Technological Rentierism and Capability Formation in Wealth-Rich Economies

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Abstract

Although many affluent nations have modernized their transportation infrastructure, telecommunication services and financial systems; it does not mean that they have developed local technological competencies. This paper defines Technological Rentierism as an explanatory theory for how high-income economies can continue to rely upon external sources of innovation in the field of technology. The ability to form domestic technological capabilities is further fragmented (i.e., more difficult) due to fragmented forms of domestic capability development, procurement processes that prioritize imported technology over domestically-developed technology, the perceived credibility of foreign technology relative to its domestic alternative (due to the legitimacy effect), and the perceived risks associated with using established systems from abroad versus establishing those systems domestically.

Keywords: Technological Rentierism, Technological Dependence, Capability Formation, Innovation Systems, Industrial Policy, Economic Development

1 Introduction

The degree of economic advancement is often assessed based upon the availability of modern technologies and the amount of money invested. These assessments, however, may fail to account for the difference between the adoption of technology and the ability to produce new technologies. For instance, two countries might both possess modern software; one country may be able to adapt and utilize the software effectively and efficiently whereas the other may not have the underlying capability to produce such modern software. Therefore, there is a possibility that an economy's technological advancements could be misinterpreted as possessing the necessary capabilities to advance technologically. An economy can implement modern software systems and yet not possess the productive capabilities that allowed for the development of these systems.

Furthermore, GDP and financial returns generated from investments do not provide an accurate assessment of an economy's technological capabilities if the majority of technological systems adopted are imports. The extent of this limitation will become apparent once foreign suppliers restrict or block access to these technological systems. Similarly, financial returns generated from investing in foreign owned businesses or foreign investments can demonstrate financial success; however, these types of returns do not assess domestic

capability growth in the same manner as investment into domestic firms and productive capabilities.

Governments and private sector organizations obtain various forms of technological systems including imports, licenses, and domestically produced systems. In many instances, it is safer for governments and organizations to procure or license software from established foreign corporations since these systems have been tested, validated, and commercially viable.

The procurement or licensing of software systems from established foreign corporations creates immediate operational advantages while also eliminating the risk associated with developing the capabilities required for producing such systems domestically. Developing the capabilities required for producing technological systems domestically requires knowledge, talent, institutional trust, and time. Nevertheless, the issue is not the use of imported or licensed technology per se. Rather, the issue arises when utilizing this type of technology becomes a predominant method of obtaining technological solutions throughout an economy. Organizations may continually opt for foreign-based systems due to their perception that foreign systems are more mature, reliable, as well as safer, more credible, and more reliable than domestic alternatives.

Although research has been conducted in areas related to talent acquisition, R&D spending, infrastructure development and industrial policies related to technology development, there continues to exist a critical puzzle. Many economies continue to rely heavily on foreign-based technology systems even after they have acquired sufficient resources for developing technological capabilities domestically. While numerous studies have attempted to address this phenomenon, they do not adequately explain why an economy with ample financial resources, state-of-the-art infrastructure and technology capable of supporting innovation may preferentially choose to continue purchasing foreign technology systems instead of creating domestic technological capabilities.

This suggests that technological dependence should be analyzed as an equilibrium problem in addition to being viewed as a resource problem.

In this paper, it is argued that technological dependence can arise as a stable equilibrium where governments, business entities, investors, and consumers repeatedly opt for imported technological solutions because each entity maximizes short-run benefit while reducing uncertainty. Ultimately, individual rational choices may lead to reduced incentives for creating domestic technological capabilities and support long-term reliance on foreign-based technologies. This paper provides insight into this phenomenon using the concept of Technological Rentierism – a conceptual framework used to analyze how economies may modernize and utilize advanced technologies while simultaneously failing to establish the requisite productive capabilities for sustainable technological self-reliance.

2 Literature Review

This area of study will review all of the major categories of literature related to technological dependency and capability development. It will focus on national innovation systems, capability theory, industrial policy, technological catch up, and import dependency. This review will be limited to identifying where previous explanations are useful for understanding technological development, and where they fall short of providing sufficient explanation as to why wealth-rich economies continue to experience technological dependency.

2.1 National Innovation Systems

While individual organizations contribute to innovation, most innovation occurs through collaboration among organizations, talent, governments, capital providers, university/research institutions. As indicated by the literature on national innovation systems, technological development is typically a result of collaborative work among the various stakeholders listed above and not solely due to the actions of single companies (Nelson 1993, Freeman 1987, Lundvall 1992). While a country may have large numbers of talented people, the mere presence of talent does not equate with the ability to develop technological capabilities without connecting those talents to domestic companies, research activities, risk capital and institutional frameworks that convert knowledge into products. Therefore, a country's "talent pool" can be under utilized based upon the overall orientation of its national innovation system being focused on importing/using foreign technology rather than developing indigenous capabilities.

2.2 Capability Theory

The emphasis in Capability Theory lies in distinguishing the possession of resources and the possibility of converting those resources into productive results. Capital, talent, and access to foreign technologies are considered resources. However, these resources alone will not result in technological capabilities. A nation with sufficient financial resources to purchase sophisticated software, hardware, or industrial systems is not necessarily domestically capable of creating designs for modification or reproduction of those systems.

The distinction between financial capability and domestic capability is at the core of an understanding of technological dependence. Access to innovative outputs by way of imports of a technological system does not equate with an automatic transfer of the capability that generated those outputs.

Acquiring advanced equipment is fundamentally different from having the engineering knowledge necessary to create equipment. Purchasing an AI System is significantly different than developing the research needed to produce such models, the compute infrastructure and data pipeline to support training of advanced models and the engineering teams necessary to train and develop the skills to use such models. Similarly, purchasing enterprise software is different from developing both the organizational and technical capability to build, adapt and scale such systems within a domestic context. Capabilities can arise from the productive application of imported technologies as well. Local actors can absorb, adapt and enhance imported technologies through experimentation and adaptation. Thus, foreign technology does not always serve to diminish domestic capability development; under certain conditions it can provide an opportunity for learning.

This opportunity exists if there are mechanisms that allow the absorption of externally generated knowledge into an overall environment of talent, documentation, experimentation, firms and institutions that can transform external knowledge into domestic competence. Mechanisms that impede learning exist when foreign technology is viewed as finished goods rather than as input to processes of learning, adaptation and building domestic capabilities.

Capability Theory therefore changes the focus from who owns resources to how they are combined, coordinated and transformed into productive capacity (Teece et al., 1997). A nation may have talent available but may not be able to utilize it effectively in companies that are capable of generating new technology. The nation may have capital available but may elect to invest that capital abroad instead of using it to foster domestic capability generation. A nation may have infrastructure available but may choose to utilize that infrastructure solely

for consumption of imported systems. Thus, technological progress does not depend solely on availability of resources but also on whether those resources are used to generate capabilities that can be reproduced and enhanced over time.

2.3 Industrial Policy and Technological Catch-Up

Technological catch up refers to the process whereby economies that trail behind technologically advanced "frontier" countries acquire, assimilate, and improve upon external knowledge (Cohen & Levinthal, 1990). Importing foreign technology is not always indicative of dependence. In fact, importing foreign technology can often serve as a productive method for learning and adapting to new technologies when domestic firms and institutions take external knowledge and assimilate it into their own local environment, lower production costs, and create independent capabilities over time.

Many economies have utilized this model where they initially learned about technology developed outside of their borders, and then went on to build their own competitive international industries. Importing technology is not inherently problematic. The issue at hand is what occurs after the initial importation of foreign technology. For example, in some economies foreign technologies serve as sources for experimentation and learning. In other cases, foreign technologies remain unaltered and are merely consumed as finished products to be subsequently replaced. When foreign technologies are studied, modified, replicated and enhanced, they can contribute to an economy achieving technological catch up. Conversely, when foreign technologies are only acquired and used as pre-fabricated finished products, they can foster dependence.

As such industrial policy has been shown to play a significant role in this process. By utilizing government actions to promote the development of capabilities through public purchasing, research grants, industry support to local companies, promoting domestic talent development, providing regulatory flexibilities to emerging sectors and offering protective measures to nascent sectors; these types of interventions can enable local companies to transition from using externally sourced technologies to creating, adapting, exporting domestically developed products. Nevertheless, policies can also limit the development of capabilities should institutions prove to be slow-moving, risk-averse or institutionally predisposed to provide established foreign providers with priority access.

In addition to illustrating that late stage development does not preclude innovation for an economy; the body of work focused on technological catch up demonstrates that economies can benefit from external technologies while remaining producers themselves provided they have adequate institutional frameworks, financial incentives and businesses capable of absorbing and enhancing imported knowledge (Cohen & Levinthal, 1990). Despite the above mentioned findings however; this literature fails to adequately address the reason(s) many wealthy economies continue to utilize foreign solutions despite having sufficient capital, talent and infrastructure to support internal capability creation.

2.4 Dependency and Institutional Explanations

There is a significant body of research examining how dependency may arise or be sustained in an economy. The theoretical base of Dependency Theory emphasizes that the inequality of relationships between economies results in a long term pattern of reliance whereby peripheral economies rely upon consuming technology and goods produced by other economies. Although dependency theory is useful in understanding structurally based dependency; it

tends to emphasize external relationships between economies rather than internal mechanisms through which dependency arises and is perpetuated.

An institutional perspective provides a complementary rationale. Organizations often implement practices and utilize technologies that are viewed as legitimate, credible and prevalent in their environment. Through repeated implementation of conventional solutions, organizations establish path dependency that guides subsequent choices. Therefore, even though viable alternative technologies may exist; organizations will select technologies with which they are familiar because they have previously been implemented.

The above perspectives contribute to understanding dependency in terms of technology. However, neither of these theories adequately address the question of why dependency persists in those economies where there is substantial financial resource availability; sophisticated infrastructure; access to information/knowledge; and expanding technical talent bases. Thus, this void presents opportunities for the development of a framework that evaluates how procurement incentives, legitimacy dynamics; capability fragmentation; and perception of risk combine to recreate technological dependency over time.

2.5 Research Gap

The body of research on innovation systems, capability formation, industrial policy and technological catch up offers a number of explanations for how productive capabilities are developed by national economies. These perspectives all identify talent, capital, institutions, technology transfer, and learning as critical to technological development. On the other hand, they all seem to treat these factors as independent of the pattern of technological dependency that evolves among nations over time.

For example, the literature generally views governments, firms, investors and institutions as separate actors within an innovation system with little consideration given to whether one actor's actions will affect the incentives, expectations, and decision making processes of other actors. For instance, if a government selects imported technologies repeatedly, then its purchasing decisions may alter the purchasing decisions of firms, investors, and institutions. These repeated purchasing decisions may then help shape collective beliefs about risk, credibility and technological legitimacy, creating a preference for foreign vendors over domestic ones.

Therefore, it is possible for economic entities to continue to exhibit technological dependency even though they possess the resources to develop their own productive capabilities. Therefore, technological dependency should not be viewed solely as a resource issue or a capability issue but rather as a systemic equilibrium created by the interactions of various actors. Thus, there exists a gap in the research that motivates the development of the Technological Rentierism framework that will be introduced below.

2.6 Positioning Technological Rentierism Within Existing Literature

While current literature provides a number of conceptual frameworks explaining how an economy is dependent upon technology (for example dependency theory; national innovation systems; capability theory), it fails to provide adequate explanation as to why a country's or region's economic development can be severely limited despite having access to all forms of

financial resources, physical infrastructures, highly skilled workers, and access to global knowledge networks.

Technological Rentierism draws upon previous research in these areas, yet expands the field of study by providing a theoretical perspective that examines the specific social and institutional processes by which dependency on external technological systems becomes perpetuated. While dependency theory illustrates the inequality inherent in a relationship between a "core" and a "peripheral" nation, national innovation systems illustrate the institutional structures necessary to create innovative products and services domestically. Capability theory describes the difference between holding resources and being able to utilize those resources productively. However, neither dependency theory nor capability theory explains why many countries have capital, labor, infrastructure, and international access to knowledge networks yet still remain significantly reliant on technology developed and manufactured outside their borders.

3 Theoretical Framework

The previous literature review provided a variety of rationales for explaining technological development using innovation systems, capability formation and technological catch-up. Although these theories offer useful information regarding the establishment of productive capabilities, none of them provide a complete explanation for why so many countries are characterized by continued technological dependency even after possessing adequate capital, talent, infrastructure and access to global knowledge. Section three presents the theoretical framework that is being used in this dissertation. The argument in this section is that capability fragmentation, combined with incentive structures and self-reinforcing behavioral dynamics can result in continued technological dependency and promote a tendency towards acquiring external technological solutions instead of developing internal productive capabilities.

Technological Rentierism was chosen as a conceptual framework rather than an established theory. A conceptual framework seeks to describe and explain certain mechanisms contributing to technological dependency and therefore does not purport to demonstrate empirical evidence for these mechanisms.

3.1 Capability Fragmentation

The coexistence of talent, capital, research activity and institutional capacity does not assure the production of technological capability. Typically these resources operate independently of one another and may not produce productive results if they cannot be adequately coordinated.

According to Freeman (1987) and Lundvall (1992), innovation is usually generated by interactions between numerous specialized actors such as researchers, engineers, firms, investors, governments, universities and related institutions.

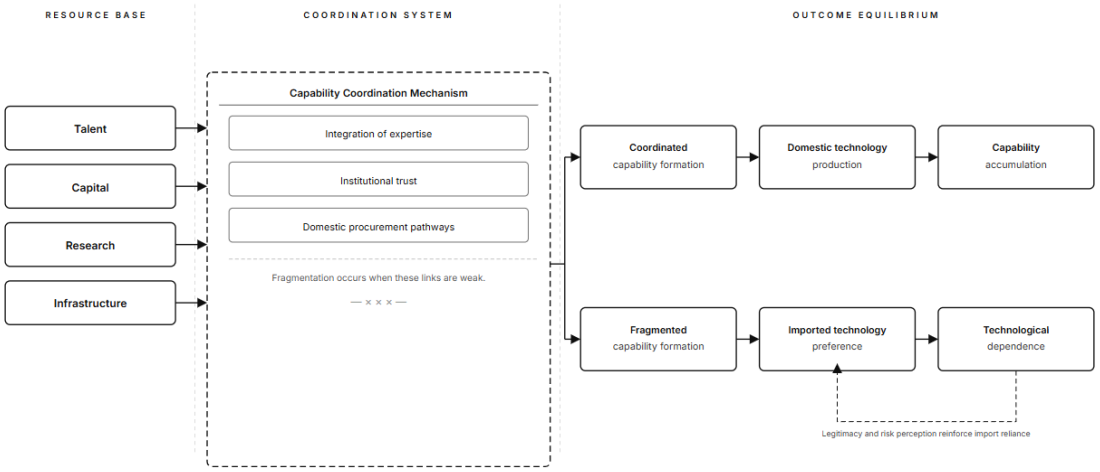

Figure 1. Capability fragmentation and technological dependence. According to the technological rentierism framework proposed in this paper, the presence of significant amounts of talent, capital, research activity, and infrastructure does not automatically guarantee the creation of technological capability.

Capability fragmentation represents a common phenomenon throughout virtually all knowledge intensive industries. For example medical practice requires coordination among specialists working with different types of knowledge. Advanced technological systems generally require the collaboration of several actors including researchers, engineers, infrastructure suppliers, financiers, product developers and regulators. Therefore, having all of the individual capabilities (talent, capital etc.) that enable technological development does not insure innovation since the structures required to allow these individual capabilities to interact are missing.

Given this situation; importing foreign technologies represents a reasonable response since it enables instant access to an integrated solution without necessitating the coordination of domestic capabilities. From this view point, technological dependency arises both from a lack of resources but also from failures in coordinating activities among various individuals. Thereby; although an economy possesses considerable quantities of talent, capital and institutional resources they will likely remain unproductive until the structural requirements for transforming those resources into productive capability are fulfilled. Consequently; foreign technologies may repeatedly be selected over domestically developed alternatives thereby maintaining a long term dependence status quo despite the availability of resources for pursuing alternate paths.

3.2 Technological Rentierism

In this paper, we define Technological Rentierism as a systemic phenomenon in which government agencies, companies, investors, and consumers gain increasing amounts of wealth from having access to technological capabilities produced outside their borders – while simultaneously investing too little money into producing their own domestic technological capabilities. The main difference between Technological Rentierism and other forms of technological dependence is that Technology Rentierism does not indicate a lack of

ability, financial support, or infrastructure; nor is there a lack of ability to access information and know-how. Instead, it represents a set of circumstances in which the economic agents involved have enough incentive to purchase pre-developed technologies (and related platforms, systems, and innovations) from elsewhere, as opposed to developing those same capabilities domestically. One reason why purchasing well-established technologies might appear to provide greater short-term benefits than creating similar capabilities at home is because existing technologies will immediately provide a level of performance (or functionality), whereas creating the same type of capability would require significant additional investment in both people and time.

Definition

The concept of technological rentierism is an economic phenomenon where certain entities can benefit economically by having control of new technology that was created elsewhere (outside of their own economy) but do little or nothing to create, maintain, modify or advance technology within their own economy.

As long as there are sufficient funds available for the purchase of advanced technology and/or systems and as long as a sufficient supply of talented people exists with the skills needed to operate such systems, it is possible to achieve rapid technological modernization and have increased access to state-of-the-art products and services. However, it is also true that in economies characterized by technological rentierism, capacity building is accomplished at a significantly lower rate than capacity consumption.

To each individual actor making such decisions, the choice to invest in technologies from abroad may seem perfectly rational. For example, a country's procurement agency may favor a foreign company providing a proven solution to minimize risk during implementation. Similarly, a company may choose to acquire a technology from another country over developing one on its own to improve its competitiveness in the marketplace by reducing the cost of technology development and accelerating the rate of growth. An investor may direct his/her investments toward mature ventures with known returns rather than taking risks by investing in newer ventures with unproven business models. And finally, consumers may prefer products that have been demonstrated globally to possess credibility within markets. However, when each actor makes these types of decisions individually, the overall effect may ultimately be reduced domestic capability accumulation.

Therefore, Technological Rentierism is distinct from importing technologies. Importing technologies is common among economies that are engaged in the processes of learning, adapting, and catching up technologically. What distinguishes Technological Rentierism is that the purchased solutions increasingly displace the creation of domestic capabilities, as opposed to contributing to them. Thus, despite expanding access to new ideas and innovations throughout an economy, the domestic ability to develop new ideas and innovations develops much more slowly or remains relatively stagnant.

Scope Conditions

The concept of Technological Rentierism is limited in that it cannot be applied to every example of a country importing technology. Technology imports may have developmental value when technology imports provide an opportunity for learning, experimenting, adapting and accumulating capabilities. Thus, this theoretical framework will apply only to those

situations where technology imports continue to replace domestic capability building rather than assist in its development.

A country should be classified as having become technologically dependent (rentier) only after there has been sufficient evidence of continued dependency despite the presence of capital, talent, infrastructure and access to knowledge; and when the use of external technological systems repeatedly diminishes domestic incentive to produce technology domestically, reduce domestic opportunities to produce technology domestically, or lessen the institutional demand for producing technology domestically.

3.3 Legitimacy Inheritance and Self-Reinforcing Equilibrium

Historical reliance on foreign sources to drive technological modernization has created an environment where domestic economic actors rely on external producers as their source of credible and reliable technological systems. Foreign firms, especially those who were first movers in fields such as computing, telecommunications, software and industrial systems, have driven many waves of technological progress. The history of the relationship between these foreign firms and domestic users has created a type of "legitimacy inheritance" in which the credibility of one generation of technological development was passed down to subsequent generations. This means that as time passes, governments, firms, investors and other users of technology begin to see foreign technological systems as the normative or default standard for quality, reliability and institutional trust. Furthermore, this perception persists even though domestic capabilities, talent and resources are increasingly becoming available.

The importance of legitimacy inheritance becomes apparent during situations where the use of certain technologies poses significant risks. For example, a company may be willing to consider a lower cost or otherwise inferior domestic provider for non-critical applications; however, once the application moves into critical areas (i.e., core business), the dynamic shifts. At that point, the decision maker's primary concern is no longer whether the technology will work or whether it is inexpensive. Rather than being concerned about functionality and price, the decision maker is now primarily concerned with being able to justify his/her decision should anything go wrong. For this reason, established foreign vendors are perceived as safe choices because they have existing global references, lengthy histories of operation, and institutional recognition.

These perceptions can develop into self-reinforcing cycles. If governments and large organizations continue to choose foreign vendors for all of their critical needs, domestic firms are deprived of opportunities to demonstrate their capabilities in complex environments. Domestic firms develop less experience, few references and diminished institutional credibility without these types of opportunities. Lack of credibility then creates additional disincentives for domestic firms to be chosen by future buyers. Therefore, technological dependence is not merely due to resource or capability shortfalls. In addition, it is influenced by trust-based behaviors developed prior to the onset of a wave of technological

modernization and reinforced by procurement behaviors, investment behaviors and institutional confidence developing over time.

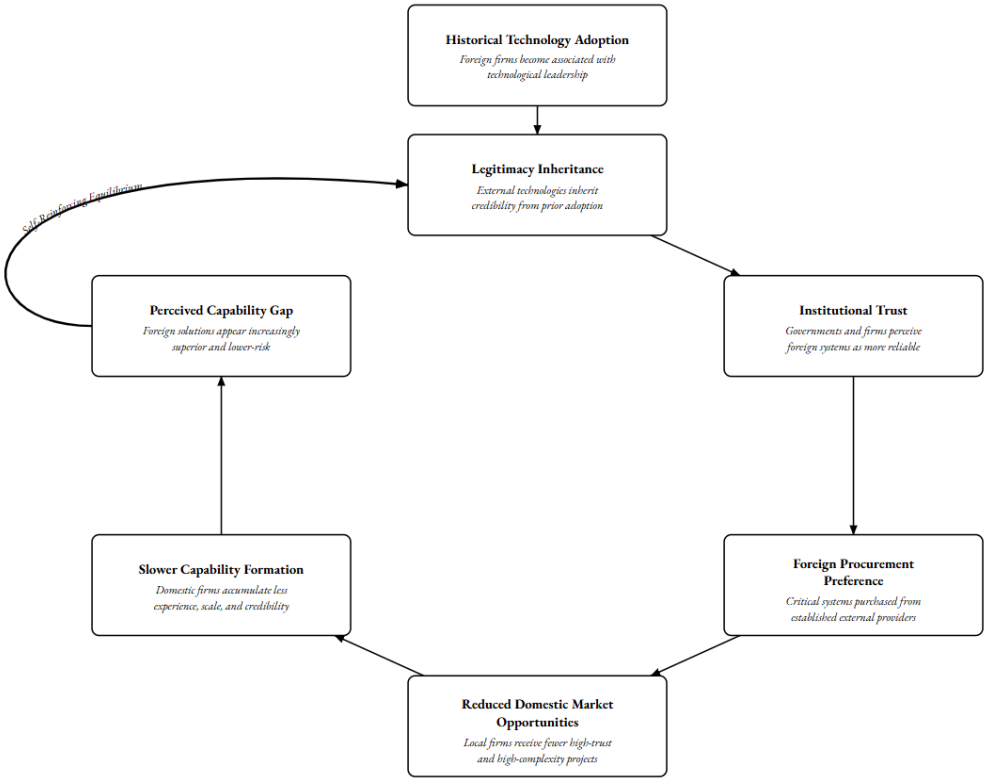

Figure 2. Legitimacy inheritance as a self-reinforcing mechanism for technological dependency.

3.4 Capability Accumulation versus Capability Consumption

Technological imports do not all have the same developmental impact. Although technological imports can provide access to new products, systems and knowledge; the ultimate result will depend upon how those technologies are utilized post-technology import. This paper identifies two distinct paths of technological utilization post-technology import: Technology consumption and Technology accumulation.

Technology consumption occurs when technological imports are primarily used as end products. At this juncture, organizations are using external systems for their benefit, and then replace them with newer systems. It represents utilizing technological values received from abroad, but very little if any effort is expended to understand the capabilities that generated such technological values. Therefore, although an economy receives innovation via technological imports, no increased ability exists within the economy to generate additional innovation.

Technology accumulation is a completely different path. This conceptualization of technology accumulation aligns well with literature that discusses the concept of absorptive capacity, and the necessity of learning, adapting and internalizing foreign based knowledge (Cohen & Levinthal, 1990). When technological imports are not only adopted, but studied, modified, improved etc., local expertise is developed along with organization wide learning and productive capability creation. Over time, what were originally foreign-based technologies begin to serve as input to domestic capability development instead of simply substituting for it. Thus, the goal is to gain access to technologies so that the economy has the ability to develop, reproduce and enhance like technologies internally.

It is the differences in these two paths that are critical since the same imported technology could lead to dramatically different results depending on the context of the economy. A technology that serves as a consumption asset in one economy could be a learning asset in

another. What determines the type of outcome is not the technology itself, but rather institutional arrangements, incentives and behaviors that direct the adoption process.

Therefore, the primary inquiry is not whether an economy adopts technologies from abroad, but does the adoption of technologies from abroad result in either capability accumulation or capability consumption? An economy that continually converts the acquisition of technologies from other countries into opportunities for learning may strengthen their productive capabilities over time. Conversely, an economy that consumes most of the technologies acquired from abroad may be able to expand their access to technology while developing their capabilities at a lower rate. Henceforth, foreign-based technologies should be assessed based not only on the value added in the present, but also on the capabilities they enable in the future.

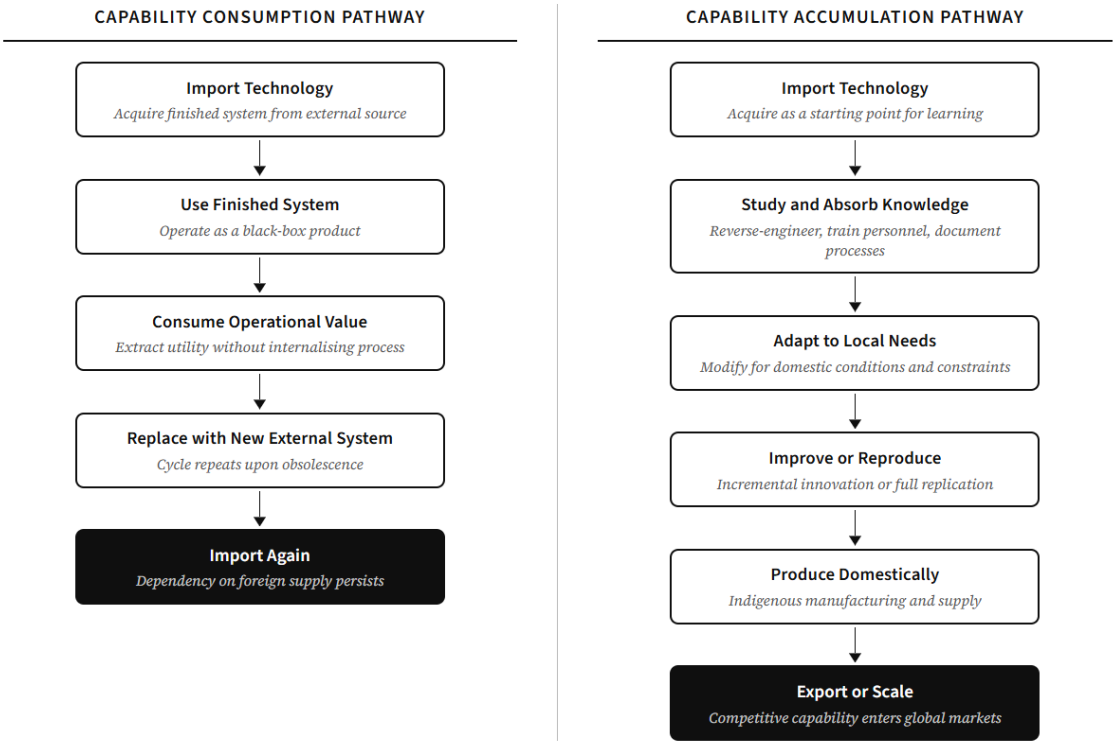

Figure 3: Capability consumption and capability accumulation.
This diagram illustrates two potential paths of technological importation. The first path is referred to as "capability consumption" where a country uses a foreign based technology as a complete system and utilizes its operationally functional characteristics until a replacement foreign based technology is obtained. The second path is referred to as "capability accumulation." The same foreign based technology becomes an opportunity for learning, adaptation and production in-country.

3.5 Theoretical Propositions

As discussed above, this framework demonstrates that technological dependence is not simply a function of resource availability; rather, it results from relationships between capability coordination, institutional behavior, perceived risk and capability formation. The above analysis leads to the formulation of four propositions.

Proposition 1. An economy can remain technologically dependent even when large amounts of capital, talent, infrastructure and access to information are available within that economy if those resources are uncoordinated.

Having the resources necessary for developing capabilities (i.e., capital, talent, research activities etc.) does not automatically lead to forming capabilities. Resources must work together in order to form capabilities. Thus, when resources are disorganized, solutions from abroad appear more appealing than investing the effort required to organize domestic capability formation.

Proposition 2. Organizations tend to prefer foreign suppliers over their local counterparts if they perceive that the risks associated with using domestic technological alternatives exceed those associated with importing similar technologies.

It would be rare for buyers of technology to base their purchasing decisions on purely technical considerations. Most times the buyer considers other factors including whether or not others have used the same technology in their business operations, whether or not others like themselves have used the same technology with success, and how easily they can explain the decision should something go wrong. In general, therefore, there appears to be a bias toward purchasing imported solutions even though identical local solutions may be available.

Proposition 3. Procurement behaviors influence how legitimacy is allocated among technological choices in an economy.

Procurement decisions made by a government agency or by some dominant institution extend far beyond the specific project being contracted. These decisions serve as indicators of credibility, reliability and risk assessment and thus signal to other organizations in the economy whether or not a particular organization should be considered credible. Legitimacy attaches to the providers who continue to receive these contracts. The longer history of contracting for services, therefore, the stronger becomes the association of legitimacy with those who receive contracts in subsequent periods. Consequently, subsequent procurement decisions regarding similar types of products/services are determined not only by the technical merits of each alternative but also by past patterns of adoption that preceded them.

Proposition 4. Technological dependence becomes increasingly difficult to eliminate once domestic firms are continually excluded from participation in "high trust" projects.

Whether or not a firm can acquire relevant experience depends upon its ability to access opportunities where that experience can be gained. If a majority of complex projects are continually awarded to established external providers then domestic firms face a vicious cycle: they are judged to lack experience because they have never worked on large-scale projects; however, since they are almost always eliminated from consideration in large-scale projects they are denied the opportunity to gain experience. Under these conditions, technological dependence continues to persist not because there exists no domestic capability but because domestic capability cannot develop quickly enough to counteract existing perceptions.

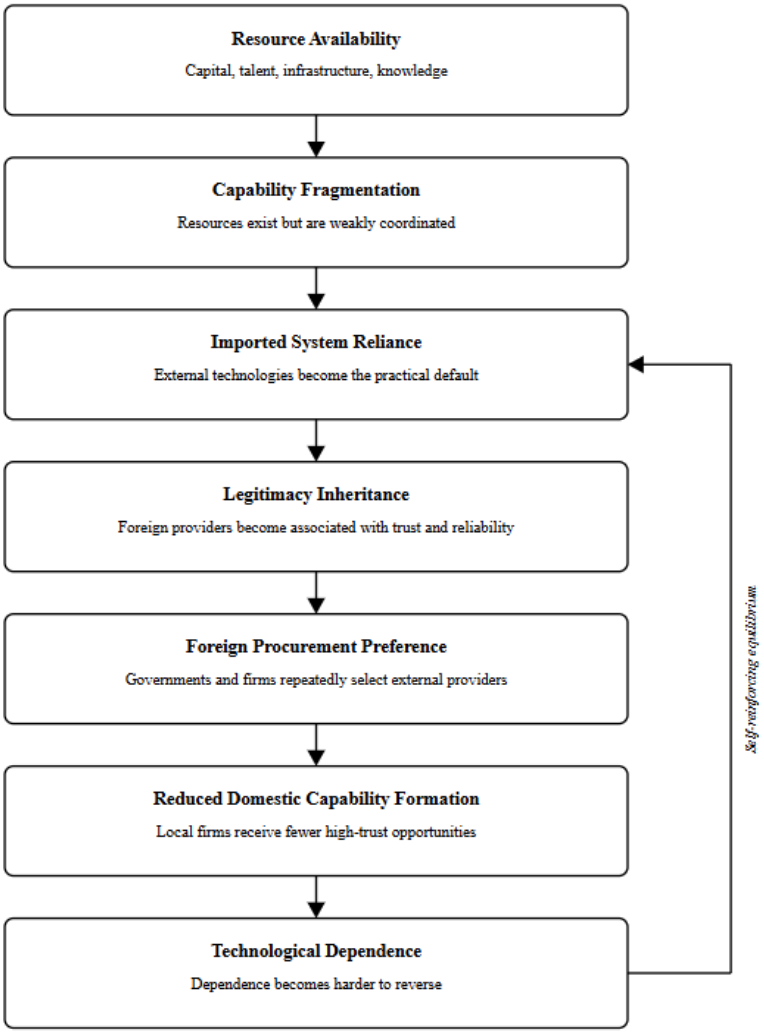

Figure 4. A combined theoretical model of Technological Rentierism. This integrated model illustrates how resource availability fails to produce domestic technological capabilities when resources do not interact well among themselves, procurement consistently prefers imported systems and legitimacy builds up around external providers. Eventually, limited opportunities domestically can contribute to maintaining dependence while making replacement of imported technological solutions more difficult.

3.6 Operationalizing Technological Rentierism

In order to test the empirical hypotheses regarding Technological Rentierism, the concepts outlined in this framework need to be operationalized. The frameworks' concepts are conceptual but there are several indicators that can measure some aspects of technological rentierism within an economy.

The proportion of strategic technology purchases from foreign vendors, the percent of high trust technologies that have been undertaken with domestic involvement, the ratio of imported technology to domestically produced technology, the percent of domestic R&D, and the ability of domestic organizations to scale up from pilot tests to large scale implementations are all possible measures of technological rentierism.

Each individual indicator does not conclusively indicate technological rentierism. These indicators provide a basis for determining if technological innovation is being followed by increases in domestic capabilities or if reliance on foreign technology is becoming a substitute for increasing domestic capabilities.

4 Comparative Country Illustrations

Country	Socio-Economic Framework	Domestic Capability & Innovation Infrastructure	Technological Rentierism Profile
South Korea	Advanced Knowledge-Based Economy (Export-Oriented)	Vertically integrated indigenous industrial base; global leadership in high-value semiconductor/electronics manufacturing.	**Negligible.** Demonstrates robust capability accumulation; systematic transformation of foreign knowledge into proprietary competitive advantage.
Singapore	Knowledge-Intensive Global Services Hub	Advanced R&D institutional integration; highly specialized, though dependent on multinational partnerships for specific innovation pipelines.	**Hybrid.** Institutional coordination mitigates reliance; external innovation networks remain a critical (yet integrated) component of capacity.
United Arab Emirates	Capital-Abundant Modernizing State	Rapid state-led investment in deep-tech sectors; nascent indigenous innovation capacity currently outpacing historical manufacturing benchmarks.	**Moderate-to-High.** Rapid consumption of advanced technological systems outpaces the maturation of endogenous productive capability.
Qatar	Hydrocarbon-Wealth Sustained Economy	Capital-intensive infrastructure investment; persistent structural reliance on turnkey foreign solutions and external technical expertise.	**High.** Structural dependence on external technological systems restricts the deepening of indigenous productive capacity.
Saudi Arabia	Vision-Driven Economic Diversification	Scaling domestic talent and enterprise ecosystems; state-backed investment in R&D and digital infrastructure development.	**Transitional.** Trajectory contingent on the efficacy of policy mechanisms translating capital allocation into sustained R&D productivity.
Bahrain	Agility-Focused Services Economy	Market constraints limit industrial scaling; procurement models favor foreign vendor dependence for digital and systems infrastructure.	**High.** Geographic and market scale limitations structurally reinforce reliance on external technological ecosystems.
Norway	High-Trust Institutional Governance	Sector-specialized technological prowess; robust capabilities concentrated in maritime and energy-sector innovation.	**Selective.** Resource wealth, mediated by strong institutional frameworks, facilitates effective mitigation of rentier risks in specialized domains.

The comparison implies that wealth does not determine technological rentierism. In South Korea, there was a process of capability building which resulted from importing technologies and through the learning process (industrial learning) developing a domestic, globally competitive production base. In Singapore, the development of its innovation system included both state-led coordinated efforts and investments; therefore, it has reduced its dependency on foreign talent and firms in the creation of new ideas. On the other hand, numerous Gulf countries represent cases of the primary question addressed in this research paper: They have large amounts of wealth, modern infrastructures, and direct access to advanced technologies; however, they still are relatively far behind other economies regarding domestically produced capabilities compared to their ability to adopt technology. Therefore, the main point made here is that whether an economy has sufficient financial

resources to purchase or utilize advanced technology is secondary to the issue of whether adopting technology will lead to a process of creating new knowledge, production capabilities, and ultimately learning within the economy.

3.7 Falsifiability and Alternative Explanations

Technological Rentierism, like all theoretical frameworks, will be tested through its implications or consequences. The more that economies reliant heavily on foreign-based technological systems exhibit strong capacity to create their own capabilities, move effectively from adopting to producing technologies, and sustain innovation domestically even while relying on international suppliers for technology; the less likely it is that an economy's reliance on foreign technological systems can be explained by Technological Rentierism.

Other possible explanations for why some countries are dependent on foreign technology could be a country's small internal market, political or geopolitical limitations, restrictive regulations within a country, lack of necessary skilled technical personnel to develop new technologies, and/or choosing to specialize in sectors of the economy where there is no need to produce technology (e.g., agriculture). Therefore, Technological Rentierism should not be seen as a single cause of technological dependency across all countries but rather as a particular set of mechanisms contributing to this issue among many other economic, institutional and structural issues.

4 Implications of the Framework

As a model, we can see that reliance on technology cannot be explained using measures like capital, talent, technology (infrastructure) or technology (adoption). To the extent that technology dependency relies on fragmentations of capability, the legacy of the legitimacy of technology, and the continued use of self-reinforcing purchasing behaviors, adding more resources will not automatically lead to the creation of domestic capability.

Therefore, there could be several implications. First, countries may still need to import new technologies although they may meet all of the criteria generally associated with innovation. For example, a country may have talented people, capital, and research activity; however, these will not automatically create the ability to innovate if they do not interact with each other or if the incentives for purchasing imported products continue.

Secondly, as foreign-based technological systems become integrated into large organizations, switching costs rise. Organizations prefer continuity based upon the existence of established infrastructure, technical expertise, operational processes and the existence of a familiarity with institutional structures even though there are existing alternatives available. Therefore, in these circumstances, technological dependence continues to exist not because there are not existing alternatives but because replacing well-established systems is viewed as too risky, uncertain and costly.

Thirdly, there may be barriers for domestic firms entering markets that relate to capabilities rather than technical capabilities. In areas of business where trust plays a significant role in creating contracts, vendors typically require evidence of past successful deployment of large

scale implementations prior to granting significant contracts. This creates a problem for new firms who cannot receive major contracts until they have proven themselves capable of implementing major projects. The results may be that domestic capabilities form at a slower pace than the underlying potential of domestic firms would suggest.

In addition, the model reinforces the importance of distinguishing between technological adoption and technological capability. An economy may implement high levels of technological utilization and yet accumulate domestic productive capabilities at a lower rate. Consequently, measures of modernization may exaggerate the development of internal technological capabilities.

5. Policy Implications

This paper presents a number of policy implications for countries which wish to improve their ability to develop domestically based technological capabilities. The technological dependency that has been identified as being generated by procurement incentives, legitimacy dynamics and risk perceptions can be mitigated through policy interventions designed to alter the institutional conditions in which technological decisions are made, rather than solely addressing the availability of resources.

5.1 Procurement Reform

Credibility is usually an essential element in technological procurement. Foreign systems are rarely chosen simply because they are less expensive or better technically. Rather, they typically derive advantage from reputation, historical records of use, and a perception that they represent the most advanced state-of-the-art technology. Use of an internationally recognized supplier can also add an institutionally valued aspect since it indicates that an organization is utilizing a global standard that is widely accepted.

Thus, procurement reform will likely involve changing how domestic suppliers are evaluated. A domestic company providing a similar product will still be considered more of a risk due to its lack of history, references and the perceived reliability of an established foreign vendor. Thus, credibility is frequently tied to origin and reputation as much as to the product itself.

Therefore, procurement reform must begin with discovering capabilities. Prior to considering foreign suppliers as an option, organizations must thoroughly investigate whether there are suitable local alternatives available. This does not imply that domestic companies must be selected as alternatives without consideration. Instead it implies that domestic capabilities must be investigated prior to dismissal. When no suitable domestic alternatives are found, foreign procurement may be justified. However, when domestic firms are never seriously investigated, the opportunity for forming capability is reduced before it ever starts.

5.2 Procurement as Capability Formation

Procurement should be viewed as a method for acquiring technology and not exclusively as a way to obtain products. Procurement decisions determine which companies acquire experience with technology, which companies build references with regard to technology and which companies become credible in terms of technology over time. Revenue received as a result of a contract represents more than just money. It represents recognition that a company is able to deliver its commitments.

When organizations with large purchasing power advertise their technology needs domestically, firms can identify exactly what is needed by the market in order to provide products. Therefore, firms will be able to plan investments, development and improvement with clarity regarding the actual requirements of the market. Absent this signal, local companies may not realize which capabilities are valuable to develop.

Therefore, procurement can help contribute toward building capability locally. First, local adoption occurs. Only after domestic firms have acquired sufficient trust, performance history and operational experience in their local market can regional or global adoption occur.

5.3 Risk-Sharing and Gradual Adoption

There is a persistent issue with regard to domestic capability development; the disproportionate risk associated with technology. When making decisions about acquisition, many decision makers will evaluate their choice based on both the positive results from the purchase as well as the negative consequences (i.e. the cost of acquiring inferior goods). As an example, purchasing equipment or services from a well established foreign vendor has historically been considered acceptable, regardless of the degree of effectiveness. Conversely, choosing a new local supplier could receive greater scrutiny should problems arise upon implementation. Thus, what is being procured is important in addition to how it impacts one's reputation.

Therefore, these dynamics create a significant competitive advantage for early stage vendors. For instance, most organizations need evidence of previous deployment successes prior to awarding large-scale contracts. Unfortunately, in order to obtain the opportunity to deploy successfully; they typically need to first be awarded large scale contracts. Consequently, domestic suppliers may find themselves in a position where they are required to prove their past experiences in areas in which they have few chances to gain them.

Thus, creating domestic capabilities through a sequential approach (as opposed to replacing existing critical infrastructure) may provide more beneficial outcomes. Developing domestic capability does not always mean substituting critical infrastructure with alternative options that have never been proven. Instead, it provides local vendors with opportunities to develop their expertise and become experienced in increasingly difficult environments. Small scale deployments, pilot programs, etc., provide examples of how organizations can gauge performance while minimizing the exposure of operations.

As time advances, successful implementation can build the references, trust and operational history needed for participation in larger projects. From this vantage point, the question is not simply whether domestic capability exists, but whether institutional structures provide enough opportunities for that capability to be demonstrated, validated and grown.

Figure 5. Sequential capability formation pathway. Domestic technological capabilities may develop through successive stages of adoption and trust accumulation. Early deployments generate experience and credibility, which can support expansion into larger markets and more complex technological domains.

5.4 From Technology Access to Technology Production

Advanced technology can lead one to believe that an economy possesses high levels of technological advancement. However, just as having the means to purchase goods at retail prices does not signify ownership of those goods, having access to advanced technology does not necessarily indicate that the economy is capable of generating or creating new technological advancements. As such, when an economy uses frontier systems, employs advanced software, and incorporates state-of-the-art infrastructure while relying upon capabilities generated outside of its own borders, there is a distinction between utilizing technology and producing technology. This specific distinction represents larger debates within the literature regarding the generation of capabilities and technological growth (Teece et al., 1997; Cohen & Levinthal, 1990).

The primary issue is not the utilization of technology versus the production of technology. An economy that merely obtains access to frontier systems utilizes the innovations after they have been created. An economy that generates frontier systems creates the knowledge base, firms, talent, and infrastructure necessary for the establishment of future markets.

There exist two types of economies: one type has obtained access to frontier AI systems developed outside of their borders and employed these systems throughout both their public and private sectors. The second economy also produces frontier AI systems that will be used by organizations worldwide. Both economies are technologically advanced; however, each serves significantly differing roles in the technological system. One is primarily a user/consumer of innovations while the second is a producer of innovations.

As previously noted, the differences are significant due to the fact that producing technology results in effects extending far beyond the actual technology being produced. Organizations which produce leading edge technologies develop specialized knowledge, provide investment opportunities, foster research and assist in the development of supplementary industries. Skills utilized to generate frontier technologies often result in valuable assets that can be applied to many aspects of the economy.

Therefore, technological progression should not be evaluated based solely upon the degree of access to advanced systems. While access to advanced systems may enhance productivity and positively affect economic performance, it is the production aspect of technological systems that signifies whether an economy provides contributions toward the development of new technological capacities. The most optimal position would be to create technological systems which other nations desire to acquire rather than merely utilize technologies developed by other nations.

5.5 Future Research Directions

The framework in this paper should serve as an empirical starting-point for future study rather than being treated as a complete or final theoretical explanation for technological dependency. The degree to which each of the four components (capability fragmentation; procurement incentives; legitimacy; risk perception) contributes to technological dependency will be examined empirically across different economic systems and different industries.

Comparative research would likely be very useful in evaluating the framework. Empirical research comparing countries that have made successful transitions from adopting foreign technology into producing their own technology with countries that continue to consume technology produced by others abroad could help determine the circumstances under which foreign technology leads to the acquisition of capabilities (i.e., does not lead to "technological dependency") versus its consumption.

In addition, empirical researchers will also be able to develop quantitative measures for assessing Technological Rentierism and test the relationships presented above using data drawn from such sources as procurement records, innovation indicators, firm level performance metrics, and longitudinal case studies.

6 Limitations

An interpretation of the arguments presented in this document would not result in an anti-technology import policy. All modern economies have utilized foreign origin technologies to stimulate development; however, there is a distinction to be made between foreign origin technologies that assist in developing new capabilities and those that simply displace developing new capabilities. There is no reason why an imported technology cannot provide a basis for both domestic learning and adaptation as well as domestic production. On the other hand, some imported technologies will continue to be nothing more than finished products which continue to be consumed domestically and do not add new domestic capabilities.

Additionally, the paper does not advocate that each country should develop all technologies internally. This is unrealistic. Modern production is based upon specialization, and countries differ with respect to their available resources, industrial structure, technical expertise, and strategic objectives. Therefore, the real issue is determining if there exist overlooked opportunities for developing new domestic capabilities through the use of foreign origin technologies.

Another limitation is that the framework presented in this document is theoretical (conceptual). Although the terms Technological Rentierism, Capability Fragmentation, and Legitimacy Inheritance are provided as examples of explanations for similar patterns observed among several different national economies, the conceptual framework presented herein has not yet been empirically validated. It is anticipated that future empirical validation will occur as a result of examining such data sources as procurement records, innovation indicators, firm level performance measures, or longitudinal case study analysis in order to verify that the causal linkages posited in this paper actually occur in actuality.

This framework provides an explanation for technological dependence resulting from at least two types of limitations. For example, some countries may experience technological dependence due to factors associated with their internal environment (i.e., limited market

size, restrictive regulations, geopolitical considerations, etc.). Other countries may lack sufficient technical knowledge to compete effectively in certain very specialized industries. In either case, the dependence may be caused by structural barriers rather than those identified within this paper.

Perhaps one of the most difficult challenges related to establishing talent availability is that the best and brightest people who possess the required skills necessary to advance many of today's high-tech fields often seek employment outside of their home country. Even countries possessing strong technological capabilities often attract talented individuals from other countries since there appears to be a global shortage of the requisite technical knowledge necessary to drive many advanced technological fields. Consequently, having strong technological capabilities in an economy does not necessarily mean that all of the technical knowledge required to support these activities was developed domestically. The ability to form new capabilities may be dependent upon recruiting as much as training talent.

The last point regarding the nature of the framework is that it addresses systemic issues rather than discrete decision-making processes. Individual entities including firms, consumers, investors, and governments make decisions on a daily basis consistent with the incentives they receive. Companies purchase products or services from suppliers with whom they have had prior dealings; investors allocate capital toward investments in markets with which they are familiar; and governments award contracts to vendors with whom they have previously done business. Each of these actions represents rational behavior given the incentive system faced by each entity. However, as noted earlier, the collective impact of repeated choices made by numerous individual actors over extended periods of time may lead to outcomes that were never intended by any individual actor.

Technological Rentierism has been suggested in this paper as a conceptual model to support the development of a potential theory that could be empirically tested. The next steps in research will involve developing quantifiable measures for all components of the conceptual model, selecting appropriate countries and technological industries as test cases, and assessing the theoretical applicability of the model across various economic and sectoral settings.

6.1 Theoretical Contribution

The theoretical contributions of this paper include developing Technological Rentierism as an analytical framework that explains long-term reliance on foreign technologies in countries with sufficient wealth, advanced infrastructure and transportation networks, global access to information/knowledge, and expanding number of technical workers. Although there are other frameworks that provide alternative explanations for long-term dependence on foreign technologies (e.g., insufficient financial and human capital; low institutional quality; lack of mechanism for transferring technology), none of them address all of the reasons why long-term reliance on foreign technologies may persist, even when most of those explanatory variables have improved.

An additional key contribution of the Technological Rentierism framework is its demonstration that technological dependence can be maintained through a self-reinforcing equilibrium, where purchasing decisions based on cost savings/procurement efficiencies, legitimacy-based preferences, perceptions of risk, and division of capabilities among multiple suppliers create a continuous cycle of selecting externally supplied technological solutions.

This type of behavior can ultimately limit future growth opportunities for domestically developed capabilities, thereby sustaining the dependency that was intended to be eliminated.

7. Conclusion

This paper was based on the premise that technological access and technological capability cannot be treated as equal. Although a nation has technologically advanced infrastructure, adopts the most cutting-edge technologies and appears to be high-tech; yet, it may still rely on foreign-developed technological capabilities.

Technological dependence can continue for a long time after basic resources such as capital, talent, and access to data/knowledge become abundant. The paper described how the effects of Technological Rentierism (the creation of rents through dependency on foreign developed technology) create conditions where economic actors will continually engage in fragmented forms of capability formation, procurements which incentivize the purchase of external solutions, legitimize their reliance on others' capabilities, and perceive risks associated with creating internal capabilities.

The paper's contribution is that it changes focus away from whether or not an economy has the required resources and towards the processes involved in coordinating these resources, trusting them to each other, and transforming them into productive capabilities. Therefore, technological development should assess not only the ability of an economy to utilize existing advanced systems but also the ability of an economy to create, develop, reproduce, and enhance technological developments internally.

When an economy uses technology for innovative purposes, they will gain benefits of innovation. When an economy develops technology, they have a role in defining what that technology will look like in the future.

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