



Singapore's semiconductor industry is a fine example of public R&D investment paying off in multiple ways for society and the economy. PHOTO: BLOOMBERG

The many valuable returns of R&D investments

The importance of science and talent for Singapore cannot be understated, as they form the bedrock upon which impact is created and delivered. BY TAN SZE WEE

LOCAL industrial output has been tepid for some quarters, reflecting weak external demand. Just about the sole bright spark comes from the electronics sector, which has managed a near-9 per cent growth in the first eight months of 2016, propped up by the semiconductor industry. The local semiconductor industry is a fine example of public research-and-development (R&D) investment paying off in multiple ways for society and the economy.

In the early days, Singapore attracted foreign players in the electronics industry by offering incentives and cheap labour. We were mere recipients of foreign direct investment (FDI), because we did not have an active R&D ecosystem then. But over time, through strategic investments in science and engineering, we have evolved to become active participants and partners within a developed research ecosystem. This has allowed us to attract some of the best semiconductor companies here.

A case in point: US-based Applied Materials, one of the world's largest semiconductor manufacturing equipment and solutions companies, announced on Sept 19 that it is extending its research collaboration with the Institute of Microelectronics (IME) by five years. IME is a research institute led by the Agency for Science, Technology and Research (A*STAR). The combined investment of this partnership is expected to reach around \$5190 million, and will expand the R&D scope of fan-out wafer-level packaging which has the potential to make chips and devices more compact, and operate more efficiently.

A*STAR and Applied Materials' partnership started in 2011, when a Centre of Excellence in Advanced Packaging was initiated with IME. Last October, Applied Materials announced another joint lab with three A*STAR research institutes for advanced semiconductor technology. The products developed through this collaboration will eventually be manufactured and sold from Applied Materials' Singapore hub, contributing to local factory output.

Over the years, the success of the

Centre of Excellence attracted similar collaborations with more industry partners to deepen R&D activities in Singapore. These took the form of four joint semiconductor R&D labs in other areas such as metrology, assembly and lithography, with 10 other companies including Dai Nippon Printing, KLA-Tencor, Nikon, and Tokyo Electronics, representing an investment of around \$5200 million.

Local small and medium-sized enterprises (SMEs) currently provide the support to MNC players like Applied Materials here, but they can also adapt some of these new innovative technologies for their own growth. This allows us to lay the foundation for a vibrant startup environment of our own, where knowledge is transferred to local companies. In this way, over time, new local businesses can be created, new revenue streams and jobs can be gener-

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ated, and GDP growth will increase.

Based on data from the Economic Development Board (EDB), manufacturing output for the electronics cluster increased from \$574 billion to \$582 billion over the decade from 2004. From modest beginnings, we can see how attempts to anchor high-value manufacturing activities for the semiconductor industry through R&D in Singapore have paid off handsomely.

MAKING RESEARCH DOLLARS WORK

Governments across the world constantly try to quantify the return on investment for their spending on research. Traditionally, output indicators of R&D activities include papers, patents and bibliographies.

Based on these matrices, Singapore has risen up the international innovation rankings. According to the latest Global Innovation Index, Singapore is now the sixth most innovative economy in the world, surpassing Germany and South Korea.

Beyond such rankings, the socioeconomic impact of R&D activities can also be measured by tangible examples like Singapore's current sizeable and well-developed electronics industry. To further translate R&D into impact, public sector research performers like A*STAR have to develop other innovation capital such as licences, startups, industry projects, technology adoption by local companies, and opportunities in emerging industries for Singapore.

Some other prominent outcomes of A*STAR's work stem from the Urban Computing and Engineering Centre of Excellence (CoE), the result of a public-private partnership between A*STAR, Fujitsu and Singapore Management University (SMU). In line with Singapore's Smart Nation initiatives, its goal is to understand the island's complex city dynamics, and turn it into a "living lab" where analytics and computational social sciences are used to test-bed next-generation solutions for heavily urbanised cities.

Through the CoE, and with live data and high-performance computing capabilities, the solution-provider Fujitsu and end-users (for instance, transport-related agencies and shopping malls) are brought together on a single platform to work on real-world problems of bustling cities.

As Singapore maintains its position as a financial hub, A*STAR is also playing its part in facilitating the financial technology (fintech) push. DBS recently announced it will be working with A*STAR's Institute for Infocomm Research (I2R), and data management and analytic platform provider Cloudera to detect fraudulent transactions through big data analytics. DBS and I2R set up a joint lab in 2014 to develop innovative banking products and services.

And to facilitate the growth of Singapore's precision engineering sector, A*STAR launched the Advanced Remanufacturing and Technology Centre (ARTC) in

2015. Asia's first centre for road-testing and developing sustainable remanufacturing technologies, ARTC is a public-private collaboration between A*STAR, Nanyang Technological University (NTU) and industry partners. To date, ARTC has 42 members, with heavyweights such as Rolls-Royce, IHI, Siemens Industry Software, and Singapore Aero Engine Services Pte Ltd as key partners. The centre focuses on five technology themes: repair and restoration, surface enhancement, product verification, robotics, and industrial 3D-printing. One of ARTC's collaborations with Rolls-Royce involves the joint development of a suite of manufacturing and repair capabilities for aerospace, land and sea components.

So, apart from the traditional innovation matrices, the positive outcomes of investment in R&D should also be tracked via innovation capital that results in multi-dimensional outcomes for society, such as a more sophisticated R&D environment and quality jobs for Singaporeans, as well as new products and services co-created with the public sector.

LOOKING AHEAD

The public sector therefore needs to support this ecosystem by creating the talent base to feed these new R&D groups, and support the new capabilities they want to build.

But we must think holistically. This means considering total manpower needs, education requirements, and the demographics of the current workforce. How do we re-skill and re-tool an ageing population? We need to project the resources we need to continue growth, and the policies and regulations that might have to be reviewed to make ourselves more nimble.

When we talk about manpower, we also need to think beyond researchers. A lot of blue-sky research will just stay on the bench, unexploited, if we do not have people who can translate and interpret it into meaningful outcomes. Therefore, we need "innovation brokers" who can communicate with, and link scientists to, companies. This is a nascent area where there is a shortage of talent. I believe if we develop this area, we can overcome the limitations of our small size.

The government's five-year Research Innovation and Enterprise 2020 journey holds exciting and numerous opportunities for A*STAR to create an impact and make a difference to the country. The importance of science and talent for Singapore cannot be understated, as they form the bedrock upon which impact is created and delivered.

We must continue to be mission-driven, creating economic value for Singapore with increased attention on growing our local companies and boosting their competitiveness. The science that we do has to result in economic outcomes, and more. Our capabilities can also be applied to address national priorities such as developing solutions for our ageing population.

And this is really where, as an R&D agency, we play a role in moulding the vision for Singapore's future.

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