VERTICAL INDUSTRY DEVELOPMENT TO LEVERAGE INNOVATION

A MODEL FOR LEAPFROGGING TECHNOLOGY AND DRIVING COMPETITIVENESS

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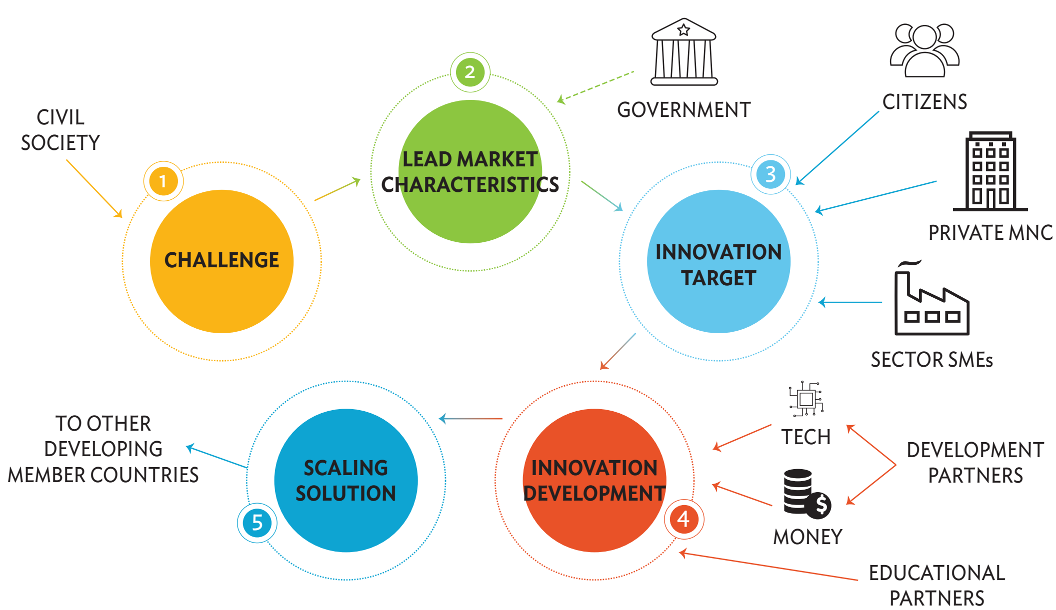
INTRODUCTION

Innovation is key for developing countries to escape the middle-income trap, for multiple reasons. First, labor-saving technologies and World Trade Organization rules restrict the ability of developing countries to pursue growth led by exports and fueled by low labor costs (ADB 2019). Second, the harmonization of trade rules increases competition in sectors where competencies are widely distributed and reinforces leading positions of countries with highly specialized sectors, such as the software industry in India, the automobile industry in Germany, or the soccer ball industry in Pakistan (Rodrik 2007). Third, countries that move from low to middle to high income are, on average, without a dedicated effort to innovate and late in developing a high level of specialization, which inhibits their ability to become competitive in global markets (Imbs and Wacziarg 2003).

In consequence, some have recently questioned whether traditional mechanisms to develop national innovation systems, such as structural reforms and investments in research and development (R&D), are enough to break out of the middle-income trap (Rodrik 2007). Structural reforms and other horizontal development mechanisms have long time lags from implementation to benefits for the national economy, and the benefits might never materialize (Rodrik 2007). This paper proposes a *vertical industry development (VID)* model (Figure 1) which can be applied to create, shape, and promote specific industries. By building on four case studies, we identify key success criteria and suggestions for process, tools, and governance. Success criteria include flexible investments, problem-centricity, lead-market characteristics, and active ecosystem governance.

These success criteria can help overcome natural barriers to industrialization that result from market imperfections in low-income countries, where, for example, firms cannot sufficiently rely on learning

Figure 1: Vertical Industry Development Model



MNC = multinational corporation, SMEs = small and medium-sized enterprises.

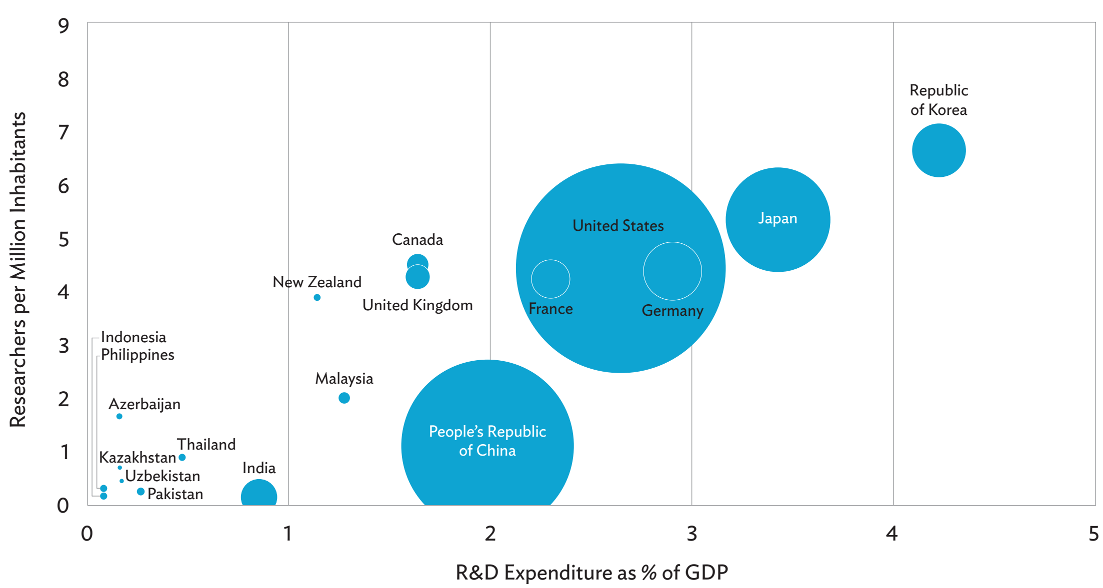
Source: Authors.

by doing: they fail too fast and such learning is therefore external to individual firms and cannot be internalized properly because of the market structure (Matsuyama 1992). Similarly, low-income markets provide insufficient opportunities to learn about the cost structures required to succeed, which differ for incumbents and for later entrants (Hausmann and Rodrik 2003). Research suggests that propagation of modern, nontraditional industry development activities requires government agencies to be willing and able to experiment with new policies, and needs coordination across public and private actors (Rodrik 2007).

INDONESIA: NEEDS AND CHALLENGES OF A MIDDLE-INCOME COUNTRY

Indonesia has experienced stable economic growth of 4.9%–5.3% in the last 14 quarters (World Bank 2019). However, even higher and faster growth is needed to enable Indonesia to become a high-income country. The gap between needed and historical labor productivity growth is large (McKinsey 2012). Innovation can be expected to play an important role in improving the competitiveness of companies, particularly small and medium-sized enterprises (SMEs), which can benefit the most from upgrading their production technologies (Zainurossalamia, Setyadi, and Rusmilawati 2016). Traditionally, Indonesia's R&D spending has been low and still ranks lowest among all countries assessed in the recent United Nations Educational, Scientific and Cultural Organization (UNESCO) study on main indicators, such as R&D spending as a percentage of gross domestic product and number of researchers per million inhabitants (UNESCO 2018) (Figure 2).

Figure 2: Research and Development Spending



GDP = gross domestic product, R&D = research and development.

Source: UNESCO Institute for Statistics. How much does your country invest in R&D.

When a country joins the innovation race from a relatively weak position, the prospect of catching up with highly developed economies might be slim, particularly if the aim is to transform the entire economy. In contrast, the chances are much higher of catching up with and surpassing spending focused on a specific vertical sector. Even developing multiple internationally competitive verticals may be in reach. A good example of a vertical in Indonesia is its aircraft industry. Before the 1997 Asian financial crisis, it supplied major jetliner makers such as Boeing and Airbus. Yet, according to Chairil (2019), even though manufacturers such as Dirgantara Indonesia and Regio Aviasi Industri are expanding, they struggle to take off. Issues with "refurbishing" this industry are partly related to difficulties of certification, intellectual property, poor maintenance because of a lack of supporting industries, and a lack of human resources. Such a systemic challenge requires a systemic response that involves orchestrating stakeholders to form new value chains. As Chairil (2019) argues, "[T]o promote its aviation industry, the government also needs to establish the aircraft industry ecosystem to improve maintenance and ensure safety on its planes."

Another promising development is the makers movement, which is gaining momentum. Unlike in developed countries, the economics of small-scale production in developing countries are extremely different, offering novel business models for small producers working from makerspaces (Silva 2019). Makerspaces allow access to tools and training that can be leveraged to enable a large part of the population to engage in innovation, testing novel ideas, developing prototypes, and experimenting with business models. Makerspaces can catalyze nurturing new industry verticals and develop skills necessary for future scaling.

Indonesia's strategy is to pursue a more inclusive economic growth model by increasing productivity, improving efficiency, and including SMEs in innovation capacity-building measures (G20 2016). In particular, modern industry policy can help catalyze and direct innovation efforts from the private sector and achieve superior growth rates if applied correctly (ADB 2019). Modern industry policy proposes a set of intelligent interventions from the government to overcome specific market failures and prioritize specific sectors (Felipe 2015, Larrue and Guellec 2018). Our VID model builds on the core idea of smart and specific government intervention to promote growth and welfare.

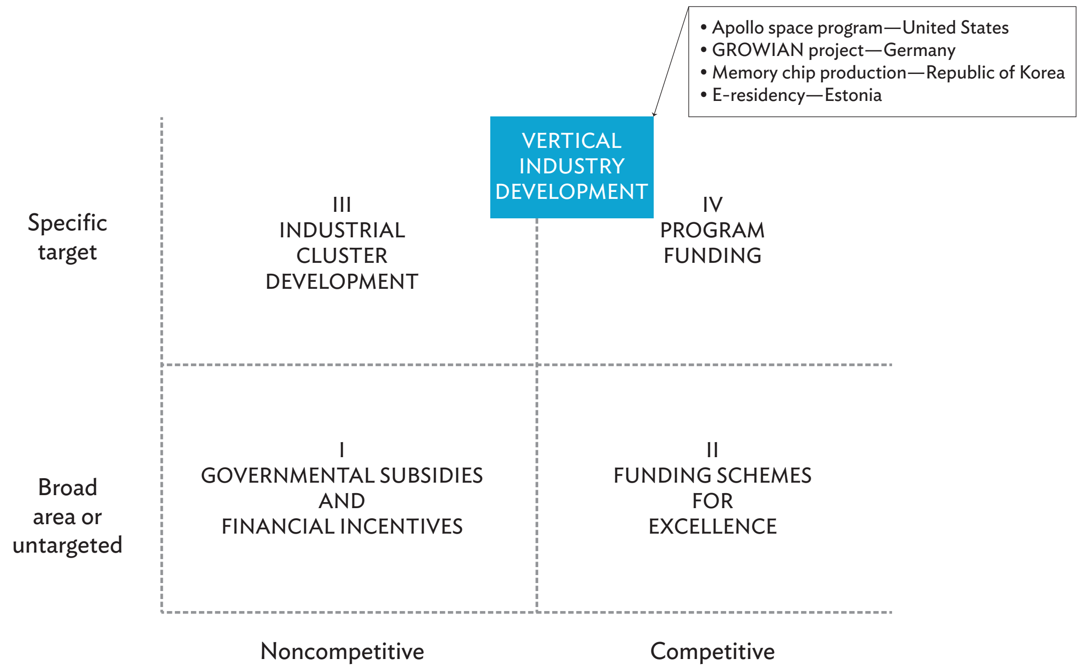
INNOVATION FOR GROWTH AND GLOBAL COMPETITIVENESS

Many countries see innovation as key for economic growth and, consequently, global spending on R&D and innovation capabilities reached a record high of almost $1.7 trillion in 2018 (UNESCO 2018) (Figure 2). How such investments are made differs significantly and results in different outcomes (Figure 3). While rich countries can afford a wide portfolio of development support mechanisms, more financially constrained economies should apply a more focused approach, directing development efforts toward prioritized action fields.

Research and innovation funding is allocated in different ways and often influenced by national innovation systems (Larrue and Guellec 2018). Traditionally, the main distinction was made between *competitive* and *noncompetitive* funding mechanisms.

Competitive funding mechanisms allocate funding, typically by funding agencies, councils, or ministries, based on a formal competition or selection based on the application. Noncompetitive funding mechanisms not only include annual allocations to universities and public research institutes but also tax breaks or other subsidies for institutions and companies that conduct research. However, these

Figure 3: Four Ways to Promote National Innovation Systems



Source: Authors.

mechanisms are often overly focused on supporting existing industries at the national level and not sufficiently on new industries and markets. It is, however, in those markets where new entrants from developing countries have the biggest chance to build competitive positions.

Recently, national funding bodies have become more active in allocating funding, directing funds for strategic priorities to specific areas (e.g., biotechnology) or even to specific targets (e.g., bringing internet connectivity to rural areas). We can thus make a second distinction between *broad-area* or *untargeted* funding and funding that is aimed at *specific targets* or *designated challenges*.

Traditional funding allocated to broad areas following noncompetitive schemes is losing importance as many countries grow impatient waiting for structural benefits and for the economy to produce results in areas where innovation is most needed (Larrue and Guellec 2018). In Europe, the smart specialization strategy allocates €67 billion to support regions that have identified their strengths and comparative assets, specialized in a competitive area, and created clear and shared innovation visions (European Commission 2018).

Traditional funding, particularly for developing countries, has failed to enable leapfrogging, i.e., surpassing dominant countries by investing in future technology generation rather than competing in the current one (ADB 2019). Such leapfrogging has, however, been applied successfully in the Republic of Korea (ROK) to capture a dominant position in selected areas in the semiconductor market. In countries of the Organisation for Economic Co-operation and Development (OECD), other strategies are gaining ground. Broad-area, competitive schemes are receiving increased attention. Of the 51 OECD countries, 31 (61%) report having initiatives based on "excellence funding schemes" that allow them to allocate large-scale and long-term funding to initiatives that are or aim to become internationally outstanding (Larrue and Guellec 2018). The principal advantage is to further strengthen already-leading clusters in a variety of regional areas. Excellence funding sources include the European Research Council, which has contributed to breakthroughs in scientific domains such as life sciences, social sciences and humanities, and physical sciences and engineering (European Research Council 2018). Excellence funding schemes are, however, more useful to drive early-stage technology developments and are less relevant for developing countries that need to speed up innovation and impact.

Recently, recognition of the importance of the United Nations Sustainable Development Goals has led to a proliferation of targeted research funding through projects, thematic research units, and national research programs. While governments aim to further promote specific desired impacts, they are starting to experiment with reengaging in governance of innovation projects and programs, blurring the line between purely noncompetitive and competitive allocation models, and entering the space of modern industry policy (Rodrik 2007). These schemes have historical roots in projects such as the Apollo space program in the United States (US) or memory chip industry development in the ROK.

Next, we discuss implications of four successful industry development cases for developing a VID model. The cases were chosen based on their focus on specific industries or challenges and their competitive nature. All four cases are well documented, which allowed a deep analysis leveraging extensive archival data to research the nature of exploration, success criteria, and difficulties of and lessons learned in each case.

CASES ON VERTICAL INDUSTRY DEVELOPMENT

For developing countries, a competitive focused strategy within the broader framework of modern industry policy is worth considering. Such strategies proved successful nationally by, for example, combining industry policy, supporting government R&D programs, and creating an innovation ecosystem in one particular sector. One such case is the ROK, which evolved from being a supplier to becoming the world leader in memory chip production. The chaebols[1] coordinated the governance (Kang 2010) that allowed them to leverage the industry's specific technology innovation characteristics and enabled markets to grow exponentially. Triggered by the initial foreign direct investment, the ROK was able to acquire key technology knowledge from overseas. In the second phase, the ROK leveraged these technologies to build a new industry in a coordinated way. The winning formula was leveraging local market characteristics; building on the tight coordination between state and firms; and forcing leading companies such as Samsung, Hyundai, and Goldstar into a competition to win the race to new technology generation (Kim 1998).

The strategy of forced competition also worked successfully for the GROWIAN project, when the Government of Germany attempted to reduce dependence on fossil fuels and energy imports. It handed this challenge to three leading companies, which were led by MAN Group.[2] Funded directly by the Ministry of Education and Research, GROWIAN resulted in erecting the first large-scale wind energy turbine, ultimately resulting in a globally leading position for the wind energy industries of Germany and Denmark, which, even after 40 years, have not lost their superior position. The GROWIAN case

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[1] The word "chaebol" is a combination of the Korean words *chae* (wealth) and *bol* (clan or clique). The ROK's chaebols are family-owned businesses that typically have subsidiaries across diverse industries (Kang 2010).

[2] German mechanical engineering company and a subsidiary of automaker Volkswagen AG.

illustrates the innovative power that can be unleashed if leading industry firms pursue highly ambitious goals (Frankfurter Allgemeine 2013, Pulczynski 1991).

Both cases did not define upfront the funding program but employed the strategy of flexible investment decisions across multiple stages. It allowed the government and the private companies to learn in parallel how the industry can and should be developed. In such a scheme, subsequent funding rounds can be conditioned on feasibility and market adoption feedback, both positive and negative, leveraging lean approaches, where minimum viable solutions generate early market feedback and enable fast iterations. Projects can, for example, at first be financed for 6–12 months and, based on the results, have the opportunity to pivot and apply for the second stage of funding adapted to their needs. Metrics in this process should be project specific and designed to reduce uncertainties (i.e., number of signed letters of intention from potential clients to use technology, local partners' interest even before the solution is implemented).

Prior cases demonstrate that leapfrogging is enabled and stabilized through demand-side government support (tax breaks, subsidies, or direct demand from the government). For example, in Singapore one government agency is coordinating efforts to develop automotive vehicles (KPMG 2019). The agency develops and applies a flexible regulatory framework. The successful elements of the regulation become permanent and the others are further developed. Supportive and proactive regulatory frameworks should be established to create an important lead-market advantage, which supports local companies and attracts leading international companies. In schemes to promote new energy systems, governments often take the role of first customer to create a market from the beginning. Similar approaches are now often implemented by large private companies that want to nurture new markets through start-up investments. BMW, the car manufacturer, pioneered this approach in its Startup Garage, where it gives business to the startups from the beginning, with initial contracts of €50,000–€200,000.

Verticals are often motivated by precise problems or challenges such as in the Apollo project, which aimed to land humans on the moon. These challenges are linked to clear high-level visions, which can be built by leveraging strategic foresight tools at the organizational, national, and global levels.[3] To enable leapfrogging, planning for industry development needs to start with a clear understanding of what the target industry will look like in the future and how a national innovation system needs to be structured to create a leading position.

The practice of starting strategic planning in the future and then planning backward has a strong tradition in leading private sector companies. Such practices are also known as corporate foresight. The leading companies in corporate foresight enjoy superior profitability and growth because they regularly strive to be ahead of the curve in developing and exploiting new markets (Rohrbeck and Kum 2018). Similarly, the ROK's success in the memory chip industry was driven by the clear vision that the new technology would allow redistributing power in the value network and enable private sector actors to leapfrog and displace the incumbents from Western countries. Despite many obstacles and extremely high costs involved, the Apollo project achieved its mission and resulted in many scientific breakthroughs in different disciplines, creating a new market in space technology. The project also led to the development of new materials and technologies, sparking digital innovations in the US and, subsequently, to a huge appetite to found

[3] Many developed and developing countries successfully leverage strategic foresight to anticipate their future and guide their investments. For instance, the APEC Centre for Technological Foresight was established in 1989 to promote cooperation among its members. Finland, Malaysia, the Republic of Korea (ROK), Singapore, and Thailand, among others, use foresight. Finland even has open foresight networks; anyone can attend their monthly meetings online, leading to a continuous foresight practice.

and fund tech-based ventures. **This challenge energized a whole generation of tech entrepreneurs** (Andrews 2016, NASA 2007).

Finally, **the "price" needs to be sufficiently high and/or the entry barriers sufficiently low to attract the best innovators**. Open innovation tools can promote learning and provide frameworks to adjust to changing circumstances by enabling the involvement of larger crowds. The case of e-residency in Estonia is a good example of this. After the fall of the Soviet Union, the government invested in digitalizing the public sector. This led to the e-residency program, where anyone can register and operate their business online and avoid the burden of long bureaucratic processes. It was not just a good "marketing" strategy for a country but also created jobs and generated tax revenue (Patricolo 2017, Pickup 2018, e-estonia.com 2019).

VERTICAL INDUSTRY DEVELOPMENT: A FIVE-STEP MODEL

In all four cases, we see industry verticals emerge. In some cases, competitive advantage has lasted decades, illustrating both the appeal of proactive vertical development and the hopelessness of attempting to catch up with the leading regions, countries, or clusters. All cases have created spillover effects to other industries.

The Apollo program, with its demand for the latest computer technology for solving complex mathematical problems, has led to US dominance in hardware and software development.

The ROK's push for global leadership in the memory chip industry has helped the country become the lead market for advanced information and communication technology.

The digitalization push in Estonia has placed Tallinn firmly on the map as a center of excellence in cybersecurity, so much so that it hosts the NATO Cooperative Cyber Defence Center of Excellence. Some of the success factors that allowed the government to set up for growth are related to the openness and liberal attitude toward external partners. With its traditionally highly competitive polytechnical education, the country is a skill-based lead market. The careful assessment and subsequent leveraging of lead-market characteristics are an important source of lasting competitive advantages (Beise 2004).

For many young well-educated Estonians, a career as a software engineer is attainable because of their internationally highly competitive education in mathematics, and is attractive as that education opens career opportunities in well-paid positions in Estonia and abroad. The simple and transparent tax system and well-focused enterprise support system that offer a variety of resources for SMEs have further promoted the capacity of the national innovation system (Ratso 2005).

From the case studies, we have identified five steps through which industry verticals can be developed systematically. Private sector firms are using similar problem-centric development models when developing and entering new markets. The five steps are (i) identifying and anticipating challenges to be tackled, (ii) understanding lead-market characteristics, (iii) designing innovative solutions for lead markets, (iv) developing innovations, and (v) scaling solutions (Figure 1). Throughout the process, leveraging various stakeholders is key for success. Successful VID initiatives not only leverage the education, government, and private sector but also involve citizens, development partners, and civil society.

VID can be further advanced by leveraging foresight, modern information technology tools, and agile innovation platforms. Such tools can drastically reduce communication and transaction costs, thanks to digital technologies, and increase the impact of investments. Broadening access to knowledge creates additional opportunities to strengthen the role of a developing country such as Indonesia and leverage skills and expertise available elsewhere.

Today, open innovation tools together with foresight and futures research tools are creating a more even playing field, enabling less developed countries to leverage the same innovation resources that were traditionally reserved for developed countries with leading research and educational institutions, a highly skilled workforce, and leading private sector actors. Tools such as open innovation communities, innovation competitions, crowdfunding, citizen engagement, among others, can be used to leverage different stages of the VID model (Figure 1). Some of the tools were used successfully by private firms and government agencies to explore which challenges needed to be tackled by engaging citizens (Kokshagina et al. 2017). Strategic foresight tools include strategic radars, which allow government agencies to monitor drivers of change and trigger industry development in sectors that have opportunities for leapfrogging. Scenario-based planning can be considered to form a consistent future outlook and to direct innovation efforts of private companies. Entirely new industry sectors often require a combination of scenario planning and systems dynamics modelling so that uncertainty does not prevent action. These and other strategic foresight tools can enable innovation in new areas and support the catalyzing of innovation efforts of participants in innovation ecosystems (Rohrbeck 2014).

For example, Dream for Sweden was organized in 2019 to ask Swedish citizens to imagine the future of Sweden, resulting in a list of challenges for a hackathon in April 2019. Platforms for citizen engagement such as Goals.org and Crowdicity engage citizens at various stages of the VID process. For instance, the Government of Brazil used Crowdicity to explore ideas for the Rio Olympic Games. Crowdsourcing competitions are often used to solve pressing issues. In the US, Challenge.gov engages the public in solving pressing issues facing federal agencies, most of which do not have the skills to innovate as quickly as crowds. The costs are higher for large bureaucracies and some solutions are typically overlooked by agencies. Consortia-led initiatives are often used to facilitate collaboration among interdisciplinary partners. Consortia are often problem driven, such as Consortia for Improving Medicine with Innovation and Technology, which aims to improve patient care, or the United Kingdom–based consortium Weavr, which develops concepts for viewing e-sports. Some consortia such as the Center for Global Development ease collaboration between stakeholders in industries where they aim to investigate needs together, select innovative solutions, and develop pilots to test them. Consortia-led projects are beneficial when the list of targeted organizations is predefined to identify market-led characteristics, set industry targets, and begin exploration. Developing partner support is crucial at the later stages of VID to start industrializing innovation, initiate deploying solutions with local partners, or access skills and expertise that some of these partners hold (Figure 4).

Figure 4: Open Innovation Tools

	1. Define Challenges	2. Lead-Market Characteristics	3. Set Innovation Target	4. Begin Innovation Development	5. Develop Scaling Solution
Open (online) communities	●	●		●	
Platforms for citizen engagement	●		●		
Crowdsourcing competitions	●	●		●	●
Consortia-led initiatives		●	●	●	●
Crowdfunding platforms; crowdlending			●	●	
Developing partner support				●	●

Source: Authors.

ALTERNATIVE PATHS TO VERTICAL INDUSTRY DEVELOPMENT

Different options can be put in place at various stages of VID. We suggest three ways to engage in the VID cycle (Figure 5): (i) build principally on open (online) communities and platforms for citizen engagement (option A), (ii) host crowdsourcing competitions (option B), and (iii) mobilize crowdfunding and crowdlending (option C). We use Indonesia as an example.

- **Option A** (for stages 1 and 2 of the model): **Imagine the future of Indonesia**. This option consists of, first, leveraging the ideas of citizens or targeted stakeholder groups to identify priorities for industry development. This stage will be as inclusive as possible, where all residents can express their needs and concerns. It can be organized as a platform to collect ideas during a certain period and can be extended to a road trip to collect ideas in some remote areas. These ideas can be clustered and, based on crowds voting and "heat maps," the most popular ideas are selected for assessment. In the second stage, the ideas are assessed for their potential and fit with lead-market characteristics. For potential future value, foresight methods heighten the ability to capture the entire future value potential. Checking for lead-market characteristics is the basis for selecting ideas in which Indonesia can build a competitive edge against other countries. This is key to select ideas that can create markets where Indonesia can attain a leading position internationally. Lead-market characteristics include price or cost, demand, transfer, export, and market structure advantages (Beise 2004). This open competition can be hosted by the government with the help of the Asian Development Bank (ADB) and external experts. The analysis can be combined with more targeted context analysis in the market to identify the most pressing challenges.

- **Option B** (for stages 3 and 4): **Solving major industry challenges**. Once priority areas are identified (using option A or based on prior analysis), the government can host an open or closed crowdsourcing competition. This competition can be organized with the help of a specialized agency or in government-based open innovation contests, such as those held by the Malaysian Industry–Government Group for High Technology (MIGHT) or Enterprise Singapore, with the help of external specialists. Indonesia can establish its own agency or use external help. The setup of such an agency and running the first projects can be supported by ADB or a specialized consultancy. We suggest co-designing the first challenge with external experts and, based on the first experience, establishing a government agency. In case of open competition, innovators in Indonesia and abroad can provide ideas for an industry vertical. An open competition is typically used to collect ideas for early-stage innovation initiatives that develop concepts and early-stage prototypes. Closed competition (inviting preselected organizations) to innovate is typically used at later stages, to implement solutions for innovation targets. In this case, solvers will already have a working prototype or even a working product, but they will have to bring it to the Indonesian market and perhaps adapt the underlying solution to the local context.

- **Option C** (for stages 4 and 5): **Leapfrogging for a specific industry**. The goal is to support innovation development and prepare to scale the solution. ADB can support tax breaks and/or a funding program for technology leapfrogging for a predefined industry to bring to Indonesia. Certain projects can be financed using crowdlending platforms similar to October.[4]

All three options can be used to develop an industry vertical. They can be used in combination or separately (Figure 5). They are designed to support innovation in a focused problem space where new capabilities are built iteratively, as we have seen across our case studies. All three options can be used to iteratively explore innovation spaces and are best combined with a flexible investment framework, where investments are staged. Each stage is run in accordance with a degree of uncertainty. With decreasing uncertainty, the investment becomes more targeted, with fewer beneficiaries and more focused success criteria. The early stages have the character of open competitions, while the later stages are designed to monitor and fund the progress of a small number of actors. Even funding only one private actor can be an option. Typically, however, the government agency identifies two to four national champions and one or two leading international partners to build the new vertical as a consortium.

The exact implementation plan should be designed with the local authorities to reflect the specificity of the country. For all three options, we suggest starting by co-designing and conducting the first phase with external experts to leverage best practices and translate the prototype. Approaches will be tested to maximize their efficiencies and incorporate the learnings.

To succeed, it is key to combine open innovation tools with strategizing within the government agency. A good example is Enterprise Singapore, an independent agency that plans and executes open innovation programs and supports and interacts with government agencies to form strategy for VID.[5] Agencies such as Thailand's National Innovation Agency with its Foresight Innovation Institute or Malaysia's MIGHT follow similar approaches.[6]

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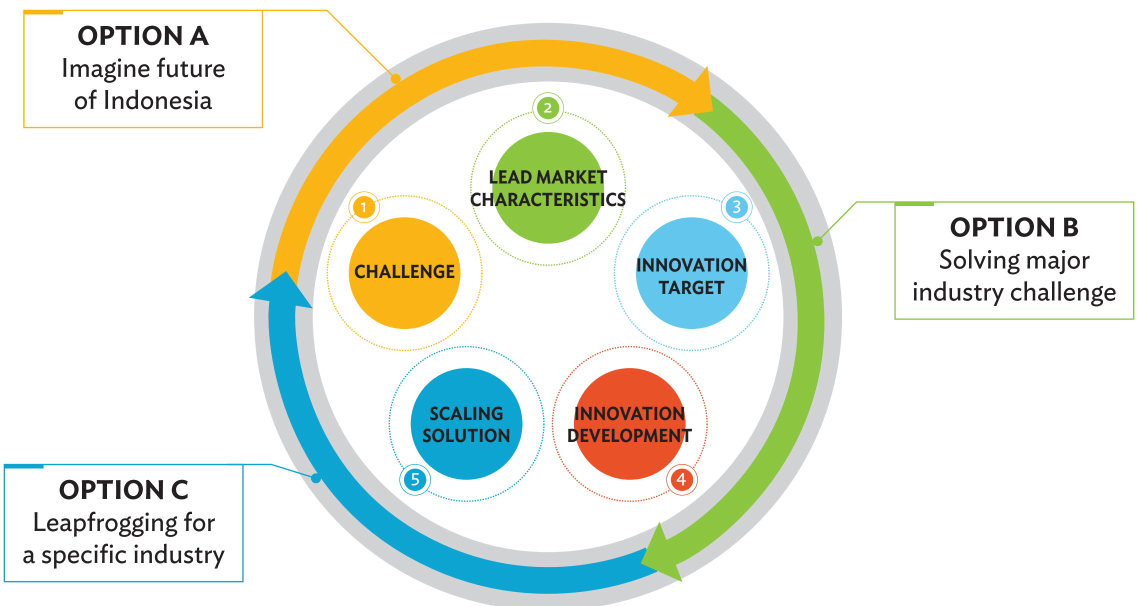
[4] October is a financing platform for SMEs in Europe that allows them to obtain business loans of up to €3.5 million (about $3.85 million) in less than a week.

[5] See, for example, Gov-PACT.

[6] Ministry of Science and Technology (Thailand) and MIGHT.

Figure 5: Vertical Industry Development Process and Tools



Source: Authors.

APPENDIX

Case Studies: Summaries

Four historical case studies were conducted that feature focused strategies of industry creation (Figure 3).

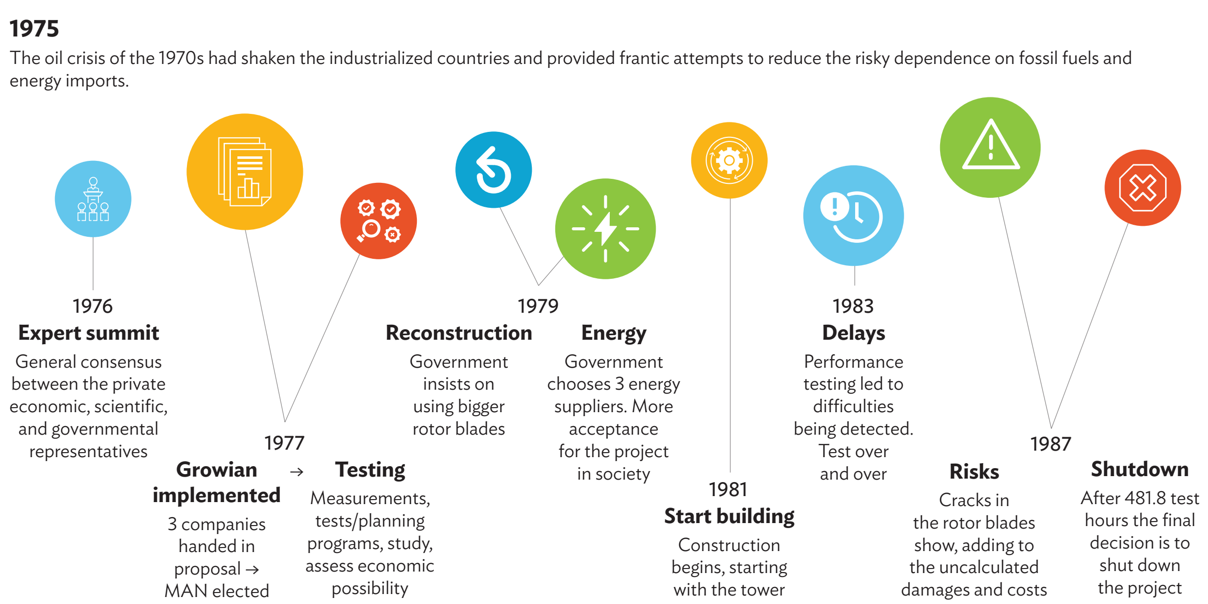
Case 1. The GROWIAN Project in Germany

The GROWIAN project, funded by the Federal Ministry of Education and Research in the 1980s, resulted in the erection of the first large-scale wind energy turbine. This ultimately led to the creation of the wind energy industry in northern Germany and Denmark, which to this day dominates the global wind energy market.

Initiated in 1975, the project was driven by the need to find alternative sources of energy after the oil crisis to replace risky nuclear power energy, fossil fuels, and energy imports (Figure A.1). Funding was further motivated by political interest in demonstrating German advanced technological capabilities. Funding came from both private and public entities such as the federal ministry of research and technology, technical companies, energy providers, and the public, resulting in a final budget of DM54.65 million. Prior scientific demonstration in Denmark showing the technical feasibility of small wind power turbines helped secure funds.

The construction began in January 1980 in Kaiser-Wilhelm-Koog and on 1 October 1982 the plant was out in the operation even if the official phase of construction had not been completed. Construction ended in 1987 officially and a few months later GROWIAN was stopped. The main obstacle at that time was the material, which was much heavier than material used today and led to multiple test failures. Still, the

Figure A.1: GROWIAN Project—Timeline



Source: Authors.

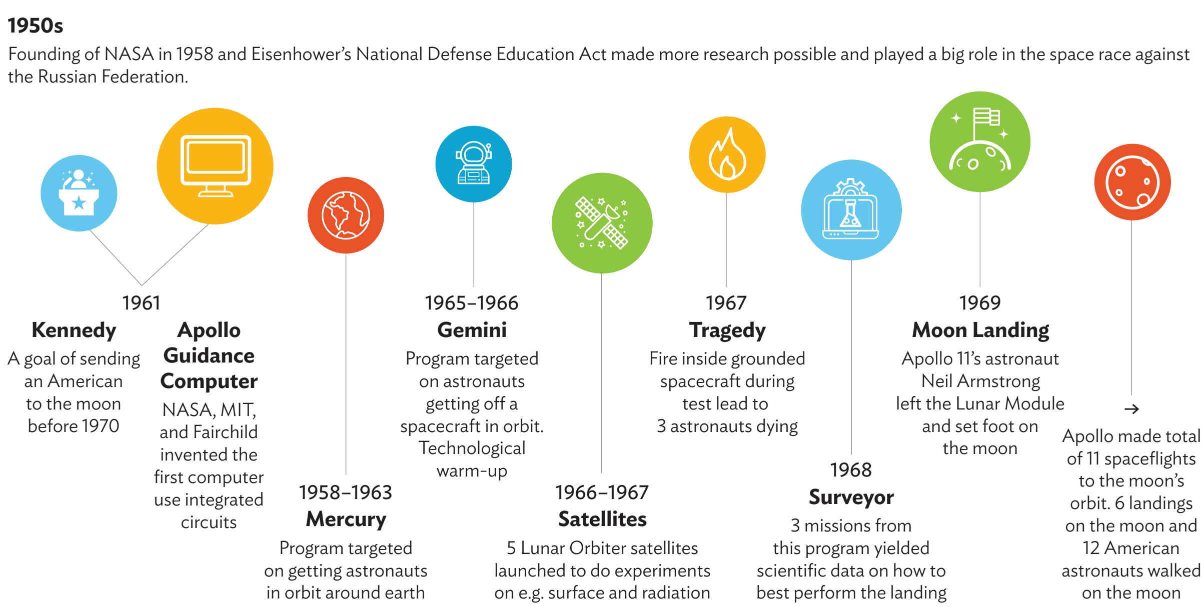
GROWIAN project demonstrated the technical feasibility of big wind power plants, eventually enabling the creation of the wind power industry. The project led to important technological breakthroughs and advanced our understanding of how to insert power into existing public power supply networks.

During the project, high technological uncertainty and a lack of understanding about the complexity of such a development led at different times to cancelation of funds for the project. The presence of multiple stakeholders at the beginning of the project, however, provided stability. They helped diffuse the innovation, which was crucial for eventually developing the industry and its value chain. The project required a high level of investment and it went on for much longer than expected. Ultimately, however, the focused push challenge and combined efforts resulted in a leading position for Germany in the wind energy market. Ten years after GROWIAN's shutdown, Germany pioneered a law on how alternative energies can be inserted into existing grids, and provided financial incentives through feed-in tariffs that led to an era of strong investments in renewable energies. So far, 61 countries have copied the law.

Case 2. Apollo Space Program in the United States

The emblematic case of Apollo was the third US human space-flight program carried out by the National Aeronautics and Space Administration (NASA), which resulted in American astronauts making a total of 11 space flights and walking on the moon. This program aimed for the goal set by President John F. Kennedy of "landing a man on the Moon by the end of this decade and returning him safely to the Earth." The main motivation for and focus on succeeding were driven by the cold war realities of the time and, in particular, by the Soviet Union's nonmilitary accomplishments in space that forced Kennedy to respond and serve notice that the US was just as capable in the space area. The successful landing by Neil Armstrong (Apollo 11) in 1969 became the iconic symbol of US technological and scientific superiority in the global competition with the Soviet Union (Figure A.2).

Figure A.2: Apollo Project—Timeline



MIT = Massachusetts Institute of Technology, NASA = National Aeronautics and Space Administration.

Source: Authors.

Apollo brought together government, NASA, research centers such as the Massachusetts Institute of Technology and the Muir S. Fairchild Research Information Center, and private institutions to work toward a common goal in a coordinated manner. The Apollo program was driven by a geopolitical situation and, therefore, the resources pulled to the program were tremendous. The US government spent $28 billion in 1960–1973 alone. With an ambitious program such as Apollo, stakeholders across the whole value chain, including leading institutions in the world, needed to be committed to succeed and ready to work with untested methods and technologies.

The benefits of the program extended well beyond the original mission and helped the US develop scientific breakthroughs in other areas such as heat-resistant materials, the cordless vacuum cleaner, and freeze drying. The Apollo Guidance Computer was a foundation for the digital revolution that followed in the 1970s. The Apollo program instilled a societal belief in the power of science and technology and inspired a generation of tech entrepreneurs, including Jeff Bezos of Amazon.

Case 3. E-residency in Estonia

E-residency or the virtual residency program launched in 2014 allows non-Estonians access to Estonian services such as company formation, banking, payment processing, and taxation. The program gives e-residents a smart card, which they can use to sign documents. This program is part of a larger movement called e-Estonia, which provides services to ease citizen interactions with the state through the use of electronic solutions (Figure A.3).

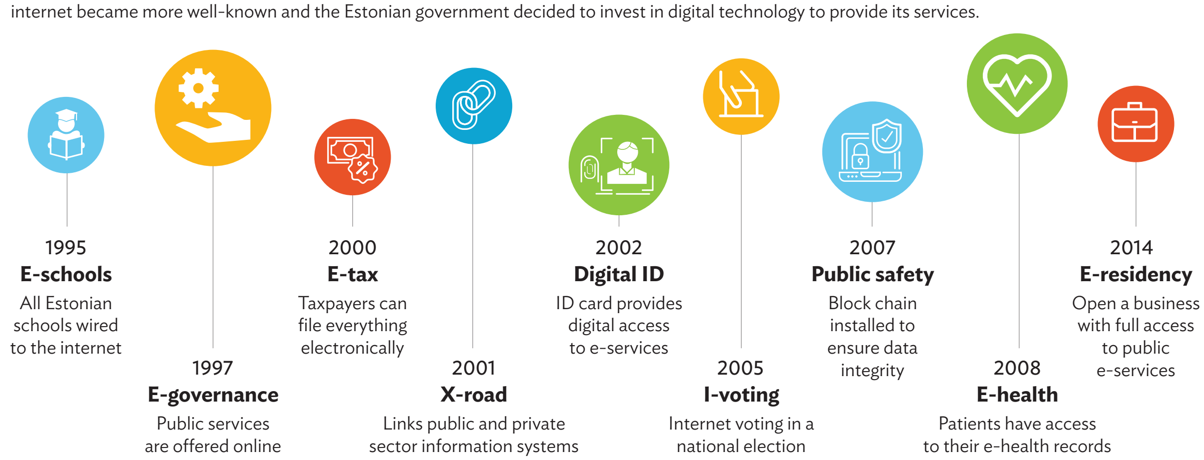
In 1992, just after the Soviet Union collapsed, Estonia managed to build an incredible foundation for the skills and services required in the digital age. The program targeted its citizens to stop the brain drain; many skilled workers were leaving for other countries offering higher pay, particularly Finland. The program was also designed to attract talent from other Baltic, Eastern European, and Asian countries, as well as foreign direct investment.

The results are impressive. In 2019, 99% of public service was available online; 95% of data generated by hospitals and doctors had been digitized. The e-resident population had grown to about 50,000 from

Figure A.3: E-residency—Timeline

1992

After the dissolution of the Soviet Republic, there was a small budget to use on building a governmental structure/functioning state. During this, the internet became more well-known and the Estonian government decided to invest in digital technology to provide its services.



Source: Authors.

157 countries by November 2018. E-residents have established about 6,000 new companies, which have now paid about €10 million in direct taxation to Estonia, two thirds paid just in 2018. Tax revenue is expected to grow to €194 million in indirect socioeconomic net benefits by 2021.

In 1990, when Estonia became independent from the Soviet Union, it was a middle-income country. It had few natural resources and an industry sector with severed supply chains. It had thus to rely on its skilled citizens. The country traditionally has a strong polytechnical education and mathematical skills, so software engineering and the information technology industry were an obvious place to start. To find a place in the global market, which was already highly competitive and dominated by the US, Estonia needed to find a way to leapfrog in a specific area.

It succeeded in leading globally in government solutions and has a strong position in cybersecurity, hosting the NATO cybersecurity center. Being regularly targeted by cyberattacks, Estonia has built up much experience in responding and in resilience strategies, which made it a natural lead market and the first choice for the NATO center.

With the e-residency program, Estonia has successfully branded itself as a future-oriented country with an agile government and has become an important hub for e-entrepreneurs.

Case 4. Memory Chip Production in the Republic of Korea

In the early 1960s, the Republic of Korea (ROK) started benefiting from foreign direct investments from US and Japanese firms that were seeking to reduce their production costs. This led to the establishment of a massive semiconductor and electronics industry in the ROK. The sudden growth of the industry awakened the interest of the state, which led to political and institutional changes to promote, innovate, and export. The ROK became the world leader in memory chip production and, in 2010, contributed more than 50% of global production.

A key factor for this success was the chaebol system. Chaebols are business conglomerates, often owned by a single family. The chaebol system is based on a reciprocal system of subsidies between state and firms. Support is typically given through credits but also through tax holidays and other subsidies. This allows chaebols to move faster and more forcefully into new businesses.

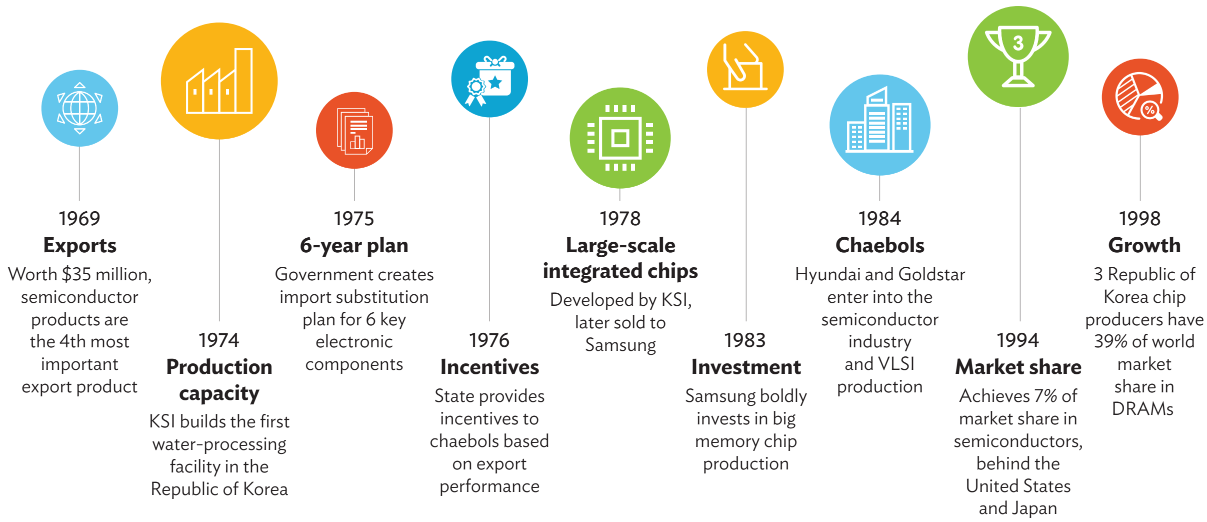
For a long time, the semiconductor industry was seen in the ROK as strategically unimportant. Until 1983, the state was mainly responding to the interest of foreign investors that were seeking sites for semiconductor assembly lines, with little development taking place in the ROK. However, strong investments, particularly from the US, by Muir S. Fairchild Research Information Center and Motorola, started to fuel the development of assembly and technological know-how. Through these investments, the ROK was bound to the global market dynamics that started to push the semiconductor business.

Initially, it was primarily Samsung's bold move to enter the semiconductor market through the memory chip niche that lay the foundation for later success (Figure A.4). Hyundai and Goldstar later launched their own semiconductor initiatives. The three leading chaebols entered into a new technological space at a time when the industry was moving from integrated circuit to very large integrated circuit technologies. The ROK started to apply the powerful policy instruments that had proved successful in developing the chemical and heavy industries in the 1970s. The reciprocal support system, which is a lead-market characteristic, the technological transition, and the decision to enter through a specific niche (memory chips), enabled ROK producers to enter a highly contested market and build a dominant position, which they still hold (Kim 1998).

Figure A.4: Memory Chip Production in the Republic of Korea—Timeline

Early 1960s

The Republic of Korea started benefiting from investments by United States and Japanese firms in low-wage countries that aimed to reduce production costs. The sudden growth of the industry awoke the interest of the state, which led it to make political and institutional changes to promote this export.



DRAM = dynamic random-access memory, VLSI = very-large-scale integration.

Source: Authors.

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Vertical Industry Development to Leverage Innovation

A Model for Leapfrogging Technology and Driving Competitiveness

Innovation is key for developing countries to escape the middle-income trap. Yet, traditional mechanisms to develop national innovation systems, such as structural reforms and investments in research and development, can be insufficient to help countries leapfrog, increase competitiveness, and create a more advanced economy. Structural reforms and other horizontal development mechanisms take a long time and often fail to produce the desired benefits. This paper proposes a vertical industry development model that can be applied to create, shape, and promote innovative and competitive industries. Based on four industry development cases, this paper explores the success criteria and highlights the difficulties of and lessons learned in each case.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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