UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

In partnership with
the Republic of Korea

Joint Research with UNIDO on

The Role of Science, Technology and Innovation Policies in the Industrialization of Developing Countries

Report Launching Seminar

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STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Research Objective

❖ To help UNIDO with policy recommendations construct its policy advisory services to member states, integrating STI policies into industrial development strategies on how to harness STI for the achievement of ISID and the SDG9.

- To carry out in-depth literature review on the linkage between STI policies and industrial policies and STI policies for sustainable and inclusive industrial development.

- To draw empirical policy implications for UNIDO and other developing countries on how Asian countries had mobilised and are leveraging on STI as part of national strategies underpinning successful industrial developmental outcomes.

Overview of the Analyzed Countries

Country		Republic of Korea	China	Thailand
GDP (current USD billion, 2020)		1,630.5	14,723	501.8
Per capita GNI (current USD billion, 2020)		32,860	10,610	7,050
Country category by income (World Bank, 2020)		High income country	Upper-middle income co untry	Upper-middle income country
Trade openness (%, 2020)		70.1	34.5	97.9
High-tech ratio of manufacturing exports (%, 2019)		32.4	30.8	23.6
Gross Expenditure on R&D (% of GDP, 2018)		4.81	2.19	1.11
Journal publication	Numbers	1,196,961	6,589,695	199,226
	World ranking	13th	2nd	44th
Patent Registration	Number (by resident, %)	125,661 (94,852, 75.5%)	452,804 (360,919, 79.7%)	3,121 (172, 5.5%)
	World ranking	4th	1st	38th
UNIDO CIP Index (2020)		3rd	2nd	24th

*Journal publication record was calculated with data between 1996-2019 by Scimago.
Source: World Bank Databank, Scimago, WIPO (2020), UNIDO Statistics Data Portal

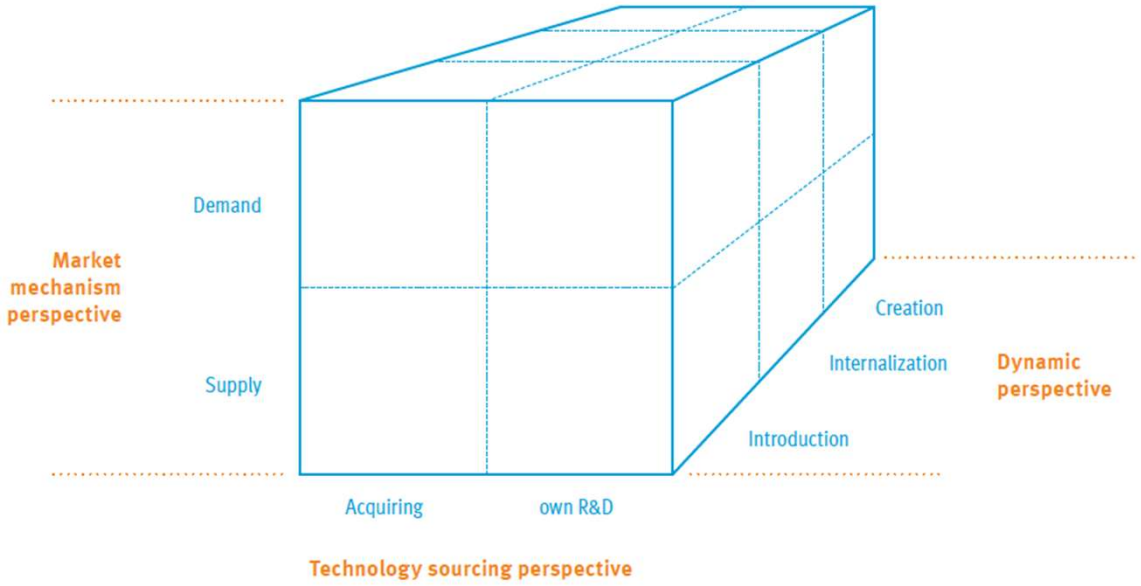
Analytical Framework

Integrative analytical framework

Dynamic perspective : Technology introduction – Technology internalization – Technology creation stage

Technology sourcing perspective : Measures to source technologies; acquiring foreign technology vs domestic R&D efforts

Market mechanism perspective : Supply-side policies designed to strengthen science and technology capabilities vs demand-side policies designed to create market needs for technology



Source: Authors' adaptation from Kim & Dahlman (1992).

Dynamic perspective in RoK

- A rapid increase (take-off) in R&D inputs and the private sector ratio overtaking the public one since the 1980s.
- A surge (take-off) in R&D outputs (patent) and the residents overtaking the non-residents in patenting with some time lag (early 1990s) from R&D inputs.

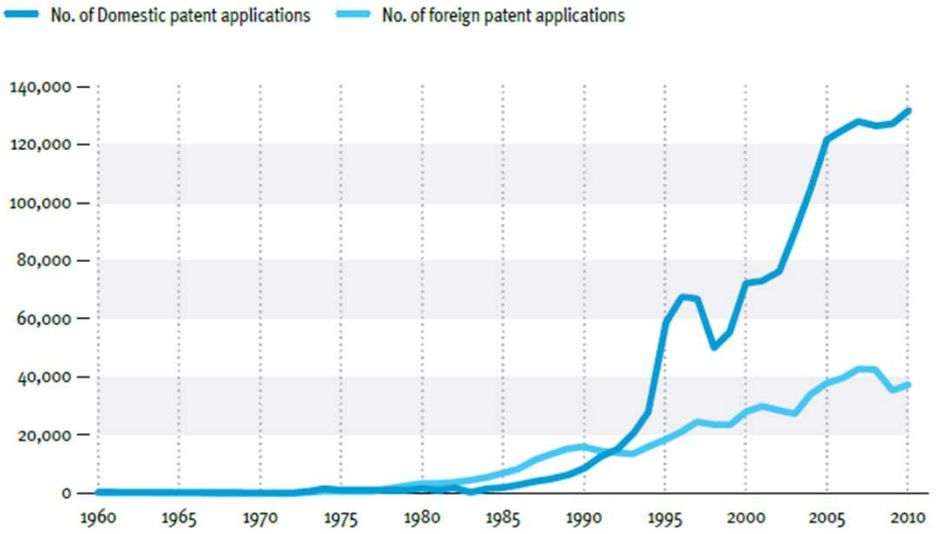
"2 take-offs and 2 overtakings"

	1971	1976	1981	1986	1991	1996	2001
R&D expenditure/GDP	0.32*	0.42	0.59	1.52	1.71	2.22	2.28
Government vs private ratio	68:32	64:36	42:58	19:81	19:81	26:74	27:73
Researcher per 1,000 population	0.08	0.33	0.54	1.33	1.68	2.18	2.88
Corporate R&D centres	1	n/a	53	290	1,201	2,610	9,070

*GNP applied

Source: Authors' elaboration. Additional data added from Kim and Dahlman (1992).

Note: GDP .. gross domestic product; GNP .. gross national product; R&D .. research and development.



Source: Shin and Lee (2012).

Dynamic perspective in RoK

- A significant improvement in technology balance of payments since early 2000s.

Thus, the RoK's industrialization can be divided into three periods:

(1) the technology introduction stage, which began in **1961** when RoK developed its first Five-Year NEDP and lasted **until 1980**;
(2) the technology internalization stage, which lasted **until 1997** and the outbreak of the Asian economic crisis; and
(3) the technology creation stage, which has been in progress **since 1998**.

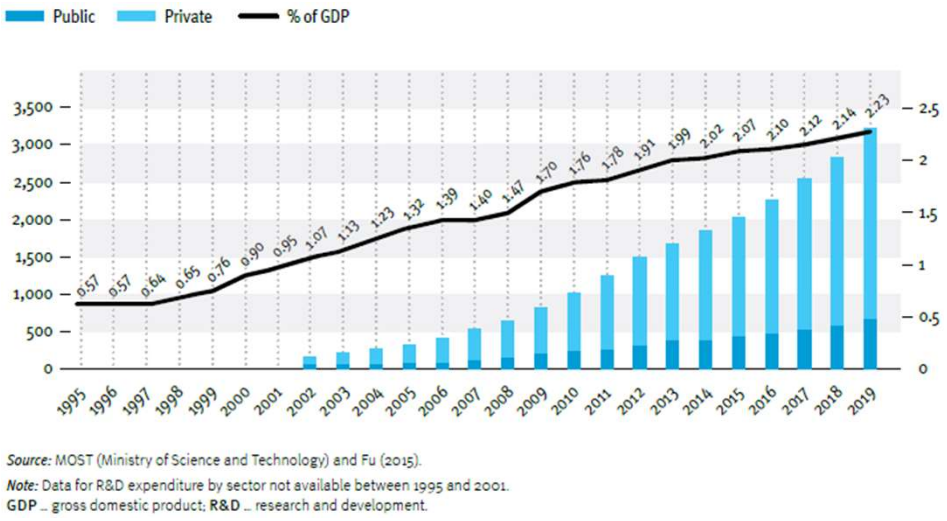
	1981	1986	1991	1996	2001	2006	2011	2016	2019
Technology exports (A)	11.8	11.7	35.2	108.5	619.1	1,897	4,032	10,687	13,756
Technology imports (B)	107.1	411.0	1,183.8	2,297.2	2,642.7	4,838	9,900	14,842	17,876
Technology balance of payment (A/B)	0.11	0.03	0.03	0.05	0.23	0.39	0.41	0.72	0.77

Source: Korea Industrial Technology Association (2020).

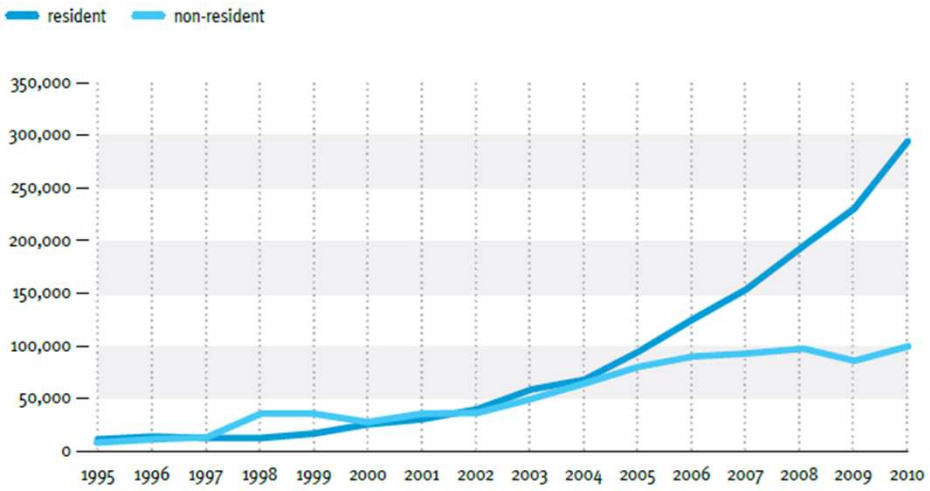
Dynamic perspective in China

- A rapid increase (take-off) in R&D inputs and the private sector ratio overtaking the public one since the early 2000s.
- A surge (take-off) in R&D outputs (patent) and the residents overtaking the non-residents in patenting with some time lag (early 2000s) from R&D inputs.

"2 take-offs and 2 overtakings"



Source: MOST (Ministry of Science and Technology) and Fu (2015).
Note: Data for R&D expenditure by sector not available between 1995 and 2001.
GDP .. gross domestic product; R&D .. research and development.



Source: Data extracted from WIPO statistical country profiles.

Dynamic perspective in China

- A world leading R&D performance since early 2010s (NISTEP, 2021).
  - China began to overtake leading countries except the US (Japan, France, Germany, and the UK) in terms of journal publications since early 2010s,
  - ranked second after the United States in terms of the top 1 percent of highly cited papers in 2018,
  - the gross R&D expenditure reached 80 percent of that of the United States in 2019.

Thus, China's industrialization can also be divided into three periods:

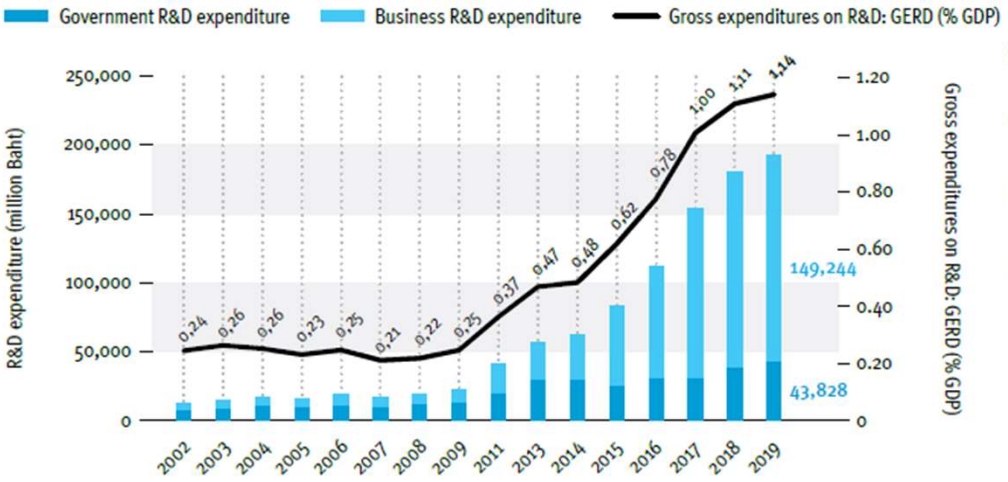
(1) the technology introduction stage lasts from 1978 when the Reform and Opening-up Policy to 2001,
(2) technology internalization stage (2002 – 2011), and
(3) technology creation stage (2012 – present).

Dynamic perspective in Thailand

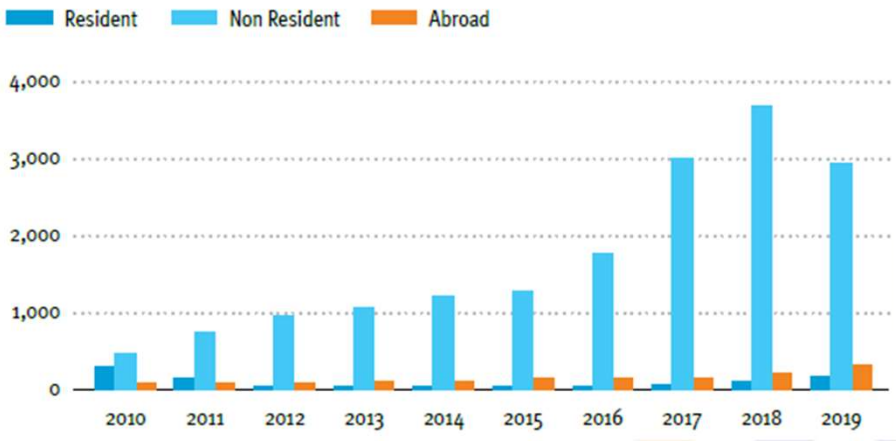
- **"Take-off and overtaking"** observed only in R&D inputs.

Therefore, we adopted a phased approach presented by the World Bank (1993) and the OECD (2021), dividing Thailand's industrial development into the following three periods, reflecting major shifts in the country's industrial and STI policies:

(1) the import substitution industrialization (ISI) period (1961 – 1980);
(2) export-oriented industrialization (EOI) period (1981 – 1996); and
(3) economic recovery and moderate growth period (1997 – present).



Source: NXPO (2021).
Note: **GDP** .. gross domestic product; **GERD** .. gross domestic expenditures on research and development; **R&D** .. research and development.



Source: WIPO statistical country profiles.

RoK : Technology introduction stage (1961~1980)

- Demand-side approach prevailed, with STI policies considered a key tool for industrial and economic policies.
- Strong coordinating institution with the support of high-level leadership
- Without inheriting any STI infrastructure, the RoK began to build STI-related institutions (ministry, laws, national plans, GRIs funding agencies
- Newly established GRIs served the private sector as a contracting intermediary for sourcing foreign technologies.

Demand-side policies	· Five-year NEDP (1961) · Establishment of EPB (1962) · Monthly Export Promotion Meeting chaired by president (1965-1979) · Promotion of light industries (1960s) · Promotion of heavy and chemical industries (1970s)
Supply-side policies	· Establishment of Bureau of Technology Management under the EPB (1962), later became MOST (1968) · Establishment of KIST (1966), six GRIs (early 1970s), KAIST (1973), and NRF (1977) · S&T Promotion Act (1967) · Import of capital goods and turnkey projects with limited FDI/FL

RoK : Technology internalization stage (1981-1997)

- Demand-side approach continued but with more emphasis on STI policies, providing required indigenous technologies to facilitate industrial upgrading.
- GRIs led national R&D programmes in collaboration with the private sector as an innovation intermediary.
- The government created markets for technologies.

Demand-side policies	· Shift of industrial policy from sectoral to functional approach · Incremental shift to trade and investment liberalization · Abolition of EPB (1993) & discontinuity of NEDP · Quarterly Technology Promotion Meeting chaired by president (1982-1990)
Supply-side policies	· Public Procurement on new technology markets (1982) · Launching of large-scale national R&D programs, first by MOST and later by other ministries (1982) Public-private partnership R&D consortiums (1982) · IPR agreement with the US (1985) · Increase of FDI/FL: positive list → negative list (1980s)

RoK : Technology creation stage (1998~)

- Demand-side approach continued with top level R&D inputs and outputs.
- The main policy target shifted from large conglomerates to small and medium-sized enterprises (SMEs) and ventures, where market failure is pronounced.
- GRIs and universities filled the gap of suboptimal R&Ds, focusing on basic research.
- The government is also constantly reviewing STI policies to improve its STI system in terms of governance, institutions, R&D investment and contents, etc.

Demand-side policies	· Promoting new growth engine industries to tackle low growth rate · 6T, 10 next generation growth engines in 2000s · Low Carbon Green Growth (2007) · The Korean New Deal (2020) and 2.0 (2021): Digital/Green/Human New Deals
Supply-side policies	· Adoption of (national, regional) innovation system in STI (2002) · Policies focus on supporting SMEs and start-up ventures · GRIs and universities focus on basic research

China : Technology introduction stage (1978~2001)

- Despite the recognition of the importance of STI, STI policies had not been well aligned with the needs of industry.
- Inheriting meaningful STI infrastructure, China adopted supply-side approach, focusing on commercialization of technologies produced by GRIs.
- It was heavily dependent on trading markets for technology to absorb foreign technologies, which resulted in minimal success between the 1980s and 1990s.

Demand-side policies	· Industry promotion based on FDI since 1978 and its expansion after Deng's Southern Tour (1992) · Shenzhen Special Economic Zone (1980) · Priority on consumer goods industry (1980s) · Promotion of pillar industries (1994): 1st industrial policy in China
Supply-side policies	· Restoration of S&T infrastructure (1977-1980) · Spark (1985) and Torch program (1988) · Push to commercialization of R&D outputs of GRIs with creation of technology market (1986), later merged to state owned enterprises (1987~) · Trading market for technology based on FDI · 6th Five-Year-Plan (1981-1985): 1st integration of S&T planning

China : Technology internalization stage (2002-2011)

- Demand-side approach was chosen with the adoption of IS concept (2002).
- Strong commitment to indigenous R&D efforts with GRIs and universities.
- Continuing technology transfer through IJV arrangements, it successfully began to absorb foreign technologies.

Demand-side policies	· Western Region Development Policy (2000-2010) · National Industrial Technology Policy (2002 & 2009) · Promotion of strategic emerging industries (2010) · Promotion of renewable (solar and wind) energy (2000s) · Demand creation in high-tech industries (telecommunication, high speed railway)
Supply-side policies	· National Mid- and Long-Term Program for S&T Development 2006-2020 (2006) · Continued IJV arrangement for FDI · Reform of GRIs · Strong university-GRIs-industry collaboration

China : Technology creation stage (2012~)

- Continued demand-side approach with market creating policies.
- Competing in high-tech and new emerging industries based on the world class S&T system.
- Strong university-GRIs-industry collaboration with private companies leading national R&D programs in new digital technology sectors.

Demand-side policies	· The Belt and Road Initiative (2014) · Promotion of new energy car and battery industries (2010s) · New Infrastructure Construction Plan (2020) · Dual Circulation Strategy (2020)
Supply-side policies	· Made in China 2025 (2015) · Internet + (2015) · Outline of the National Innovation-driven Development Strategy (2016) · Strong university-GRIs-industry collaboration with private companies leading national R&D programs in new digital technology sectors

Thailand : Technology introduction stage (1961~1996)

Import Substitution Strategy (1960-1980)

- Dominance of industrial, trade, and investment policies.
- Sourcing foreign advanced technologies through FDI was a main mechanism.
- There was very limited interest in STI policies.

Demand-side policies	· Establishment of BOI (1966) · Alien Business Law (1972) · Promotion of FDI in import-substituting local industries · Diversification of agricultural products · Promotion of local industries such as textile, automobile, pharmaceutical
Supply-side policies	· FDI based technology import · Establishment of MOSTE (1979)

Thailand : Technology introduction stage (1961~1996)

Export Oriented Strategy (1981-1996)

- Dominance of industrial, trade, and investment policies continued.
- Successfully transitioned from ISI to EOI strategy.
- Interest in STI policies emerged but it was mainly supply-side approach focusing on academic research with the linear model of innovations.
- STI policies had been isolated from industries.

Demand-side policies	· Enactment of the Investment Promotion Act (1977) · Transition from ISI to EOI (early 1980s) · Depreciation of Baht (1984) · Promotion of FDI in export-oriented businesses.
Supply-side policies	· STDB and 3 sector-specific GRIs founded in 1980s and later merged to NSTDA in 1993 by S&T Development Act · 7th NESDP(1991) with target of GERD/GDP · First policy effort for backward linkages in automotive and electronics by BOI and MOI (SMEs promotion) (1990s)

Thailand : Technology internalization stage (1997-)

Economic Recovery and Moderate Growth

- Thai government began to recognize the importance of STI as a tool to tackle its structural weaknesses.
- It stressed a demand-side approach at the policy design level, adopting the concept of National Innovation Systems.
- However, STI policy at the implementation level remains fragmented and inefficient.

Demand-side policies	· Elimination of LCRs (1997) and fixed exchange rate system (1997) · Foreign Business Act (1999) · Thailand 4.0 & EEC with 10 strategic industries (2016) · Promotion of FDI in strategic industries
Supply-side policies	· A package of SME supporting policies (1998-2000) The ten-year Science and Technology Strategic Plan for 2004–2013 · Industrial Technology Assistance Program (ITAP) · 7-Year Investment Promotion Strategy (2015-2021) · Skill, Technology and Innovation scheme by BOI (2006) · BOI's reform of investment incentive scheme: activity/merit-based (2015) and technology-based incentives (2017)

Lessons from the past (1)

- **Key STI indicators are useful in diagnosing the stages of technology development.**

STI indicators of R&D inputs and outputs were useful for understanding different technology development stages of a developing country. However, policymakers should not assume that increasing R&D inputs will automatically upgrade a country's technological development.

- **STI policies should be demand-driven.**

STI policies should be closely aligned with demand-side industrial policies as they are complementary to each other. Accordingly, the content of STI policies should evolve over the course of a country's industrial development as each stage manifests different needs of industry.

- **Investment-led growth has its limits.**

The Thai case illustrates the limitations of investment-led growth strategy to sustain a country's industrial development. Thailand became successful in reaching upper-middle income status by FDIs. However, it has failed to sustain economic growth without sufficient indigenous technology development efforts.

Lessons from the past (2)

- **Utilization of foreign technologies never diminishes.**

The relative importance of sourcing and learning foreign technologies decreases over the course of industrial development. However, utilization of foreign technologies remains one of important mechanisms to source technologies.

- **A coordinating mechanism of STI policies with the support of high-level leadership is critical.**

It is important to have a coordinating mechanism as STI requires inter-ministerial collaboration. Both the RoK and China had the full support of high-level leadership, while Thailand has a policy coordinating body but without the prime minister's support.

- **Creating markets facilitates industrial upgrading.**

Government interventions in creating markets, including public procurement and standard setting policies, can facilitate industrial catch-up and leapfrogging. They reduce technology and market uncertainties of domestic R&Ds.

Policy implications

The main policy conclusion from our findings on three East Asian countries in implementing successful STI policies is summarized by three key principles:

(1) demand-driven approach throughout the process of industrial development;
(2) strong commitment to indigenous innovation efforts beginning with the technology internalization stage; and
(3) government's capacity to reflect on and adapt to changing environments.

The main driver of these principles is the increasing need for active government involvement in a country's industrial development. Considering the contemporary challenges—namely, digital transformation, climate change and inequality, it is imperative for developing countries to play a more active role in addressing the "twin challenges".

Thank you!