturers;
- Key role ensuring national or economic security;

- Leveraging US strengths –availability of workforce, education system, infrastructure or policies.

An independent evaluation of the institutes was carried out by Deloitte in 2017 with generally positive findings (Deloitte, 2017). Overall, by 2017, 14 institutes were already established with an option for additional one to be established if funding were available (ibid):

- **America Makes – the National Additive Manufacturing Innovation Institute**, the first manufacturing institute, announced in 2012, with the mission to accelerate additive manufacturing and its widespread adoption by bridging the technology gap between research and technology development and deployment.
- **Digital manufacturing and design innovation institute (DDMII)**, with the mission to lower product design costs by fostering deep connections between supplies, has 201 members and received federal financing of 70 million USD matched by additional 248 million USD financing by industry and states;
- **Lightweight innovations for tomorrow (LIFT)**, with the mission to innovate in lightweight high-performing metals production, has 78 members and received federal financing of 70 million USD, matched 1-to-1 by partners;
- **Power America – for next-generation power electronics with the mission to** develop wide bandgap semiconductor technology having over 30 members;
- The **Institute for Advanced Composites Manufacturing Innovation (IACMI) with the mission** to develop and demonstrate technologies that will make advanced fibre-reinforced polymer composites at 50% lower cost, using 75% less energy, with 95% or more reuse or recycling of material within a decade. It has around 90 members and federal award of 70 million USD was matched by 180 million USD spending by other parties;
- The **American Institute for Manufacturing Integrated Photonics (AIM Photonics), with the goal** to foster ultra-high-speed transmission of signals for communications, new high performance computing and sensors, and imaging for health sector advances. The federal award was matched by over USD 200 million in state and industry support.
- **Flexible Hybrid Electronics (NextFlex) with the goal** to produce highly tailorable devices on flexible, stretchable substrates that combine thin complementary metal oxide semiconductor technology for constructing integrated circuits components with new components added through printing processes. The federal award of 75 million USD was match by 96 million USD spending from other parties.
- **Advanced Functional Fabrics of America (AFFOA) aims to serve** as a public-private partnership to support an end-to-end innovation ecosystem in the United States for revolutionary fibres and textiles manufacturing. The federal award of 75 million USD was match by 240 million USD funding from other parties.
- The **Smart Manufacturing Innovation Institute** will focus on integrating information technology in the manufacturing process through devices like smart sensors that reduce energy use. The federal award of 70 million USD is matched 1-to-1 from other parties.
- The **Rapid Advancement in Process Intensification Deployment Institute (RAPID)** will focus on developing breakthrough technologies to boost domestic energy productivity and energy efficiency by 20% in five years. The federal award of 70 million USD is matched with more than 1-to-1 financing from other parties.
- The **National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)** will aim to transform the production process for biopharmaceutical products. The federal award of 70 million USD is matched with 129 million USD financing from other parties.
- The **Advanced Regenerative Manufacturing Institute (ARMI)** is tasked with developing and biomanufacturing tissues and organs that can be transplanted into patients and co-financed by New Hampshire state with matching 80 million USD.

- **Reducing Embodied Energy and Decreasing Emissions (REMADE)** in Materials Manufacturing will focus on driving down the cost of technologies needed to reuse, recycle and remanufacture materials such as metals, fibres, polymers and electronic waste and aims to achieve a 50% improvement in overall energy efficiency by 2027. Federal award of 70 million USD will be matched by 70 million USD from other parties.
- **Advanced Robotics Manufacturing Institute (ARM)** to focus on building US leadership in smart collaborative robotics, where advanced robots work alongside humans seamlessly, safely, and intuitively to do the heavy lifting on an assembly line or handle with precision intricate or dangerous tasks. Federal award of 80 million USD is matched by 170 million USD financing from other parties.

Finally, moving over the Pacific Ocean towards Asia and more specifically **China**, would provide an example of the most pro-active and interventionist industry policy of the three major economies of the world. China, while historically being a socialist command and control economy, gradually liberalised its economy with nearly two thirds of value added nowadays being generated by the private sector. This however still leaves a major section of the economy under direct public control via stated-owned enterprises. Furthermore, public sector retained leading control of the financing sector – with 70% of the total assets of banking sector belonging to state-owned banks and banking sector remaining the predominant part of the overall financial system (ILO, 2014).

Some authors divide economic modernisation of China, with respect to industrial policy, into two distinct stages: 1970s to mid-1990s and from mid-1990s until recent years. The first stage prominent for being consumption-led and judged to correspond to comparative advantage following industrial policy strategy, which is notable for state action in developing appropriate framework conditions (market liberalisation) but inaction as regards direct intervention in the process of industrialisation. During the second stage investment-led industrialisation became prominent, thus showing features of comparative advantage defying industrial strategies and witnessing industrial policy action both further fine-tuning the framework conditions as well as pursuing direct state intervention into industrialisation process (ibid.).

A number of high-level policy documents have been adopted since 2010, promoting the development and uptake of selected technologies. These policy documents, for example, include the The Decision on Accelerating the Fostering and Development of Emerging Industries of Strategic Importance, establishing seven emerging industries of strategic importance that are expected to represent 15% of GDP by 2020. These seven industries are Energy-saving and environment-protection technologies, next-generation ICTs, biotechnology, advanced equipment manufacturing, new sources of energy, new materials, and new energy vehicles (ibid).

Next, an important document, adopted in 2015 was the Made in China 2025 strategy, setting indicators for the industry on such aspects as innovation, quality, digitalisation and greenness. The targets include, with the target-year 2025: R&D spending as a share of manufacturing sales to reach 1.68%; annual growth in labour productivity is planned to be 7.5% until 2020, and then 6.5% until 2025; broadband coverage should increase from 50% in 2015 to 82% in 2025; and energy consumption per unit of added value should fall by 34% by 2025 (ibid.).

Made in China 2025 strategy also provides ten strategic technologies: biopharmaceutical and high-end medical equipment; energy equipment and technology; integrated circuits and new generation IT; new and advanced materials; new energy vehicles; advanced rail and equipment; agricultural machinery and technology; aviation and aerospace equipment; advanced marine equipment and high-tech vessels; advanced manufacturing control equipment and robotics (ibid.).

Finally, in 2016 the adopted 13th five-year plan provides another, latest list of technologies of strategic importance: gene industrialisation, green energy and nuclear power; integrated circuitry, advanced equipment and new materials; advanced manufacturing (ibid.).

Despite policy proclamations and substantial investments to promote industrial upgrading in China the results of the later, interventionist policy was mixed even if somewhat better than in the previous period. There were several sectors which seemed to progress more in terms of technological maturity and export capacity, most notably high-speed railways. The success in automotive sector was more limited, despite growing exports it seems lacking in adopting of frontier technologies, private capital investment and local brand development. As a sector with potentially least success in developing indigenous industrial capabilities beyond low-cost processing and assembly operations, semiconductor is exemplary for a very large negative trade balance versus rest of the world (ILO, 2014).

Chinese case would highlight the limitations and often an opportunistic nature of direct, large scale industrial policy interventions into frontier or emerging technology sectors. At the same time, China, while being a major economy globally, is at the same time characterised by large regional, sectoral and technological disparities going from the most backward subsistence agriculture activities to the most advanced fintech products. This provides plenty of opportunities for experimentation and selection of interventions that are best fit for the specific level of development in a particular sector or locality. At the same time, it is also difficult to provide a clear-cut macro-level overview of national level policy framework, which at the same time lacks coherence, seems to be frequently changing and result in various overlaps and massive duplication and local level – for examples with 300 cities launching photovoltaic industry and 100 developing infrastructure for it (OECD, 2017).

2.2. Intangible capital and industrial policy

For many of the developed, high-wage economies, largely including Singapore, economic growth in large part is generated from the particular capabilities in those economies to generate knowledge. This includes ICTs, innovation and development of firm-specific competencies, with important complementarities between different assets and spillovers, including from human capital (Corrado et. al., 2014). However investment in intangibles is also important for developing states to avoid middle-income trap that requires advanced capabilities in skills, technology and knowledge creation (IBRD/WB, 2017).

Nevertheless it is still early days in terms of capacity for the public sector to reliably monitor such knowledge generation activities and evaluate national capabilities – their strengths or weaknesses, inhibiting the development of effective policy response. Substantial work has been undertaken in the US and EU recently to improve the data availability and thus provide empirical evidence on the scale of investment in and the outcomes of intangible capital. A standardised taxonomy of intangible capital has been developed, indicating the extent to which such assets is included in national accounts and generating experimental data on areas where until now such data was missing. Other countries could build upon this work.

Table 1. Intangible capital asset types (Corrado et. al., 2012).

Asset type	Included in National Accounts?
Computerized information	
1. Software	Yes
2. Databases	?[1]
Innovative property	
3. Mineral exploration	Yes
4. R&D (scientific)	Satellite for some[2]
5. Entertainment and artistic originals	EU-yes, US-no[3]
6. New product/systems in financial services	No
7. Design and other new product/systems	No
Economic competencies	
8. Brand equity	
a. Advertising	No
b. Market research	No
9. Firm-specific resources	
a. Employer-provided training	No
b. Organizational structure	No

1. SNA 1993 recommended capitalizing computerized databases.
2. R&D satellite accounts are available, or under preparation many countries. Results for Finland, Netherlands, United Kingdom, and the United States are publically available.
3. The US BEA plans to include entertainment and artistic originals and R&D as investment in headline GDP in a revision in 2013.

Latest assessment of available data proves the importance of investment in intangible capital – particularly so for the US economy where investment in intangibles during the period 2000-2013 outpaced investment in tangible capital (Corrado et. al. 2016). The impact on economic growth of intangibles also became pronounced, particularly in the US and UK, where contribution to economic growth by intangibles is more than double as that of tangible capital investment (ibid.). Furthermore, decomposing the investment in intangibles using the taxonomy above would indicated that most important part of intangible capital formation is that of economic competencies, closely followed by innovative property intangibles (ibid.).

Finally, intangible assets are not only important from economic policy point of view to monitor and stimulate investment and growth, but also from taxation and competition policy. Recent work by the OECD highlights that in some cases companies inappropriately use intangible assets through transfer pricing for tax optimisation purposes (OECD, 2013). In any case, to the extent that data on intangibles is limited there are clear obstacles to monitor, evaluate and assess effectiveness of policy interventions in those areas.

2.3. Global value chains and industrial policy

Recent discussion in literature also raises the question to what extent earlier iterations of industrial policy – be it import substituting or export oriented fit the contemporary global economy with wide-spread complex production networks and corresponding global value chains. These policy iterations could be summarised into three distinct steps (Gereffi, G. 2014): import substituting industrialisation (ISI), export oriented industrialisation (EOI) and finally, GVC-led vertically specialised industrialisation (VSI). This, latest stage of internationalisation, requires particularly complex policy effort in terms of managing trade, FDI and exchange rate policies as well as, in case for middle and high income countries – to innovate, as also mentioned in previous section (ILO, 2014).

In terms of industrial policy, GVC perspective indicates that industrialisation process in the contemporary global economy would start by entry into new industry via lowest value added activities, such as assembly. Following this, upgrading within the respective GVC would be required to increase the value added, captured by national production activities. Upgrading is defined as either moving to more rewarding positions in the value chain or producing products with higher value added (ibid.). Economy upgrading can take four forms: process upgrading – i.e. growth of productivity of existing production activities; product upgrading - production of higher value added products; functional upgrading - move into more sophisticated or integrated production process and intersectoral upgrading - moving in adjacent sectors/value chains (ibid.).

Several challenges are identified in the literature as regards VSI and industrial policy (ibid.):

- Industry disaggregation, notably that policy intervention must become more fine-graded and to avoid entering industries where upgrading capabilities are limited;
- Export promotion must be combined with liberalised import of intermediary products;
- Coordination with lead and supplier firms, being responsive to their strategies and sensitive to power structures in supply networks;
- Promotion of regional production networks, given regionalisation of trade;
- Ensuring social upgrading, for which GVC upgrading is necessary but insufficient factor and low employment elasticity in most innovative activities;
- Measuring value added in trade, which seems to be a specific challenge given its cross--national nature as well as the deep level of disaggregation and specification (i.e. of trade between related parties; ownership; etc.) required for policy-relevant analysis (IBRD/WB, 2017).

Overall and similarly to the case with the role of intangibles, these new developments in the organisation of global economy, trade, sourcing and production networks pose a substantial challenge from the perspective of industrial policy due to its complexity and data limitations.

2.4. Analytical frameworks for industrial policy

As examples in previous sections shows, industrial policies have very diverse nature and features in each of the major world economies. A comprehensive comparison of those would require a broad and in-depth review of the policy framework in each single country, which is beyond the scope of such paper. Nevertheless, an effort will be made to carry out a tentative comparison between Singapore and the major global economies using some existing industrial policy classifications and evaluation frameworks.

In the following text, five such frameworks is reviewed, including varieties of capitalism perspective (Garcia C. A., & Coulter, S., 2017), recent work carried out within the remits of international organisations – OECD (Warwick, K. 2013), United Nations (ILO, 2014), Inter-American development bank (IAB, 2014) and World Bank (IEG, 2016).

2.4.1. Varieties of capitalism framework

The analytical framework of varieties of capitalism is an approach developed several decades ago, used to explain the differences across economic systems and models, from the point of view that specific features in financing, training and innovation systems in a country aligns towards unique institutional arrangements for the coordination among key actors, which together result in a specific **economic governance** model in each country. Developed primarily for the analysis of developed economies, it was later extended also to cover developing and newly industrialised economies, including Singapore. The main criteria according to which different economies are being analysed are (Hall and Soskice, 2001):

- Financing, i.e. sources of financing that can comprise financial markets (stock or bond financing) or the banking sector (more traditional financing via debt);
- Internal firm structures, i.e. the extent to which internal firm decisions are coordinated with employees or their representatives (unions);
- Industrial relations, i.e. ways how work and wage coordination is carried out at industrial and national level between employees, firms and labour unions;
- Education and training systems, i.e. how extensive are skills development systems and how comprehensive are the industry-specific and firm-specific skills requirements;
- Inter-company relations, i.e. how technology is developed and diffused across firms.

Based on these criteria, two major forms of capitalism are singled out – Coordinated Market Economies (most notably Germany) and Liberal Market Economies (most notably US). However, for the analysis of Asian economies, some adaptation and extension of the model has been proposed, given the different roles that the governments, labour unions and other social actors play across different Asian economies (Witt and Redding, 2013). Based on this analysis, Singapore is considered **an open, state-led capitalist economy**. Main differences compared to a coordinated market-economy are the different role of labour unions in wage-bargaining (with a reduced role and subject to extensive government control); weaker skills formation systems; weaker cross-industry cooperation and much stronger role of government.

2.4.2. "Beyond industrial policy" by the OECD

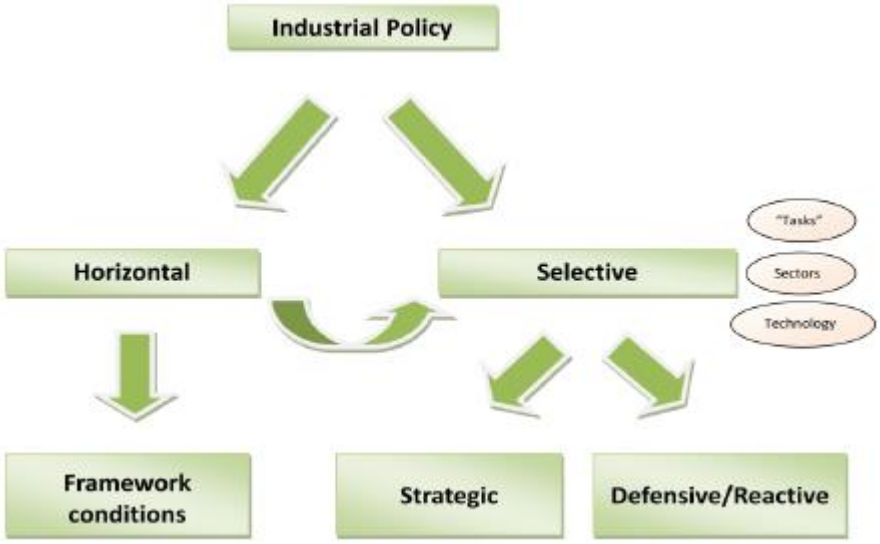
The OECD, in 2013, recognising increasing interest in industrial policy, particularly taking hold after financial crisis, completed a review of latest trends and activities of countries in this area (Warwick, K., 2013). As a result of the review, three-fold typology has been developed proposed to classify industrial policy interventions/activities by domain (Figure 1), by policy orientation (Figure 2) and by industrial policy focus (Figure 3).

Figure 1: A typology of industrial policy instruments by policy domain (Warwick, 2013)

Domain	Horizontal Policies	Selective Policies
Product markets	Competition and anti-trust Indirect tax Product market regulation Exchange rate policy	National Champions Nationalisation/privatisation Output subsidies/state aids Export promotion Price regulation (*e.g.* pharma) Public procurement Trade policy Car scrappage
Labour and skills	Skills and education policies Training subsidies Wage subsidies Income and employment tax Management advisory services Labour market regulation	Targeted skills policies Apprenticeship policies Sector-specific advisory services
Capital markets	Loan guarantees Corporate tax/capital allowances Macro/financial stability Financial market regulation	Strategic Investment Fund Emergency Loans State Investment Bank Inward investment promotion
Land	Planning regulation Land use planning	Enterprise zones Place-based clusters policy Infrastructure
Technology	R&D tax credit Science Budget IPR regime	Green technology Lead Markets Public procurement for innovation Patent Box Selective technology funding Centres of expertise
Systems/Institutions	Entrepreneurship policy Scenario planning Distribution of information Overall competitiveness strategy	Indicative planning Foresight initiatives Identifying strategic sectors Sectoral competitiveness strategy Clusters policy

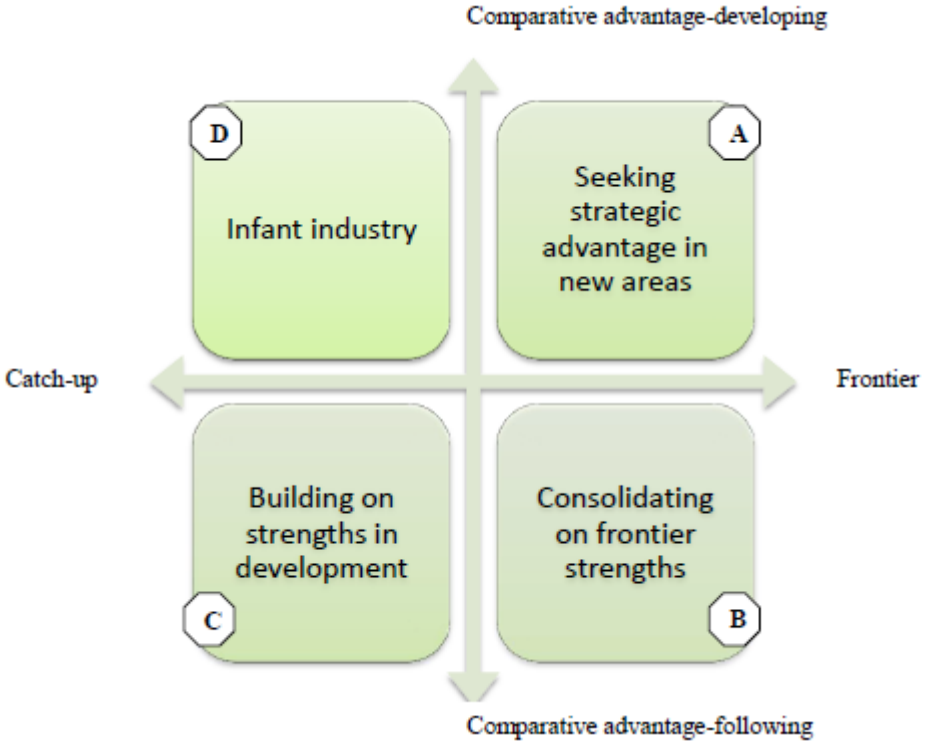
The first part of the typology to classify industrial policy domains (Figure 1) is inspired by growth accounting framework, classifying policy instruments according to domains covering product, labour, capital, land and technology markets, with an addition of a domain for policy coordination/governance.

Figure 2: A typology of industrial policy by policy orientation (Warwick, 2013)



The classification of industrial policy interventions, beyond clustering them into domains, could be further extended by analysing selective policies by their selection mechanism (that could be tasks, sectors and/or technology) as well as the reasons behind adoption of such policies, with those reasons potentially being either strategic or defensive/reactive (Figure 2). Finally, a further refinement as regards selective industrial policy interventions that are pursued for strategic reasons, distinguishing between catch-up v/s frontier policies and between policies developing v/s following comparative advantage (Figure 3).

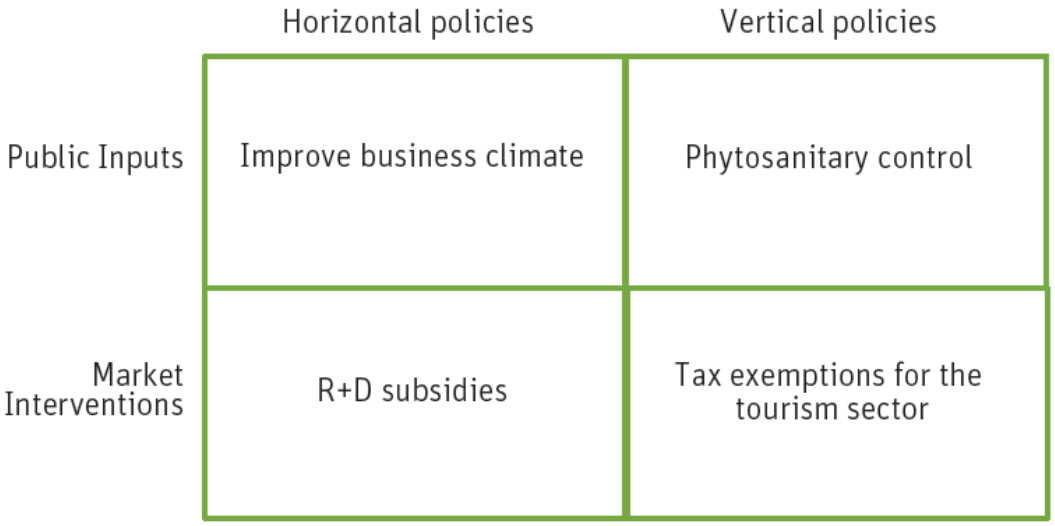
Figure 3: A typology of strategic industrial policy by policy focus (Warwick, 2013)



2.4.3. "Rethinking productive development" by the IAB

The Inter-American Development Bank, shortly following the earlier OECD publication, likewise devised an updated perspective towards industrial policy – defining a concise conceptual framework, identifying key policy areas and institutional arrangement to attain more effective interventions by countries. The publication also proposes to use a different term – instead of industrial policy calling it productive development policy. The conceptual framework, in a simplified form, also follows the (more elaborate) approach by the OECD.

Figure 4: The typology of productive development interventions (IAB, 2014).



The key areas of intervention for productive development policies highlighted in the report are:

- Promoting innovation by established firms, with targeted support for collaborative R&D activities with larger spillovers, diffusion potential and intangible assets;
- Start-up and scale-up of productive firms, with selective interventions for high growth companies and support for management practices required for scale;
- Education and training;
- Financing – credit guarantees, subsidised loans and development banks;
- Coordination function where private sector faces coordination failures;
- Support for internationalisation;
- Selection of sectors for vertical policies, assessing cost-benefits of the support.

Finally, the report also highlights that necessary prerequisites and public sector capabilities are required for successful policy implementation, both in terms of avoiding inappropriate "capture" or rent seeking as well as ensuring technical and political feasibility. To achieve this, policy must be set-up as a scanning and search devise as many of the solutions are not known in advance; it must also include constant learning and evaluation processes, good cooperation with the private sector and address clear market failure. Furthermore, public sectors must possess appropriate technical, organisational and political capabilities.

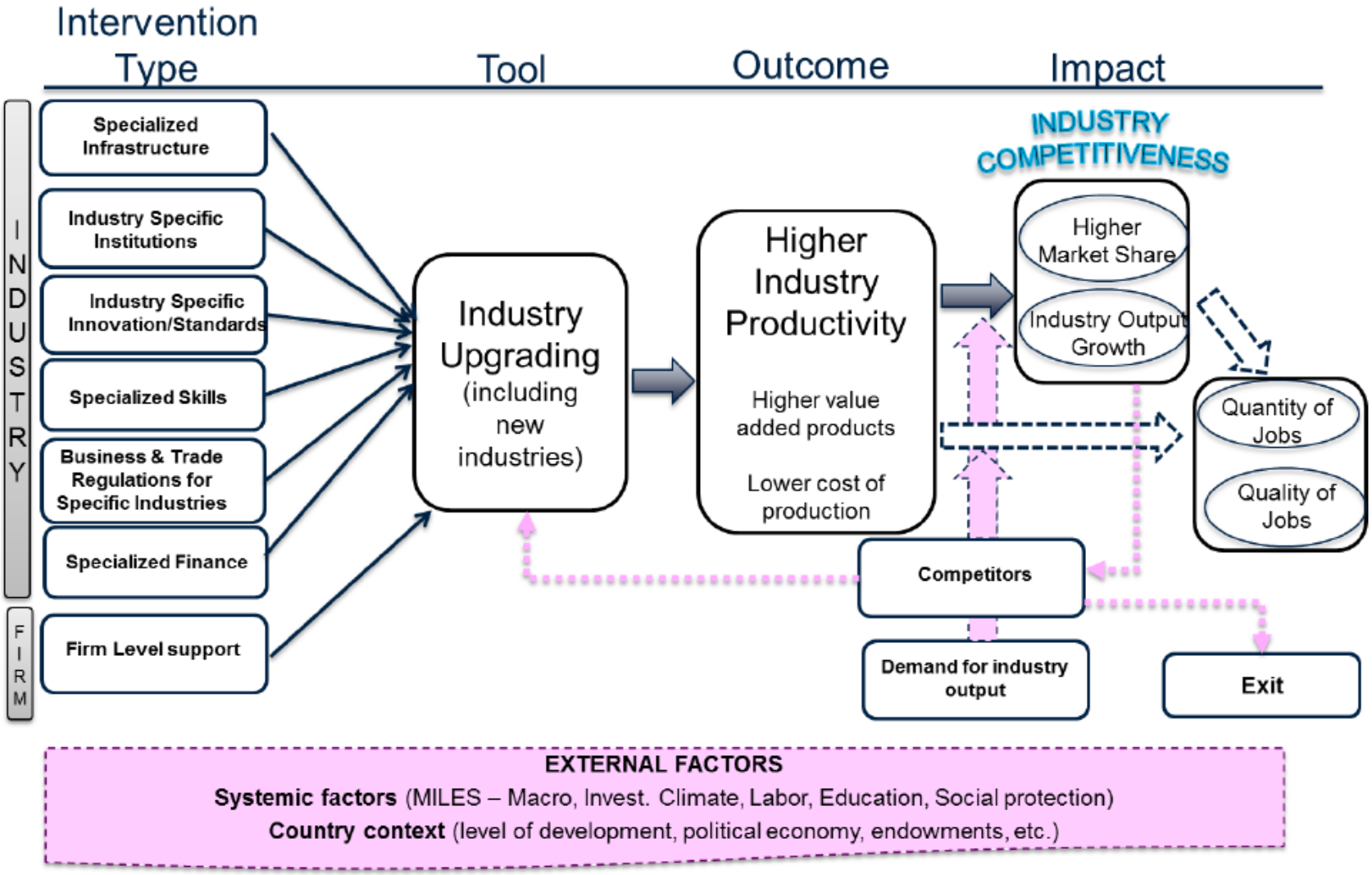
2.4.4.World Bank: Industry competitiveness framework

In 2015, the World Bank group decided to undertake an independent evaluation of the impact of its industry-specific project portfolio, targeted at developing countries, in their capacity to support productivity, competitiveness and their impact on jobs. As part of this task, the evaluators designed an evaluation framework to depict the intervention logic of different types of actions to the expected outputs - i.e. industry upgrading, outcomes - higher industry productivity and results - industry competitiveness, evaluated as growth in market share and industry output; as well as the quantity and quality of jobs (IEG, 2015).

The results of the evaluation have been published in 2017 (IEG, 2016). It is notable, that the evaluation did not find empirical confirmation that the intervention logic was functioning as planned. Specifically, it did not find significant improvements in industry productivity; however in some cases there were improvements in outcomes – industry output and market share growth. This indicates that the mechanism enhancing competitiveness might not be working at the country/industry level as intended.

The evaluation used two evaluation approaches: (1) assessing, through statistical analysis, before-and-after performance of industries/sectors, where World Bank interventions have been active and (2) comparing the performance of industries/sectors receiving World Bank support with the performance of industries/sectors in the same or similar countries without World Bank interventions. A similar approach could be applied evaluating the impact of interventions also at a single-country level, which however requires more fine-tuned data and to compare (similar) individual firms, rather than industries or sectors.

Figure 5: Industry competitiveness framework and logical framework of the Evaluation (IEG, 2016)



2.5. Analytical frameworks for skills policy

Apart from industrial policy, reaction to the changing economic and technological environment also saw a more pronounced discussion as regards skills policies. Human capital and skills have for a long-time been recognised as an important prerequisite for economic growth, even if the some authors suggest that the role of different production factors might change when moving through different stages of economic development (Greiner, A., Semmler, W., & Gong, G., 2016). The current academic discussion on the role of skills and human capital in the global economy, while indicating the need for a new perspective, suggests that until now the existing approaches are either based on universalistic theories – i.e. human capital theory; skills bias theory or particularistic theories - notably the varieties of capitalism theory (Lauder, H., Brown, P. and Ashton, D., 2017).

However, link between skills and industrial policies is not straightforward. On the one hand, from earlier discussion it has been evident that skills-focused interventions are usually an integrated element, among many others, of industrial policies. On the other hand, the level of integration between broader skills policies pursued by countries and industrial policies is often weak if at all present. It could be argued, that in many cases sector-specific industrial policy interventions concern skills in a very narrow way – limited both in terms of volume (i.e. number of people to be trained) as well as content (types of skills pursued). On the other hand, for horizontal industrial policy, skills governance interventions might seem too generic, lacking tangible indications of being identified as a pressing bottleneck (such as trade barriers or unfavourable exchange rates) or a visible outcome, such as an attracted FDI, jobs and infrastructure.

Therefore, the approaches to govern as well as analyse skills systems across countries are often rather “soft”. Two primary examples are, firstly, pursuing statistical analysis to understand the way skills (or more broadly) – human capital markets function across countries and secondly, pursuing (qualitative) analysis of skills policies, adopted to influence skills markets and in most cases focusing on skills development - i.e. initial and continuing education and training. In the two sections below, a concise review will be provided of some of the existing work by the European Commission and the OECD in terms of monitoring skills systems and analysing skills policies. For further in-depth discussion on latest skills policy issue a good reference points is the evidence collected and reviewed within the latest annual Development in Americas (DIA) report (IAB, 2017).

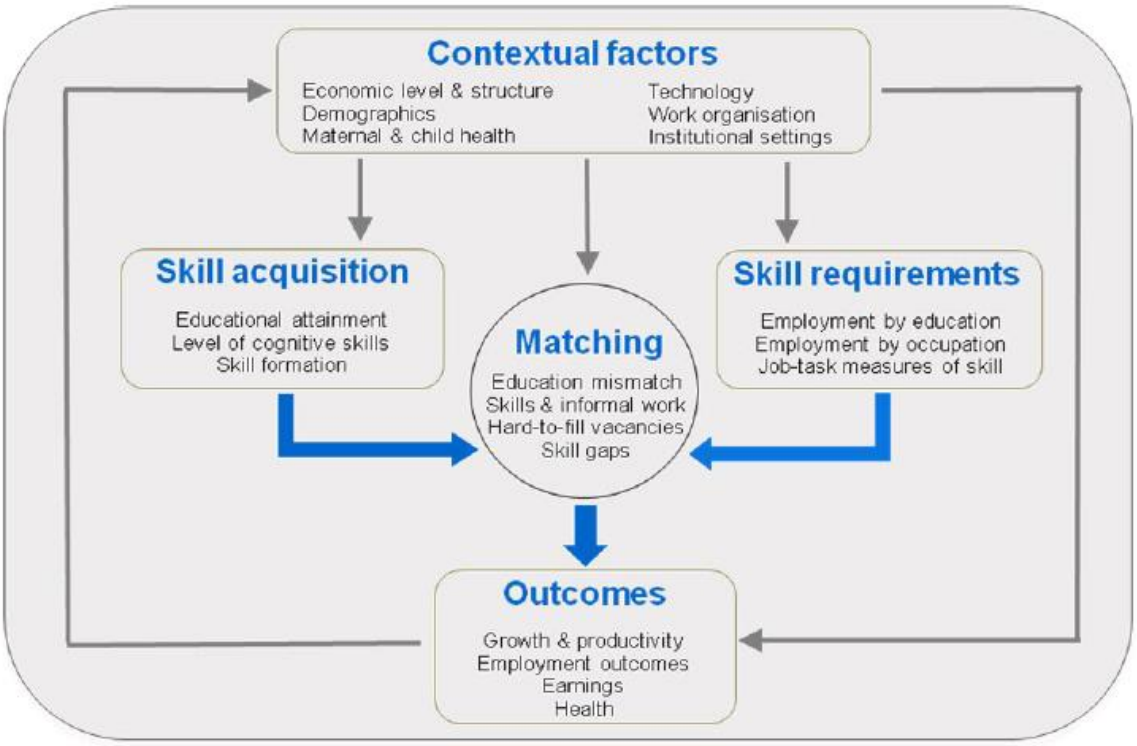
2.5.1. Workforce skills (development) systems

Two frameworks, developed at the international level since 2010 can act as a useful guide in monitoring skills systems. The first one, developed between 2011 and 2013 by the OECD and World Bank in cooperation with ETF, ILO and UNESCO. It was developed following a call by leaders of G20 and implementing G20 multi-year action plan on Development, adopted in Seoul summit in November 2010. The second one was developed by the European Commission in 2016 during a review process of skills statistics in the EU.

The OECD-World Bank framework was developed with the aim to act as a guide supporting countries, particularly those at lowest level of development in selecting indicators to monitor and benchmark skills development policies. It is a based on a supply-demand framework and consisting of five main domains and proposing a list of internationally comparable indicators available for majority of countries globally. The five domains include: contextual factors that drive supply and demand for skills; skills acquisition covering investment, stock and distribution of skills; skills requirements covering the demand side; matching of supply and demand in terms of labour market relevance of

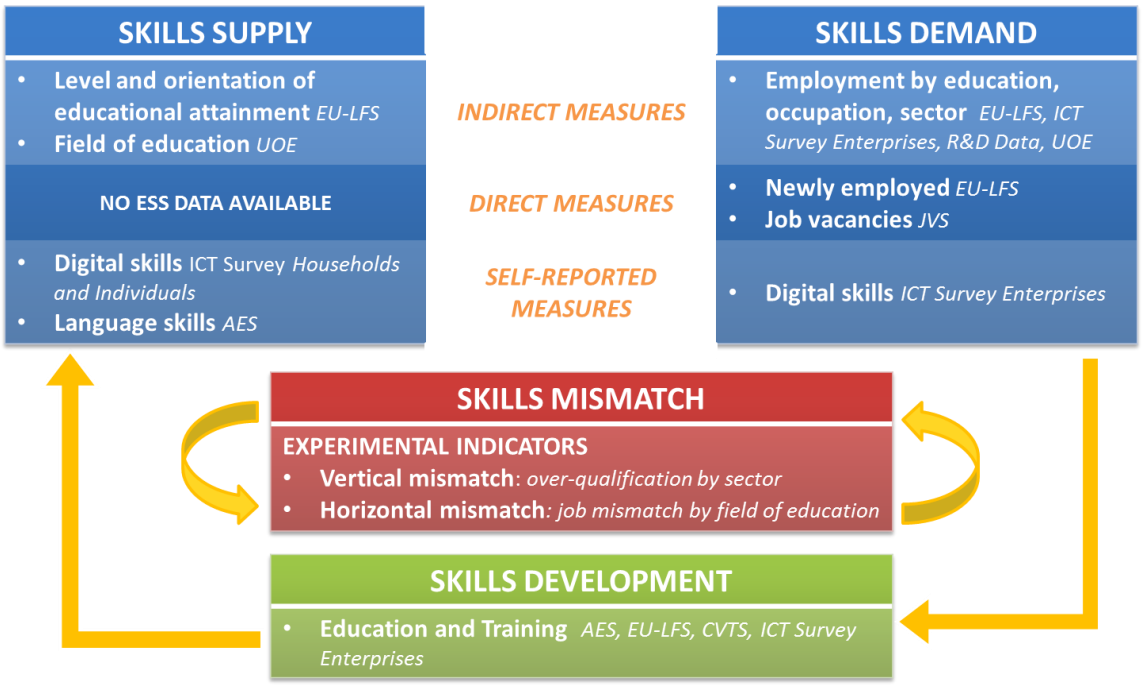
skills; and finally outcomes of skills that reflect the impact on economic performance and employment and social outcomes.

Figure 6: Conceptual framework for indicators of skills (OECD/WB, 2013)



The second framework, focusing on the policy priorities and availability of skills-statistics in the European Union, was also based on a supply-demand framework, but giving more equal emphasis between “flow” and “stock” measures of skills and evaluating the quality and relevance of different statistical measures (European Commission, 2016d)

Figure 7: Conceptual framework for skills related statistics (European Commission, 2016d)



http://ec.europa.eu/eurostat/web/skills/overview

Both of these frameworks and corresponding types of indicators can be used as an inspiration for and monitoring skills requirements to support the implementation of industrial policies. At the same time, as noted earlier, contemporary industrial policy often requires a deep level of disaggregation of indicators beyond the level of generic industry. This puts substantial burden on the existing statistical systems as regards their ability to generate data at the required level of disaggregation. This becomes even more difficult when data for comparison reasons is needed from different countries. Even more pronounced challenge is acquiring such data for relatively small countries and for relatively large companies, where sample sizes are often too small to be published in order not to disclose the identity of specific companies or individuals.

2.5.2. Workforce skills (development) policies

As regards skills policy interventions, some notable work on their classification has been carried out (but primarily focusing on continuing education and training) as part of the OECD INES network (Borkowsky, A., 2013) – see Figure 5 and the work of the European Commission on adult learning policy (European Commission, 2016a) – see Figure 6. The latter also included a literature review on the effectiveness of different policy interventions.

A major difference between these two frameworks is their practical applicability – the OECD framework has been called a “theoretical framework” due to absence of concrete indicators (data) to implement actual policy monitoring at the OECD level. Conversely, the analysis and monitoring framework developed by the European Union took into account the availability of data, which covers well a large part of the elements within the framework.

A further difference in the development of these frameworks has been the way to identify policy areas for monitoring. The framework developed by OECD was informed by policy experts – identifying policy priorities relevant in their countries, while the framework developed by the European Union was

based on a broad literature review, with the goal to identify policy interventions that have been researched and their evaluations indicated a certain level of evidence on their effectiveness.

At the same time, limiting the analysis only on those policy interventions that have been proven to work would prohibit reflection and analysis of any innovative measures, that have not been implemented yet or that have been implemented very recently and therefore were still not evaluated.

As can be seen from the mapping of skills oriented policy outcomes, some of these link to the goals of industrial policy in general and such policy in Singapore in particular. Notably two areas – capacity to find (a better) job due to increased employability as well as productivity and innovation outcomes at company level are two important elements/goals target by industrial policy in Singapore. Evidently, skills related interventions could be able to support the achievement of those targets.

Figure 8: The framework for monitoring adult learning systems (Borkowsky, A., 2013)

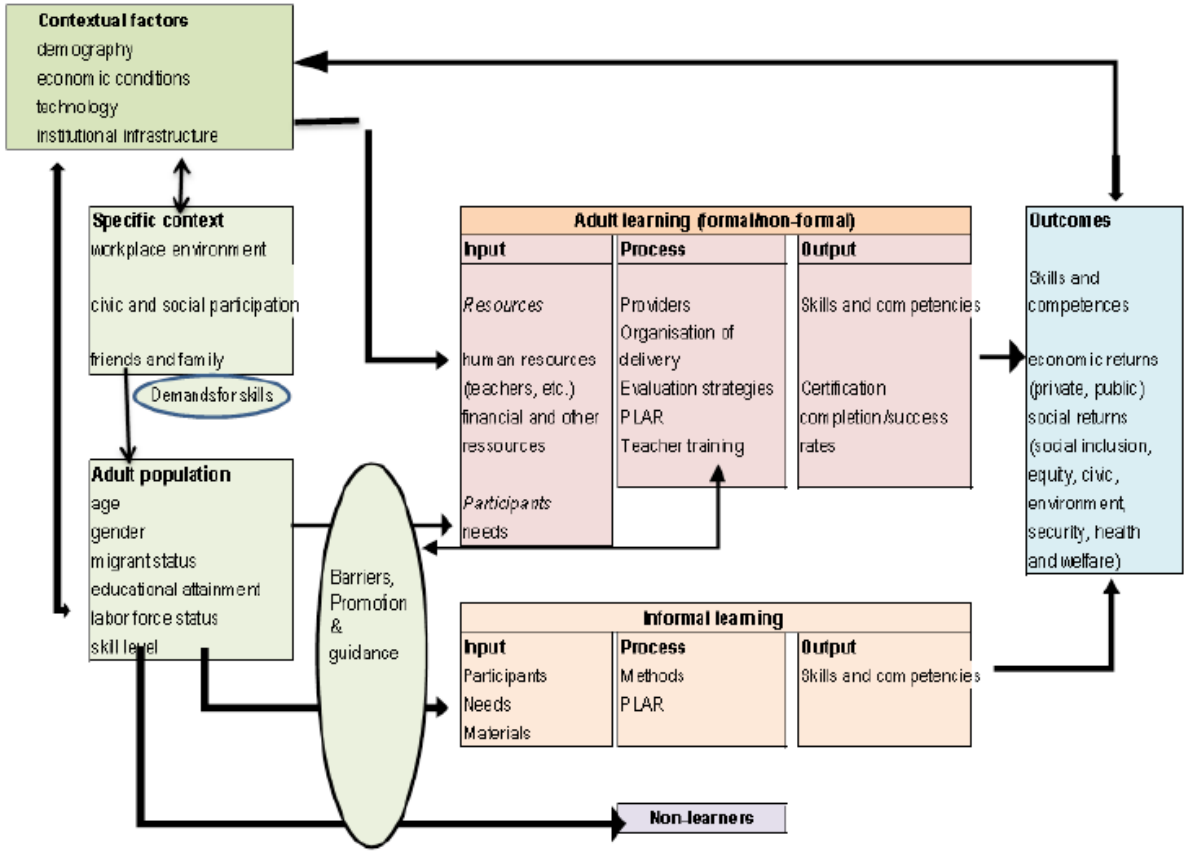
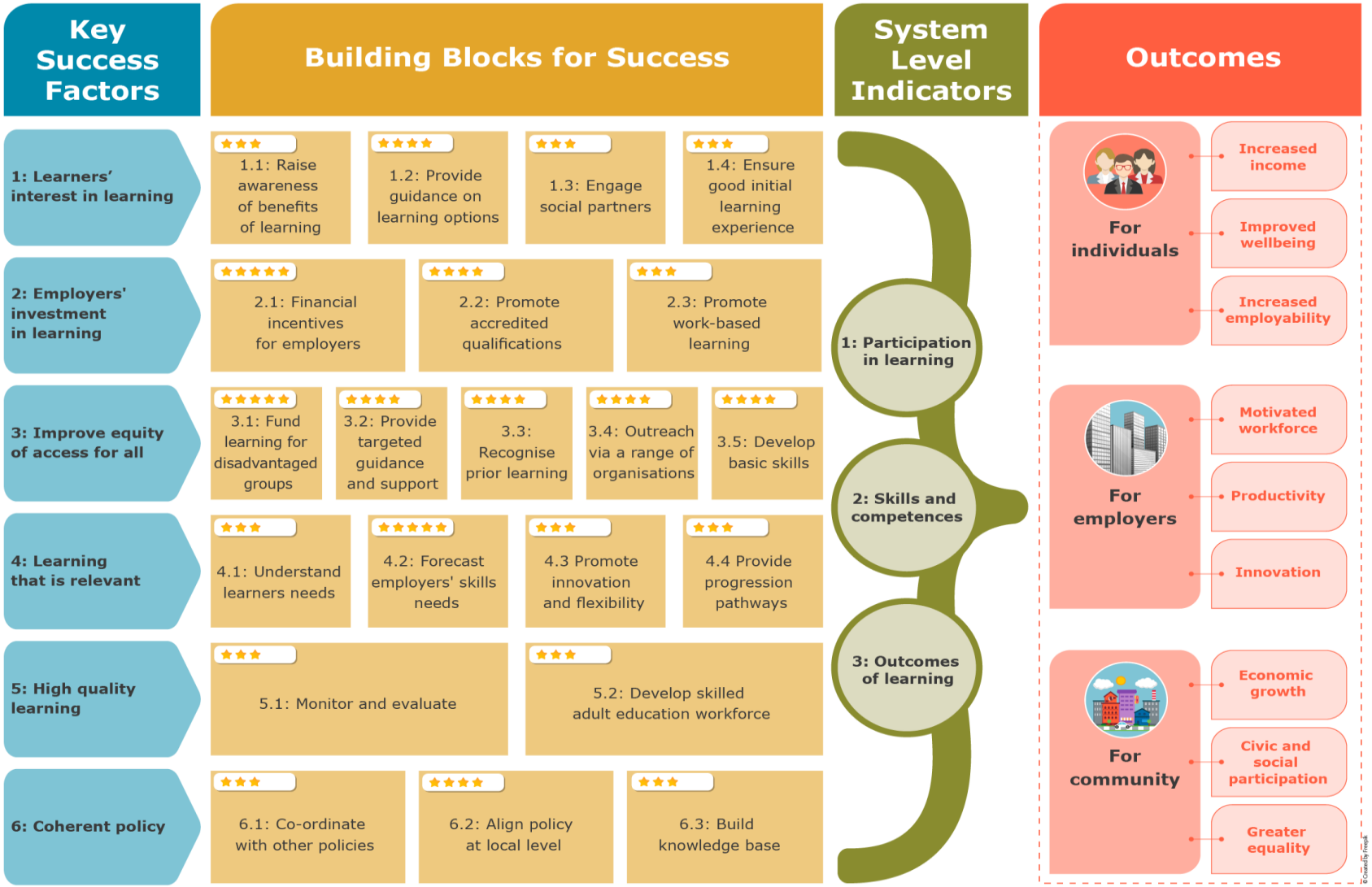


Figure 9: Conceptual framework for the assessment of adult learning policies (European Commission, 2015)



2.6. Industrial policy evaluation

Almost all of the analysis until this point was focused on the comparison or classification of industrial policies in countries. However knowing if or what some countries do or do not is still a long way from the policy-relevant conclusion on what is best to do. For this purpose some answers could be provided by policy evaluation – assessment as regards the impacts of specific policy interventions, policy packages or even overall policy frameworks.

However in the current state of socio-economic sciences such kind of evidence is scarce; even to carry out single evaluation, in a fast-changing policy and economic world is difficult and costly. Even if some evaluations are available, it is often questionable the extent to which examples from one place are applicable to another place as policy interventions are almost always carried out with modifications. There is also usually difficulty to use a control-group in policy setting, therefore compromising causality assumptions in any such evaluations. Finally, many of the evaluations are carried out only over a short period of time (during which the impact might not become visible) and must somehow take into account variety of other simultaneous interventions and asymmetric shocks. Therefore it is unsurprising that there is a lack of robust industrial policy evaluations (OECD, 2014).

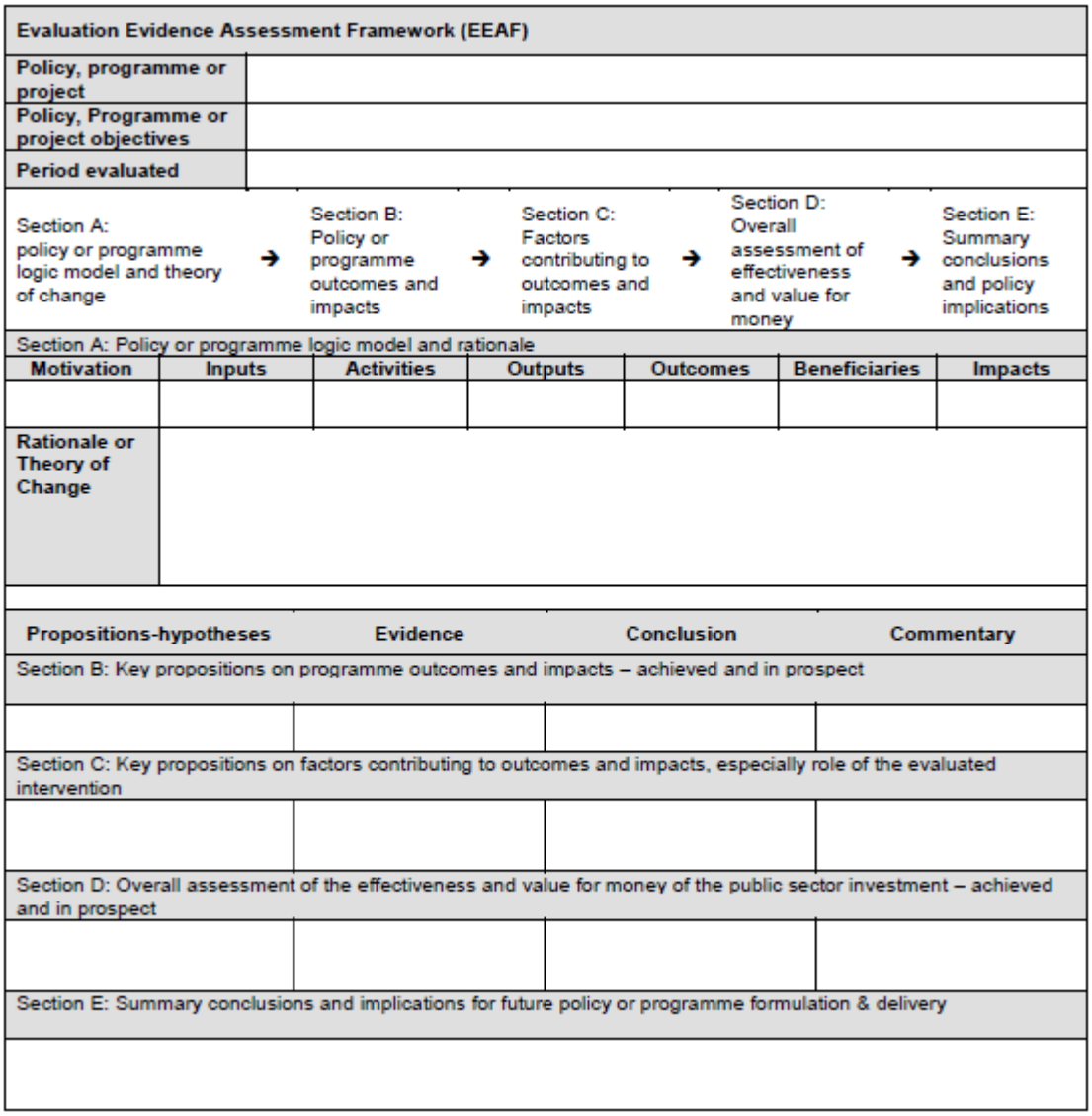
There are two emerging perspectives, worth mentioning that could somehow improve the value of evaluation for policy making: First of all, it must be recognised right away that existing most rigorous evaluation methods are difficult to apply to majority of policy interventions. Evaluations using counterfactuals and control groups should be selected only for simple policy measures such as market interventions. For more complicated measures (such as policy packages or broad-based policies targeting sectors/regions) use of evaluations with counterfactuals and control groups only for those elements where they are best fit and for most complex policy frameworks these must be evaluated informally, with lots of experimentation and learning by doing.

Secondly, for evaluation to become more useful given the growing complexity of policy, it is to use it more in developmental, rather than evaluative form and design policy implementation process in a way that it allows constant feedback, frequent re-assessment and if required modification of goals as well as a multitude of continuous learning. In such format, evaluation should avoid being a one-off large project but rather a continuous flexible and lean process.

As one possible example of innovative evaluation approaches, Matthews and White (2013) proposed a developmental industrial policy evaluation method using sequential hypothesis testing. They propose to adopt a lighter alternative than traditional evaluation, using techniques originating from intelligence community. The core of the method is sequential testing of concise hypotheses (propositions) about policy status under the conditions of uncertainty and complexity and using a standard reporting template putting them together under a unified framework for analysis, with conclusions to be used for policy (re-)design.

An example of such an evaluation framework and reporting template is provided below, with five sections for testing, including the intervention logic, programme outputs and outcomes; factors contributing to outputs and outcomes; assessment of effectiveness and finally summary conclusions.

Figure 10: Evaluation evidence assessment framework (Matthews and White, 2013)



Evaluation Evidence Assessment Framework (EEAF)						
Policy, programme or project						
Policy, Programme or project objectives						
Period evaluated						
Section A: policy or programme logic model and theory of change →	Section B: Policy or programme outcomes and impacts →	Section C: Factors contributing to outcomes and impacts →	Section D: Overall assessment of effectiveness and value for money →	Section E: Summary conclusions and policy implications		
Section A: Policy or programme logic model and rationale						
Motivation	**Inputs**	**Activities**	**Outputs**	**Outcomes**	**Beneficiaries**	**Impacts**
Rationale or Theory of Change						
Propositions-hypotheses	**Evidence**	**Conclusion**	**Commentary**			
Section B: Key propositions on programme outcomes and impacts – achieved and in prospect						
Section C: Key propositions on factors contributing to outcomes and impacts, especially role of the evaluated intervention						
Section D: Overall assessment of the effectiveness and value for money of the public sector investment – achieved and in prospect						
Section E: Summary conclusions and implications for future policy or programme formulation & delivery						

Overall, some of existing industrial policy reviews would conclude, there are three important aspects to keep in mind for industrial policy design and implementation (Rodrik, D. 2008):

- It must be well embedded locally, therefore cooperation with private and non-profit sector actors is critical;
- It must make full use, as necessary of both sticks and carrots, to avoid capture;
- It must ensure strong accountability, including transparency, openness and high degree of discussion.

2.7. Concluding assessment

Following the review of literature and experiences in other countries, a number of lessons and insights are drawn as regards Singapore industrial policy in general and the ITP in particular. In a sequential order, in the following section a discussion will be provided as regards implications for Singapore

arising from the discussions on different analytical frameworks and comparison with other countries, the coverage of skills aspects, policy implications as regards investment in intangible assets and aligning industrial policy with the global value chains perspective on international trade as well as, finally, the insights from industrial policy evaluation literature for Singapore's industrial policy in general and the ITP in particular.

However before going further into details, several major limitations need to be kept in mind, warranting caution as regards the interpretation of these initial conclusions:

- Most of the discussion here is built on a comparative perspective, i.e. comparison between the presence or the absence of a particular aspect in Singapore industrial policy framework. Such perspective, while indicating some missing elements, does not automatically mean that those elements are necessary or useful in Singapore (or for that matter – any other country) context.
- Furthermore, many of the assessments done are based on a limited amount of information as regards industrial policy frameworks, in particular when concerning policies adopted in such broad jurisdictions as the EU, US or China. Therefore it is quite likely that some of the elements are not covered in the sources and thus not reported in the conclusions below.
- In addition, each of the perspectives and frameworks, used for comparative review, when being designed had a separate purpose (i.e. classification, evaluation), specific underlying philosophy (growth accounting framework; intervention logic) as well as different sources of evidence (academic literature, case studies, project data), providing a multi-perspective view on this complex topic, as detailed below.

First of all, as already has been discussed in the literature, the **varieties of capitalism** framework indicates the potential importance of a coherent institutional framework governing the industrial-innovation system in a country. In this respect, an important aspect for industrial policy in Singapore is the perceived presence of elements from both of the two ideal innovation system types – radical (exemplary case US) and incremental (exemplary case Germany). Some authors argue, that due to absence of prevailing innovation system (or alternatively presence of conflicting innovation styles), a sustainable innovation activity of either type would not take hold (Carney, 2013) resulting in fragmented and subdued innovation activities and outcomes. This would imply that for Singapore to retain competitiveness it is critical to make its innovation system work.

Secondly, the industrial policy in Singapore, as announced in ITP, can be assessed in terms of its comprehensiveness, using **industrial policy classification by domain** developed by Warwick, 2013. From the discussions under ITP, it would seem that the promotion of R&D in terms of research and technology adoption would take the primary role (having two of the four ITP pillars focusing on this aspect, as well as the majority of financing initiatives announced – such as, revolving R&D tax credit facility, programmes to finance research as well as the adoption of automation and robotisation technologies). Efforts to address any bottlenecks in the skills and labour markets are also evident, but not as pronounced as those targeted at R&D. As regards product markets, some effort is programme as regards trade promotion, but seems to be, at least in the scope of IPT, focus primarily on company-specific support for internationalisation. Also some action as regards the functioning of systems/institutions some forward-looking analysis is carried out as part of planning individual ITMs, but it is unclear how does it link with broader competitiveness framework in the country. The last two aspects –land markets and capital markets are the least pronounced in the IPT. This is telling, as it would seem that most of public sector support to implement ITP is distributed as government grants, with limited role of private capital markets – the banking sector or financial markets.

When comparing the latest industrial policy initiatives in Singapore with those present in other major world economies, like US, China, Germany, France or the United Kingdom using **industrial policy classification by focus**, three different approaches emerges. For China, at least as far as policy communication is concerned, an aggressive selective policy, with a strategic focus for a number of frontier sectors is being pursued (recently most notable being aerospace industry) using the comparative advantage development orientation. For Singapore, there is overall a comprehensive combination of horizontal approach, covering most of economic sectors but within at least some ITMs (i.e. precision engineering) there seems to be a substantial expectation also for the development of some frontier sectors, which are not necessarily fully based on existing comparative advantage (a good example would be additive manufacturing). For the United States, the overall limited industrial policy is focused on a number of sectors through the advanced manufacturing institutes' initiative. In Germany, industrial policy would overall seem to be mostly horizontal, while in France and the UK sectoral industrial policy might be defensive, rather than strategic. Still, classification of overall industrial policy in horizontal v/s vertical terms is problematic as countries often have a mixture of both, with little data to judge which of the two orientations is more important, which is even likely to be the case in China. This type of analysis is likely an over-simplification, of low reliability and thus must be referred-to with due caution.

As regards the use of **skills-related interventions** as part of overall industrial policy, it must be acknowledged that often skills policies go beyond or at least in parallel to industrial policy. Education and training systems in many cases have broader functions beyond the support for industrial transformation, including employment and social aspects. Still, in Singapore it could be argued that skills policy frameworks are quite elaborate, with substantial effort both to provide framework conditions (like qualification framework), promoting sector-specific career pathways, dedicated workforce training programmes for emerging industries as well as broader support for lifelong learning. It also reserves a substantial role for the demand side, most notable in the ITP as forecasting and planning high-quality (PMET) job creation, indicating intention to stimulate demand for skills.

As regards the links between ITP and the **global value chains perspective**, it could be stated that Singapore ITP seem to address some, but not all of the challenges identified within the literature on the implications of GVC perspective on industrial policy. The issues which seem to be addressed substantially include social upgrading, with clearly vision of what type of jobs are aimed to be created as well as disaggregating industries to understand their dynamics – at least in the analytical phase. Some issues are addressed somewhat, but with less emphasis, including emphasis on regional trade through the support for Singapore companies to develop regional supply chains and overall import-export promotion. What seems to receive less explicit attention is cooperation with lead firms in the international supply chains to support local SMEs linkages to those chains and the overall effort to improve understanding of the role Singapore companies play in global value chains.

The role of **intangible capital investment** in Singapore's ITP seems to be mostly limited to public financing of R&D and aggressive promotion of the adoption of advanced technologies. Workforce training investment seems to be less pronounced, particularly firm-specific training while other investment types, like brand development, market research, product development are likely promoted only on a case-by-case basis within the broader package of firm-specific support measures. There is an impression that the promotion of technological modernisation by companies is very much supply driven (initiated by public policy push), with the risks that such efforts for many SME's might be misplaced, misused or simply fail, resulting in large deadweight losses of such investment. Such conclusion is inferred from the pronounced duality of Singapore's economy, with large section of low-productivity SMEs, facing constraints as regards their capacity to absorb technology and its fit with their underlying low-cost business models, strategies and mindsets. To change those, support for

investment in technology might not be a fully effective approach, trying to deal with symptoms rather than underlying causes.

Finally, if evaluating the overall state of industrial policy design in Singapore using the three synthetic factors from **industrial policy evaluation** review, it is interesting to note that the assessment would be rather pessimistic. Industrial policy is embedded in local economy only to the extent of its coordination with large companies, while the link with SMEs is very much top-down. It would also seem that industrial policy while having plentiful of carrots might be lacking sticks to provide stronger incentives for transformation. Finally, as regards accountability, this would seem, at least from a foreigner point of view, to be an area facing largest weaknesses having a lower degree of openness, transparency or discussion.

Overall, given the variety of perspectives used for this comparative assessment of the situation in Singapore as compared to other major economies and current debates in the literature, it should provide a rich and comprehensive overview form multiple points of view. Even if in many cases somewhat superfluous and inconclusive it could be a useful reference in generating debate, raising new ideas and initiating collection of further evidence, particularly where specific aspects reported here are found to be relevant for the perspective of national expects who possess an in-depth tacit knowledge of industrial policy framework in Singapore and can quickly assess these tentative conclusions through their own experience.

3. The evolution of Singapore's economy and policy

3.1. Singapore's industrial policy in a historical perspective

The Government of Singapore has a long tradition in pursuing activist economic and industrial policy. Already since the independence of the country in 1965, it adopted an interventionist approach to develop the economy, including through an activist industrial policy, even though during the last decades it has been progressively combined with a free-market approach (Lam, N. M., 2000). Economic policy since independence has been guided by regular national committees setting strategic economic vision. These started right after gaining self governance in 1959 (Abeysinghe, T., 2007) and include the First Plan (1960), the Second Plan (1980), the Economic Committee Report (1985), Strategic Economic Plan (1991), the Competitiveness report (1998) right after followed by Industry 21 and Manpower 21 reports (1999) and the Economic Review Committee (2002). In 2010, in part as a reaction to global financial crisis, the report of the Economic Strategies Committee was adopted to provide a broad vision and guidance for Singapore economic development for the next decade, also marking important change of the economic growth model and ambitions.

For most of the time since independence, the political rhetoric and economic policy thinking was underpinned by the perception of Singapore being a developmental state – a state actively driving the industrialisation and economic modernisation efforts. In the case of Singapore this was primarily carried out by very strong and active efforts to attract foreign investment, together with keeping business costs low through wage cost control, providing favourable tax regime and ensuring responsive immigration policy in the case of local labour market tightening. A brief account of historic changes to economic and industrial policy can help illustrate this economic model and mindset.

Singapore's economic development could be divided into four major periods: the first one took place since the independence until the first economic crisis in 1985; the second one between 1985 crisis and the Asian financial crisis of 1997; the third one until the global financial crisis in 2009 and finally the current (new) stage that started from 2010. A certain pattern could be seen through each of these periods – starting with an effort to drive economic growth following an instance of economic difficulties or crisis, followed by expansion in economy and workforce with a large contribution of immigrant population, which then raised concerns of low productivity and reliance on cheap foreign labour leading towards efforts to increase labour costs and limiting (foreign) labour supply to drive productivity growth which is then again followed by an economic contraction.

This cycle is most clearly evident in the first period of economic development – which started with rapid industrialisation to fight unemployment as of 1965, which allowed achieving full employment already by 1970. In the subsequent years economic growth was strongly supported by growing workforce, including through the supply of immigrant labour. By 1980, the emerging recognition of risks entailed in growing foreign population incentivised the government to rapidly raise workers' salaries. During the three years between 1979 and 1981 the recommended wage level increased by around 50%. This seemed not to have an impact on the inflow of foreign labour, therefore government also started to impose quota restrictions on immigration as of 1982. However, by 1985, with the arrival of the first recession after the independence, the government initiated a strong cut-back of labour costs and relaxed immigration controls.

During the second period between 1985 and 1997, the government seemed to be less concerned with the further growing abundance of foreign labour. However, in early 1990s new evidence started to emerge initiating a renewed scepticism about the longer-term sustainability of East Asian economic

model, driven by the accumulation of the quantity of production factors (labour and capital) rather than quality of their utilisation (i.e. productivity). Singapore was an exemplary case in this argument, actively accumulating (often low-skilled) immigrant labour force together with the aggressive pursuit of foreign investment and capital to support economic growth. By 1996, following the spread of this criticism, Singapore government initiated a broad policy effort to improve economic efficiency. However this effort was (again) interrupted by the 1997 Asian economic crisis.

Even while Singapore's economy was not directly affected by the Asia crisis, due to strong currency the cost-competitiveness of Singapore declined as compared to other major economies in the region. This called the government to take action and restore cost-competitiveness, with cutting employer tax contributions linked to the workforce, coupled with wage reduction, which went even further than in 1985, when wage growth restrictions were deemed sufficient. The time between 1997 and 2008 was manifested by a number of further negative economic shocks – the dot-com bubble, 9./11 and SARS epidemic. Economic growth during that period was mostly concentrated between 2004 and 2007, strongly reliant on a rapid expansion of the labour force, including foreign labour.

At the same time after 1997 economic crisis there was a stronger policy effort to deliver more of the economic growth through innovation. This was manifested in policy targets to increase R&D expenditure – both public as well as private to the levels seen in developed economies and supporting the build-up of an active and friendly start-up ecosystem. Favourable economic environment and dedicated policy measures, i.e. the set up of National Research Foundation in 2006, allowed increasing R&D spending from 1.9% in 2000 to 2.77% in 2008.

The ESC report explicitly states that skills, innovation and productivity should form the basis to sustaining economic growth in Singapore, enabling inclusive growth and allow income to rise for all Singapore citizens. It set the target of 3% to 5% of average GDP growth and 2% to 3% average productivity growth target during the decade until 2020. It also set the goal to achieve 3.5% of GDP invested in R&D from below 3% in 2009, to be on par with the levels seen in Japan, Finland and Sweden. It should be driven by private investment, while keeping the public R&D investment commitment (of 1% of GDP). Furthermore, a goal was set to double the number and ensure that 1000 Singaporean enterprises would have achieved a turnover of at least 100 million SGD. It is worthwhile keeping in mind that all these targets are to be achieved in the absence of (or at least a great limitation in) additional labour inflow.

A number of policy initiatives have been taken in the following years to implement the recommendations of the ESC. This firstly included the set-up of National Productivity Fund as a dedicated arm for public financial support to productivity-enhancing projects as well as broad-based financial incentive (CIP – Productivity and Innovation Credit) for companies and in particularly SMEs to invest more in productivity enhancement. The government also set up the National Productivity and Continuing Education Council, which was responsible to oversee the development of sector-based productivity strategy and the development of comprehensive system for continuing education and training (CET).

Since 2015, the economic governance cycle has now entered a new stage – both due to the need to assess the impact of policy actions taken early in the decade as well as take account of further transformations within the international economic environment. The statistics on economic development has not been great after the bounce-back effects, following the global financial crisis, wore-off. Without the supportive growth effect of labour force expansion and slow pace of productivity increase (despite generous public support even worse than in previous decade) GDP growth decelerated reaching only around 2% in 2015 and 2016, though picking-up somewhat in 2017.

The years 2015-2017 have been also notable for a pro-active policy state. In 2015, following a broad review of vocational post-secondary education pathways (ASPIRE) the government launched a major effort to strengthen skills development system in Singapore – SkillsFuture Singapore movement. This initiative aimed to strengthen the effort to further enhance continuing education and training system in Singapore, also expanding the funding from (already increased as of 2010) average annual spending of 600 million SGD between 2010 and 2015 to on average 1 billion SGD annually between 2016 and 2020. It also include three areas of action – carrier oriented activities in pre-employment training; support for training after completing pre-employment training and enhanced sector-specific cooperation in planning manpower needs by developing sectoral manpower plans and providing support to SMEs to access relevant skills.

The year 2016 also saw the launch of 2 new strategies: a new 5-year R&D strategy following the expiration of previous one as well as a renewed initiative to strengthen sector oriented productivity growth strategy – the Industry Transformation Programme (ITP). In 2017, renewed emphasis was put on businesses' international expansion, particularly with a new International Partnership fund of 600 million SGD. The new R&D strategy adopted in 2016 – Research, Innovation, Enterprises 2020 (RIE 2020) plan: winning the future through science and technology, with a dedicated budget of 19 billion SGD is to guide and drive the public sector R&D investments up to year 2020 (RIE Secretariat, 2016). The new research programme target four main technological domains – advanced manufacturing; health and biomedical sciences; urban solutions and sustainability; and services and digital economy.

The other one – Singapore's Industry Transformation Programme (ITP), announced in the Singapore Budget 2016 as a 4.5 billion SGD multi-policy programme. It includes several new policy instruments dedicated to support the automation and robotisation of the economy. It also includes an effort to streamline and increase coordination and integration of the different public policy initiatives through sector specific roadmaps – so called Industry Transformation Maps (ITMs). These should cover most important actions falling under the innovation, productivity, skills and trade policy fields (so called "pillars" of ITMs) and coordination the activities of the government agencies responsible for those fields. It should also improve the cooperation with businesses through multilayer tripartite consultation at an industry sector level, an industry cluster level comprising several sectors and the national level. This sector-specific coordination effort at the same time should be quite broad, covering all main economy sectors of Singapore, together representing around 80% of Singapore GDP.

Furthermore, in parallel to these policy initiatives, the government also set-up the Committee on the future economy (CFE), which was tasked to carry out a mid-term evaluation and produce a new strategic vision for Singapore economic and industrial policy in the next years, publishing its final report in 2017 (The Committee on the Future Economy, 2017). One particular feature that stands-out from the committee report is further reduction of growth ambition – aiming to reach only 2% to 3% GDP growth annually by 2020. Another important feature is the recommendation not only to strengthen skills acquisition, but also ensure appropriate skills utilisation at the workplace, by ensuring that training is closely linked to the requirements of the job. Furthermore, it further stressed the need to proceed with developing and implementing ITMs as a tailor-based and coherent approach to industry transformation.

While the economic rebound from 2010 crisis initially was again combined with a large increase in foreign labour, this did not continue further during the decade. Therefore, it seems that a longer-term change is taking place. This change is mostly manifested by two key factors – accepting a lower economic growth ambition and committing to reduce the reliance on foreign labour inflow even at the expense of economic growth. By 2017 these trends became entrenched in the government rhetoric, policy decisions as well as statistical data. Nevertheless, the government retains the objective to increase economic prosperity, which now however needs to be delivered more through productivity

growth rather than depending on further capital and labour accumulation. As an indication, the word "productivity" is again frequently mentioned in budget statements, with 2010 Budget being particular with 72 mentions of productivity – more than double the previous peak of 26 times in 1983 and an average of 5 times between 1985 and 2009 (Auyong, H. 2016).

The Industry transformation programme, as the key strategy of the government to ensure sustainable economic growth in this new economic and policy environment thus was selected as the focus of this research exercise. In particular, the analysis will focus on (i) the de-construction, based on public statements, document analysis and individual interviews, of the logic and scope of the programme and (ii) an evaluation, based on collected evidence, its capacity to achieve impact on productivity and economic growth. Given that ITP is combining many of the on-going productivity and growth oriented policy measures, notably those introduced since 2010, the analysis will have to cover also the scope of those policies in order to put together a comprehensive overview of all the major interventions covered, related or having similar goals and being implemented in parallel to the ITP.

3.2. The underlying logic of economic development policy

Ensuring continuing growth of Singapore citizens' income has for a long time been the primary political goal of Singaporean government. In addition, the perceived capacity to achieve this goal was an important factor legitimating the stay of People Action Party (PAP) in power during each election since the time of independence in 1965.

In order to achieve this goal, it is argued by some authors that the government pursued a pragmatic economic and industrial policy approach – not driven by any specific political ideology, but rather as the main criteria to choose among competing policy options using a short and medium term potential of those policy options to generate higher economic growth and, presumably, consequently increasing the income of Singapore citizens.

Such economic logic can be well illustrated by the opening statements of the Economic Strategies Committee (ESC) report published in 2010 – an outcome of one of the latest national long-term strategic guidance exercises which states that:

> "The goal
> High skilled people, innovative economy, distinctive global city
> We must make skills, innovation and productivity the basis for sustaining Singapore's economic growth. This will also provide for inclusive growth, with a broad-based increase in the incomes of our citizens. <...>
>
> 1. The Singapore economy has fared well amidst the challenges of the last decade. Growth averaged 5 percent per year during the period, even with the deep recession of the last two years. The majority of households have seen significantly higher real incomes over the decade, with median incomes rising by over 20 percent."

In addition to these high-level economic and development policy goals, political decision making in Singapore has also been objectively constrained by the geo-economic conditions of the Singaporean state. These constraints, but also enabling factors, which have been explicitly acknowledged numerous times by the government leaders, include:

- Lack of natural resources;
- Small amount of land;
- Limited internal market;

- Constrained supply of manpower (though high unemployment was registered during early years after independence);
- Geographical location that is suitable for trade;
- Some valuable institutional, legal and economic structures inherited from the British rule (though this last factor might be more explanatory rather than decision-driving element).

The economic and industrial policy choices, that locked-in Singapore's developmental model since independence have also been highly conditioned by the advice received during those early years from the community of international organisations. The most notable one was the United Nations Expanded Programme for Technical Assistance (EPTA). The UN, within the scope of this programme and at the request of Singapore government in 1960 sent a dedicated mission, led by Dr. Albert Winsemius to advice on future economic and industrial strategy of Singapore. The recommendations of this programme together with the continued long-term economic advice by Dr. Winsemius for Singapore government are often attributed as several of the leading architects of Singapore's economic model and success.

In the 1960s the key choices recommended and implemented could be summarised as:

- An active pursuit of foreign capital investment, focused on labour-intensive manufacturing, to be consistent with the trade and export-oriented economic structure as well as to address high unemployment at that time.

During later years, there have been several modifications to this, highly aggregated policy formula, but those changes did not, at least until around 2010, change the underlying developmental logic of Singapore state – the pursuit of internal and external capital investment, consistent with trade and export oriented economic structure (therefore usually concentrated into tradable industry sectors), with a generally favourable manpower supply and competitive labour cost and tax regime.

The few modifications, or rather newly emerging and recognised constraints that also had an impact on policy choices (though evident at a later stage of Singapore development – as of late 1970s onwards), have been the emerging understanding that:

i. Labour-intensive industrialisation is not sustainable given the small land area, slow population growth and limited tolerance to foreign population growth;
ii. The need to transition towards high value-added activities in order to ensure income growth for Singapore citizens, rather than only GDP-oriented growth model.

These two economic and political constraints were likely the driving factors incentivising governments' efforts to limit the growth of foreign worker population and concerns with (insufficient) productivity growth. A particular concern during 1990s has been the multi-factor productivity growth, which seemed to be very small in Singapore but also other Asian economies (Korea, Taiwan and Kong Kong) compared to the western countries, given the input (capital and labour) intensive economic growth (Krugman, 1994).

A number of policy instruments have been tested to address those challenges – including migrant quota systems; salary increases (but subsequent reductions given the reliance of economic model on competitive cost structure); migrant worker levies; education, training and skills development efforts, innovation expenditure and more generally efforts to increase productivity growth through economic restructuring policies.

These restructuring efforts could be said to combine almost the full array of policy areas in government responsibility, comprising different mixtures at different stages and situations:

- Tax policy (i.e. employer social security - CPF contributions);

- Industrial policy (i.e. attracting FDI);
- Innovation policy (i.e. promoting R&D);
- SME policy (i.e. policy support to SMEs);
- Workforce policy (hiring incentives and wage policy);
- Migration policy (i.e. foreigner quotas and levies);
- Trade policy (i.e. trade agreements, trade barriers);
- Internationalisation policy (i.e. support for internationalisation);
- Entrepreneurship policy (i.e. support for start-up ecosystem); and
- Education, Training and Skills policy (i.e. financing, incentives, pathways).

However, as a general starting point and based on the analysis above, the key perimeters as publicly discussed by political leaders are likely to be based on these core indicators:

- GDP growth;
- Capital investment;
- Labour force;
- Labour productivity;
- Labour income.

To simplify the economic policy logic further, the key indicators seem to correspond well to the economic growth accounting conceptual framework, which in principle would state that:

Income = GDP = Investment + Employment + multifactor productivity (MFP)

Furthermore, given the recent policy intention to limit labour force growth, as well as almost zero unemployment in Singapore which can be administratively controlled through the supply of foreign labour, the updated economic logic could be presumed as:

- Keeping the labour supply growth component low or zero;
- Focusing investment towards capital intensive and higher value-added (productivity enhancing) activities;
- And as policy outcome using labour productivity growth, i.e.

Income growth = GDP growth = Labour productivity growth

An explicit statement of such interpretation was indicated in ESC report (ESC, 2010) as well as stated in some of the government statements during Budget (Committee of Supply) debates in the Parliament (MTI COS, 2016) as well as stated in the 2017 budget speech.

3.3. Strategy setting bodies and economic strategy since 2010

Further to the analysis above deconstructing the long-term economic development logic, it can be assessed to what extent this logic is also represented (or changing) in the latest national initiatives to review Singapore's long term economic development vision and strategy.

Since 2010, there were two notable efforts to set the direction and vision for economic development of Singapore – the Economic Strategies Committee and the Committee on the Future Economy.

3.3.1. Economic Strategies Committee 2009-2010

The first one, convened in 2009 and producing the final report in 2010, was the Economic Strategies Committee. It has set five notable **quantitative outcome targets** for the decade until 2020 (but did not provide precise definitions for those targets):

- GDP growth is aimed to be on average between 3% and 5%, similar to the average growth of 5% during the previous decade;
- Productivity growth is aimed to be on average between 2% and 3%; doubling or tripling it as compared to the 1% average growth during previous decade;
- To raise total R&D expenditure to 3.5% as compared to nearly 3% in 2008;
- To retain manufacturing share in the economy between 20% and 25% of GDP.
- To reach the number of Singaporean enterprises with more than 100 million SGD turnover to over 1.000 from about 280 in 1998 and 530 in 2007.

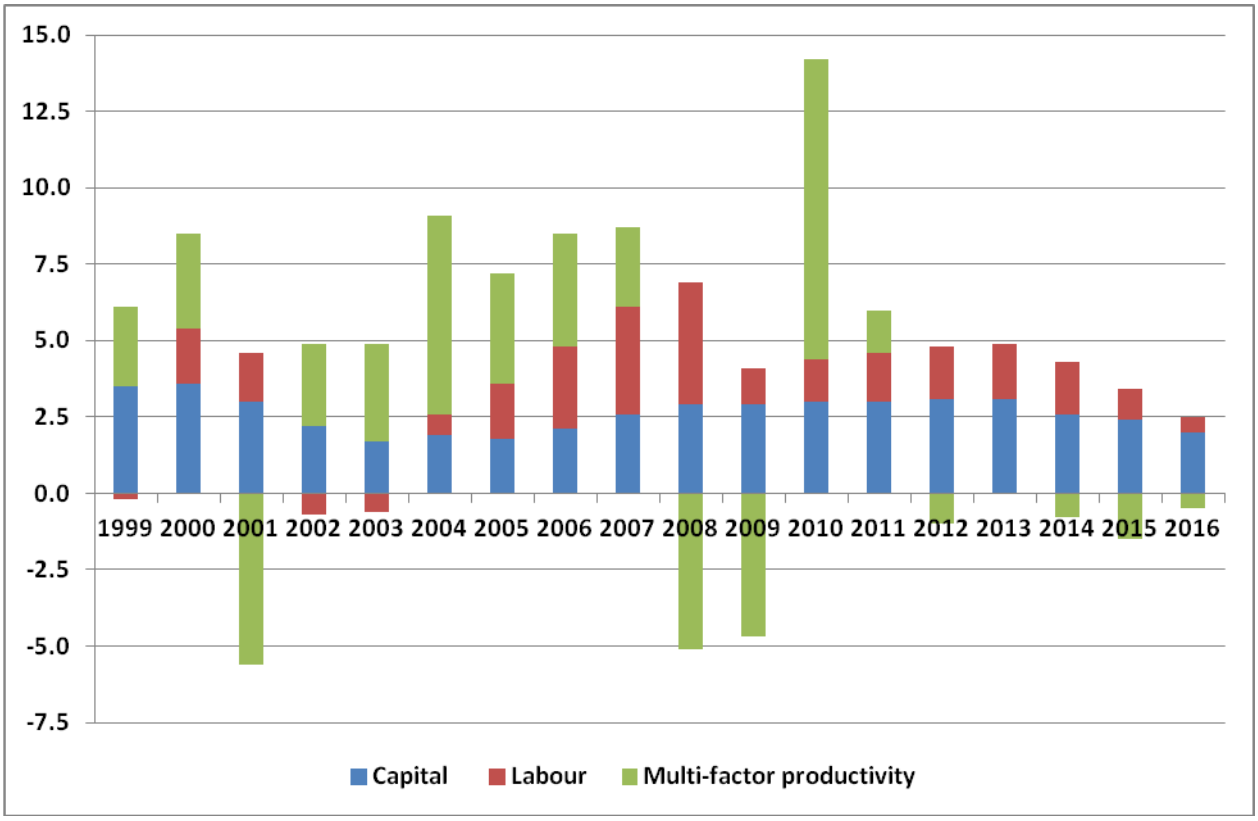
Importantly, the ESC report explicitly links the expected growth in productivity to achieving GDP growth targets:

> "17. Achieving this higher rate of productivity growth will, even with the slower growth in the labour force, allow us to **grow our GDP by 3 to 5 percent per year. Productivity improvements will therefore account for about two-thirds of our GDP growth, compared to just one-fifth in the last decade**."

The focus on productivity is further noted from the international comparative perspective, arguing that Singapore can target the level of productivity achieved in most advanced economies like US or Japan as Singapore is still lagging in most sectors of the economy. For example, in Singapore the productivity level in manufacturing is at 63% and in services 58% if compared to the USA; while in construction only at 34% if compared to Japan. Analysis of these gaps and productivity targets indicate the ambition in Singapore at that time to reach comparable level of productivity to those seen in the leading countries Furthermore, the report provided a rather detailed list of some quantitative (like size of co-investment capital funds for SMEs), but mostly qualitative policy instrument to achieve the goals set in the report.

The success of this plan could be put into context by analysing the key statistical indicators achieved by 2017. It would seem that GDP growth was reaching its target. In the case of productivity measures, during the years 2012-2016 the older measure – productivity growth per worker was below the target fluctuating between 0% and 1%, whereas the more precise measure of productivity growth per actual hour worked was a bit higher between 1% and 1.5% but still below the targeted level of 2% to 3%.

Chart 1: Capital, labour and MFP contribution to real GDP growth between 1999 and 2016 (SINGSTAT, accessed 03.08.2017)



3.3.2. The Committee on the Future Economy 2016-2017

The next (and currently the most recent) long-term strategic vision as regards the economic model of Singapore was presented in early 2017 as the report from the Committee on the Future Economy (CFE, 2017). The report has been much less specific about concrete targets to be achieved and rather took a more general approach by only setting the targeted level of annual GDP growth between 2% and 3% coupled with 7 strategies to achieve such growth.

While this report is much less explicit about the underlying economic development model as compared to the previous one, there seem to be two factors considered as the most important:

- Targeting specific geographic regions for cooperation (US/EU) or growth – Asia and emerging world);
- Targeting specific industry sectors which are expected to grow more rapidly than the rest of the global economy.

The report also lists four main directions how government could support utilising those factors and enable the continued (even if less ambitious) economic growth:

- Internationalisation, deepening and diversifying international connections and ensuring (access to) open and free markets;
- Acquisition and utilisation of deep skills by the workforce;
- Strengthen enterprise capabilities for innovation and competitiveness;
- Develop strong digital capabilities and adoption of digital technologies.

These four strategic directions will be supported by investment in physical and social infrastructure, stronger industry-specific coordination effort through the Industry Transformation Maps as well as more effective governance including through more comprehensive consultation and partnerships with stakeholders.

Even if the latest strategic review is less specific of the underlying macro-economic model and the logic of growth, it would seem from the on-going discourse that productivity oriented thinking is still an important conceptual model driving (or at least strongly influencing) the planning efforts and coordination of government policy. This is particularly seen from the budget statement in 2017, where it was explicitly stressed that achieving growth necessitates pressing on productivity.

This model of the GDP growth equals productivity growth was also directly stated in the Committee of Supply debates in 2016 by the Minister of Manpower. Finally, the importance of productivity, manpower and added-value indicators is explicitly seen in the target setting exercise as part of setting the Industry Transformation Maps and is also retained as an important part of the stated KPIs of the lead ministries – the Ministry of Trade and Industry and the Ministry of Manpower.

3.3.3. Conclusions

Overall, despite the decision to limit the growth of immigrant labour, which is a very notable change in the economic strategy recently, the government continues to openly rely on the same, growth-accounting inspired economic governance model, with a particular emphasis on productivity growth. Nevertheless, risks to this growth model are recognised, including the slowing down of international trade; subdued demand in the largest markets and growing competition for higher value-added manufacturing, for example coming from China. Also there are risks felt as regards the potential transformation of economies due to enhanced adoption of digital and automation technologies, arguing for the need to develop capabilities that would help to adapt as soon as such changes start materialising.

3.4. Policy implementation bodies

Besides long-term economic national targets set by the aforementioned committees, the policy work in Singapore is further guided by three further levels:

- Annual budget, announcing main policy interventions, regulatory changes and distribution of budgetary resources;
- Annual expenditure plans, expenditure reports and performance monitoring frameworks at the ministerial level, in particular the two important ministries dealing with industrial and workforce issues – Ministry of Trade and Industry (MTI) and Ministry of Manpower (MOM);
- Annual reporting by the thematic agencies, responsible for the implementation of policy interventions – i.e. statutory bodies like EDB, Spring, SSG/WSG, A*STAR and IE.

In order to analyse policy implementation capacity, it is important understand the links between these other levels bodies to the broader framework of the economic development logic as well as the coordination of their activities. Therefore, below an overview of the objectives, planning and reporting structures of these bodies is presented analysing reporting documents available at the public domain.

3.4.1.Governance through annual budget

The adoption of the annual budget is an opportunity for the government every year to state their latest policy priorities as well as announce latest policy initiatives. These announcements provide probably the most detailed public account of the overall economic and social policy framework in Singapore. All major economic and industrial policy initiatives, including the Industrial Transformation Programme, have been usually announced when presenting Singapore's annual budget. It is also the time when multi-year financial appropriations and commitments are publicly announced. The annual budget proposal also includes detailed breakdowns of expenditure plans by each relevant ministry (see more details in the discussion below).

3.4.2.Ministerial-level governance

The ministerial level is the most important level of governance where the design of policies and their implementation takes place. For industrial policy, the most important portfolio falls under the Ministry of Trade and Industry (MTI), which was set as the responsible body for the implementation of Industrial Transformation Programme. Ministry of Manpower (MoM) and Ministry of Education (MoE) are also important from the perspective of developing skills and ensuring adequate supply of labour.

As part of the process of the adoption of annual budget, ministries must also present detailed expenditure plans for the parliament in the so called "Committee of supply" debate; furthermore, each ministry, including the office of prime-minister have a set of global performance indicators, with MTI tasked to be responsible for the economic performance indicators – GDP growth, productivity growth, R&D investment and other.

It is notable, that performance indicators of MTI have witnessed a notable change since 2010, when earlier indicators measuring the added value of MTI policy (primarily EDB projects), such as total added value from EDB projects; total fixed asset investment from EDB projects; total business spending from EDB projects and total skilled jobs created from EDB projects have been discontinued, in exchange providing only indicators of added value for broad sectors (services and manufacturing). Still, the indicators on value added from EDB projects continue to be available in the EDB annual reports.

MTI, in its operational budget also is responsible for all the major statutory boards (agencies) responsible to support economic development and industrial policy in Singapore – Economic Development Board (EDB); Spring Singapore; Agency for Science, technology and research (A*STAR); International Enterprise Singapore (IE) and Singapore Tourism board.

3.4.3.Government agencies (statutory boards)

The Economic Development Board (EDB), presumably the oldest agency in Singapore dealing with industrial policy and competitiveness, established in 1961. It is responsible for planning and executing strategies to enhance Singapore's position as a global business centre. In 2017 budget it was provided with 175.84 million SGD operational budget and to oversee a 419.3 million SGD development budget. In terms of results of its activities every year it provides an overview of key performance indicators based on project commitments that were attracted and agreed by EDB. In 2016, the results of EDB activities were reported as: committed 9.4 billion SGD total fixed capital investment; committed 8.3 billion SGD total business expenditure per year; expected 12.9 billion SGD incremental value-added contributed to Singapore GDP per year and 20.100 jobs are expected to be created.

The standards, productivity and innovation board (SPRING), is the main agency for enterprise development, and it aims to enhance the competitiveness of enterprises to develop a strong base of dynamic and innovative Singapore enterprises. It is also the national standards and conformance body, established in 1996 as a result of a merger between two previously independent bodies. In 2017 budget it was provided with 97.42 million SGD operational budget and to oversee a 300.8 million SGD development budget. In terms of results of its activities every year it tracks the amount of projects agreed with companies and the expected or committed outcomes of those projects. In 2016, the results of SPRING activities were reported as: 16.300 companies engaged in projects; 7.8 billion SGD value-added contributed for the economy and 21.400 skilled jobs are expected to be created.

The agency for science, technology and research (A*STAR) is the lead public agency that drives mission-oriented research to advance scientific discovery and technological innovation and to bridge the gap between academia and industry in terms of research and development, established in 1991. In 2017 budget it was provided with 48.5 million SGD operational budget and to oversee a 1.19 billion SGD development budget. In terms of results of its activities every year it tracks outputs like R*D activities, outcomes and training. In 2016, the results of A*STAR activities were reported as: 1800 R&D projects; 233.61 million SGD industry R*D spending; 235 licenses issues; 9.05 million licensing revenues received; 107.1 industry cash funding received (as part also of 2nd performance indicator); 17 spin-offs; 66 researchers seconded to industry and 126 PhD Postgraduates trained or in training.

International Enterprise Singapore (IE) is the government agency promoting international trade and partnering Singapore companies in their overseas expansion efforts. IE Singapore plays a key role in strengthening our trading ecosystem and promoting Singapore as a thriving trading hub for global commodities traders. IE Singapore also leverages its global network of overseas centres to help Singapore-based companies in various stages of growth gain global competitiveness. In 2017 budget it was provided with 121.84 million SGD operational budget and to oversee a 47.1 billion SGD development budget. In terms of results of its activities every year it tracks the level and engagement of Singapore in international trade as well as support measures provided. In 2016, IE reported to have assisting 37.000 companies with 73.4 million SGD in grants; supporting 450 projects – 75 related to market entry, 45 e-commerce and 21 M&A, with expected overseas sales of 9.4 billion SGD.

Singapore Tourism board (STB) has the responsibility to oversees all aspects of tourism, including resource allocation and long-term strategic planning as well as establishing offices around the globe to actively market the Singapore destination. In 2017 budget it was provided with 205.29 million SGD operational budget and to oversee a 452.07 million SGD development budget. In terms of results of its activities every year it tracks the amount of promotional activities organised, partnerships formed and their outputs – i.e. arrivals and receipts generated. In 2016, the results of STB activities were reported as: support for 410 business events; 343.000 visitors' arrivals and 611 million SGD tourism receipts generated.

3.4.4.Conclusions

In conclusion, for the implementation of industrial policy initiatives a key role is played by the government agencies that are granted with substantial financial resources for operational purposes as well as tasked to disburse financial resources as support or incentives for the private sector. They usually use very concrete performance indicators, most important those linked to calculating the value-added that is expected or linked to their activities and support provided; but also indicators such as jobs, investment or trade generated. Still, there is little information on the methodology behind such indicators and their contribution to the broader performance of the economy, i.e. indicatively in the case of EDB the leading proportion (50% or more) of VA are generated by headquarters, R&D and professional services sector.

3.5. Policy coordination bodies

Existing international literature clearly indicates the importance of cooperating with the private sector when designing and implementing industrial policy (Page, J. and Tarp, F. 2017). Singapore, at least since 2010 has been setting-up a comprehensive institutional framework for public-private coordination, integrating both tripartite and sectoral aspects.

Three stages could be identified since 2010 in realising an enhanced coordination of industrial policy in Singapore: the initial set-up, with a unified council for skills and productivity and a limited sectoral coverage between until 2014, focus on skills from 2014 to 2016 and a new push for integrated sectoral strategies with the IPT as of 2016.

3.5.1. National productivity and continuing education council (NPCEC) 2010-2014

Following the conclusions of the conclusions of Economic Strategies Committee in 2010, which explicitly requested to set-up “a high-level national council <...> to oversee and drive efforts to boost productivity and expand CET”. Soon after the adoption of ESC report, such body, named “National Productivity and Continuing Education Council (NPCEC)” was set-up, with the inaugural meeting held already on the 30 of April, 2010. Chaired by the then Deputy Prime Minister Teo Chee Hean and with an initial mandate for 2 years, it was set to comprise representatives from the unions, private and public sectors. The council was set to oversee efforts to improve productivity and competitiveness at sector, enterprise and individual level, most notably being sector-specific productivity development roadmaps.

The sectoral coverage was substantial (i.e. covering a “significant” share – 40% of GDP) but not overly- comprehensive, with 12 sectors to be covered (as of 2012 extended to 16 to cover 55% of GDP). The sectors to be covered included: construction; electronics; precision engineering; transport engineering; general manufacturing; retail; food and beverages; hotels; healthcare; infocomm; logistics&storage; administrative and other support services. Council members included 7 public sector representatives (deputy minister; senior ministers, ministers and ministers of state for industry, manpower, trade, national development and education); 4 trade union representatives from NTUC, SISEU and FDAWU and 8 industry representatives from National employers federation (SNEF); Singapore productivity association (SPA) and companies such as Levi Strauss (apparel), Keppel (marine and infrastructure), CapitalLand (real estate), Apex-pal (food services), Shell (petrochemicals), Tion Seng (construction).

By 2012 the council has approved productivity development roadmaps for 11 sectors (for two sectors from the initial list – electronics and transport engineering such plans were not prepared but an additional sector – food manufacturing has been included). That same year the mandate for the council has been extended for another two years and the membership has been updated with 14 new members. Almost all of the original public-sector members have been re-appointed, while the majority of business and labour unions representatives were changed. New representatives included a consultant – managing directors of BCG Singapore; an academic representative – deputy dean from national university Singapore business school. Representation from industry has been extended with 5 members from trade associations and chambers (SPA and SNEF re-appointments) and new appointments from restaurant association (RAS), federation of merchants association (FMAS) and Singapore business federation (SBF). From companies, re-appointments included from Levi Straus and Tiong Seng and new appointments from Griffin Kinetic (marine logistics), Tetra Pak (food

packaging), Nan Guan Construction (construction), Harry's holdings (food services), Molex (electronics) and Teckwah (packaging).

3.5.2.Skills Future Council (SFC) 2014-2016

In 2014, initial media reports stated a second renewal of the mandate of NPCEC towards 2016, however towards the end of 2014 with a new initiative – Skills Future Singapore to be launched, also a new council – Skills Future Council (SFC) has been announced, devolving the responsibility for CET from NPCEC to this new council and renaming NPCEC as national productivity council (NPC). However, given pronounced emphasis on Skills Future Singapore, announced in Annual Budget 2015, little further work of the NPC has been made public – though SPRING Singapore has adopted several second-stage sector productivity roadmaps in 2015 for sectors such as retail and food services.

The composition of SFC has been quite similar to the previous NPCEC – a number of ministers lead by deputy prime minister, labour unions representatives, representatives from research and education institutions, employers associations and individual companies, for the latter representing Park Hotel group (hotels), Infineon technologies (semiconductors), Keppel (offshore and infrastructure), Microsoft (software), Breadtalk (food services), Fluidgim (micro-bio manufacturing), DHL (logistics), Evonik (chemicals), Cathay (leisure), Cold Storage (retail), ITL corporation (medical manufacturing).

3.5.3.Council for Skills, Innovation and Productivity (CSIP) 2016-2017

In 2016, following the announcement in the annual budget statement of the launch of Industry Transformation Programme (ITP), a new council has been launched again merging the previously separate Skills Future Council (SFC) and National Productivity Council (NPC) in a new Council for Skills, Innovation and Productivity (CSIP), with the aim to bring forward the implementation of ITP and in particular to oversee the development of sectoral industry transformation maps (ITMs).

The structure of the membership of the council remained similar as before, with 7 public sector representatives (deputy prime minister and ministers), a mayor, labour unions and employer associations and individual companies, including Infineon (semiconductors), AsiaPac executive insights (consultancy), Scanteak (retail), Monk's Hill ventures (venture capital), CapitalLand, Straits construction, Evonik, KPMG, McKinsey, Fluidigm, ITL corp.

3.5.4.Future economy council (FEC) 2017-...

In 2017, following the publication of the report from the Committee on the future economy (CFE) a new, future economy council was set up to take forward and implement the recommendations stated in the report as well as continue the oversight of the implementation of Skills Future Initiative and the Industry Transformation Programme (ITP) through Industry transformation maps (ITMs). The Council member composition includes representatives from the Government, private sector, unions, Institutes of Higher Learning and Trade Associations & Chambers. Besides the main Council, 6 tripartite FEC sub-committees, led by private and public sector co-chairs, will coordinate the efforts for 6 clusters of industries. At the industry level, Industry Tripartite Committees will be leading the work on the Industry Transformation Maps (ITMs).

3.5.5.Conclusions

Since 2010, Singapore government has been engaged through a structured framework with employers, labour unions, individual companies and other actors to consult and coordinate the design

and implementation of its industrial policy initiatives and in particular the sectoral policy interventions – productivity roadmaps between 2010 and 2014 and industry transformation maps since 2016.

It is interesting to note the change of the composition and structure of cooperation bodies. In terms of composition it started with more limited representation with up to 2 representatives from unions and employers' side and a small selection of companies, with an over-representation of construction, infrastructure and heavy manufacturing sectors, moving later to extend the size of the membership and include more representatives from advanced manufacturing, business and personal services sectors. The complexity of the coordination framework also increased substantially, especially since 2017 with the launch of FEC which includes not only national, but also cluster-level and sector-level coordination bodies.

3.6. The status of industrial, skills, innovation and trade policies

As discussed earlier in the report, a number of different policy areas have (sometimes a substantial) influence on industrial performance and modernisation. With the reference to earlier mentioned approach to classify industrial policy interventions using the growth accounting framework, major policy areas that could be distinguish are those regulating product markets (notably competition policy, exchange rate policy), capital market (notably fiscal and monetary policy), labour markets (education, training and labour market policies), technology markets (intellectual property, research and innovation) and other.

In this analysis it is not possible to review the context of all the relevant policy fields in Singapore, however it is worthwhile to look into those fields that have stronger links to the Industry Transformation Programme, which, as analysed in more detail below, focus on four key pillars: productivity, skills, innovation and trade.

3.6.1. Productivity promotion

Singapore has a long tradition in pursuing efforts to promote productivity growth. The early efforts can be traced to the first years of independence, with the set-up first of a "productivity unit" under the purview of the EDB was set-up in 1964, promoting it to a national productivity centre in 1967 and finally setting-up a dedicated national productivity board in 1972[1]. As already mentioned in a concise manner in previous chapters, there has been at least two major efforts that were notable in public communication – the productivity promotion effort in early-1980s, with the effort to curb the growth of immigrant labour and increase productivity of local enterprises, that later coincided with (but also likely made it worse) the first post-independence recession of 1985 that forced the government to promptly reverse prior decisions to increase labour costs and introduce immigrant labour quotas (Auyong, 2016).

The second more notable episode appeared in 1994 with the publication of the article in Foreign Affairs by the notable economist P. Krugman (who later was awarded a Nobel prize in economics) highlighting the lack of productivity growth in East Asian economies, notably Singapore (Krugman, P., 1994). In this article it was argued that growth in East Asian economies were driven primarily by factor accumulation, similar like in the Communist countries, without corresponding increase in productivity and innovation, therefore due to diminishing returns of such input accumulation being not a sustainable growth path in the long term. The government of Singapore, while dismissing the critique,

[1] http://eresources.nlb.gov.sg/history/events/1322f7a8-b6d8-4d0f-89cb-0c712119b7a5, accessed 2018.01.20

took notice. Three month after the publication of the article a dedicated task-force has been set-up to examine ways to improve total factor productivity (McDermott, D., 1996).

The task-force came to a similar conclusion of the low-level of MFP growth in the years since 1980s and agreed of the need to increase the contribution to growth from MFP, away from capital and labour accumulation. The major sources of MFP growth have been identified as being: changes in the education level of the workforce, extent of economic restructuring, changes in the capital structure, technical progress and intensity of demand The three major strategies, proposed by the task-force, included the (continued) importance of education and training (manpower development), economic restructuring and technical progress (NPB, 1995).

Now, since 2010 and following the aftermath of the global financial recession, at least three further productivity related initiatives could be identified: first, with the budget 2010 an introduction of a number of new instruments to promote productivity growth was announced. Fiscal instruments include the set-up of National Productivity Fund (NPF) and the productivity and innovation credit (PIC), analysed in more details in the next chapter. Non-fiscal instruments include the set-up of NPCEC and launch of "productivity development roadmaps". Next, in 2012, a national productivity movement "Way To Go, Singapore" complemented by a publicity campaign was launched. Finally, in 2016, the Industry Transformation Programme (ITP) has been announced, which is the original focus of this research paper and analysed in a more detailed manner in a dedicated chapter further-on.

This continued promotion of productivity, certainly also linked to other factors discussed in this report, provided support to Singapore's economy to surpass, in terms of productivity growth its main competitors in Asia and reach comparable productivity levels to that of the other developed economies. An indication of this productivity growth can be the comparison of average productivity per hour worked among the major Asian, European and North American economies. Based on these figures, it could be stated that Singapore's economy is state-of-the art reaching the technological frontier. At the same time, a major caveat in such analysis is the fact that Singapore is city-state without large hinterland as is the case for all large economies, therefore is likely not fully comparable in this respect.

Table 2. Adjusted labour productivity per hour worked, in 2016 USD PPP.

	1950	1960	1970	1980	1990	2000	2010	2017
United States	19	24	31	36	42	52	67	69
Germany	8	15	24	35	43	57	63	68
France	9	15	26	36	48	57	62	66
Switzerland	19	26	35	43	47	55	61	62
Singapore	8	9	16	24	34	43	55	60
Hong Kong	3	5	9	15	27	32	45	53
United Kingdom	14	16	23	29	35	45	51	53
Taiwan	2	3	6	10	18	31	45	51
Japan	3	5	12	18	27	36	42	46
South Korea	2	3	4	6	11	20	31	36

Source: The conference board (https://www.conference-board.org/data/economydatabase/index.cfm?id=27762

In 2016, in the context of the seventh Singapore trade policy review, the World Trade Organisation has produced an inventory of schemes and incentives available in Singapore to facilitate business restructuring and the overall economic transformation. The list provides a quite comprehensive

overview of the instruments, in place during 2015/2016. At the same time, it must be kept in mind that such instruments are continuously modified, old instruments withdrawn and new instruments introduced, as will be seen from the review of annual Budget announcements as regards the changing landscape of these instruments. Therefore, when analysing the existing policy environment from a multi-annual perspective, such continuous changes must also be taken into account.

Table 3. Business development incentive schemes in 2015/2016

Incentive scheme / administering agency	Description	Selected eligibility criteria
Inland Revenue Authority of Singapore		
Integrated Investment Allowance Scheme	Allows businesses to claim capital allowance for equipment and plant expenses; Allowance on a percentage of approved fixed capital expenditure to be incurred on productive equipment that is used outside Singapore for an approved project – this allowance is granted on top of normal 100% capital allowance	Singapore-based company which carries out a project through an overseas subsidiary may apply in respect of the fixed capital expenditure for the project
Productivity and Innovation Credit (PIC) Scheme	400% tax deduction (up to S$400,000) for investment in productivity and innovative activities; Budgeted amount: S$3.6 billion for the years 2016-18	Qualifying activities include: acquisition and leasing of PIC IT and automation products; training; registration of certain IPRs; R&D activities; acquisition or licensing of IPRs; and design
Double Tax Deduction for internationalisation (DTDi)	Tax deduction of up to 200% on qualifying expenses incurred on qualifying market expansion and investment development activities	Businesses engaged in internationalisation activities
Merger and Acquisitions (M&A) Allowance	Allowance equivalent to 25% of the value of acquisition (with a cap of S$5 million), and double tax deduction of related transactions (up to S$100,000) and stamp duty relief (capped at S$40,000) for the qualifying share acquisition	After the acquisition, the acquiring company must achieve at least 20% of ordinary shareholding in the target company (if it's original shareholding was less than 20%), and more than 50% (if it's original shareholding was 50% or less)
SPRING Singapore		

Incentive scheme / administering agency	Description	Selected eligibility criteria
Angel Investors Tax Deduction Scheme (AITD)	Tax deduction of 50% of the cost of the investment in a start-up at the end of a 2- year investment holding period for approved angel investors	Minimum investment of S$100,000 in a qualifying startup; eligible investment capped at S$500,000 per year of assessment; demonstrated ability to nurture investee companies
Business Angel Scheme (BAS)	Dollar-for-dollar matching investment (up to S$2 million) in a Singapore-based start-up able to attract investment from participating angel investors	Incorporated as a private limited company for less than 5 years; paid-up capital of at least S$50,000, ability to demonstrate substantial innovative and intellectual content for products
Sector Specific Accelerator (SSA)	Dollar-for-dollar matching investment (up to S$4 million) in a Singapore-based start-up able to attract investment from approved accelerator operators (SSA operators)	
Incubator Development Programme	Up to 70% grant support for cost incurred to develop programmes, mentor and nurture local start-ups	Incubators or venture accelerators with a sustainable revenue model and a proven management team
SPRING Start-up Enterprise Development Scheme (SPRING SEEDS)	Dollar-for-dollar matching investment (up to S$2 million) with third-party investors in Singapore-based start-ups	Incorporated as a private limited company for less than 5 years; paid-up capital of at least S$50,000; ability to demonstrate substantial innovative and intellectual content for products
Technology Enterprise Commercialisation Scheme (TECS)	Funding up to 85% (Proof of Value) or 100% (Proof of Content) of qualifying costs for early-stage companies to develop and commercialize innovative technology ideas (up to a maximum of S$250,000 or S$500,000 depending on the stage of development of the technology/concept)	Qualifying costs include basic manpower costs, professional services, equipment and software, IP rights, materials and consumables
Action Community for Entrepreneurship Startups (ACE Start-up Grant)	Matching contribution of S$7 dollars for every S$3 dollars raised (up to S$50,000) by a Singapore citizen or permanent resident who is a first time entrepreneur	First-time entrepreneurs

Incentive scheme / administering agency	Description	Selected eligibility criteria
SME Talent Programme	Up to 70% funding support for the internship stipends or study sponsorships	
Local Enterprise Finance Scheme (LEFS)	Loan of up to S$15 million to finance the automating and upgrading of factory and equipment and/or purchasing of approved factory and business premises	SMEs
Micro Loan Programme (MLP)	Loan of up to S$100,000 for the financing of daily operations or for automating and upgrading factory and equipment	Companies with 30% local shareholding, less than 10 employees or a turnover less than S$1 million
Capability Development Grant	Up to 70% funding support for qualifying project costs incurred in upgrading capabilities in areas such as increased productivity, process improvement, product development and market access	SMEs with 30% local shareholding, group annual sales turnover of not more than S$100 million or employment size of not more than 200 employees
Innovation and Capability Voucher Scheme	S$5,000 voucher for projects aiming to strengthen business capabilities in the areas of innovation, productivity, human resources and financial management	Same as above
Economic Development Board		
Research Incentive Scheme for Companies	Co-funding to support the development of in-house R&D capabilities	Singapore-registered business entities
Innovation Development Scheme	Co-funding to support innovation, productivity and capabilities development	Singapore-registered business entities
Initiatives in New Technology	Co-funding to support manpower development in the application of new technologies and professional know-how	Singapore-registered business entities
Pioneer Enterprise (Manufacturing or Services)	Tax exemption on income from qualifying activities	Manufacturing: companies acquiring new technologies, skills or knowledge that raise overall industry standards; Services: qualifying activities include: any engineering or technical services, including laboratory, consultancy and research and development activities; computer-based information and other computer related services; the development or production of any industrial design

Incentive scheme / administering agency	Description	Selected eligibility criteria
Development and Expansion Incentive (DEI)	Reduced corporate tax rates of 5% or 10% on incremental income from qualifying activities	Qualifying activities include: manufacturing or increased manufacturing of any product that would be of economic benefit to Singapore; or same qualifying activities as Pioneer Enterprises in services
Investment Allowance (IA)	Allowance of 30% or 50% of fixed capital expenditure on top of normal 100% capital allowance	Companies that are investing in equipment for greater productivity or introducing new technology to the industry
Finance & Treasury Centre Tax Incentive (FTC)	Reduced tax of 10% on fees, interest, dividends and gains from qualifying services/activities; Withholding tax exemption on interest payments on loans from banks and network companies for FTC activities	Companies which provide finance and treasury services; at least annual total business spending of S$750,000; three professional staff employed by the FTC; and 3 qualifying FTC services to 3 or more network companies
Approved Royalties Incentive	Reduced withholding tax of 0% or 5% on royalty payments to access advanced technology and know-how	Companies which enter into a royalty agreement whereby royalties or technical assistance fees or contributions to R&D are payable to the non-resident person
Approved Foreign Loan	Reduced WHT 0%, 5% or 10% on interest payments on loans taken to purchase productive equipment	Loan where the credit facilities are granted for the purchase of productive equipment, lender is a non-resident person, and the relief from Singapore tax will not increase his/her liability in his/her country of residence
Land Intensification Allowance (LIA)	An initial tax allowance of 25% and annual tax allowances of 5% on capital expenditure incurred for the construction or renovation/extension of a building or structure (extended until 2020)	Companies that engage in the construction or renovation/ extension of buildings or structures which meet gross plot ratio benchmarks
Headquarters Programme (HQ)	Companies managing international HQ activities out of Singapore pay a lower corporate tax of 10% or 5%	Business entities incorporated or registered in Singapore providing corporate support and headquarters-related services and business expertise on a regional or global basis
Section 19B of the Income Tax Act	Writing down allowance over 5 years for acquisition of IP rights	Companies carrying on a trade or business incurring capital expenditure in acquiring intellectual property (IP) rights for use in that trade or business

Incentive scheme / administering agency	Description	Selected eligibility criteria
Partnerships for Capability Transformation	Co-funding for qualifying costs of domestic or overseas relocation arising from need to optimize land use	Singapore-registered business entities
Capital Assistance Scheme	Double deduction for expenditure incurred in approved investment feasibility/due diligence studies, site visits and operation of overseas project development office against income tax	Singapore-registered business entities
Land Productivity Grant	Co-funding to support the development and commercialization of products or services	Local and foreign companies

Source: WTO, 2016.

3.6.2.Manpower, Education, Training and Skills

Another important policy area, as frequently testified in the different announcements of Singapore government, its advisory and coordination bodies are the policies addressing functioning of the labour market, or more broadly the formation and supply of human capital. In Singapore, this area is heavily influenced both by manpower policy, with a dedicated ministry – Ministry of Manpower (MoM) dealing with labour supply issues and another ministry – Ministry of Education (MoE) dealing with the formation of skills, particularly in the formal education sector. At the interlink between the two a new area of Skills policy has recently emerged, with the launch of SkillsFuture Singapore movement and the formation of SkillsFuture Singapore (SSG) and Workforce Singapore (WSG) statutory boards.

In terms of Manpower policy, Singapore has for a long time relied on immigrant labour, with the oversight of it delegated to the MoM, including, most recently, the administrative actions such as increase in foreign worker levies and more stringent issuance of work permits leading by 2017 to a virtual stall of immigrant population growth. While similar actions have been earlier tried before in the 1980s, at that time the policy had to be reversed with the arrival of major recession in the 1985. While the opinion that Singapore's growth model was too reliant on immigrant labour growth has been voiced many times before, only after the publication of the Population White Paper in 2013, projecting an increase of Singapore population to 6.9 million by 2030 and instilling one of the largest public protest movements since the independence, did the government take decisive action to limit the influx of foreign workers.

Table 4. Workforce statistics in Singapore (MoM, 2017)

Pass Type	Dec 2012	Dec 2013	Dec 2014	Dec 2015	Dec 2016	Jun 2017
Employment Pass (EP)	173,800	175,100	178,900	187,900	192,300	189,900
S Pass	142,400	160,900	170,100	178,600	179,700	179,400
Work Permit (Total)	942,800	974,400	991,300	997,100	992,700	975,800
- Work Permit (FDW)	209,600	214,500	222,500	231,500	239,700	243,000
- Work Permit (Cons)	293,300	318,900	322,700	326,000	315,500	296,700
Other Work Passes	9,300	11,300	15,400	23,600	28,300	29,800
Foreign Workforce	**1,268,300**	**1,321,600**	**1,355,700**	**1,387,300**	**1,393,000**	**1,374,900**

Pass Type	Dec 2012	Dec 2013	Dec 2014	Dec 2015	Dec 2016	Jun 2017
Resident Workforce	2,119,600	2,138,800	2,185,200	2,232,300	2,257,600	n/a
Total Workforce	**3,361,800**	**3,443,700**	**3,530,800**	**3,610,600**	**3,672,800**	**n/a**

Sources: The source of the data on Foreign Workforce numbers is MoM. The source of the data for total workforce and resident workforce is the Comprehensive Labour Force Survey. Notes: "FDW" refers to Foreign Domestic Workers. “Cons” refers to Construction. The totals do not sum-up due to different data sources.

In terms of education and training policy, historically Singapore relied heavily on up-skilling its population over the years since independence to support industrialisation and economic growth. The expansion of educational attainment can be easily evaluated comparing the educational attainment of different population cohorts. As can be seen from the table below it is clear that Singapore started with somewhat less educated population than the average in the OECD and moved somewhat faster to increase the educational attainment for the youngest cohorts.

Table 5. Educational attainment in Singapore and the OECD (2011 & 2013)

Cohort	Attainment level	Singapore	OECD average
25-34 year-olds	Below upper secondary	4.7	14.6
	Upper secondary	21.1	42.7
	Tertiary	74.1	41.5
35-44 year-olds	Below upper secondary	12.7	18.1
	Upper secondary	23.0	43.1
	Tertiary	63.8	37.5
45-54 year-olds	Below upper secondary	26.5	25.5
	Upper secondary	33.9	42.7
	Tertiary	38.6	30.6
55-65 year-olds	Below upper secondary	40.1	35.1
	Upper secondary	35.4	38.3
	Tertiary	21.4	25.1

Source: OECD Survey of Adult Skills (PIAAC). OECD (2016), “Skills matter: further results from the survey of adult skills, OECD Skills Studies, OECD Publishing, Paris. Reference years for the data are 2011 & 2013 depending on the year of data collection. Notes: the average for OECD countries is un-weighted and includes only those OECD countries that took part in PIAAC. Singapore sample does not include non-resident population (foreign workers).

Furthermore, the educational expansion has been rather recent – in the year 1990, 60% of the resident population still had their highest educational attainment at less than upper-secondary level. However since then a major educational expansion took place, most vivid for tertiary educational attainment increasing from 5.2% in 1990 to 34.2% in 2016. Nevertheless, the share of adults possessing less than upper-secondary educational qualification remained at a substantial 21% level, a little lower than a similar 23% level in the European Union but quite higher as compared to (2012 PIAAC data) in the US (14.1%) or Japan (14.6%).

Table 6. Evolution of educational attainment of Singapore resident population aged 25-64

	1990	%	2000	%	2010	%	2016	%
Below Secondary	873,100	*60%*	736,900	*40%*	614,300	*28%*	476,800	*21%*
Secondary	375,900	*26%*	479,900	*26%*	457,300	*20%*	422,600	*18%*
Post Secondary (Non-Tertiary)	75,300	*5%*	180,000	*10%*	230,900	*10%*	223,100	*10%*
Diploma & Professional Qualification	58,300	*4%*	199,100	*11%*	332,400	*15%*	389,100	*17%*
University	75,900	*5%*	246,500	*13%*	597,200	*27%*	786,100	*34%*
Total	**1,458,300**	***100 %***	**1,842,600**	***100 %***	**2,231,900**	***100 %***	**2,297,800**	***100 %***

Source: Singstat.

Finally, with regard, to skills, two other points worth noting: according to the OECD Survey of Adult Skills, Singapore's resident population performed below the OECD average in both literacy and numeracy skills, with large differences between younger and older cohorts, which is expected given the recent rapid expansion of educational attainment.

Recent policy actions, linked to industrial and skills policy, put substantial emphasis on continuing education and training (in alternative terms – lifelong learning or adult learning). A notable features of Singapore's institutional environment is the presence of Lifelong-learning endowment fund, set-up in 2001 as a source of long-term financing of lifelong learning system. Furthermore, in 2005, a national qualifications framework - that Singapore Workforce Skills Qualifications (WSQ) was launched. Policy coordination included the set-up of NPCEC in 2010, who was tasked to oversee both productivity policy initiatives as well as CET system, with Skills Future Council taking over responsibility for CET as of 2014.

In 2014, two major events took place – the publication of the results of Applied study in polytechnics and ITE review (ASPIRE), tasked to analyse the applied educational pathways in Singapore as well as shortly followed s strategy for Continuing education and training (CET) (i.e. CET 2020 Masterplan). Main ASPIRE recommendations included the need for strengthening guidance services, establishing more links to industry to increase the relevant of training programmes (including through place-and-train programmes) and developing industry sector specific skills frameworks and career progression pathways, describing the different job profiles, their skills needs and links between those progressing through one's career. CET 2020 masterplan, in part responding to ASPIRE recommendations, therefore announced the goals to formulate sectoral manpower plans to identify the sector-specific manpower and skills requirements; sectoral competency frameworks (including career progression pathways), manpower and training advisory services for SMEs, improve the information and guidance available on training opportunities and enhance CET provision.

The final key policy development that was announced in the Budget speech 2015 was the launch of Skills Future initiative to promote lifelong learning. This initiative firstly includes the Skills Future credit – an individual training account with initial 500 SGD value together with an on-line individual training portfolio. The initiative further introduced or enhanced measures such as stronger guidance services in schools, national and international internships, earn-and-learn programmes, schemes to support mid-carrier training like awards, scholarships, subsidies and corporate leadership development and finally sector-specific work through sectoral manpower plans and support for SMEs through mentorship programme.

All these initiatives, often targeted to promote CET (i.e. lifelong learning/adult learning), it would seem that have contributed to an increase in job-related training participation rates of the resident population active in the labour market, reaching 42% in 2016 compared to fluctuating average of around 30% between 2006 and 2013 (MoM, Adult Training Survey). This was driven primarily by the participation of employed individuals (42.7%) while unemployed adults were less involved in training (26.7%) in 2016. Still, it must be kept in mind that a large proportion of the labour force is not considered residents, often working in low-skilled and low-productivity sectors such as construction or personal care therefore available figures might over-state the actual training participation rates in the overall economy. With the increase in participation rates, the participation rate would seem to be comparable to that of the average EU participation rate of a comparable population group.

Table 7. Skills Future Singapore initiatives (announced in 2015, 2016 and 2017)

Initiative	Description
Initial education and training	
Education and Carrier counselling workforce	Develop a professional core of Education and Career Counsellors equipping them with the industry experience and knowledge needed to provide informed guidance. Scaling of Career counselling services at Singapore Workforce Development Agency (WDA) for working individuals
Enhancing internships in higher education institutions	Improving internships to make them more structured and meaningful; more students will also get international exposure
Continuing education and training	
Skills Future credit (from 2016)	SkillsFuture Credit will be given to all Singaporeans aged 25 years and above with an initial credit of $500 per person, which will be topped up at regular intervals and will not expire, but can only be used for education and training courses supported by Government agencies
Individual learning portfolio (from 2017)	All Singaporeans will have an online Individual Learning Portfolio, a one-stop education, training and career guidance resource that will help them plan for their education and training needs starting from their time in secondary school
SkillsFuture Earn and Learn Programme (from 2015)	Recent graduates from polytechnic and tertiary education institutions will be placed in jobs and receive a salary while undergoing structured on-the-job training that leads to an industry-recognised qualification; both trainees and employers should receive public support
Enhanced subsidies for mid-career Singaporeans (from second half of 2015)	Subsidies provided for Singaporeans aged 40 years and above will be enhanced to a minimum of 90% of training costs for courses funded by Ministry of Education (MOE) and WDA. All Singaporeans will also be able to receive subsidies from MOE for modular courses at all levels, and regardless of age

Initiative	Description
SkillsFuture Study Awards (from 2015)	This award is for Singaporeans to develop specialist skills required for future growth clusters, as well as to support those who wish to develop other competencies such as business and cross-cultural skills. It is eventually to be awarded to about 2,000 recipients per year
SkillsFuture Fellowships (from 2016)	This award is to develop Singaporeans to achieve mastery in their respective fields, with about 100 fellowships to be awarded each year
SkillsFuture Leadership Development Initiative	Collaborations with strategic companies will be stepped up to develop a pipeline of Singaporeans to take on corporate leadership roles and responsibilities. In 2017 a target was announced aiming to develop 800 leaders by 2020.
Industry collaboration	
Sectoral Manpower Plans ("SMPs")	The Government will strengthen collaboration between training institutions, unions, Trade Associations, and employers to develop and implement SMPs in all key sectors by 2020
SkillsFuture Mentors (from 2015)	To help SMEs overcome the constraints they face in training capabilities and capacity, the Government will work with industry partners to develop a shared pool of SkillsFuture Mentors with specialised and industry-relevant skills, which SMEs can tap on
Other initiatives announced after 2015	
TechSkills Acccelerator (announced in 2016)	Three elements: (i) Identify specific skills in demand in sectors such as finance and healthcare and support development of relevant training supply; (ii) Develop industry-recognised skills standards and certification; (iii) Develop pay-for-skills systems (hiring and paying based on certified skills proficiency)
Global Innovation alliance (announced in 2017)	(i) Innovators Academy building on the NUS Overseas College programme, which connects students to start-ups overseas, making these opportunities available to students from other Singapore universities and aiming to grow the annual intake of students from 300 to 500 over the next five years.
	(ii) Innovation Launchpads in selected overseas markets, creating opportunities for entrepreneurs and business owners to connect with mentors, investors and service providers.
	(iii) Welcome Centres, innovative foreign companies can also link up with Singapore partners to co-innovate, test new products in Singapore, and expand in the region

Source: Budget announcements in 2015, 2016 and 2017.

Finally, a rather important and relatively large scale programme was the Special Employment Credit – an incentive scheme to retain older Singaporeans in work, but introduced in part as a compensation of increased employer social security contribution rate. It was first introduced in 2011 as one-off measure for 3 years to cover 50% of employer social security contributions for workers aged 55 to 59 and up to 80% for those 60 or above. In 2012 the scheme was substantially enhanced, aimed to cover up to 8%

of wages of low-paid older Singaporeans aged 50 or older and expected to cost in total 470 million SGD per year. The programme was further extended in 2016 to last until 2019, with more concentrating the support towards those at older age, in particular those above re-employment age (65 until 2017 and 67 afterwards).

3.6.3.Research, development and innovation

Another policy area, which provides an important contribution to the transformation and modernisation of Singapore's economy, is the promotion and financing of innovation, research and development in public agencies as well as private enterprises. This policy field gained prominence at least since early 1990s, with establishment of National Science and Technology Board in 1990 and then the adoption of first 5-year Science and Technology support plan (National Technology Plan, 1991-1995), marking a start of 5-yearly strategies to support innovation, research and development of new technologies. The budget of these strategies have grown substantially – the first plan had a budget of 2 billion SGD, the second one (1996-2000) had 4 billion SGD, the third (2001-2005) – 6 billion, while the fourth (2006-2010) – 13.55 billion SGD.

The industrial alignment of the R&D policy in Singapore is indicative when looking at the sources and destinations of financing of the overall budget: the largest part of the budget has been delegated through the Ministry of Trade and Industry (7.5 billion SGD), to be distributed through two of its business-oriented agencies A*STAR (5.4 billion SGD) and EDB (2.1 billion SGD). The other part of the funding came from National Science Foundation (5 billion SGD) and via Ministry of Education to Academic Research Fund (1.05 billion SGD). In some documents it is stated that 65% of the funding in this period was dedicated for industry oriented R&D – either via public agencies or private actors.

In 2011, the fifth plan, called Research, Innovation and Enterprises (RIE) 2015 with a budget of 16.1 billion SGD was announced, aiming to spend at least 70% of the dedicated funding to industry oriented R&D. RIE 2015 portfolio included 9.615 billion SGD funding (60%) for public research, 2.5 billion SGD (15%) for supporting private R&D, 1.6 billion SGD of "white space" funding for unforeseen needs, as well as incubation and commercialisation of research, infrastructure investment and ensuring talent pipeline. The goals of the plan was to reach 1% of forecasted GDP to be investment as public R&D, and aiming for additional 2.5% of GDP investment into R&D by the private sector.

In 2016, the sixth R&D promotion plan was adopted with the funding of 19 billion SGD, keeping the rate of 1% public investment into R&D as a share of expected GDP. This plan had more pronounced sectoral structure, with 17% of funding (3.3. billion SGD) dedicated to advanced manufacturing and engineering; 21% (4 billion SGD) to health and biomedical sciences as well as 5% (0.9 billion SGD) for urban solutions and sustainability and 2% (0.4 billion SGD) for services and digital economy. Cross-cutting themes also included 13% of funding (2.5 billion SGD) designated for "white space" investment into emerging areas, 15% (2.8 billion SGD) for academic research and 10% (1.9 billion SGD) for manpower development.

The overall spending on R&D reached a healthy 2.4% of GDP in 2015, above a large number of countries globally, near the level of spending in the US, but below Korea, Japan as well as the earlier national target of 3.5% of GDP (A*STAR, 2016).

3.6.4.Internationalisation and trade

When analysing trade and internationalisation policy of the country, several factors are noted to be very important: first of all, trade openness; secondly the exchange rate regime and thirdly, the pro-active policy ecosystem support the internationalisation of business. Each of these policy areas seem

to be highly developed in Singapore. Firstly, Singapore is arguably one of the most open economies for trade, evidenced by the world-highest trade-to GDP ratio reaching 400%. It can easily be concluded that there are very few barriers for either imports or exports, particularly tariff-based barriers. Singapore is also a party to numerous bilateral and multilateral trade agreements (WTO, 2016).

Secondly, Singapore is considered to have a rather unique exchange-rate regime. In many of the discussions on industrial policy, the importance of having a competitive currency exchange rate level, which can support economic restructuring and industrialisation, is often considered as a must. However, in Singapore, at least since 1981, even by having a so-called managed float regime, the currency has appreciated significantly against the basket of currencies against which Singapore dollar is indexed. It is stated, that the purpose of the exchange regime management is not to target the level of the exchange rate (and thus competitiveness), but rather price stability and some other secondary considerations like output or employment (Mccallum, B., 2006). It is also stated, that the Government of Singapore prefers direct measures to intervene in case of competitiveness loss like salary cuts, rather than currency markets interventions (MAS, 2001).

As for the third element – public sector support for trade and export promotion, Singapore has a dedicated public body – statutory board International Enterprise (IE) Singapore and a large number of different instruments to support the internationalisation and trade of Singaporean firms. All these instruments are clustered around two comprehensive programmes: Global Company Partnerships (GCP) and Market Readiness Assistance (MRA). The former (GCP) consists of wide range of mechanisms to support business already having established presence abroad to further improve the scale and competitiveness of their international presence. The latter (MRA) aims to provide support for early stage exploratory and contact-making activities like initial overseas set-up, missions, fairs, presentations, etc. The WTO, in the context of seventh Singapore trade policy review, has presented an inventory of such instruments (WTO, 2016).

Table 8. Instruments of Global Company Partnerships (GCP) programme

Area/activity or programme	Description	Eligibility	Enhancements measures, 2012-15
Capacity building			
Build crucial business capabilities for overseas expansion	Grants of up to 50% (70% for SMEs) of eligible costs incurred in engaging a third-party professional to build up relevant firm-level capabilities	Global HQ anchored in Singapore; annual sales turnover of at least S$500,000; and a minimum paid-up capital of S$50,000	Funding support increased to a maximum of 70% for SMEs
Market access			
Enhance market presence	Grants of up to 50% (70% for SMEs) of eligible costs incurred in engaging a third-party professional to enhance market presence in overseas markets	As above	Funding support increased to a maximum of 70% for SMEs

Area/activity or programme	Description	Eligibility	Enhancements measures, 2012-15
Gain entry into new markets	Grants of up to 50% (70% for SMEs) of eligible expenses incurred when entering new markets, capped at S$100,000 per year	As above	Funding support increased to a maximum of 70% for SMEs
Double-tax deduction for internationalization (DTDi)	200% tax deduction on the first S$100,000 of eligible expenses for the following activities: overseas business development; investment study trips and missions; and trade fairs	Businesses registered in Singapore or that have a permanent establishment in Singapore with the primary purpose of promoting the trade of goods or provision of services	Enhanced to include qualifying salary expenses incurred for employees posted overseas in an overseas entity
Manpower development			
Talent attraction	Grants of up to 50% (70% for SMEs) of the costs incurred in engaging third-party recruitment consultancy services to hire top senior executives (C-suites) and critical talent	Global HQ anchored in Singapore; annual sales turnover of at least S$500,000; and a minimum paid-up capital of S$50,000	Funding support increased to a maximum of 70% for SMEs
Talent development	Grants of up to 50% (70% for SMEs) of the costs incurred: · for nominating a Singaporean and permanent resident employee on the overseas attachment · in engaging a third-party professional to conduct customized training for nominated Singaporean or permanent resident employees	As above	Funding support increased to a maximum of 70% for SMEs
International human resource strategies	Grants of up to 50% (70% for SMEs) of the costs incurred in engaging an established third-party HR consultancy firm for strategic international manpower projects	As above	Funding support increased to a maximum of 70% for SMEs
Access to financing			
Internationalisation Finance Scheme (IFS)	Co-sharing of the default risk to help companies secure mid-to-long tenure loans for internationalization through the co-sharing of default risks with participating financial institutions	Singapore-based company with at least 3 strategic business functions in Singapore The turnover is not to exceed S$300 million (S$500 million for trading companies)	The loan quantum per borrower was doubled to S$30 million in 2014 The coverage was expanded in 2015 to include support for M&A financing

Area/activity or programme	Description	Eligibility	Enhancements measures, 2012-15
Political Risk Insurance Scheme	Co-funding (up to 50% and the first three years) of the premium paid to protect overseas investment and projects against political risks (up to S$500,000 per applicant company)	Global HQ in Singapore, and turnover not exceeding S$500 million	None
Loan Insurance Scheme (LIS/LIS+)	Co-sharing of the default risk to help companies secure short-term trade facilities	Singapore-based company with at least 3 strategic business functions in Singapore The turnover is not to exceed S$300 million (S$500 million for trading companies)	None
Trade Credit Insurance Scheme (TCIS)	Co-funding (up to 50%) of the premium paid towards the trade credit insurance policy to safeguard against buyers' non-payment risks (up to S$100,000 per applicant company)	Singapore-based company, with at least 3 strategic business functions in Singapore The turnover is not to exceed S$100 million	None

Source: WTO, 2016.

3.7. Policy instruments adopted or modified since 2010

Given the activist role of state in Singaporean economy, it is no surprise that through the years a large number of industrial policy initiatives, bodies and instruments have been used to support the economic growth and driven industrial transformation. As a focus of this analysis, however, the time-horizon is selected to include initiatives launch during or after 2010, given, as argued before, amplification of constraints for the original growth model, changing global economic environment and increasing awareness nationally that adjustments are needed.

To provide a good overview of the key industrial policy instruments used in Singapore starting from 2010 until 2017, a review of all industry-related instruments launched as major initiatives during the adoption of the national budgets in Singapore every year since 2010 is carried out below. Even if this may not provide an exhaustive list of all instruments and schemes that were in place during that time to promote growth, innovation, productivity, skills, labour mobility and other important elements pursued over recent years it should provide a good overview covering all those instruments that were deemed most important and that had a major financial (budgetary) implications.

3.7.1. Budget 2010

The budget in 2010 was adopted after the peak of the recession was reach in 2009 and signs of economic recovery were already visible. The goals presented in the budget refer to the recommendations of ESC report adopted the same year aiming to implement them, with a pronounced focus on productivity growth, aiming to double it from 1% in the decade until 2010 towards 2% to 3% during the next until 2020. Efforts to raise productivity by deepening skills and promoting innovation were expected to require 5.5 billion SGD over the first five years. To support this, the launch of National Productivity and Continuing education Council was announced as well as a commitment to spend 2.5 billion SGD to further expand continuing education and training sector.

In terms of specific industrial policy instruments, this year market the introduction of productivity and innovation credit (PIC) – a tax deduction for up to 250% of investments in productivity enhancements, i.e. R&D, training, design, automation, etc. with expenditure capped for each activity at 300.000 SGD. It was an enhanced over existing tax incentives for innovation, that were limited to R&D activities with a recoverable ceiling of 150% from the investment amount. The scheme was expected to cost the budget 480 million SGD a year set to be available from 2011 to 2015.

Next, the set-up of national productivity fund was also announced, with the target that the fund will reach 2 billion SGD and initial injection of 1 billion SGD, with NPCEC setting the priorities and programmes for the fund. Out of initial 1 billion SGD funding, 250 million SGD were earmarked for projects to raise productivity in the construction sector.

Furthermore, to promote restructuring, a tax incentive to facilitate M&A's was greatly enhanced, including an one-off allowance of up to 5% of acquisition value to be deducted from taxable income with a maximum ceiling of 5 million SGD per year, applicable to deals of up to 100 million SGD. Furthermore, a waiver for the stamp duty on the transfer of unlisted shares for such acquisition deals. Both these incentives were expected to cost up to 100 million SGD per year to the state budget.

To facilitate internationalisation and building upon already existing Local Industry Upgrading Programme (LIUP) that aim to strengthen procurement linkages between local SMEs and MNCs, such collaboration was extended to also cover the development of new capabilities of local SEMs to meet manufacturing quality and certification requirements. This new programme, called Partnerships for Capability Transformation (PACT) was expected to cost 250 million SGD over five years also subsuming the previous LIUP programme to cover part of the cost of such partnerships. Further support was also granted for initiatives to strengthen business associations to drive productivity growth and internationalisation, with a dedicated budget 100 million SGD over five years.

To further increase investment in R&D to reach the 3.5% of GDP target recommenced by the ESC, the government committed to sustain public sector investment at 1% of GDP. Therefore, in addition to previously committed 2.2 billion SGD to the National Research Fund, a top up of 1.5 billion SGD was also announced. In support of private investment in innovation, beyond PIC as described earlier, the government also announced Public-Private co-innovation Partnership for government agencies to co-develop innovative solutions addressing medium and long-term needs in areas such as urban mobility, environmental sustainability and energy security. The government agencies are to share their technology roadmaps and future needs publicly and provide grants to test-bed innovative solutions in addressing those needs, committing 450 million SGD for such activities over five years.

To improve access to growth finance, an incentive for angel investment was introduced to claim a 50% tax deduction on his investment after a two year holding period, capped at 500.000 SGD per year, to cost the government 60 million SGD over a five year period. The government also committed to mobile up to 1.5 billion SGD growth capital over ten years period, contributing up to half the capital. The first phase contained 250 million SGD of public investment, to be matched by private capital to reach a total of 500 million SGD.

Finally, in terms of mobilisation of labour, the government committed to extend schemes incentivising employment of low-skilled medium and old aged people. The existing Workforce Income Supplement (WIS) programme was increased to allow a maximum annual payment reaching 2800 SGD, from 2400 previously for older aged people who work to incentivise their employment. Furthermore, a new Workforce training scheme (WTS) was introduced for those aged 35 to incentivise training take-up and covering absentee payroll and course fees and providing cash grants to participants themselves. An increase in foreign worker levies and access to young talent for SMEs were also announced.

3.7.2.Budget 2011

The year 2010 proved to be very positive for Singapore, with a record double-digit GDP growth of 14.5%, recovering from the effects of the crisis. Income growth for all Singaporeans was stated as an important priority in this year budget, especially for the poorest 20%. The government stated expectation to increase the income of an average Singaporean by 30% in real terms over the decade. To reach this, continued effort to increase skills and productivity is needed. Particularly, in terms in terms of productivity promotion, the government reported that during 2010 the utilisation of National Productivity Fund was 150 million SGD, expected to reach 800 million SGD by 2015. To ensure availability of funding beyond 2015, a top-up of another 1 billion SGD was provided to the fund.

The Productivity and Innovation Credit (PIC), introduced in 2010, was announced to be enhanced in 2011, for the tax allowance to reach 400% of the investment into broad six innovation areas to be deductable from taxable income, up from 250% announced in 2010 and raising maximum claim per category from 300.000 SGD to 400.000 SGD. Also the ceiling to opt for a cash-credit rather than a tax allowance for companies who pay little taxes was enhanced from the 21.000 SGD to 30.000 SGD for the first 100.000 SGD of investment. A front-loading of the investment was also eligible as well as, from 2011, recovery of R&D costs carried outside Singapore. The cost of the programme for the public budget was thus increased to reach 520 million SGD per year.

Next the availability and quality of continuing education and training (CET) for professionals, managers, executives and technicians (PMETs) was to be enhanced, planning to increase training places by 60% until 2015. Also a subsidy for part time-adult learning pursuing PMET degrees was introduced to correspond to the incentive for full-time students. These benefits are expected to be used by 30.000 people, costing around 30 million SGD per year. Furthermore, the government also announced a top-up of 500 million SGD to the Lifelong learning endowment fund, increasing the fund size to 3.6 billion SGD, to assure long-term financing availability for lifelong learning.

As regards the labour market, given the speedy economic recovery further increases in foreign worker levies for all sectors was also announced. A special employment credit for companies to retain older workers was also announced, with up to 50% of employer central provident fund contributions for workers aged 55 to 59 and up to 80% credit for workers aged 60 or above. To support high-growth enterprises, 850 million SGD in grants under the Enterprise Development Fund (EDF) was committed to be disbursed over five years, an increase of about 45% compared to previous five-year tranche. To support R&D activities and the implementation of Research, Innovation and Enterprise (RIE) 2015 plan, a top-up of 1 billion SGD to the National Research Fund was announced.

To enable the EDB to further strengthen Singapore’s value proposition as an Asian base for corporate headquarters and other high value activities, 2.5 billion SGD were set aside for the Economic Development Assistance Scheme (EDAS).

3.7.3.Budget 2012

Following a healthy but slower growth of economy in 2011 at around 5%, but an expected slow-down of growth in 2012, the government re-stated the need to pursue growth that is less reliant on foreign labour and more productive. Given a rapid growth of foreign workforce during 2010 and 2011, in order to slow-down this growth the government reduced the ceiling for the ratio of foreign workers out of total workforce.

To promote employment of older workers, the Special Employment Credit, introduced in 2011 was enhanced, covering older workers above 50 and earning up to 3000 SGD per month. The companies

will receive the credit worth 8% of wages, with a lower SEC also available for older workers earning between 3000 and 4000 SGD. The SEC was set to be in place for five years between 2012 and 2016.

The PIC, first announced in 2010 and utilised by companies in 2011, with a total tax savings reaching 650 million SGD, was announced to be further enhanced. The ceiling for cash payout for companies paying little tax was to be further enhanced to 60% of their first 100.000 SGD investment, thus increasing to a maximum of 60.000 SGD from 30.000 SGD ceiling set in 2011. The speed of disbursement was also set to increase, to be eligible on a quarterly, rather than annual basis. Requirement for training to be certified was also removed for any training up to 10.000 SGD per year.

To promote training by SMEs, for all certified courses a 90% course subsidy will apply, which together with the previous measure would effectively cover almost all cost of training sponsored by an SME. Also absentee payroll cap was also to be increased from 4.5 SGD to 7.5 SGD per hour. The programme is to be available for three years. Similar training benefits for self-employed people will also be provided. Capability development grants, issues by SPRING and IE, will benefit from enhanced subsidy rate of 70% from 50% earlier.

The M&A Allowance scheme, introduced in 2010 allowing for a 5% tax allowance on acquisitions of up to 100 million SGD was enhanced with 200% tax allowance over the transaction costs incurred, such as legal and tax advisory services, caped at 100.000 SGD. To improve the status of cross-border financed, requested by SEC in 2010, the government announced the set-up of specialised project finance company (PFC), expected to provide 400 million SGD of financing annually, catalysing 2 to 3 billion SGD of projects. An expansion of trade financing schemes including political risk insurance scheme is also planned.

3.7.4.Budget 2013

The budget in 2013 was introduced in the context of a very sluggish growth recorded in 2012 of 1.3%. Even in this low-growth environment, further restrictions to foreign workforce employment were announced as regards additional selective cuts for dependency ratio ceiling as well as workforce levies increases. To further support restructuring processes, a three year transition support package was announced with three measures: wage credit scheme (WCS); Productivity and Innovation credit (PIC) bonus and corporate income tax (CIT) rebate.

To promote the increase in workers' salaries, the government introduced WCS, in total worth 3.6 billion SGD. Through this scheme any increases in worker's salaries, over the forthcoming three year period, will be co-financed by the government at a rate of 40%, applicable for workers earning up to 4000 SGD per month. To promote investment by SMEs, PIC bonus will allow for a business investing a minimum 5000 SGD a year dollar-for-dollar matching cash bonus. PIC bonus is expected to cost 450 million SGD over three years. CIT rebate, expected to cost 1.3 billion SGD over three years, is set at 30% of tax payable up to 30.000 SGD per year.

Also a significant enhanced of productivity incentives introduced in 2010 were announced. This include collaborative industry projects, where firm consortia together develop solutions for industry productivity challenges (estimated at 100 million SGD over 3 years); broadening of partnerships for capability transformation programme to other sectors beyond manufacturing (estimated 60 million SGD over 3 years); enlarging the list of eligible expenses under PIC (estimated 130 million over 3 years); land productivity grant to intensify land use including through partial off-shoring while retaining core activities (60 million SGD); linking SMEs with public research institutions to identify and develop productivity solutions (51 million SGD);

In terms of skills, an enhancement to the workforce training support programme, introduction of SME talent programme to promote graduate employment in SMEs as well as a top-up of 500 million SGD for the lifelong learning endowment fund were announced. To support new growth opportunities, EDB will set aside 500 million SGD for future of manufacturing plan as well as a 90 million SGD satellite industry support fund will be set-up. To help SME's export, beyond the political risk insurance mechanism announced in 2012, an expansion of Asian development bank trade finance programme to provide credit guarantees for Singapore exporters is planned.

3.7.5.Budget 2014

The budget was presented in the context of a healthy growth of economy in 2013 at a rate of 4.1%. The transition support package announced in 2013 has seen significant take-up with updated estimate of 7.3 billion of expenditure. Nevertheless, a further extension for the PIC was announced, increasing the maximum expenditure cap from 400.000 SGD to 600.000 SGD per year. Extensions of a tax deduction of 50% for qualifying R&D expenditure until 2025, of other tax deduction administered by EDB, of writing down allowance for the acquisition of qualifying intellectual property and of intensification allowance – all until 2020, were announced. In addition, a further top-up of 500 million SGD to the lifelong learning endowment fund, bring it to 4.6 billion was stated.

To catalyse adoption of ICT, particularly in SMEs, an ICT Productivity and Growth (IPG) programme was launched with three main activities. First, to mainstream the adoption of innovative ICT solutions developed under iSPRINT programme to be deployed by 10.000 SMEs, beyond the current 500 SMEs, by subsidising 70% of the costs. Second, to support piloting of emerging solutions, for example innovations in sensors, data analytics or robotics, a subsidy of 80% of qualifying costs will be granted capped at 1 million per participating firm. Third, to support high-speed connectivity, fibre broadband subscriptions will be subsidised for SMEs while business owners will be subsidised at 80% of the costs to install broadband connectivity, capped at 250.000 per building. All these initiatives are expected to cost 500 million SGD over a three year period.

In 2010, the Co-investment programme (CIP) was launched, setting aside 250 million SGD, to be matched by private sector investment, to make growth capital (equity investment) available for SMEs. 160 million SGD from government financing has been deployed, generating over 500 million SGD contributed from private sector. A second round of financing is therefore to be launched with public investment of 150 million SGD, to be matched by private sector, allocated towards SME Co-investment fund II and a new SME Mezzanine growth fund to launch such a hybrid debt-equity financing instrument. In addition, an enhancement to the micro-loan programme (MLP), launched in 2001, to share the risk for very small loans below 100.000 SGD. The risk share of MLP will be raised as of 2014 from 50% to 70% for young (less than 3 year old) SMEs.

For internationalisation, the government announced raising maximum loan quantum supported by the Internationalisation Finance Scheme (IFS) from current 15 million SGD to 30 million SGD. Also an enhancement of Global Company Partnership (GCP) Programme raising support level for pilot and test-bedding projects from existing 50% to 70% and expanding support for staff attachments overseas were announced.

Finally, efforts to further upgrade construction sector, with upstream measures to tackle construction productivity, levies and monitoring for foreign workers.

3.7.6.Budget 2015

The budget of 2015 was adopted in the context of rather healthy economic environment, with previous year growth reported to be 2.9%. As a major initiative in the budget, the launch of SkillsFuture Singapore initiative has been announced with the aim to promote quality and relevant initial and continuing education and training. An important aspect of the initiative was the plan to develop sectoral manpower plans (SMPs), enhance CET financing from 600 million SGD p.a. to 1 billion SGD p.a. and a 1.5 billion top-up to National Productivity Fund.

In terms of industrial policy initiatives, a graded-phase out of the Transition Support Package, introduced in 2013 was signalled, extended Wage Credit Scheme (WCS) and Corporate Income Tax (CIT) rebate for two additional years and letting Productivity and Innovation Credit (PIC) Bonus expire. For WCS, it is modified reducing the co-fund rate from 40% to 20% of the wage increases for those with monthly earning up to 4000 SGD. Those companies which increased salaries in the previous years will continue to receive the co-funding at the new rate. The extension of the programme should cost 1.8 billion SGD over 2 years. CIT rebate is kept for additional two years at the same rate of 30%, but with a lowered maximum cap at 20.000 SGD per company per year, costing additional 800 million SGD over 2 years.

In terms of promoting innovation SPRING Capability Development Grant (CDG) scheme will be modified, making an easier application for small-scale projects up to 30.000 SGD and extending the enhanced funding support level of up to 70% until 2018. The enhanced CDG is expected to cost 600 million SGD over three years. Further promotion of industry collaboration was signalled with the plan to extend SPRING's Collaborative Industry Projects (PIC) and the Partnerships for Capability Transformation (PACT) schemes. Public support to innovation, which since 2011 has catalysed 8.6 billion SGD private will be continued via the new iteration of Research, Innovation and Enterprise plan to be released later in 2015 coupled with a top-up of 1 billion to the National Research Fund.

Support for access to finance will also be improved, increasing co-financing cap for SPRING's Startup Enterprise Development Scheme (SEEDS) and Business Angel Scheme (BAS) including a top-up to BAS to extend the size of the programme. A venture debt risk-sharing instrument will also be piloted with SPRING providing 50% risk sharing for loans of an initial period of two year, expected to catalyse around 100 venture debt loans of a total value of 500 million SGD.

In terms of internationalisation, the support level for all International Enterprise (IE) Singapore grant schemes (i.e. Global Company Partnerships – GCP and Market Readiness Assistance – MRA) will be increased from 50% to 70% for three years. Also enhancement of Double Tax Deduction for Internationalisation to cover salaries of overseas postings as well as a new tax incentive – International Growth Scheme (IGS) with concessionary 10% tax rate for qualifying companies and for qualifying activities were announced costing a total of 240 million SGD.

In terms of promoting scaling-up, an increase of tax allowance for acquisition costs from current 5% to 25% of the value of acquisition, also reducing the threshold for minimum shareholding acquisition down from 50% to 20% of share ownership and extension of the overall validity of this programme, started in 2010, for another five years until 2020 were indicated. To further support M&A, the scope of IE Singapore Internationalisation Finance Scheme (IFS) will be enhanced to also cover M&A activities that help international expansion. These enhancements will cost an additional 100 million SGD over five years.

3.7.7.Budget 2016

The budget of 2016 was adopted in the context of unimpressive GDP growth rate of 2% in 2015 as well as the celebration of the 50th anniversary of Singapore's independence. As part of the transition

support package, introduced in 2013 and being phased-out, the Wage Credit Scheme (WCS) will result in a largest to date payout of 1.9 billion SGD in salary increase compensations, distributed to companies in 2016. In addition, an enhancement of another package measure – Corporate Income Tax (CIT) rebate, increasing its ceiling from 30% to 50% of tax payable capped at the same 20.000 SGD maximum was indicated. This budget is also marked by the launch of Industry Transformation Programme (ITP).

With regards to SME financing, the government introduced the new SME Working Capital Loan scheme for loans of up to 300.000 SGD, with government co-sharing 50% of the default risk. The scheme will be available for three years and is expected to catalyse more than 2 billion SGD in loans over the period.

The Industry Transformation Programme (ITP) was introduced as a follow-up of the 2013 quality growth programme, most notable for the transition support package, to expire by 2018 and promotion of company collaboration and internationalisation. ITP aims to integrate better all the different initiatives to promote innovation and productivity, use more extensively sectoral approach to fine-tune those activities and deepen partnership between government, unions, employers and all other relevant actors. ITP includes such activities as launching business grants portal as a one-stop-shop for all public support services; a 3 year automation support package of 400 million SGD, including 50% grants for automation projects, 100% investment allowance for automation equipment and risk-sharing of SME loans from current 50% to 70% for qualifying projects.

As part of the ITP, other earlier instruments were also enhanced, for example expanding the Mezzanine Growth Fund from 100 billion SGD to 150 billion SGD with additional 25 million SGD of public investment to be match by private funding. The M&A support will be enhanced increasing the M&T tax allowance cap from previous 20 million SGD up to the 40 million SGD of the value of the deal; also the non-taxation of companies gains on the disposal of equity investments rule was extended until 2022. To support internationalisation, Double Tax Deduction for Internationalisation scheme was also extended until 2020.

To provide assistance to specific industries, the ITP includes launch of national trade platform as one-stop service for sharing trade information with government and business partners. As an open innovation platform, also other service providers will be able to develop additional services and apps on the platform. It is expected to cost 100 million SGD. To promote adoption of robotics, a three year national robotics programme was also announced with the budget of 450 million SGD.

To strengthen trade associations and chambers (TACs) and building upon existing Local Enterprise Association Development (LEAD) programme, a new LEAD plus programme will be instituted, to support TACs to attract talent, develop capabilities and services. Public sector will second up to 20 officials to interested TACs and will also partner with them, via SPRING, to develop new industry-wide solutions via up to 30 dedicated projects. This will cost in total 30 million SGD over next 5 years.

To support innovation by companies, up to 4 billion SGD of the announced Research, Innovation and Enterprise (RIE) 2020 plan will be dedicated to industry-research collaboration. To support RIE 2020, a top-up of 1.5 billion SGD will be delivered to the National Research Fund. Other actions include the set-up of SG-Innovate entity to support entrepreneurs linking them with mentors, venture capital and research institutions as well as development of new Jurong Innovation District. The total budget of Industry Transformation Programme is planned to 4.5 billion SGD, including to-ups to R&D, National Productivity, Enterprise Development Funds and Economic Development Assistance Scheme (EDAS).

Beyond the actions falling under the ITP (with more details on them provided in the dedicated chapter of this report), modifications in broad-based measures were also announced, including the modification of PIC lowering cash payout rate from 60% to 40% with the expected expiration of PIC after 2018. Finally, under SkillsFuture initiative, an enhancement of employment support through the "adapt and grow" initiative, extending the outreach to PMETs from 2000 to 4000 and the launch of TechSkills Accelerator are foreseen.

3.7.8.Budget 2017

The budget was adopted in the context of slow but stable GDP growth rate of 2% in 2016. A more sector-specific approach in terms of industrial and economic policies was stressed, given the differing performance across sectors. Programmes to facilitate labour mobility between sectors will be enhanced, in particular through "Adapt and Grow" initiative, increasing wage and training support for Carrier Support, Professional Conversion and Work Trial programmes with an additional 26 million SGD per year spending.

Support for companies will be continued and extended through Wage Credit Scheme, expected to reach 600 million SGD; Special Employment Credit; SME Working Capital Loan; enhancement of Corporate Income Tax (CIT) rebate, enhancing the cap of the rebate from 20.000 SGD to 25.000 SGD for 2017 and extension of CIT rebate, at a reduced rate of 20% payable and reduced cap of 10.000 SGD until 2018, in total costing 310 million SGD. Furthermore, to support employment of older Singaporeans, an extension of the additional special employment credit till end-2019 was announced. All these business support measures together will cost 1.4 billion SGD over one year.

To promote digitisation, SMEs Go digital programme will be launched to provide technological advice through sector Industry Digital Plans, in-person help for SMEs at SME Centres and a new SME Technology Hub, SMEs pilot emerging ICT solutions as well as strengthen capabilities in data and cybersecurity, with a total price-tag of 80 million SGD. To further support innovation, A*STAR will scale operation and technology roadmapping services, continue improving access to intellectual property through Intellectual Property Intermediary and HeadStart programme as well as launching new tech access initiative to support the use of advanced machine tools for prototyping and testing by SMEs.

For internationalisation, a new International Partnership Fund will be set with up to 600 billion SGD public sector capital commitment to co-invest with Singapore-based firms helping them scale-up and internationalise as well as the Internationalisation Finance Scheme will be enhanced to enable more companies to take on more overseas projects.

Furthermore, to help Singaporeans acquire new skills to operate overseas, government by global innovation alliance will include programmes such as innovators academy for students; innovation launchpads for entrepreneurs and welcome centres for innovative foreign companies will be launched while SkillsFuture Leadership Development Initiative will support companies to groom Singaporean leaders, targeting the development of 800 leaders over the next three years. These programmes will cost a total of 100 million SGD. Finally, to support skills acquisition for everyone, training will be made more accessible using short, modular courses and online learning while support of skill utilisation through better job matching and cooperation in training design and delivery with TACs.

With 500 million SGD National Research Fund top-up and 1 billion SGD National Productivity Fund top-up, 2.4 billion are set aside in total for 4 years for these initiatives.

3.7.9.Conclusion

As seen from the analysis above, since 2010, when productivity challenge came vividly back on the political agenda a wide range of measures have been introduced to promote innovation, productivity, and internationalisation of companies as well as skills and employment of the individuals in Singapore. The main ones available during the period between 2010 and 2017 included support for innovation and productivity development; scale-up particularly through M&A, research, industry cooperation, access to finance and internationalisation. However, before summarising different instruments, it is important to highlight the performance of endowment and trust funds as well as other funds and large-scale schemes used for or linked to industrial policy. These include:

- National Productivity Fund, set-up in 2010 to support industrial transformation initially guided by NPCEC, with a cumulative budget of 4.5 billion SGD put together with top-ups in 2010 (1 billion), 2011 (1 billion), 2015 (1.5 billion) and 2017 (1 billion) with its utilisation was expected to reach 150 billion by 2011 and 800 billion by 2015. Actual spending was only reported for 2014 – 164 million SGD, for 2015 – 283 million SGD and for 2016 – 303 million SGD.
- National research fund, existing prior 2010, with initial budget of 2.2 billion SGD and further top-ups in 2010 (1.5 billion), 2011 (1 billion), 2015 (1 billion), 2016 (1.5 billion), 2017 (0.5 billion). Actual spending was only reported for 2014 – 1.05 billion SGD, 2015 – 828 million SGD and 2016 – 1.2 billion SGD.
- Enterprise Development Fund (EDF) with 850 million SGD in grants for high-growth enterprises was committed in 2011, to be disbursed over five years, an increase of about 45% compared to previous five-year tranche; and another tranche indicated in 2016 budget.
- Economic Development Assistance Scheme (EDAS) with 2.5 billion SGD in 2011; another tranche indicated in 2016 budget.
- International Partnership Fund was launch in 2016 with up to 600 billion SGD public sector capital commitment to co-invest with Singapore-based firms helping them scale-up and internationalise

A number of programmes supporting productivity, R&D and innovation already existed before 2010 but were continued or enhanced afterwards, including:

- R&D tax deduction of 50% on qualifying expenditure and qualifying R&D, set to expire by 2015, was extended in 2014 up until 2025; and a further tax deduction on EDB projects approved by 2015, was extended to cover projects approved by 2020;
- Capital allowance, available for plant and machinery investment, was extended in 2016 as part of automation package with an investment allowance, allowing up to 100% of the approved capital expenditure;
- Innovation and capability voucher scheme (ICV), with 5.000 SGD value per voucher;
- Increase SME productivity with infocomm adoption and transformation (iSPRINT), grants with up to 70% of qualifying cost to adopt packaged or customised solutions;
- Inclusive Growth Programme (IGP), to encourage business to become more productive co-fund projects that improve productivity using measurable indicators and improve the value of low-wage jobs; providing 50% co-financing capped at 150.000 SGD per project and 500.000 SGD per company per year;
- Capability Development Grant (CDG), to co-finance capability development projects at a rate of 50%. In 2012, to aid restructuring, the scheme was enhanced increasing co-financing rate up to 70%, for a three year period. In 2015 it was further modified, making an easier application for small-scale projects up to 30.000 SGD and extending the enhanced funding support level of up to 70% until 2018. The enhanced CDG is expected to cost 600 million SGD over three years. In 2016, as part of automation package, CDG was expanded to support roll-out or scaling-up of automation projects at up to 50% of the qualifying costs, capped at 1 million SGD.

New programmes launched to support productivity and innovation since 2010 include:

- Productivity and innovation credit (PIC), launched in 2010 and expired by the end of 2018, as a tax deduction for productivity related investment, at a total value of around 500 million SGD p.a. or 4 billion SGD over the duration of the programme;
- ICT Productivity and Growth (IPG) programme, introduced in 2014, to support projects adopting innovative ICT solutions developed under iSPRINT or developing new specific solutions and ensuring broadband connectivity, with expected 500 million SGD price-tag;
- National robotics programme, announced in 2016, was set to have a budget of 450 million SGD and last for three years;
- SMEs Go digital programme, introduced in 2017, to promote digitisation and provide technological advice through sector Industry Digital Plans and other services with a total cost of 60 million SGD.

Programmes for scale-up included:

- M&A tax deduction allowances, introduced in 2010 for 5 years, initially allowing up to 5 million SGD tax deduction (5% ceiling for project size up to 100 million SGD) as well as transaction costs to be deducted from taxable income, was further extended in 2015 for another 5 years, changing the formula but keeping the deduction ceiling of 5 million SGD (25% ceiling from project size up to 20 million SGD). This measure also includes a relief of stamp duty for the transfer of unlisted shares. In 2016, the measure was enhanced doubling the maximum tax deduction up to 10 million SGD (25% ceiling for project size up to 40 million SGD).

Programmes to promote industry partnerships included:

- Local Enterprise and Association Development (LEAD) programme and Enterprise Development Centres (EDCs), with commitment between 2010 and 2015 of 100 million SGD to scale-up support for business associations, drive productivity and facilitate international market access. In 2016, a new LEAD-plus programme was launched, to support trade associations and chambers (TACs) and also in partnership with public sector to develop new industry-wide solutions via up to 30 projects with a total cost of 30 million SGD.
- SPRING Collaborative Industry Projects (CIP), set to promote industry-wide collaboration in addressing industry-specific productivity challenges initially covering 3 sectors, was extended in 2013 to cover additional 7 industries with estimated cost at 100 million SGD over three years and further extended in 2015 to cover all sectors, with funding support up to 70% and number of projects per year to be increased from 5 to 15;
- Partnerships for Capability Transformation (PACT) programme, encouraging partnerships between global manufacturers and local suppliers to upgrade suppliers' capabilities, with expected cost of 250 million SGD over 5 years was introduced in 2010, extended in 2013 to sectors beyond manufacturing with additional funding of 60 million SGD. It was further extended in 2015.
- Public-Private co-innovation Partnership for government agencies to co-develop innovative solutions, committing 450 million SGD for such activities over five years;

Programmes to improve access to finance included:

- SPRING's Local Enterprise Finance Scheme (LEFS), in 2016 modified to increase government risk share from 50% to 70% for qualifying projects applying for equipment loan; the scheme was also expanded to cover non-SMEs at 50% risk share.

- SPRING's Startup Enterprise Development Scheme (SEEDS) and Business Angel Scheme (BAS), under which government co-invest in companies less than 5 years old to support early stage financing, were modified in 2015 increasing co-investment cap up to 2 million SGD including a top-up to BAS programme of 75 million SGD;
- Angel investors tax deduction (AITD) incentive, introduced in 2010 allowing a 50% tax deduction on such investments after a two year holding period, to cost the government 60 million SGD over a five year period, was further extended in 2015 for another five year period until 2020;
- Co-investment programme (CIP), launched in 2010, to make growth capital (equity investment) available for SMEs. 160 million SGD from government financing has been deployed, generating over 500 million SGD contributed from private sector. Co-investment programme II (CIP-II) was launched in 2014 with a 150 million public sector budget, to be share with another newly launched instrument – Mezzanine growth fund (MGF). The MGF was further enhanced in 2016 increasing its size from 100 to 150 million SGD with additional public funding up to 25 million SGD.
- Micro-loan programme (MLP), launched in 2001, enhanced in 2014, raising the risk-share for young SMEs (less than 3 year old) from 50% to 70%.
- A venture debt risk-sharing instrument pilot was announced in 2015, with SPRING providing 50% risk sharing for loans of an initial period of two year, expected to catalyse around 100 venture debt loans of a total value of 500 million SGD.
- SME Working Capital Loan scheme was introduced in 2016 for loans of up to 300.000 SGD, with government co-sharing 50% of the default risk. The scheme will be available for three years and is expected to catalyse more than 2 billion SGD in loans over the period.

Programmes, to promote internationalisation included:

- Market readiness assistance (MRA) programme, existing prior 2010, grants to co-fund 50% of costs (in 2012 increased to 70% to some activities), capped at 20.000 SGD per company per year, for pre-scoped professional services related to market assessment, market entry and business restructuring through internationalisation. In 2015, the co-financing rate was increase to 70% for all activities, to be valid until 2018.
- Global Company Partnership (GCP) programme, existing prior 2010, supporting internationalisation capability building (branding, strategy, design, etc.), market access (including pilot and test-bedding), manpower development. In 2012, risk sharing percentage for some activities was increased to 70% for 3 years until 2015 and in 2014 the support level for pilot and test-bedding projects was raised from existing 50% to 70%. It also includes access to finance schemes such as:
    - Internationalisation finance scheme (IFS), with IE sharing up to 50% of risk to help secure medium- and long-term capital facilities. The maximum loan quantum in 2014 was raised from existing 15 million SGD to 30 million SGD. In 2015 the co-financing rate was increased to 70% for all activities, to be valid until 2018 with M&A also becoming eligible to be covered.
    - Loan insurance scheme (LIS) to secure short-term trade financing lines.
- Project finance company (PFC), set up in 2012 to co-finance cross-border projects, to provide 400 million SGD annually, catalysing 2 to 3 billion SGD of projects;
- Double Tax Deduction for Internationalisation, with a 200% tax deduction on qualifying expenditure, capped at 100.000 SGD. It was enhanced in 2015 by increasing the scope of eligible activities to include qualifying manpower expenditure, capped at 1 million SGD per year. In 2016, the scheme was extended until 2020.
- Growth Scheme (IGS) was introduced in 2015, as a concessionary 10% tax rate for qualifying companies and for qualifying activities costing a total of 240 million SGD.

As a conclusion, it is evident that many of productivity focused policy programmes have been present already before 2010 however a renewed emphasis on productivity resulted in a number of new programmes. The most notable are tax allowance (credit) for innovation and productivity (PIC) providing a total of 4 billion SGD in tax savings for companies between 2010 and 2018, National Productivity Fund spending of around 1 billion SGD during the same period and an enhancement of Capability Development Grant (CDG) in 2015 for 3 years to cost additional 600 million SGD. In the context of industry transformation programme in 2016 only national robotics programme was announced as a new instrument of 450 million SGD, without much further details. These instruments were complemented with financing, internationalisation and R&D instruments; however it is not possible to estimate their exact financing scope and evolution.

3.8. Industry transformation programme (ITP)

Industry Transformation Programme (ITP), launched in 2016 as part of the annual budget announcement, with the overall announced budget of 4.5 billion SGD, will include both horizontal as well as sectoral initiatives to promote industrial transformation, support productivity growth and enhance coordination between different government programmes and initiatives, covering 23 industries grouped in 6 clusters. For each of the industry, in consultation with employers, labour unions and other actors, a dedicated Industry Transformation Maps (ITMs) will be developed, to guide public support and investment. Under a common structure of the ITP, all the planned actions (policy interventions) shall fall under one of the four thematic pillars that shall underpin each ITM and would drive industry transformation:

- Actions to **raise productivity**, in particular targeting SME's;
- Actions to **develop skills**;
- Actions to **drive innovation**, particularly through R&D;
- Actions to **promote trade and internationalisation**.

In addition, three further factors are considered as critical to ensure success of the ITP/ITMs:

- Ensuring broad coordination across agencies and stakeholders;
- Reaching a substantial industry coverage;
- Achieving ownership by social partners – both employers and employees.

The horizontal actions of the ITP are grouped around three “thrusts”: supporting the transformation of enterprises, supporting the transformation of industries and driving the transformation through innovation. The instruments targeted at enterprises include:

- Business grant portal;
- Automation support package;
- Financing and tax incentives to support scale-ups;
- Support for internationalisation.

The instruments targeted at industries include:

- National trade platform;
- Leveraging new technologies via national robotics programme;
- Increasing outreach through TACs

The instruments to support transformation through innovation include:

- Deepening innovation capabilities;
- Strengthening innovation and enterprise networks;
- Launch of Jurong Innovation District.

The responsibility to implement the ITP has been distributed between (or more precisely being carried out in cooperation with) a number of dedicated bodies. The overall responsibility of the ITP has been designated with the ministry of trade and industry (MTI). At the same time, the responsibility for each specific ITM has been dedicated to a particular government agency.

Furthermore, the implementation of actions under each of the four pillars of every ITM is carried out in coordination with other specialised agencies, which are responsible for the particular instruments. In the case of policy instruments aimed at skills development and workforce planning the responsible agencies are respectively SkillsFuture Singapore (SSG) and Workforce Singapore (WSG). For productivity it is Standards, Productivity and Innovation board (SPRING); for innovation – Agencies for Science, Technology and Research (A*STAR) and for internationalisation – International Enterprise (IE) Singapore.

If compared to the effort in 2010, the sectoral coverage of the ITP is more extensive, including 23 sectors that represent 80% of Singapore GDP. They are grouped into six clusters, with each ITM designated with a responsible body:

- Manufacturing cluster, with Energy & Chemicals, Precisions Engineering, Marine & Offshore, Aerospace and Electronics sectors, all within the Economic Development Board (EDB) responsibility.
- Built environment cluster, with Construction (responsible Building and Construction Authority), Real Estate (responsible Council for Estate Agencies), cleaning (responsible National Environment Agency) and Security (responsible Ministry of Home Affairs) sectors.
- Transport & logistics cluster, with logistics (responsible EDB), air transport (responsible civilian aviation authority), sea transport (responsible maritime and port authority), land transport (responsible land transport authority) and wholesale trade (responsible International Enterprise Singapore) sectors.
- Essential domestic services cluster, with healthcare (responsible ministry of healthcare) and early childhood and private education (responsible ministry of education) sectors.
- Professional services cluster, with professional services (responsible EDB), ICT and media (responsible ministry of communication and information) and financial services (responsible Singapore monetary authority) sectors
- Lifestyle cluster, with food services (responsible SPRING), retail (responsible SPRING), hotels (responsible Singapore tourism board) and food manufacturing (responsible SPRING) sectors.

By the end of 2017, 15 out of 23 industry transformation maps have been launched, with many of the launched ITMs including rather explicit targets. These targets usually focus on value added and productivity growth; new PMET jobs created and in some cases manpower growth projections and other more sector-specific objectives. For example:

- Logistics ITM includes a value added target - aiming to reach 8.3 billion SGD as well as jobs target, aiming to create 2000 new PMET jobs;
- Retail ITM includes productivity target (1% growth p.a.) as well as specific target for e-commerce share to reach from 3% to 10% of industry turnover;
- Food manufacturing ITM has a value added growth target of 6.5% p.a.; overseas income growth target of 8% p.a. and productivity growth target of 4.5% p.a.;

- Food services ITM has a productivity growth target of 2% p.a.; under a 0% manpower growth target/projection;
- Precision engineering ITM has a value-added growth target from 8.8 billion SGD to 14 billion SGD; output growth target from 32 billion SGD to 42 billion SGD; 3000 new PMET jobs creation and PMET workforce share growth from 48% to 58%.

From the analysis above it would seem, that industry transformation programme is not a standard government intervention for industrial transformation, but rather a coordination system, replicated the more limited effort carried out between 2012 and 2014 through NPCEC. However this time it is much more consistent, being followed-up more systematically, with more elaborate coordination at three different levels – sector level, cluster level and national programme level. It is also more public, with each ITM launched publicly and often stating concrete targets and actions to be achieved, showing stronger government commitment.

3.9. Economic performance of industrial sectors since 2010

The analysis of the capacity of industrial policy to influence the growth prospects of the overall economy in general and the selected industries in particular should ideally follow at least several analytical stages:

- First of all, the analysis should review the historical growth tendencies of the overall structure of the economy, including the size and performance of different sectors of the economy;
- Secondly, it should also analyse the performance of industries, covered by industrial policy, separately from sectors that are not covered/targeted by the policy which is being evaluated;
- Thirdly, in case there has already been sector-specific policy implemented in the country, it should be assessed to what extent the goals (targets) and the aims of earlier policy correspond to the actual performance of the industry;
- Fourthly, in case there is available data or evaluations, it should be assessed what was the contribution of the policy to the overall performance of the sector (taking into account that other factors, besides policy, influence sector performance and many of those factors are not controlled and can only be addressed by policies in a partial way;
- Finally, this would allow comparing any new/forward-looking targets to be compared with historical development as well as evaluation to what extent policy targets in the past correspond to the actual past economic performance of the selected industries.

Importantly, it must be kept in mind, that any comparison between policy targets and the actual performance of the system targeted by the policy (in this case – economic performance of a particular industry) should not presumed as an evaluation of the effect of a particular policy due to other factors at play. In other words, there can easily be situations, where the intended scope and focus of the policy has reached its target, but other developments, external to the policy (i.e. global performance of that sector; any economic shocks; impact of other policies) had a negative impact, the result of which is the discrepancy between system-level targets and the actual performance of the system, despite policy being effective as intended (planned).

Even if the most precise way to evaluate the impact of a policy would be to assess the level of its contribution towards a particular indicator, given the current state of evidence-base such level of contribution is very difficult, if at all possible, to estimate and such estimation is beyond the scope of this particular exercise. Therefore any final assessment of policy effectiveness is likely to be based upon logical/qualitative/comparative evaluation between specific activities and targets of a policy and the performance of the targeted system (industry sector(s)).

The analysis in the next sections of historical performance of industrial intervention in Singapore as well as the assessment of the prospective impact of Singapore industry transformation programme will therefore follow the analytical steps as described above.

3.9.1. The performance of economic sectors after 2010

Overall, between 2011 and 2016 the economy of Singapore grew by 18.4%, mostly driven by growth in employment. The three sectors with highest value added growth were Finance and Insurance; Construction and Information and Communication. The three broad sectors with highest employment growth were business services, information and communication as well as construction, each with more than 20% growth in absolute employment figures. Only in the manufacturing sector the absolute employment decreased between 2011 and 2016. As a consequence to the growth patterns, real productivity significantly improved only in three sectors – finance and insurance, which together with significant growth in value added maintained much slower growth in employment; wholesale and retail trade sectors, having an average growth rate but very slow employment growth and manufacturing, having very slow value added growth but negative employment growth. It is notable, that the two sectors with largest employment shares – business services (15.1%) and other services (21.6%) had both negative productivity growths. Construction sector, representing large employment share, showed positive but not exceptional gains in productivity.

Table 9: The development of economic sectors in Singapore between 2011 and 2016.

	Real GDP[1]		Employment[2]		Productivity[3]	
	Share, 2016	**5 year growth**	**Share, 2016**	**5 year growth**	**'000 $, 2016**	**5 year growth**
Goods Producing Industries	**24.1%**	***7.4%***	**26.9%**	***6.6%***	**98.1**	***0.8%***
Manufacturing	17.9%	*2.9%*	13.6%	*-4.8%*	144.8	*8.1%*
Construction	4.7%	*27.4%*	13.3%	*21.3%*	39.0	*5.0%*
Utilities and other	1.4%	*10.0%*	0.7%	*14.5%*	207.0	*-3.9%*
Services Producing Industries	**67.4%**	***21.5%***	**72.4%**	***16.7%***	**102.0**	***4.1%***
Wholesale & Retail Trade	18.4%	*18.6%*	13.4%	*7.7%*	150.7	*10.2%*
Transportation & Storage	7.8%	*17.0%*	6.6%	*15.4%*	129.4	*1.4%*
Accommodation & Food	1.8%	*11.3%*	6.7%	*17.9%*	29.6	*-5.6%*
Info Comm	3.8%	*27.1%*	3.5%	*22.0%*	119.3	*4.2%*
Finance & Insurance	12.9%	*44.1%*	5.6%	*15.6%*	254.3	*24.7%*
Business Services	13.1%	*16.1%*	15.1%	*23.7%*	94.9	*-6.2%*
Other Services	9.6%	*13.6%*	21.6%	*17.6%*	48.8	*-3.4%*
	Real GDP[4]		**Employment[5]**		**Productivity[6]**	
Total economy	**410271**	**18.4%**	**3,673.1**	**13.8%**	**109.5**	**3.2%**

1. Source: Statistics Singapore (SINGSTAT). The table does not include GVA from ownership of dwellings and GVA correction for taxes on products.
2. Source: Statistics Singapore (SINGSTAT).
3. Source: Derived by the author using real GDP and employment data.
4. Source: Statistics Singapore (SINGSTAT).
5. Source: Singapore Ministry of Manpower (MoM).
6. Source: Derived by the author using real GDP and employment data.

When disaggregating the growth of Singapore's economy through different sectors, it is also very important, both from policy and from analytical point of view, to identify whether employment growth in different sectors has been driven by local or foreign labour. This might well indicate the aspirations of local employees, their skills-base as well as attractiveness of different occupations for them. The analysis of changes of local versus foreign labour across sectors indicates very clearly these patterns.

Notably, the sectors with highest productivity growth – wholesale and retail trade and finance and insurance, overall had rather slow employment growth, which was however primarily driven by growth in local employment and reduction in foreign labour. Conversely, manufacturing saw a significant drop in local labour and rather high growth in foreign labour, despite moderate overall reduction in overall employment.

However overall employment was primarily driven by two largest sectors in terms of employment share – Business Services and Other Services (Other Services comprising Education, Healthcare and other social and personal services) – and in these sectors employment growth was equally distributed between local and foreign employees. Also notable is construction sector, which was a sector with third-largest absolute increase in employment, almost all of it driven by foreign labour. Finally, in the remaining three more significant sectors (Transportation&Storate; Accomodation&Food services and Info Comm) employment growth was also primarily driven by foreign labour.

Table 10: Changes in local and foreign employment between 2011 and 2016, in thousands.

	Change in local employment[1]	**Change in foreign employment[2]**	**Change in total employment**
Goods Producing Industries	**-63.7**	**124.4**	**60.7**
Manufacturing	-64.9	39.8	-25.1
Construction	1.2	84.6	85.8
Utilities and other	-3.4	6.8	3.4
Services Producing Industries	**233.5**	**147.1**	**380.6**
Wholesale & Retail Trade	63.6	-28.6	35.0
Transportation & Storage	-3.6	35.7	32.1
Accommodation & Food	3.0	34.5	37.5
Info Comm	-0.8	23.8	23.0
Finance & Insurance	45.2	-17.6	27.6
Business Services	63.1	43.5	106.6
Other Services	63.0	55.5	118.5
Total economy	**166.4**	**278.0**	**444.4**

1. Source: Singapore Statistics (SINGSTAT).
2. Source: Derived by the author based on publicly available data from SINGSTAT and MoM.

Such an analysis of sector-specific flows could be a first indication of possible areas of more pressing skills demands. But other factors should also be taken into consideration, such as drop in employment due to retirement, flows into sectors covered by pre-employment education and training systems as well as post-retirement employment – both in high-skills as well as low-skill occupations.

It is also worth paying attentions that sectors with highest employment growth were also sectors with lowest levels of productivity, likely further depressing or at least limiting the potential of productivity growth.

3.9.2.Productivity roadmaps 2010-2014: plans and results

Singapore's government already at least as of 2010 was working on the basis of sector-specific industrial policy. Firstly, in 2010, with the set-up of the National Productivity and Continuing Education Council, 12 priority sectors were selected at the forefront of productivity drive. Later, in 2012, 4 additional sectors were added to the priority list at the occasion of the renewal of the mandate of the NPCEC. In a public press release it was stated that the initial list of 12 priority sectors covered 40% of GDP and 55% of employment, while the enlarged list of 16 sectors covered 55% of GDP and 60% of employment.

The reconstructed list with presumed coverage of the sector based on Singapore Standard Industrial Classification 2015 (SSIC 2015) is presented in table 11. While it has been publicly stated that initially in total 16 sectors are to be covered by this productivity initiative, one additional sector (Food Manufacturing) has been included in the public list describing the sector-specific productivity roadmaps, thus in total it is presumed that 17 sectors where to be covered by this sector-specific policy initiative between 2010 and 2015.

Out of 17 identified sectors, some data on productivity oriented initiatives and targets has been disclosed for 11 sectors while no information has been identified for 6 sectors (these sectors under the "coverage" column are indicated as "unavailable"). Furthermore, as regards specific data on targets, for two sectors - Hotels and Healthcare, where some information has been disclosed, no quantitative targets have been indicated.

Thus, overall for 9 sectors it should be possible to assess correspondence between targets sets and actual economic development. Still, such analysis first of all depends on correct attribution of industrial classification groups to particular sectors, as these might have been defined differently by Singapore government (and no public correspondence tables are available as regards sector coverage); also any comparison between the targets set and industry-wide development as captured by statistics depends on the availability of data and access to appropriate level of disaggregation of such data.

Table 11 Sectoral coverage of industry productivity roadmaps between 2011 and 2015.

Industry sector	Coverage and information availability	Presumed sector in SSIC 2015	Information availability on targets
Goods producing industries			
Manufacturing	Not fully covered		
Furniture manufacturing	**Available**	31	**Available**
Food manufacturing	**Available**	10, 11	**Available**
Precision engineering[1]	**Available**	Multiple	**Available**
Transport engineering	***Unavailable***	29, 30	***Unavailable***
Process, construction and maintenance[2]	***Unavailable***	Multiple	***Unavailable***
Electronics	***Unavailable***	Unknown	***Unavailable***

Construction	**Available**	F (41-43)	**Available**
Utilities and other	Not covered		

Services producing industries			
Wholesale and retail trade	Not fully covered		
Retail trade	**Available**	47	**Available**
Transportation and storage	**Available**	H (49-53)	**Available**
Accommodation and food services	Not fully covered		
Hotels	**Available**	55101/2	***Unavailable***
Food services	**Available**	56	**Available**
Information and communications	Not fully covered		
ICT and Media (3 priority sectors)	**Available**	62	**Available**
Finance and insurance	Not fully covered		
Financial services	***Unavailable***	64	***Unavailable***
Business services	Not fully covered		
Professional services	Not fully covered		
Accountancy	***Unavailable***	692	***Unavailable***
Environmental services	**Available**	81	**Available**
Other services	Not fully covered		
Healthcare	**Available**	86-87	***Unavailable***
Social care	***Unavailable***	88	***Unavailable***

1. Precision engineering sector presumably includes parts of SSIC 22, 25, 26, 27, 28.
2. Process, construction and maintenance sector presumably includes parts of SSIC 19, 20, 21, 35.

As can be seen from table 12, summarising the targets as revealed in publicly accessible documents, for almost all of the sectors, for which data is available, the main type of target is the growth of value added per worker (sometimes specified that this is in nominal terms).

Table 12. Sector-specific productivity targets for industry productivity roadmaps 2011/2012.

Sector	Launch	Target	Value S$	Duration	Investment
Furniture manufacturing	2011	20%	n/a	2015	17 million $
Food manufacturing	2011	20%	n/a	2016	45 million $
Precision engineering[1]	2011	165%	178,000	2020	52million $
Construction	2010	20% - 25%	n/a	10 years	250million $
Retail trade	2011	25%	46,000	2015	86million $
Logistics and transportation	2012	n/a	130,000	2015	42million $
Food services	2011	20%	27,600	2015	75million $
ICT and media[2]	2012	33%	105,434	5 years	46million $
Environmental services	2010	28.0%	n/a	10 years	12 million $

1. Target (value added per worker) for precision engineering is calculated from the level of S$67.000 in 2008, aiming to reach S$178.000 by 2020 (resulting at 8.48% CAGR).
2. Target (value added per worker) for ICT and media sector was based on a fixed-rate CAGR target of 7%, leading to VA/worker growth from S$79,451 to S$105,434.

For most of the sectors, where sector-specific policy targets have been revealed, it is possible to carry out a comparison between actual economic performance of the sectors and the earlier targets. The performance of targeted sectors between 2010 and 2015 is presented in table 13. As can be seen, four sectors (food manufacturing, food services, ICT and media and Cleaning and landscaping) have likely developed corresponding to the targets set. Two major sectors, assuming the statistical data corresponds to intended coverage, have clearly under-performed without any progress in productivity. Another two sectors (precision engineering and retail), while performing positively, had clearly set too optimistic/too ambitious targets for the respective sectors. Finally, there was no available data for furniture manufacturing.

Table 13. Performance of sectors targeted by sector-specific policy between 2010 and 2015.

SSIC	Value added[1], S$, million		Employment[2], '000		VA/worker, S$, '000		
	2010	2015	2010	2015	2010	2015	+%
Furniture	368.3	311.9	n/a	n/a	n/a	n/a	n/a
Food, Beverage & Tobacco	2326.3	3763.0	35.8	45.1	65.0	83.4	28%
Precision engineering[3]	6927.9	9056.5	91.4	90.3	75.8	100.3	32%
Construction[4]	14221.2	19009.6	380.7	500.0	37.4	38.0	2%
Retail trade	5296.2	6667.3	145.0	165.1	36.5	40.4	11%
Transportation & storage	24305.2	28217.9	202.4	237.1	120.1	119.0	-1%
Food & beverages services	2238.3	3230.0	167.6	205.6	13.4	15.7	18%
IT & Other Info (J62-63)	4161.4	7797.5	60.0	84.2	69.4	92.6	34%
Cleaning and landscaping	655.6	1396.2	40.1	57.7	16.3	24.2	48%

1. Source: SINGSTAT (manufacturing and services statistics)
2. Source: Ministry of Manpower
3. Source: Singapore Economic Survey (EDB)
4. Source: SINGSTAT. Value added for construction sector is provided as real sectoral GDP at constant 2010 prices.

As discussed earlier, the potential impact of policy cannot be directly derived from the comparison between target and actual industry performance – for that taking into account other contributing factors and/or estimating the potential scope of policy impact would be needed. While it is beyond the scope of this exercise to estimate other potentially contributing factors to the economic performance of specific industries, some very indicative estimation of policy scope is possible using industry value added or turnover data with the data on the expected size of policy intervention.

During the period 2011-2015 both industry-specific as well as horizontal programmes supporting industrial and productivity development were in action. As regards industry-specific support, some data has been published as regards the size (in terms of public investment) of industry-specific policy support interventions/packages during 2011-2015. In table 14 an estimation of the size of policy package, in comparison with the size of the industry in terms of its value added has been calculated. The estimation presumes that all of the envisaged support has been successfully committed during the period, as there is only very limited data on the actual implementation of policy support programmes.

Table 14: The size of industry-specific support compared to sectoral value-added.

	Value added, S$, million, 2010	Planned public investment, S$, million	Investment share of value added
Furniture	368.3	17	4.6%
Food, Beverage & Tobacco	2326.3	45	1.9%
Precision engineering	6927.9	52	0.8%
Construction[4]	14221.2	250	1.8%
Retail trade	5296.2	86	1.6%
Transportation & storage	24305.2	42	0.2%
Food & beverages services	2238.3	75	3.4%
IT & Other Info (J62-63)	4161.4	46	1.1%
Cleaning and landscaping	655.6	12	1.8%

As can be seen from the table 14, the size of support planned to be provided has been varying. In absolute terms, the largest package was foreseen for the construction industry (S$250 million) and smallest for cleaning and landscaping industry (S$12 million). As a share of each sectors respective value added, this share varied from 0.2% in transportation and storage sectors to 4.6% in furniture sector.

In terms of specific activities planned in productivity roadmaps, industry productivity roadmaps focus on training, capacity and expertise building, redesign of products or services, innovation adoption and market outreach – more details are provided in table 15.

Table 15. Industry-specific support measures between 2011 and 2015.

Sector	Policy support
Furniture	Training and process optimisation; strengthening the industry's design and branding capabilities; and enhancing the sector's international expansion capabilities.
Food, Beverage & Tobacco	Automation and innovation adoption, and manpower development.
Precision engineering	Industry transformation, operational efficiency improvement and manpower development. S$52 million were set for skills upgrading.
Construction	Workforce development and skills upgrading, technology adoption and capability building.
Retail trade	Adoption of info-comm technologies, training, optimal manpower scheduling and deployment; service excellence through Customer-Centric Initiative.
Transportation & storage	Enhancing Supply Chain Management Expertise and Enhancing Innovation and Efficiency at Enterprise and Industry Levels.
Food & beverages services	Re-design processes; upgrade manpower and HR capabilities and facilitates the development of innovative food products and dining concepts.

Sector	Policy support
IT & Other Info (J62-63)	To reengineer industry solutions, provide access to cost effective productivity tools & resources, training for productivity related skills and help extend market outreach.
Cleaning and landscaping	Workforce upgrading and the restructuring of industry operations.

In addition to industry specific plans, a number of horizontal measures have also been in operation. A tentative list of most important measures, initiated during or after 2010 is provided in table 16.

Table 16. Horizontal support measures

Initiative	Target
Continuing Education and Training	Increase CET training places from 6.400 to 10.000 (noting a reduction in required training hours from 1800 to 900)
iSPRINT - An Integrated Scheme To Drive Infocomm Adoption Among SMEs	Support 5000 SMEs. More than 2,800 SMEs have benefitted from iSPRINT between 2010 and 2012. iSPRINT has committed $85.5m for the next 5 years from 2011.
SME Productivity Roadmap (SME-PRO)	Reach out to 100,000 SMEs by 2012.
Inclusive Growth Programme	IGP is a $40 million initiative which aims to improve the skills, productivity and wages of 25,000 low-wage workers.

3.9.3.ITP – covered industries and their historic performance

As compared to earlier sector-specific productivity development maps, the selection of industry sectors seem to be much more wide-ranging, has a deeper disaggregation and corresponds better to the way sectors are being statistically monitored (in particular manufacturing industry sectors). Also some of the large sectors targeted earlier have been disaggregated, potentially making them easier to cover and design more adaptive policy. The list of sectors included in the ITP and their coverage is detailed in table 17.

Table 17. The statistical correspondence and adoption status of ITP Industry sectors.

Industry sector	Status in 2017.08.31	Presumed sector in SSIC 2015
Good producing industries		
Food manufacturing[1]	Adopted	10-12
Precision engineering	Adopted	Multiple
Energy and chemicals	n/a	19-20
Marine & offshore	n/a	301
Aerospace	n/a	303
Electronics	n/a	Multiple
Construction	n/a	41-43

Industry sector	Status in 2017.08.31	Presumed sector in SSIC 2015
Services producing industries		
Wholesale trade	n/a	46
Retail trade	Adopted	47
Land transport	n/a	49/5221
Sea transport	n/a	50/5222/5225
Air transport	Adopted	51/5223
Other transportation ("Logistics")	Adopted	521,5224, 5229,53
Accomodation[2]	Adopted	55
Food services	Adopted	56
Information & Communications	n/a	58-63
Financial services	n/a	64, 66
Professional services	n/a	69-75
Real estate	n/a	68
Security	n/a	80
Environmental services	n/a	81
Education	n/a	85
Healthcare	n/a	86

1. This is broader than food manufacturing and includes tobacco manufacturing (SSIC 12).
2. This is broader than only hotels sector (SSIC55101/2) and includes also "other accommodation" sector, of the size at around 10% as compared to the size of hotel sector in terms of value added.

Using the available data and according to the presumed correspondence of the sectors covered in the ITP and activities within the Singapore standard industrial classification, it is possible to estimate the historical performance since 2010 of the sectors covered by the ITP.

Table 18. Historical economic performance of goods producing sectors covered by ITP

	Value added		Employment		Productivity	
	2016, S$, Million	5 year growth	2016, '000	5 year growth	2016, '000, S$	5 year growth
Manufacturing	**69328.8**	**20%**	**381.9**	**-9%**	**181.5**	**32%**
TOTAL ITP MNF	*49129.4*	*23%*	*292.1*	*-12%*	*168.2*	*39%*
Food manufacturing	3744.0	69%	30.5	15%	122.6	47%
Precision engineering	8898.8	23%	88.6	-4%	100.4	28%
Energy and chemicals	13650.4	163%	24.9	2%	549.1	157%
Marine & offshore	3813.8	-30%	62.8	-27%	60.8	-4%
Aerospace	3357.2	13%	19.2	0%	175.1	13%
Electronics	15665.2	-7%	66.1	-19%	236.8	16%
Construction (SINGSTAT, MoM)[1]	**19038.6**	**27%**	**488.5**	**21%**	**39.0**	**5%**

Source: Singapore Economic Survey (EDB). Data for 2016 is preliminary. The comparison is to 2011.
1. Value added for Construction sector estimated using Construction sector contribution to real GDP.

Table 19. Historical economic performance of services producing sectors covered by ITP

	Value added		Employment		Productivity	
	2015, S$, Million	5 year growth	2015, '000	5 year growth	2015, S$, '000	5 year growth
Services producing industries	**193,270**	**21.8%**	**2,615.2**	**19.8%**	**73.9**	**1.7%**
TOTAL ITP SERVICES[1]	*153,632*	*16.6%*	*1,529*	*14.1%*	*100.5*	*2.1%*
Wholesale trade	49,474	-7%	325.6	10%	151.9	-16%
Retail trade	6,667	26%	165.1	14%	40.4	11%
Land transport	3,502	26%	93.0	15%	37.7	10%
Sea transport	12,141	7%	51.2	14%	237.1	-6%
Air transport	6,993	18%	29.2	23%	239.5	-4%
Logistics	5,582	32%	63.7	21%	87.6	9%
Accomodation[1]	3,636	39%	35.1	-1%	103.6	40%
Food services	3,230	44%	205.6	3%	15.7	41%
Info & Comm	16,154	43%	125.3	4%	128.9	37%
Professional services	24,861	39%	244.0	30%	101.9	7%
Real estate	18,535	38%	90.7	13%	204.4	22%
Security	1,461	73%	42.3	32%	34.5	31%
Environmental services	1,396	113%	57.7	44%	24.2	48%
Specific sectors						
Education	8,281	40%	n/a	n/a	n/a	n/a
Healthcare	7,807	53%	n/a	n/a	n/a	n/a
Financial services	n/a	n/a	167.3	22%	n/a	n/a

Source: SINGSTAT, Ministry of Manpower. The comparison is to year 2010.

1. Excluding specific sectors lacking data - education, healthcare and financial services.

2. Available data is broader than only sector for hotels and includes also a small "other accommodation" sector, which is at around 10% size of hotel sector in terms of value added.

The performance of good producing industries is detailed in table 18 and performance of services producing industries is provided in table 19, disaggregating data by value added, employment and productivity.

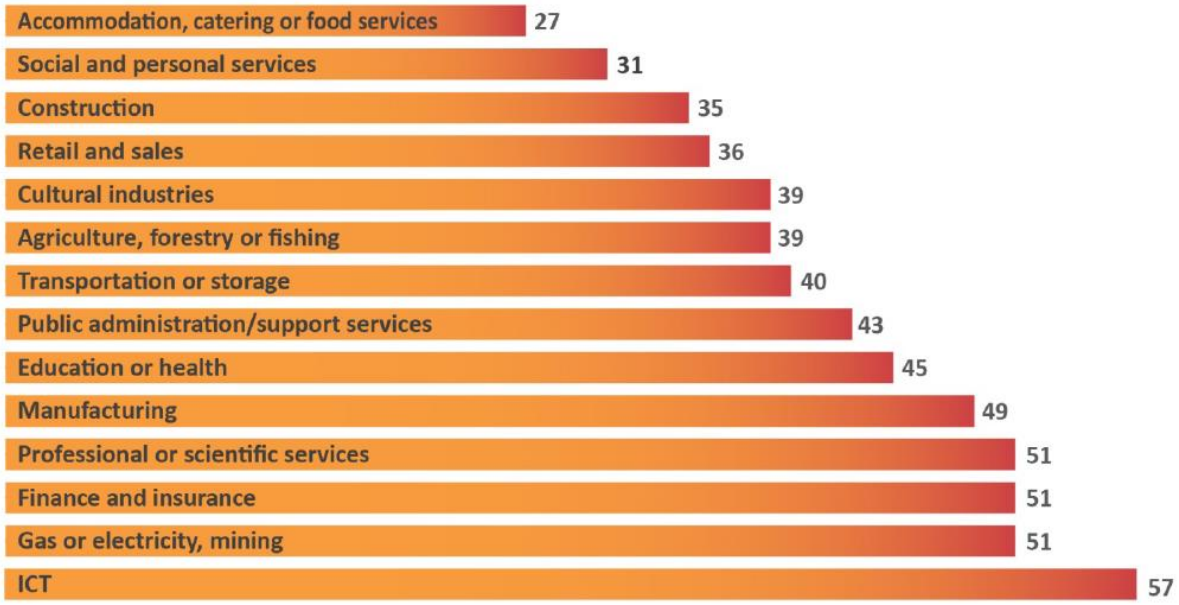
Across the goods producing sectors, fastest growth in productivity was observed in energy and chemicals, followed by food manufacturing and precision engineering sectors. Across the services producing sectors, fastest growth in productivity was observed in environmental services, food services and accommodation services.

3.9.4.ITMs: industry growth prospects and targets

The adoption of industry-specific transformation maps (ITMs) is still in progress at the time of drafting this report. By mid-2017 only 7 out of 23 ITMs have been launched. While the amount of information provided publicly on the ITMs is limited, it would seem that they mostly correspond to the overall ITP framework – following the four key pillars (productivity, skills, innovation and internationalisation) as well as the productivity growth model (i.e. added value growth = productivity growth + employment growth) putting targets over each of the elements in this model as well as planning for certain amount of growth in the number of PMET (professional, manager, executive or technician) jobs. Furthermore,

the key elements of the ITMs seem to be promotion and support for companies to adopt productivity enhancing and automation technologies and processes.

Figure 11. Employees with technological change in past five years in EU (CEDEFOP, 2017)



Given that data on targets and expected impact of ITMs is not publicly available, it is difficult at this stage to assess the size of possible impact of ITP/ITMs. Also historical analysis indicates possible challenges, particularly as regards non-tradable sectors with historically low productivity level and its growth. Such challenges are also seen in Europe.

4. Precision engineering (PE) industry case study

Precision engineering industry has a long history in Singapore, starting to take shape already as early as 1970s. Its development was also likely strongly linked to another key industry sector in Singapore – semiconductor manufacturing, as precision engineering sector is a substantial supplier of semiconductor manufacturing equipment. Overall, precision engineering sector as defined in Singapore does not correspond to any single group of economic activities as provided in the international standard industrial classification system. Rather, it includes many elements from a number of major groups of the classification - manufacture of rubber and plastic products, manufacture of fabricated metal products, manufacture of test, measurement and optical equipment, manufacturing of electrical equipment as well as manufacture of general and special purpose machinery.

For industry analysis, the Economic Development Board (EDB) divides precision engineering industry into three major sectors: complex equipment, precision component and general manufacturing supply products and services. Complex equipment sector consists of the production of semiconductor, solar, test and measurement and automation equipment as well as machine tool making. Some of notable companies based in Singapore as reported in 2013 included Applied Materials – a producer of wafer fabrication equipment manufacturing semiconductor equipment; Kulicke & Soffa – semiconductor assembly equipment design and manufacturing firm; Rohde & Schwarz – a German test and measurement company; Makino – a leading Japanese firm specialising in metal cutting and manufacturing technology.

Precision component sector (alternatively sometimes called component original equipment manufacturing sector) companies conduct manufacturing and assembly of critical components and modules, such as optics, lasers, pumps, motors and connectors required for diverse industries. More notable companies in this sector around 2013 included FCI Microconnections, manufacturing flexible printed circuits (FPC) for contact smartcard applications; IFM Electronic gmbh, a manufacturing of components and modules used in automation industry; Coherent, a leading supplier of laser marker manufacturing systems.

Manufacturing supply sector include companies that are specialised in various manufacturing-related services, processes or products, such as contract manufacturing, plastic-rubber moulding, metal fabrication or surface treatment. Some more advanced technologies adopted in Singapore include plastic and metal injection moulding, 5-axis machining, electro-mechanical system integration and other. Notable companies include Ultra Clean Technology, a developer and supplier of critical subsystems for semiconductor equipment, flat panel, medical, energy and research industries including gas and liquid chemical delivery systems complex sub-system assembly for semiconductor process modules; Meiban, a Singapore-grown plastic supplier: Knust-SBO a 5-axis precision machining company.

Finally, PE industry also includes sub-sectors with high expected future growth potential, including robotics, additive manufacturing and advanced materials.

4.1. Recent performance of PE industry

In 2015, precision engineering sector produced 34.7 billion SGD of output (12.2% of the total in manufacturing), creating 9 billion SGD value added (13.1% of the whole manufacturing sector). It was

also the third largest sector in terms of employment size, providing 90 thousand of jobs (or 22% of the total in manufacturing). Having large employment size but smaller value added share also indicates that in terms of labour productivity it was significantly behind the average productivity in the manufacturing sector in Singapore, with 100.000 SGD value added per worker as compared to the average manufacturing value added per worker of 171.000 SGD. For the performance analysis of the sector, a potential source is the annual economic survey of Singapore, which however provides precision engineering industry breakdowns different than the ones used for policy analysis: i.e. machinery & systems sub-sector and precision modules & components sub-sector.

The analysis of recent performance of the sector must also take note of a significant change between 2010 and 2011. Notably, the total output of the sector (and more specifically in the machinery and systems sub-sector) jumped in one year from 14 billion SGD to almost 22 billion SGD as well as the added value jumped from 3.6 billion SGD to 5.4 billion SGD, without corresponding change in employment or remuneration, highly elevating output or productivity figures but without a corresponding change for jobs. This uncertain change complicates any comparisons between the performance figures before and after 2011. Furthermore, there is a substantial cyclical element in the performance of the sector.

Table 20. The performance of precision engineering industry since 2011.

Indicator	Sector	Average 2011-2012	Average 2014-2015	Growth, %
Employment ('000)	Total	94,006	92,221	-2%
	Machinery & systems	42,563	46,608	10%
	Precision modules & components	51,444	45,613	-11%
Remuneration (billion SGD)	Total	4,159	4,502	8%
	Machinery & systems	2,183	2,570	18%
	Precision modules & components	1,977	1,933	-2%
Total output (billion SGD)	Total	34,352	33,553	-2%
	Machinery & systems	22,878	22,999	1%
	Precision modules & components	11,474	10,554	-8%
Value added (billion SGD)	Total	8,286	8,972	8%
	Machinery & systems	4,905	5,504	12%
	Precision modules & components	3,382	3,469	3%
Value added per worker (thousand SGD)	Total	88	97	10%
	Machinery & systems	115	118	2%
	Precision modules & components	66	76	16%

Source: Economic Survey of Singapore, MTI

4.2. PE productivity roadmap in 2011

Following the conclusions in 2010 of the Economic Strategies Committee and with the lead of newly established National Productivity and Continuing Education Council (NPCEC) an effort took place to support productivity growth via some horizontal initiatives as well as development of sector-specific productivity development strategies. The aim was to develop up to 17 such sector-specific productivity development strategies ("productivity roadmaps") between 2010 and 2014, even though by 2015 there was public information about up to 11 such roadmaps. Precision engineering (PE) industry was

one of the sectors to be covered by this initiative with productivity roadmap launched in 2011 with a 10 year horizon.

The key highlight from this roadmap was setting a productivity target, aiming to reach, by 2020, an average 178.000 SGD level of value-added (VA) per worker in the industry, from the baseline level of 67.000 SGD in 2008. To support this goal, a 52 million SGD budget was set aside from National Productivity Fund (NPF) to support skills upgrading activities for the precision engineering workforce. This included the creation of a Master Craftsmen Programme to offer advanced vocational training and recognition for PE professionals. The roadmap consisted of three major priorities ("thrusts"): growing higher value added activities; improving firm-level operational efficiency; and further upgrading PE workforce.

Growth of higher value added activities was seen to be achieved by broadening and strengthening manufacturing capabilities for larger scale operations, designing, developing and production of high-mix low-volume manufacturing equipment and other advanced technologies and know-how as well as diversifying as history showed, to become a supplier to a broader mix of industries including aerospace, medical devices or offshore equipment.

The improvement of firm-level operational efficiency was aimed to be reached via increasing capital productivity, automation, process improvement and job redesign. The enhanced Productivity and Innovation Credit (PIC) was to be used as an important measure supporting such transformation activities and reducing their costs.

The promotion of higher skills for the industry – the third and last priority of the productivity roadmap, saw the proposal of establishing a Master Craftsmen Programme at Nanyang Polytechnic, reserving for this initiative 52 million SGD from the NPF. Modelled on successful examples of vocational training programmes in Europe, this programme was expected to provide a new pathway to attract talented individuals to PE carriers and equip them with necessary skills to support productivity upgrading of the industry.

The progress of productivity upgrading in PE has not been sufficiently rapid to enable achieving the productivity targeted, furthermore it was highly influenced by the one-off jump between 2010 and 2011 in output and value added, also driving up productivity level. Besides this jump, since 2011 sector growth and productivity upgrading has been very limited, with value added per worker increasing by 10% from around 88.000 SGD in 2011/2012 to 97.000 SGD in 2014/2015.

4.3. PE Industry Transformation Map

In October 2016, following the announcement of Industry Transformation Programme earlier in the year, the Industry Transformation Map for Precision Engineering industry was launched by the Minister for Trade and Industry. It set a number of specific targets, to be achieved by 2020, including the creation of 3000 PMET jobs, expected growth of the value added created by the industry from 8.8 billion SGD in 2014 upwards to 14 billion SGD in 2020. By 2020, the share of PMET jobs were also set to increase from 48% to 58% while the overall output of the sector is expected to grow from 32 billion SGD to 42 billion SGD.

Key elements supporting the implementation of the ITM include the complementarities with Research, Innovation and Enterprise (RIE) 2020 plan, in which 3.2 billion SGD were set aside for R&D in Advanced Manufacturing and Engineering; the 450 million SGD National Robotics Programme announced in 2016 budget; the National Additive Manufacturing Innovation Cluster (NAMIC) housed

at Nanyang Technological University with its dual mandate to support R&D in additive manufacturing and adoption of the technology by SMEs.

The ITM is supposed to implement two dedicated initiatives to encourage innovation: **Model Digital Factories** will be set up in A*STAR's Singapore Institute of Manufacturing Technology (SIMTech) and Advanced Remanufacturing & Technology Centre (ARTC) to develop digital technologies and solutions for MNCs and SMEs as well as grooming locally based companies to become **Digital Champions**, i.e. digitalise their factory operations. Providing the needed skills for the industry was also seen as an important goal, with the supporting launch of dedicated Skills Framework for Precision Engineering, development of Professional Conversion Programmes under the Adapt and Grow initiative as well as advanced manufacturing master classes.

As part of the ITM, it was envisage to also enhancing tripartite collaboration and consultation to improve joint work with industry, associations, unions and various government agencies. The plan also includes strengthening the Singapore Precision Engineering and Technology Association (SPETA) aiming to increase its membership from 170 in 2016 to 400 by 2020.

Given the rather dismal recent performance of the overall PE sector, a number of areas of PE globally were identified as potential markets to penetrate and ensure PE industry growth in Singapore. Notably, 7 high-growth sub-sectors should form the basis to drive PE industry growth until 2020. These 7 sub-sectors include: Semiconductor equipment; test& measurement instruments; lasers and optics; additive manufacturing industry; robotics industry; sensors industry and finally advanced materials industry (notably plastics). All these sub-sectors are expected to show relatively healthy growth internationally and therefore could become the drivers of PE industry growth in Singapore. The ambition is that together these 7 growth sub-sectors should by 2020 be able to increase their value added from around 4 billion SGD to around 9 billion SGD and their workforce from current 14 thousand to 42 thousand. Their international potential can be shown as:

- Semiconductor equipment market, expected to grow from USD 36.5 billion in 2015 to USD 51 billion by 2020, driven by proliferation of mobile and IoT applications that require increasingly energy-efficient and miniaturised semiconductor packages;
- Test and measurement equipment market, expected to grow from USD 20 billion in 2015 to USD 30 billion by 2020, driven by growing demand for sophisticated testing methods and equipment required for highly compact and integrated chips-sets and components;
- Laser and optics equipment, expected to grow from USD 32 billion in 2015 to USD 47 billion by 2020, driven by low-cost high power innovations broadening applications space and industry leaders shifting into visual processing software;
- Additive manufacturing, expected to grow from USD 5 billion in 2015 to USD 18 billion by 2020, anticipating mainstream adoption;
- Robotics, expected to grow from USD 27 billion in 2015 to USD 45 billion by 2020, driven by global push into networked automation to increase productivity and higher flexibility, expected in both emerging and developed markets;
- Sensors, expected to grow from USD 80 billion to USD 128 billion by 2020, driven by broader applications and demand growth enabled by increasing use of complex equipment and cloud connectivity;
- Plastics (advanced materials), expected to grow from USD 64 billion in 2015 to USD 81 billion by 2020, driven by advanced manufacturing techniques requiring the development of new material formulations and processes.

Using some available indicative data on the size of VA of these sub-sectors in Singapore, a back-of envelop transformation of these measures into USD (with a 0.75 current currency exchange rate) and

then into output (with a conversion rate based on average VA-output relationship in the Singapore PE industry) is made. It is then possible to estimate the current and expected global market share for these specific SG PE industry sub-sectors.

Table 21. Forecasting estimated market share of Singapore PE growth sub-sectors.

	V/A 2014 bSGD	V/A 2020 bSGD	SG Output 2014 bUSD	SG Output 2020 bUSD	Global Output 2015 bUSD	SG market share 2015	Global output 2020 bUSD	SG market share 2020
Semiconductor	1.8	2.5	5.3	5.6	36.5	14%	51	11%
Test&Measurement	1.2	2.5	3.5	5.6	20	17%	30	19%
Lasers&Optics	0.4	0.9	1.1	1.9	32	3%	47	4%
Robotics	0.1	1.0	0.3	2.3	27	1%	45	5%
Sensors	0.1	0.9	0.3	1.9	80	0%	128	1%
Plastics	0.6	0.9	1.8	1.9	64	3%	81	2%
Additive manuf.	0.0	0.6	0.0	1.2	5	0%	18	7%
7 growth sectors	4.0	9	12.0	20.3	n/a			
Rest of PE	4.8	5	14.4	11.3	n/a			
Total	**8.8**	**14**	**26.4**	**31.5**	n/a			

Source: calculations by the author using PE industry data and global market forecasts. Also based on PE ITM forecasts the VA-output relationship in Singapore is expected to change from 0.275 in 2014 to 0.33 in 2020.

To encourage productivity development in the PE industry, the key focus is on the promotion of automation technologies adoption. For that purpose the key demand-side bottlenecks for the adoption of automation technology will be addressed including the unattractive level of ROI, limited in-house expertise of companies to adopt such solutions. This is expected to be achieved financial support for adoption (making ROI more attractive), providing external expertise as well as supporting companies to develop internal know-how. Supply-side limitations like lack of standardised solutions as well as capabilities and know-how of local system integrators will be address via supporting the development of standardised solutions, develop interoperable modular solutions and strengthening capabilities of local system integrators.

With regards to skills pillar, the underlying instrument helping developed a supply of skilled workforce is the Skills Framework, developed for a number of sectors, including Precision Engineering, that should explain potential carrier paths, describe job profiles and the required skills in those jobs as well as indicating potential education and training programmes providing those skills. Sourcing labour for this sectors signified by contracting labour force might be challenging, particularly due to “leakage” from pre-employment education and training sector where only a limited number of graduates would choose to enter the sector (it is estimated that 60% of engineering students do not enter engineering professions, however there seems to be lack of direct links between study programmes and specific industry sectors). Therefore schemes to make initial jobs in industry more attractive are important, like earn and learn programmes as well as carrier conversion programmes for professionals from other sectors. Still, a system monitoring inflow-outflow of manpower from the sector, as well as linking to graduation and transition statistics from education and training programmes could be beneficial for planning sectoral manpower as well as educational opportunities.

An important role in supporting companies to upgrade their business models is expected to be played by SPETA association. It should provide additional consultancy help to business in particular when

they faces challenges not so easily addressed by policy interventions – for example succession planning, improving the efficiency of use of material and financial resources thus alleviating challenges related to access to capital and modernising work processes, but in particular management practices which might often be a major challenge for SMEs. To support these tasks SPETA advocate for more broad-based used of larger number of productivity and profitability indicators, i.e. beyond labour productivity also looking into land/space productivity, productive assets productivity, cash productivity and productivity of knowledge creation and accumulation activities (include reporting).

Business associations like SPETA, can assist government agencies and other involved actors using their networks to address the long list of other challenges often faced by business and SMEs, including making sense of multiplicity of public and private support and advice services, aligning the needs of business to those of other actors, providing continued support for companies instead of one-off solutions and ensuring broad-based reach-out and engagement of large number of private sector actors.

4.4. PE Industry in the European Union

Given that precision engineering industry, as defined in Singapore, includes a list of sectors and sub-sectors belonging to different manufacturing activities, it is not straightforward to compare the sector as it is defined in Singapore to a similar sector in other countries. Furthermore, even if an ideal reconstruction of the sector would be possible, further complexities are involved, including (slightly) different industrial classification systems in each country/region, differences in data collection instruments, different definition of concepts as well as statistical practices like accounting for price changes across countries.

When comparing the Singapore Standard Industrial Classification (SSIC) with International Standard Industrial Classification (ISIC) and then with Statistical Classification of Economic Activities in the European Community (NACE) for Precision Engineering industry, a limited number of differences emerges, particularly notable as regards the treatment of repair activities for different manufactured goods – whereas in the EU such activities have singled out categories, in Singapore such activities are included together with the production activities of those specific products. This difference might be substantial, as the repair sector in the EU is quite significant. The other differences are minor, including the treatment of natural rubber processing, uncertain treatment of machining which is part of treatment and coating of metals sector in ISIC and NACE but is not mentioned in SSIC as well as not fully clear attribution of the manufacturing of lifting and handling equipment sector – presumably the sector most linked to automation through robotics technologies. Finally, the attribution of installation of industrial machinery and equipment economic activity is also uncertain.

When analysing European Precision Engineering industry, several sub-sectors stand out in terms of their size (turnover), the largest being manufacture of plastic products (235 billion EUR turnover in 2015), manufacture of general-purpose machinery (216 billion EUR turnover in 2015). In terms of employment, the leading sector again is manufacture of plastics products (1.3 million employees in 2015), closely followed by treatment and coating of metals/machining sector (1.1. million employees in 2015). In terms of productivity (value added per employee) three sectors standing out are the Test&Measurement sector (with 79.000 EUR VA per employee), Laser& Optics sector (with 78.000 EUR VA per employee) and Plastic and Rubber machinery sector (with 78.000 EUR VA per employee).

In terms of sector size, Germany is leading the list of countries with almost 600 billion EUR of turnover, followed by Italy (almost 260 billion EUR), France (around 180 billion EUR) and United Kingdom (150 billion EUR). In terms of productivity in the overall sector, the highest rate is found in Switzerland, with almost 131.000 EUR VA per employee, followed by Belgium, Netherlands and Norway at around 85.000 EUR VA per employee. Singapore productivity in PE sector stands at 62.2 thousands EUR/employee (using current currency conversion rate of 0.62) somewhat above the EU average of 56.2 thousands EUR/employee.

Table 22. Precision Engineering industry in Europe in 2015

	Turnover, million EUR	Value added, million EUR,	Persons employed,	VA per worker, EUR
European Union (28 countries)	**1,727,100**	**565,452**	**10,051,397**	**56,256**
Belgium	33,842	10,003	124,422	80,395
Bulgaria	5,225	1,485	125,214	11,860
Czech Republic	44,177	12,781	504,260	25,345
Denmark	34,502	10,096	147,602	68,400
Germany	585,073	204,948	3,011,315	68,059
Estonia	2,484	681	26,601	25,608
Ireland	4,043	831	22,024	37,718
Greece	6,862	1,830	57,372	31,902
Spain	78,205	24,432	479,325	50,971
France	182,487	56,093	865,522	64,809
Croatia	3,891	1,323	65,412	20,229
Italy	257,914	79,651	1,315,325	60,556
Cyprus	357	127	4,870	26,160
Latvia	1,210	369	22,490	16,385
Lithuania	2,196	650	34,113	19,051
Luxembourg	1,599	437	6,150	70,992
Hungary	23,651	6,366	223,133	28,531
Malta	17	7	2,251	3,287
Netherlands	54,578	17,189	236,142	72,793
Austria	51,557	18,516	229,767	80,584
Poland	60,734	16,861	733,836	22,976
Portugal	14,739	4,336	149,307	29,039
Romania	13,005	3,098	224,558	13,797
Slovenia	7,124	2,380	69,475	34,255
Slovakia	14,757	3,757	162,505	23,120
Finland	29,492	8,547	130,323	65,583
Sweden	43,529	14,141	193,087	73,238
United Kingdom	153,436	59,221	728,489	81,292
Norway	15,724	5,272	62,852	83,872
Switzerland	67,139	28,920	221,019	130,847
Singapore	**21,573**	**5,615**	**90,250**	**62,216**

Source: Eurostat, Structure of Business Statistics.

It is also possible to analyse the performance in Europe of some of the growth sectors as identified in the PE ITM in Singapore, even if there is no reliable statistical data for specific PE sub-sector in Singapore. Using European statistics, it is possible to identify the performance of three out of the 7 "growth sectors" as identified in PE ITM: Plastics (presumably including advanced materials), Test & Measurement as well as Laser & Optics. The key indicators of those sectors across European countries and on average in the European Union are presented below.

Table 23. Plastics manufacturing sector in Europe in 2015

	Turnover, million EUR	Value added, million EUR	Persons employed	VA per worker, EUR
European Union (28 countries)	**235,000.0**	**68,400.0**	**1,336,733**	**51,170**
Belgium	6,373.1	1,734.7	20,540	84,455
Bulgaria	1,172.2	263.1	23,487	11,202
Czech Republic	6,271.0	1,738.1	65,511	26,531
Denmark	2,863.2	1,098.8	15,095	72,792
Germany	66,112.3	20,000.3	344,092	58,125
Estonia	303.1	77.5	3,281	23,621
Ireland	1,486.8	513.4	7,032	73,009
Greece	1,664.0	443.9	10,553	42,064
Spain	14,680.0	4,058.2	68,853	58,940
France	24,344.5	6,761.3	108,585	62,267
Croatia	746.1	178.2	10,086	17,668
Italy	32,120.8	8,137.1	131,931	61,677
Cyprus	79.3	24.5	851	28,790
Latvia	190.2	46.3	2,796	16,559
Lithuania	881.7	181.4	8,379	21,649
Luxembourg	901.0	203.8	2,485	82,012
Hungary	3,359.8	758.1	35,545	21,328
Malta	:	:	1,033	:
Netherlands	7,978.4	2,337.4	27,489	85,030
Austria	5,852.4	1,977.8	27,511	71,891
Poland	14,705.3	3,756.0	151,240	24,835
Portugal	2,869.6	705.6	19,628	35,949
Romania	2,677.9	604.6	41,292	14,642
Slovenia	1,296.9	372.9	10,627	35,090
Slovakia	2,483.1	556.9	22,916	24,302
Finland	2,287.8	673.0	10,707	62,856
Sweden	3,958.3	1,171.9	17,417	67,285
United Kingdom	27,634.1	10,047.0	147,771	67,990
Norway	1,135.6	343.6	4,023	85,409
Switzerland	6,176.4	2,420.2	21,748	111,284

Source: Eurostat, Structure of Business Statistics.

The plastics manufacturing industry is identified using the sector as defined in the international standard industrial classification group 222 "Manufacture of plastics products" and the corresponding sector in the EU industrial classification NACE Rev. 2. It is notable, that the total turnover of the

respective industry sector has been substantially larger than that estimated as the “global output” of this industry; it might be due to differences in the definition of the sector or different definition of turnover.

Table 24. Test and measurement manufacturing sector in Europe in 2015

	Turnover, million EUR	Value added, million EUR	Persons employed	VA per worker, EUR
European Union (28 countries)	**79,668.4**	**31,747.1**	**403,688**	**78,643**
Belgium	665.2	260.3	2,954	88,118
Bulgaria	114.7	42.3	2,131	19,850
Czech Republic	2,850.0	646.1	16,213	39,851
Denmark	1,880.8	893.9	9,157	97,619
Germany	30,331.9	12,582.6	155,383	80,978
Estonia	73.5	15.5	494	31,377
Ireland	:	:	:	:
Greece	232.2	59.4	1,302	45,622
Spain	1,160.6	449.7	7,497	59,984
France	12,536.7	4,853.2	55,937	86,762
Croatia	82.1	36.1	1,282	28,159
Italy	5,860.1	2,055.9	27,927	73,617
Cyprus	0.0	0.0	0	0
Latvia	28.6	9.1	456	19,956
Lithuania	89.9	42.5	1,266	33,570
Luxembourg	:	:	:	:
Hungary	369.6	107.7	4,615	23,337
Malta	:	:	:	:
Netherlands	2,588.9	926.8	10,529	88,024
Austria	1,070.0	561.3	5,965	94,099
Poland	931.6	386.6	14,356	26,930
Portugal	96.0	33.2	1,304	25,460
Romania	615.9	162.5	9,222	17,621
Slovenia	:	:	:	:
Slovakia	503.9	114.9	2,475	46,424
Finland	1,118.3	487.2	6,180	78,835
Sweden	1,618.4	611.4	6,367	96,026
United Kingdom	13,199.4	5,676.0	:	:
Norway	1,418.3	506.0	4,630	109,287
Switzerland	28,962.0	12,104.1	67,778	178,584

Source: Eurostat, Structure of Business Statistics.

The test and measurements instruments manufacturing industry is identified using the sector as defined in the international standard industrial classification group 265 “Manufacture of measuring, testing, navigating and control equipment, watches and clocks” and the corresponding group in the EU industrial classification NACE Rev. 2. It is notable, that the total turnover of the respective industry sector has been substantially larger than that estimated as the “global output” of this industry; it might be due to differences in the definition of the sector or different definition of turnover.

Table 25. Laser and optics manufacturing sector in Europe in 2015

	Turnover, million EUR	Value added, million EUR	Persons employed	VA per worker, EUR
European Union (28 countries)	**10,610.3**	**3,894.1**	**49,907**	**78,027**
Belgium	:	:	:	:
Bulgaria	57.4	24.5	1,527	16,045
Czech Republic	103.4	54.9	2,988	18,373
Denmark	169.4	66.1	662	99,849
Germany	7,067.8	2,556.8	27,135	94,225
Estonia	:	:	:	:
Ireland	:	:	:	:
Greece	38.7	9.9	124	79,839
Spain	:	:	:	:
France	:	:	2,087	:
Croatia	5.3	1.9	136	13,971
Italy	498.6	153.6	1,984	77,419
Cyprus	0.0	0.0	0	0
Latvia	:	:	77	:
Lithuania	50.3	27.3	413	66,102
Luxembourg	0.0	0.0	0	0
Hungary	27.9	11.5	692	16,618
Malta	0	0	0	0
Netherlands	152.1	58.6	973	60,226
Austria	192.5	85.8	1,041	82,421
Poland	64.7	27.6	1,851	14,911
Portugal	49.2	17.1	553	30,922
Romania	17.7	9.2	756	12,169
Slovenia	7.1	2.9	99	29,293
Slovakia	8.6	1.7	86	19,767
Finland	:	:	:	:
Sweden	157.6	51.9	634	81,861
United Kingdom	1,127.0	442.4	:	:
Norway	:	:	240	:
Switzerland	1,379.6	663.3	4,187	158,419

Source: Eurostat, Structure of Business Statistics.

The test and measurements instruments manufacturing industry is identified using the sector as defined in the international standard industrial classification group 267 “Manufacture of optical instruments and photographic equipment” and the corresponding group in the EU industrial classification NACE Rev. 2. European turnover in this sector, being 10 billion, is one third of the total estimated global industry output, with the estimation for this industry output and EU statistics being potentially more comparable than previous two sectors analysed.

4.5. Conclusions: Precision Engineering ITM

For conclusion, it could be stated that PE ITM (similarly as many other ITMs) is primarily a policy initiative to improve the coordination of different public agencies supporting the development of this (as well as other) sectors in the fields of productivity upgrading, skills and workforce training, research and development and as well as international trade. The majority of instruments, available for companies to support their productivity and industrial upgrading have been available before the introduction of the ITM – like the 5-yearly R&D support plans (RIE); variety of tax credits available from companies; public support for training measures and support to build international trade capacity. Some measures will even be discontinued soon after the adoption of the ITM, notably the Productivity and Innovation Credit (PIC), to be discontinued after 2018.

At the same time, Precision Engineering Industry might be one of few industry sectors to benefit of the two new industry upgrading initiatives of the government: the Automation Support Package and the National Robotics Programme. The sector would potentially benefit of these products both directly, by enabling with public sector support to increase the level of automation of production as well as indirectly – by increased demand for automation and robotisation technologies, while being a key supplier for deployment of these technologies.

Furthermore, the economic performance of the sector, at least since 2011, has been rather constrained, showing very limited output or productivity growth; despite ambitious targets and supposedly substantial public sector support since the adoption of 2011 productivity roadmap for precision engineering industry. It would seem that there are some major barriers for further development of the sector and it is likely to be difficult to jump-start the growth of the sector.

In terms of the analysis of the sector, it is difficult to disaggregate the sector performance into constituent sub-sectors due to uncertain statistical definition of those sub-sectors; they also different from the sectors as analysed and presented in policy documents. The preliminary comparison with the European Union data (creating, based on available statistics; a similarly defined PE sector) indicates, that PE sector in Singapore has somewhat above the average productivity level in the EU of the correspond group of industry activities, but significantly behind the level of productivity achieved by a number of countries like Switzerland, Norway, Belgium, Austria or United Kingdom.

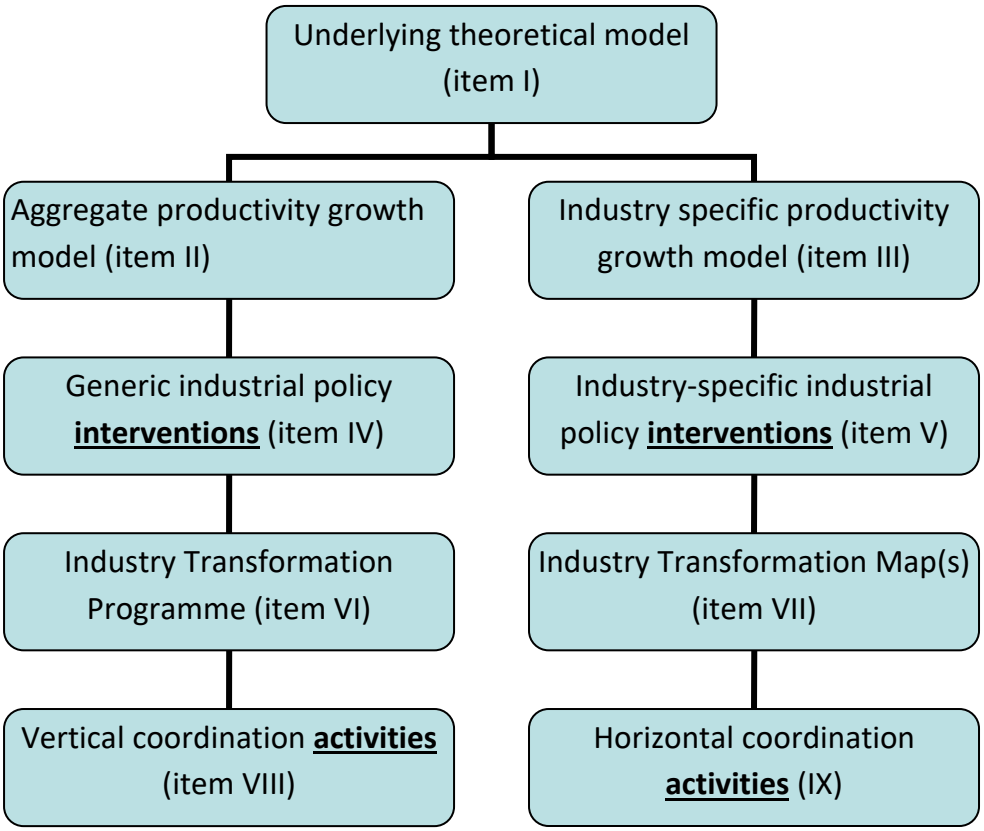
Finally, in terms of the forecasts for high-growth cluster of activities within the sector, it is uncertain how these sectors are defined as international analyses do not correspond well with the performance when analysing expected industry sectors as defined by international standard industrial classification of economic activities. In some cases the sectors identified correspond more to emerging technologies applied across industries, rather than a specific industry itself – also then limiting the capacity to capture added value by any particular sector linked to the application or sourcing for the deployment of such technology.

5. The structure of Singapore's industrial policy logic

Given that Singapore's industrial policy covers multiple instruments and levels, the analysis of the intervention logic of ITP needs to cover the links of ITP to higher-level industrial and economic policies (into which the ITP is integrated) as well as lower levels of the ITMs and specific pillars – thematic areas of ITMs interventions that should bring about the realisation of the ITP. Therefore, these different levels of the intervention logic can be represented as a pyramid going from more abstract and higher levels of policy formulation to more specific, lower levels of policy implementation.

Based on previous analysis it is presumed, that the different layers of policy discourse both historically as well as more recently are based on a similar underlying logical model/mental representation, mostly resembling that of growth accounting framework model. Such interpretation is made due to the use in policy discourse of goals and indicators that resemble elements of this highest-level model and correlates to the discussion in literature as well as broader policy discourse. The rest of lower-level policy initiatives and interventions feed into realising this highest level intervention logic.

Chart 2. The hierarchy of industrial policy concepts in Singapore



I. Growth accounting framework (historical-theoretical basis)

This highest level of intervention logic represents the indicators and discourse over a longer term historical period, stressing investment, economic growth, and productivity growth as key variables targeted by policy makers.

Investment + Employment + MFP = **(equals)** = GDP growth

II. <u>Aggregate</u> competitiveness and productivity (policy discourse)

This, more detailed recent model tries to specify how productivity and economic growth would lead to improvement in living standard of Singapore citizens, it also includes an explicit role for skills policy and training as a prerequisite for such improvement.

Productivity growth* + Employment growth = GDP growth > **(leads to)** > more better jobs*** > **(leads to)** > occupied by higher-skilled core*** > **(leads to)** > income growth

*As regards the definition of productivity growth, in the policy context it is more usually defined as value-added per employee and therefore it is not directly comparable to MFP concept. Value-added per employee might grow both due to increase in MFP, but equally (or more likely so) via increase in capital intensity (additional investment).

** Better (PMET) jobs do not automatically come from economic growth; therefore an important role for public policy is to promote "good growth" - i.e. growth that brings better jobs and limiting growth that is driven by the expansion of low-quality employment

*** Economic growth is only an enabler of growing individual prosperity; the latter can only be realised when attaining appropriate skills. This is the meritocratic element in the conceptual framework of the causal factor(s) of economic prosperity.

III. <u>Industry-specific</u> competitiveness and productivity growth (adjusted from IEG)

As visible over the recent years (but potentially present also earlier in industry-specific policy actions) the policy discourse stresses the necessity to address industry-specific needs and accordingly industry-specific policy requirements, which is then implicitly assumed to lead to aggregate effects at the level of the overall economy.

Market size growth + market share growth – employment growth (aggregate cumulative effect* in item II) > **(leads to)** > Industry-specific productivity growth

*Given that more emphasis is put on sector-specific interventions, the importance of sector-specific growth is more pronounced. However to realise economy-wide growth, a cumulative growth effect should be achieved across all economic sectors together, which might not necessarily be the case, particularly given the constrained labour market (zero-sum competition for labour) and other possible asymmetric effects across industries.

IV and V: Economic/ industrial policy interventions (using typologies from literature)

At this level the various policy interventions (both generic and sector-specific), such as tax regimes, migrant levies, various financial and non-financial incentives to direct and incentivise companies' behaviour towards bringing about the capabilities and putting down investment to increase growth and

productivity can be included. There are numerous typologies of industrial policy instruments that could be used to classify the policy instruments used in Singapore, or for that matter in any other country.

Economic and industrial policy interventions > **(leads to)** > better business conditions and capabilities > **(leads to)** > more output and productivity enhancing investment (including foreign) > **(leads to)** > aggregate output and productivity growth > **(leads to)** > more impact on items III and II and I.

VI and VII: Industry Transformation Programme (based on policy discourse)

This level of policy intervention describes the role and position of ITM, as primary focus of the analysis and how it fits into the broader logic of economic and industrial policy framework. It is presumed, that ITP is primarily a governing and information flows enhancing intervention (i.e. focused on changing processes of decision making rather than creating specific new external interventions targeted at specific companies or individuals), even if through representative bodies certain level of external impact (i.e. influencing companies by information and networking to adjust their activities towards the broader agreed aims/objectives) could also be envisaged.

More internal and external coordination > **(leads to)** > more efficient and effective interventions > **(leads to)** > more impact in items IV and V*;**

*Assuming that all other changes, both intentional – i.e. the possible re-distribution of financing towards sector-specific rather than generic interventions and unintended/unexpected effects will have neutral cumulative effect.

** Depending on the share of interventions/public investment covered by ITP (this could be a specific indicator created to evaluate the scope of ITP)

VIII. De-constructing ITP coordination <u>activities</u> (based policy discourse):

The core action of ITP is to improve coordination across and between different levels, with specific activities and bodies set for that purpose.

ITM-specific coordination + Cluster-specific coordination + horizontal coordination of ITP via CSIP > **(leads to)** > more internal and external coordination (item VI)

IX. De-constructing ITMs - coordinating across four pillars (based on policy discourse and ITM structure):

ITM's are the lowest level of public discourse/reporting, bringing together different agencies and structuring coordination activities across different areas as prescribed in the ITP (and requested in the Future Economy Council) – productivity, skills, innovation and internationalisation.

Coordination of productivity interventions + coordination of skills interventions + coordination of innovation interventions + coordination of trade/internationalisation interventions > **(leads to)** > more sector-specific coordination (item VII)

5.1. The intervention logic of ITP

While the Industry Transformation Programme has been launched in 2016, many of the actual policy interventions, that will be covered by this programme, have been launched earlier – in some case as early as 2010 when a renewed emphasis on productivity has been placed by the Government of Singapore (Auyong, H., 2014).

Therefore, the context of the ITP and each ITM falls within the broader GDP and productivity growth agenda as stated in the Economic Strategies Committee (ESC) report in 2010 and re-confirmed by the Committee on the Future Economy (CFE) in 2017.

It is also notable that to support the achievement of national productivity and GDP growth targets set in 2010, already from the beginning of the decade the most important industry sectors have been set productivity growth targets towards 2020. Some of these targets, set in 2011 and 2012, are retained as targets also for the ITMs (for example in PE ITM).

Therefore a comprehensive analysis of ITP intervention logic had to include at least four separate levels of analysis, i.e.:

- The broader governance and institutional logic of the ITP (particularly the coordination, consultation and targeting functions)
- The specific instruments in action between 2010 and 2017 (including through instruments announced as part of the ITP), and
- The content – actions and logic behind specific ITM(s)
- The links between these three levels and the general strategic development framework as set in the ESC 2010 and CFE 2017 reports.

5.1.1. Stated intervention logic of the ITP

The Industry Transformation Programme, as stated in the Budget 2016, has four main mechanisms how it will generate impact:

> a. It will involve **integrating our different restructuring efforts.** Our efforts to raise productivity develop our people, and drive research and innovation are working, but we can maximise impact by pulling these together.
> b. We will take a **more targeted and sector-focused approach to better meet the needs** of firms in each sector.
> c. We will **deepen partnerships between government and the industry, and among industry players** to identify challenges, and develop solutions to support transformation.
> d. And we will place a stronger emphasis on **technology adoption and innovation.**

5.1.2. Stated intervention logic of the ITMs

The 2016 budget statement includes these explicit purpose set for the ITMs:

> "As a government, we must adopt a **more integrated** approach to support transformation. Our

agencies will work more closely together, integrating their different support schemes to take a **more targeted** approach to developing each industry. We will work closely with enterprises and at the industry level to develop transformation maps for each sector. These will help us allocate the resources to develop each sector appropriately."

Furthermore, the 2017 budget statement includes some further details:

"To systematically facilitate such partnerships, I announced in last year's Budget a major initiative, the Industry Transformation Maps, or ITMs. The ITMs are integrative platforms, bringing together various stakeholders – TACs, unions, and Government – so as to align our efforts around a common plan to transform each sector. We will develop ITMs for 23 sectors, covering about 80% of our economy. Six have already been launched. We will keep this going at a good pace, and launch the remaining 17 within FY2017.

The ITMs help us to identify key enablers, which involve different stakeholders, to transform sectors. For example, the Centre of Innovation for Supply Chain Management at Republic Polytechnic works with companies to level up their capabilities and provides students with hands-on experience.

As I said last year, the ITMs are "live" plans that we will adjust along the way. Where we spot opportunities, including ones that do not fit any existing industry, we will adapt our ITMs to seize them. We must also maximise synergies between related ITMs, such as between the Food Services and Hotel industries.

Our companies, TACs and unions can play a key role in the success of our ITMs."

Similarly, but somewhat even more focused position is confirmed by the statement of the Minister for Trade and Industry of Singapore in the Committee of Supply debate in the Parliament of Singapore in 2017, indicating that the two primary objectives of the ITMs are:

i. "Integrate Government policies and initiatives"; and
ii. "Promote collaboration among industry stakeholders to achieve transformation and growth through productivity, skills development, innovation and internationalisation."

5.1.3. Mandates of different bodies in the ITP/ITM process

From the documents available in the public domain there is as of yet no very clear view of the distribution of responsibilities between the different actors and different bodies (particularly the tri-partite bodies at national, cluster and sectoral levels) within the overall process of designing and implementing the ITP/ITMs.

5.1.4. Other (hypothetical) effects of the ITMs

In addition, beyond the explicit intervention logic, from previous analysis it could be presumed that introduction of ITMs as policy instruments carries also other effects. These effects could be intended in advance, but they can also be un-intended consequences of inter-institutional politics as well as other, ad-hoc or instrumental uses of the ITMs resulting from accumulation of experience within ITP/ITMs processes and newly recognised opportunities:

a. Distribute more clearly the lead responsibility for sector-specific coordination of industry transformation policy efforts;

b. Further utilise and mainstream the use of the productivity-growth nexus conceptual framework as economic development logic;
c. Further lock-in the four driving strategies of the CFE as four pillars of the ITMs;
d. Indicate, at least in the case of some ITMs, more clear or more explicit distribution of agency responsibility for activities falling under specific pillars;
e. Deepen tripartite coordination to reach sectoral level;
f. Increase the depth of legitimacy of public support towards sectoral level;
g. Increase the efficiency of public support via better coordination;
h. Increase the effectiveness of public support via better consultation;
i. Distribute (and make less explicit) the decision making, possibly to reduce government public relation risks as regards unsuccessful or miss-used industry-specific investments, which are easier to identify for horizontal instruments like CIP
j. Develop/improve matrix-type governing structure (functional and sectoral dimension)

5.1.5. Potential decision power re-distribution effects of ITMs

The introduction of ITMs, as policy coordination platform might also generate some tensions between the earlier hierarchical structure of decision making in the public sector and the new, more horizontal cross-departmental and cross-sector coordination. This would likely be particularly visible in cases where certain bodies would be interested to use the platform to increase the power in influencing decision making in other bodies. For example this could include strategic, intended or unintended actions to enlarge or reduce the power by:

a. ITM lead agency over horizontal agencies as regards planning of specific activities falling under specific ITM;
b. ITM lead agency over financial distribution and scope of activities within / across ITMs;
c. The pillar-specific agency to influence activities falling under a specific pillar but implemented by other agencies (i.e. productivity – SPRING; skills – SSG; internationalisation IE; research A*STAR);
d. The TAC to influence activities and funding decisions of the public sector;
e. The Unions to influence activities and funding decisions of the public sector;
f. The MTI to have more control levers over the implementing agencies.

5.2. ITP impact-capacity assessment framework

Initial reflection allows understanding and analysing the impact of ITIP/ITMs (various effects might be intended or un-intended; expected and un-expected) as a **governance/political intervention** via these dimension, i.e. as an instrument of:

- Vertical governance, via:
  - Programming of the (mental) growth model (productivity = growth);
  - Lock-in the use and integration of the four CFE strategies;
  - Industry sector as the locus of government intervention;
- Horizontal governance and power (re-)distribution, via:
  - Designating responsibilities for pillars and sectors;
  - Mainstreaming a 3-dimensional matrix governing structure
- Public administration/industrial policy quality management/improvement, via:
  - Efficiency improvements (concentration and duplication avoidance);
  - Effectiveness improvements (more optimal focusing of interventions);
- Internal and/or external legitimacy, via:

    - Deeper (sectoral and cluster level) legitimation vis-a-vis industry;
    - Distribution of accountability among social partners (tripartite bodies);
    - Defensibility of decision making mechanism by introducing analytical logic (based on sectoral growth forecasts and productivity comparisons).
- Analytical/feedback-loop
    - A government-wide analysis and forecasting exercise, carried out with industry partners, to identify broad industries as well as specific sectors with largest growth potential and focus public investment to develop those sectors

It is important to highlight that only one of the four angles of impact assessment has been publicly acknowledged – that of quality management (as defined by the author of the report), presuming an improvement of efficiency and effectiveness of government industrial policy interventions to be achieved via the ITMs. This angle, being explicitly intended and publicly acknowledged, could be called a “surface level impact mechanisms” of ITP as a governing intervention, while the other three aspects, all of which are presumed by the author and would need an empirical assessment to what extent they are actually present, noticed, intended and expected. These angles could be called the “deep level impact mechanisms” of the ITP as a governing intervention.

6. Discussion

The review of international literature on industrial policy, the history of economic development of Singapore as well as the configuration of relevant policy domains with various policy instruments/interventions in action allowed to situate the ITP within the broader Singapore economic and policy context. This also allows concluding, based on publicly available evidence that the ITP can be described as a governance instruments, i.e. re-arranging the institutional framework of governance and consultation, rather than being a direct market intervention. Based on the classification provided by Inter-American development bank (IAB, 2014) such an intervention would correspond to horizontal, public-input intervention, like policies aimed to provide macro-level favourable business working conditions. However, unlike business-focused policies like competition, property rights or intellectual property, the ITP is targeted primarily at the public sector bodies themselves and only indirectly/un-intentionally might have effects on actors external to the public sector.

As a public governance instrument, ITP is thus also very intimately linked to the overall underlying logic/ “raison d’etre” of public economic governance model in Singapore. This linkage is very clearly seen from the structure of ITP, i.e. the four pillars corresponding clearly to the priorities of long-term economic strategy set, for example, by the Committee on the future economy (CFE). Majority of ITM’s also explicitly refer to the discourse of growth-accounting framework, as main targets identify value added growth, productivity growth, employment size and numbers of high-quality (i.e. PMET) jobs. Therefore, an assessment of ITP is in essence can be viewed as assessment of (i) the underlying logic of economic development as viewed through the lens of growth accounting framework (i.e. “system-level” analysis); (ii) the links between ITP and other industrial policy instruments not fully covered by the ITP (policy-level analysis) and (iii) the consistency of the logic between different levels and/or different areas of ITP (intervention-level analysis).

Before summarising the reflections as regards the policy configuration and alignment within Singapore, it is also important to reflect on the aspect of cross-national comparison, as initially planned within the strategy of this research exercise. Based on the review of literature about industrial policy context and interventions across major world economies and regions, only very tentative comparisons are feasible due to often superficial level of policy analysis at the international level across countries as well as the fact that that focus of this research exercise – the ITP – is not so much an industrial policy intervention, but rather a policy governance, coordination and consultation framework. Existing literature on industrial policy only very sporadically address the issue of governance and consultation. Two notable exceptions, one focusing on Asia and Africa is the compilation of reviews by Page, J. and Tarp, F., 2017 and another one, focusing on Latin America, by Schneider, B. R., 2015). Therefore, besides similarities as regards high level priorities like automation, advanced and additive manufacturing and new technologies in general, few conclusions can be drawn if based solely on the review of existing literature, referring here to research tasks 1.1. and 1.2.

Furthermore, the analysis of existing conceptual/analytical frameworks that could be applied for the analysis of industrial policy in a particular country or across countries, as the next element of literature review (referring to research task 1.3.) provides more insights. This is particularly useful as regards the understanding and de-construction of some elements of Singapore’s industrial policy intervention logic. First of all, the varieties of capitalism framework provide some potential explanations as regards one of long-time concerns in Singapore – the unsatisfactory level of innovation activities, particularly among local businesses, or alternatively the capacity to enhance multi-factor productivity (MFP). In addition, the recent discussion on the role of intangible capital also provides some new insights on the

performance of MFP. The framework proposed by OECD (Warwick, 2013) clearly indicates that ITP is a parallel process to the majority of horizontal, market-based industrial policy interventions available in Singapore for a long time before ITP. On the other hand, both OECD and IDB frameworks help situate ITP as a "governance" intervention.

The framework developed as part of IEG evaluation (IEG, 2016) is rather insightful as a potential forward-looking way how to assess the performance of specific industries (to the extent that data could be available at the international level). It proposes a way to evaluate the level and progress of the competitiveness of specific industry sectors, taking into account the international trade position, productivity as well as employment effects. Besides industry output and productivity measures, it suggests looking also at market size (either local – for non-tradable sectors or global – for tradable sectors) as important indicators for assessing industry performance as well as explaining productivity and employment changes.

On the other hand, when trying to situate the strategic orientation of Singapore's industrial policy using the second and third parts of the OECD industrial policy typology (Warwick, 2013), it becomes evident that most policies have interventions and aims corresponding to a number of different strategic goals and judgement on which is dominant requires complex assessment of both policy discourse as well as policy instruments. At least for Singapore, different interventions target industries and companies in the catch-up as well as frontier situations; building on existing strengths but also aiming to develop new ones.

Finally, as regards the analysis of skills policy, ITP seems to focus on two areas. On the one hand it includes different supply-side measures to promote education and training (like Skills Future credit). On the other hand it aims to further deepen the existing qualifications framework (Workforce Skills Qualifications – WSQ) enriching it with industry-specific information (Manpower plans and skills forecasts), carrier pathways and describing skills content of jobs/training programmes aiming to facilitate the communication between companies and industries on the one side and education and training providers on the other.

Overall, whichever element of the ITP is analysed, it soon appears that ITP is functioning somehow "in parallel" to the variety of existing instruments – be it focused on productivity, skills, R&D, trade or other elements of the broader industrial and economic policy context. This conclusion very well leads to the assessment of the ITP via three lenses as proposed above – the system, policy and intervention levels.

From the system-level perspective, as discussed previously, the growth-accounting logic of economic and industrial policy pervades also the logic of the ITP. However, this underlying logic and the overall economic structure of Singapore have notable paradoxes that are likely not to be sufficiently addressed by the ITP. At least several paradoxes have been identified with regard to the economic system of Singapore:

- The reliance on high savings and investment rate to generate growth. Most notably raised by Paul Krugman in 1990s, this investment-driven growth model is argued to be time-bound due to the presumed law of diminishing returns, applicable to capital investment. In a way it could be argued that this is already evident in Singapore, with falling economic growth rates in last decades.
- The reliance of immigrant labour, both to complement capital investment but also by itself bring additional growth, as in growth accounting framework expansion of employed workforce would supposedly lead to increased economic growth. However due to popular discontent the

rates of immigration have been greatly reduced since 2013, also evident in the reduced growth rates, reliant primarily on capital deepening.

- High rates of investment in the economy, likely achieved by substantial government intervention, also raises the possibility of certain inefficiencies in the factors markets, notably capital market in Singapore. A possible example of the effect of high rates of capital formation would be a subdued level of consumption in the local economy, having then a drag on the non-tradable sectors that on the other hand often must absorb labour, released due to efficiency gains from the tradable sectors. This is further aggravated by the presumably low wage-share in the economy.
- From the perspective of varieties of capitalism literature, some authors argue that the specificities of Singapore's market governance structure (i.e. state-led capitalist economy) results a mixed (or conflicting) innovation system, i.e. an absence of prevailing innovation style is resulting in inefficiencies and subdued innovation activities.
- The economic structure in Singapore is exemplified by presence of three economic sectors: highly attractive state sector and state controlled enterprises; as well as MNC dominated export sector (both with limited employment potential) diminishes ("crowds out") human and other resources that are needed to develop a competitive local SME sector. This results in significant duality within the labour market and the overall economic structure.
- Finally, the existing institutional structure in Singapore has been developed to support such growth model, including the framework of incentives and monitoring, with example being key performance indicators used by MTI and its statutory boards strongly linked to the attraction of capital investment and growth in value-added.

Given all these paradoxes embedded in the underlying economic development model and the institutional architecture in Singapore, ITP would be likewise constrained by these same paradoxes. On its own, it would have only limited capabilities to address them given that in itself ITP very much follows the same underlying growth-accounting inspired economic development logic and through ITMs is actually helping to further mainstream it.

Next, from the policy-level analysis further two constraints emerge as regards the capabilities of ITP: ITP coverage and the relation with existing fiscal industrial policy instruments. As regards ITP coverage, from the outset it has been declared that ITP shall not cover the whole economy. From available public information it is stated that ITP shall cover around 80% of Singapore GDP. This is an obvious further constraint given the fact that 20% (1/5) of economic activities shall not be influenced by ITP activities and the economic performance of those sectors cannot be attributed to ITP related actions.

Furthermore, ITP has been designed in parallel to the variety of existing instruments targeting the activities of companies – be it R&D incentives, productivity upgrading incentives, trade support and many others. Given that few additional resources have been designated to support industrial transformation in line with ITP and that ITP bodies have seemingly not been given mandate to directly oversee the design and implementation of the existing instruments, ITP would need to act somewhat in parallel to those existing instruments (or trying to influence them indirectly), but without the explicit capacity to align those instruments to realise ITP and ITMs goals.

Finally, when analysing ITP as an intervention, some limitations can be identified as regards its internal consistency or implicit assumptions. One notable issue that is evident from the outset is that there are few financial instruments that were declared to be directly linked to the implementation of the ITP. The budgetary announcements linked to ITP include top-ups to existing funds like national productivity fund, national research fund and several other funds as well as some seemingly self-standing programmes like automation support package and national robotics programme. Therefore

the financial fire-power of ITP is not fully clear. The withdrawal of the Productivity and Innovation Credit (PIC) will also likely have a further negative impact.

Furthermore, ITP as a programme has not been announced to have clear output targets. Rather each separate ITM would define targets relevant for the ITM. Without a consistent framework to estimate the cumulative effects of all ITMs together under a unified framework it is difficult to unearth the overall aims of the programme as well as to evaluate the outcomes – whether targets have been achieved or not. It is also then not possible to estimate what is the expected and actual contribution of the programme towards achieving those targets, as many other factors and actors influence them. Any evaluation is also further complicated by co-existence of numerous parallel policy instruments supporting companies to upgrade their productivity, workforce skills, research and development activities or trade links.

In addition, within each specific ITM, there is no explicit mechanism that would help to connect the different activities under each pillar of the ITM to the overall goals under each ITM, as outputs under each pillar is often set in a different framework than the targeted outcomes of the ITM. This would accordingly make it very difficult to identify which activities falling under specific pillars contributed to the achievement of ITM targets and what was the size of such contribution.

Overall, it is concluded that ITP is neither a usual market-specific interventions to support industrial transformation nor an umbrella program for such interventions. It is rather a type of governing intervention, with the explicit goals of enhancing inter-agency coordination and tripartite consultation at the industry and sectoral levels. It seems to have little explicit linkages to other financial, market-oriented industrial policy instruments deployed in Singapore. It could be argued, that the overall aim of such enhanced coordination could be to improve the knowledge and assessment of different investment options and therefore reduce their risks and correspondingly their costs. The investment opportunities falling under each of the pillar covered by ITP covers usually carries substantial uncertainty and risks – be it introduction of new technology, upgrading skills, investing in research and development or pursuing international expansion.

A particular potential weakness of the ITP is its capacity to address the needs of SMEs. For SMEs, especially those functioning at the non-tradable sectors and based on low-cost business models, there might be limited benefits from the areas where efficiency improvements are expected to be realised via ITP. Notably, SME's are often less interested in pursuing technological investment, skills upgrading, even less likely is their capacity to pursue R&D or internationalisation activities. For SMEs, often the primary concerns are access to finance with their limited collateral, increasing the efficiency of resource use, succession planning, modernisation of management and the overall business processes. Firm-level priorities might diverge from policy-level priorities, especially for SMEs.

Therefore, it might be assessed that even if ITP could potentially contribute to the industrial transformation process of Singapore, this contribution is likely to be far from sufficient to ensure the attainment of broad economic and productivity growth targets. It is furthermore likely to be very difficult, given existing evidence, even to estimate the level of contribution or if at all the programme by 2020 has contributed to the economic transformation.

Nevertheless, some (potentially positive) outcomes of ITP could be expected. This for example might include enhanced capacity to act for the lead statutory boards or other agencies that were delegated the responsibility for specific sectors. It might also somewhat improve the understanding within lead agencies about the situation in specific sectors thus enabling better policy targeting. It might provide some visibility if majority of industry-specific targets are achieved, even though the results of previous effort with the productivity roadmaps adopted in 2010/2011 were quite mixed with some industries

substantially over-performing while others substantially under-performing. The impact of ITP might be enhanced if indeed its coordination bodies and lead agencies are able to better alignment between industry needs and existing policy instruments.

Finally, it would be important to ensure the continuous effort of monitoring and reviewing ITMs. This could be achieved for example by requiring continuous monitoring; pursuing sectoral benchmarking with other developed countries to identify possible productivity bottlenecks and overall embedding more decision authority in ITP bodies.

7. Conclusions and Recommendations

As stated at the beginning of this paper, the purpose of this research project has been to analyse the capacity of Singapore's Industry Transformation Programme (ITP) to meet the expectations. A number of activities have been carried out to underpin the analysis, including a review of relevant research literature, analysis of publicly available documents about Singapore's ITP and industrial policy in general as well as a number of targeted interviews to understand better specific aspects of different elements of ITP and industrial as well as skills policy in Singapore more generally.

An important note to point out that analysis of expectations of a specific programme must enable clearly identifying what those expectations are. In the case of ITP, two elements can underpin the understanding of the expectations. Firstly, quantitatively, the overall goals as regards the rate of economic and productivity growth could be inferred from those set by strategic governing bodies in 2010 and later in 2017. More specifically, the economic growth targets for the overall economy are aimed to reach 3%-5% annually; with productivity growth being the key driver (aimed at around 2% annually). These economy-wide economic and productivity growth targets are then segmented into sector-specific targets. This include also targets for the Precision Engineering Industry, aiming i.e. at around 8% added-value growth and around 10% productivity growth annually (reaching around 178.000 SGD per employee, as set in the PE productivity roadmap in 2011), as well as creating 3000 new PMET jobs in the sector until 2020. Secondly, qualitatively, the expectations can be derived from the communicated purpose of the ITP – to improve the coordination capacity of public policy bodies, together with other stakeholders, in promoting economic restructuring.

As regards the capacity to realise expectations for quantitative growth, one basis for the assessment can be past efforts, including through the outcomes of 2011 productivity roadmaps, that also included precision engineering industry. Quantitative analysis for the overall ITP is complicated by the fact that there is no clear quantitative statement as regards the expected targets to be reached by the ITP – the only targets that are available at that level is the targets of the overall economic and productivity growth of the country; however, ITP does not cover the whole economy – sectors included in ITP represent around 80% of Singapore's GDP. It is also not clear, if the growth targets of all the sectors included in the ITP will cumulatively arrive at a joint growth figure corresponding/supporting the national economic growth targets. Still, historic growth rates, driven by capital-investment, could overall result in the expected rates of productivity growth at around 2%.

On the other hand, quantitative analysis at the sector-specific level is somewhat easier as there exists concrete targets for the Precision engineering industry. From that point of view, while the level of ambition has been retained the same for the sector as set in 2011, the results of the sector between 2010 and 2015 were substantially below these targets. Accordingly, unless there is a major additional drive and investment in the sector beyond the one realised between 2010 and 2015 and/or substantially changed industry dynamics nationally and internationally, it is not likely that those quantitative targets will be reached.

However, the most difficult part in the analysis of the capacity of a policy intervention/ programme to achieve expectations is the analysis of attribution, i.e. the impact that can be attributed exclusively to the specific intervention, while eliminating the effects of other interventions or actions and activities carrier out outside the realm of public policy or even outside the country altogether. Therefore, even if trend analysis of statistical indicators would indicate that the targets are likely to be achieved, it must be clear how and to what extent the specific policy intervention contributed to reaching those targets.

After the analysis of the industrial policy context in Singapore a conclusion is drawn that the ITP/ITM(s), while having the potential to contribute in helping realise the specific policy goals, will not be sufficient on their own to ensure the attainment of those targets. This conclusion is drawn from several specific assumptions, based on the evidence collected in the report:

- The largest financial instruments, supporting industrial transformation are market-based and thus horizontal in their nature, as opposed to the sectoral nature of ITP;
- ITP/ITM carries few additional financial commitments from the government to be invested in the economy beyond what is already existing since 2010 or even before;
- ITP/ITM is in essence a "governing" intervention, aiming to change (improve) the coordination among existing actors and/or re-distribute decision-making power. The benefits of such intervention are limited to efficiency gains, which are often small and realised in a very gradual (incremental) manner, with substantial time lags.

The research task also included a question of which are the main gaps as regards the capacity of this specific type of intervention to realise expected outcomes. The key gap can be concluded to be a disconnection between the instruments available to be deployed and their size (mostly limited to coordination activities) as part of the intervention, compared to the level of expected outcomes (assumed to be sectoral/national economic growth targets). At the same time, the intervention is likely to bring some positive impact, but the size of the impact can be expected to be limited, in proportion to the resources deployed, which, as argued before, are rather modest.

These conclusions, it must be kept in mind, cover only the industry transformation programme, but does not fully assess the impact of overall industrial policy in Singapore which includes many policy instruments besides ITP. The existing (and often long-standing) instruments promoting in different ways the industrial transformation are quite substantial in their scope, are rather broad and diverse in their nature, covering majority of areas of industrial policy as discussed in the literature – including land-use; access to financing; international development; competition; intellectual property; ecosystem supporting local innovators and start-ups and attracting those from abroad and many others. Thus it might even be speculated, that policy intervention like ITP might have other purposes and/or a way to improve analytical and information gathering activities of the public sector agencies, rather than being an industrial policy intervention in its essence.

Furthermore, the research tasks included an aim to identify possible ways how to improve the capacity of these (or similar) policy instruments to generate impact. Therefore, a list of tentative recommendations are provided below that could be useful.

Recommendation 1: clarify the actual level of impact that a policy intervention is expected to achieve. As an example, for ITP/ITMs, a forecast could be done to assess trends with business-as-usual assumptions and then developing scenario(s) as regards possible intervention(s) and their attribution to the outcomes beyond business-as-usual scenario.

Recommendation 2: for policy learning, develop an ITP monitoring framework and evaluation strategy, that would collect and present in an easy-to-analyse manner the key parameters of all the ITMs adopted, included value-added, productivity, manpower (R&F and PMET), the size of investment and it's outputs/outcomes (like investment commitments), to the extent possible disaggregated at a sub-sector level, capturing also the qualitative element of the intervention.

Recommendation 3: evaluate the methodology behind key performance indicators used in Singapore, i.e. investment commitments, incremental VA commitments, job commitments and their links to the macro-level indicators (growth of value-added; growth of employment).

Recommendation 4: further develop the understanding of the impact of policy measures at micro and (cumulative) macro levels, notably the scope, reach and impact of financial public sector investment (grants; discounted loans; tax incentives), including the number and type of beneficiaries (employment, turnover, value-added), the distribution of public financial investment across beneficiaries and their impact, that could lead to the capacity to monitor the committed and realised outcomes at an aggregate (sector, economy) level.

Recommendation 5: improve the monitoring of manpower flows – in and out of the labour market as well as across sectors, improving the capacity to identify manpower/skills gaps.

Recommendation 6: improve the capacity to account-for intangible investment (including investment in skills) in national accounts and growth accounting framework, thus revealing part of the residual multi-factor productivity.

Recommendation 7: given very high levels of investment in Singapore and specific labour market structure, pursue better understanding on the efficiency of factor markets in Singapore (notably capital and labour) as well as monitor if diminishing returns to capital investment are becoming more evident given lower-growth economic environment in the last decade.

Recommendation 8: to ensure ITP sustainability, embed more decision power as regards distribution of financial resources in ITP bodies as well as ensure continuous analytical capability and monitoring task for the ITP secretariat.

Recommendation 9: finally, pursue more detailed sector-specific benchmarking and carry out case-studies to identify bottlenecks for productivity growth.

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Annex I. Correspondence tables between SSIC, ISIC and NACE for Precision Engineering industry (Please see explanatory notes at the end of table)

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
Complex equipment	Semi-conductor	2827	Manufacture and Repair of Semiconductor Related Equipment	Part of*	2829	Manufacture of other special-purpose machinery	2899	Manufacture of other special-purpose machinery n.e.c. (including manufacture of semi-conductor related equipment)
	Test & Measurement	2651	Manufacture and Repair of Measuring, Testing, Navigating and Control Equipment	Equals*	2651	Manufacture of measuring, testing, navigating and control equipment	2651	Manufacture of instruments and appliances for measuring, testing and navigation
		2652	Manufacture of Watches and Clocks	Equals	2652	Manufacture of watches and clocks	2652	Manufacture of watches and clocks
	Other complex equipment	2816	Manufacture and Repair of Lifting and Handling Equipment	Equals*	2816	Manufacture of lifting and handling equipment	2822	Manufacture of liftng and handling equipment
		2819	Manufacture and Repair of Other General Purpose Machinery (including 28191 - Manufacture and repair of refrigerating, air-conditioning and ventilating machinery and equipment except household refrigerators	Covers*	2818	Manufacture of power-driven hand tools	2824	Manufacture of power-driven hand tools
					2819	Manufacture of other general-purpose machinery	2829	Manufacture of other general-purpose machinery n.e.c.
							2825	Manufacture of non-domestic cooling and ventillation equipment
		2821	Manufacture and Repair of Agricultural and Forestry Machinery	Equals*	2821	Manufacture of agricultural and forestry machinery	2830	Manufacture of agricultural and forestry machinery

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
		2822	Manufacture and Repair of Metal-Forming Machinery and Machine Tools	Covers*	2822	Manufacture of metal-forming machinery and machine tools	2841	Manufacture of metal-forming machinery
							2842	Manufacture of other machine tools
					2823	Manufacture of machinery for metallurgy	2891	Manufacture of machinery for metallurgy
		2825	Manufacture and Repair of Machinery for Food, Beverage and Tobacco Processing	Equals*	2825	Manufacture of Machinery for Food, Beverage and Tobacco Processing	2893	Manufacture and Repair of Machinery for Food, Beverage and Tobacco Processing
		2826	Manufacture and Repair of Machinery for Textile, Apparel and Leather Production	Equals*	2826	Manufacture of machinery for textile, apparel and leather production	2894	Manufacture of machinery for textile, apparel and leather production
		2829	Manufacture and Repair of Other Special Purpose Machinery	Equals* / Covers	2829	Manufacture of other special-purpose machinery	2899	Manufacture of other special-purpose machinery n.e.c.
							2895	Manufacture of machinery for paper and paper board production
							2896	Manufacture of plastic and rubber machinery
		2830	Installation of Industrial Machinery and Equipment	Equals*	2830	Installation of Industrial Machinery and Equipment	3320	Installation of Industrial Machinery and Equipment
Component OEMs	Laser & Optics	2670	Manufacture of Optical Instruments and Photographic Equipment	Equals	2670	Manufacture of optical instruments and photographic equipment	2670	Manufacture of optical instruments and photographic equipment

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
	Other Component OEMs	2513	Manufacture and Repair of Steam Generators except Central Heating Hot Water Boilers	Equals*	2513	Manufacture of steam generators, except central heating hot water boilers	2530	Manufacture of steam generators, except central heating hot water boilers
		2710	Manufacture and Repair of Electric Motors, Generators, Transformers, Electricity Distribution and Control Apparatus	Equals* / Covers	2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	*271*	*Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus*
		2732	Manufacture of Electronic and Electric Wires and Cables	Covers	2731	Manufacture of fibre optic cables	2731	Manufacture of fibre optic cables
					2732	Manufacture of other electronic and electric wires and cables	2732	Manufacture of other electronic and electric wires and cables
		2733	Manufacture and Repair of Wiring Devices	Equals*	2733	Manufacture of wiring devices	2733	Manufacture of wiring devices
		2811	Manufacture and Repair of Engines, Turbines except Aircraft, Vehicle and Cycle Engines	Equals*	2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
		2812	Manufacture and Repair of Pumps, Compressors, Taps and Valves	Covers*	2812	Manufacture of fluid power equipment	2812	Manufacture of fluid power equipment
					2813	Manufacture of other pumps, compressors, taps and valves	2813	Manufacture of other pumps and compressors
							2814	Manufacture of other taps and valves
Other PE	Plastics	2221	Manufacture of Plastic Products except Plastic Footwear and Toys	Part of	2220	Manufacture of plastics products	*222*	Manufacture of plastics products

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
		2222	Plastic Product Services	Part of			2221	Manufacture of plastic plates, sheets, tubes and profiles
							2222	Manufacture of plastic packing goods
							2223	Manufacture of builders' ware of plastic
							2229	Manufacture of other plastic products
	Other PE except plastics	2219	Manufacture of Other Rubber Products except Rubber Footwear and Toys (excludes processing of natural rubber)	Part of	2219	Manufacture of other rubber products (includes processing of natural rubber)	2219	Manufacture of other rubber products (includes processing of natural rubber)
		2511	Manufacture of Structural Metal Products	Equals	2511	Manufacture of structural metal products	*251*	*Manufacture of structural metal products*
		2591	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	Equals	2591	Forging, Pressing, Stamping and Roll-Forming of Metal; Powder Metallurgy	2550	Forging, pressing, stamping and roll-forming of metal; powder metallurgy
		2592	Treatment and Coating of Metals	Equals (?)	2592	Treatment and coating of metals; machining	*256*	*Treatment and coating of metals; machining*
							2561	Treatment and coating of metals
							2562	Machining
		2593	Manufacture of Cutlery, Hand Tools and General Hardware	Equals	2593	Manufacture of cutlery, hand tools and general hardware	257	*Manufacture of cutlery, tools and general hardware*
							2571	Manufacture of cutlery

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
							2572	Manufacture of locks and hinges
							2573	Manufacture of tools
		2594	Manufacture of Metal Wire and Cable Products	Part of	2599	Manufacture of other fabricated metal products nec	*259*	*Manufacture of other fabricated metal products*
		2595	Manufacture of Metal Cans, Containers and Related Products	Part of				
		2599	Manufacture of Other Fabricated Metal Products nec	Part of				
		2814	Manufacture of Bearings, Gears, Gearing and Driving Elements (including repair)	Equals*	2814	Manufacture of bearings, gears, gearing and driving elements	2815	Manufacture of bearings, gears, gearing and driving elements
		2815	Manufacture and Repair of Ovens, Furnaces and Furnace Burners (including repair)	Equals*	2815	Manufacture of ovens, furnaces and furnace burners	2821	Manufacture of ovens, furnaces and furnace burners
		2816	Manufacture and Repair of Lifting and Handling Equipment *(double counting with complex equipment)*	Equals*	2816	Manufacture of lifting and handling equipment	2822	Manufacture of liftng and handling equipment
***Repair**		n/a	Repair of fabricated metal products (25) - combined in SSIC but separate in ISIC and NACE; therefore coverage is different (2513 in Component OEMs, 2511, 2591,		3311	Repair of fabricated metal products (whole of 25)	3311	Repair of fabricated metal products (whole of 25 - Manufacture of fabricated metal products, except machinery and equipment)

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
			2592, 2593, 2594, 2595, 2599 in other PE, rest excluded)					
		n/a	Repair of electronic and optical equipment (26)- combined in SSIC but separate in ISIC and NACE; therefore coverage is different (2651, 2652 in Complex equipment, 2670 in Component OEMs, rest excluded)	*Different	3313	Repair of electronic and optical equipment (whole of 26)	3313	Repair of electronic and optical equipment (whole of 26 - Manufacture of computer, electronic and optical products)
		n/a	Repair of electric equipment (27) - combined in SSIC but separate in ISIC and NACE; therefore coverage is different (2710, 2732 2733 in Component OEMs, rest excluded)	*Different	3314	Repair of electrical equipment (whole of 27)	3314	Repair of electrical equipment (whole of 27 - manufacture of electrical equipment)

Broad sectors	Growth sectors	SSIC code	SSIC name (Singapore Standard Industrial Classification)	Relation	ISIC code	ISIC name (International Standard Industrial Classification)	NACE code	NACE name
		n/a	Repair of machinery (28)- combined in SSIC but separate in ISIC and NACE; therefore coverage is different (2824 excluded; 2816, 2819, 2821, 2822, 2825, 2826, 2829 - in Complex equipment; 2811, 2812 - in Component OEMs; 2814, 2815, 2816 in other PE)	*Different	3312	Repair of machinery (whole of 28)	3312	Repair of machinery (whole of 28 - Manufacture of machinery and equipment n.e.c.)

Reading note: the asterisk and text indicated in red marks differences between corresponding categories in different classifications. A particular difference is the treatment of repair activities, which in SSIC is presented in combination with the production activities of the corresponding sector, while in other classifications it is presented as a distinct activity. Relation “covers” indicates that in SSIC the category is broader, while “part of” that the category is narrower as compared to the corresponding sectors in other classifications.