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National Innovation Systems in Developing Countries

Evaluating Malaysia's Use of NIS Concepts in Public Policy between 2010 to 2020

by

Danial Johan Lissborg

da3532li-s@student.lu.se

NIS concepts are increasingly being utilised to inform public policy, both in the developed and developing world. This paper attempts to add to the discourse on how it is being applied within a developing context, particularly within a country aiming to transition into one developing its own innovation capabilities. By examining Malaysia as a case study, utilising NIS literature, domestic innovation surveys and international innovation benchmarks, weaknesses of the country's approach are identified which can be used to inform the actions of policy makers operating within similar context. The key recommendations are to ensure government efficiency through horizontal and vertical alignment across public organisations on key innovation outcomes in order to reap the benefits of any targeted innovation policies.

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1 Introduction

The National Innovation Systems (NIS) approach has garnered much attention since its first public use by Christopher Freeman in 1987 (Fagerberg and Srholec, 2009). Since being adopted by the OECD in the 1990's, its framework has been increasingly adopted globally by policy makers seeking to further understand and improve the systems that govern their domestic technological capabilities. As the world grows increasingly complex and countries more interconnected with the onset of the Fourth-Industrial Revolution, the catch-all concept of innovation has been steadily turned to as a means of ensuring global competitiveness and socio-economic development (Pérez et al., 2009).

Initially centred around the experiences of the developed West (Sharif, 2006), NIS literature has recently advanced towards understanding the role it could play in achieving progress in still developing countries (Pérez et al., 2009) . Many developing countries now employ some form of NIS thinking into their public policy to capitalise on latent domestic capabilities that would aid their progress towards catching up to their developed peers (Chaminade et al., 2009).

1.1 Research Problem

This paper aims to assess how effectively NIS recommendations has been implemented in reality by Malaysia, a developing country with a dual innovation system aiming to transition into mature innovation systems. This paper will examine whether the application of NIS thinking between 2010-2020 by the Malaysian government has been able to effectively improve the performance of its innovation system. The main research question being addressed is *What are the strength and weaknesses of the Malaysian government in promoting NIS development between the years of 2010 to 2020?*

Going off of the strategies outlined in the 10th and 11th Malaysia plans, both five-year national strategising documents, the effectiveness of NIS implementation will be evaluated through domestic and international benchmark surveys over the 10 year period. Afterwards, this shortcomings of these policies will be outlined and recommendations for the future made based upon current NIS literature.

1.2 Aim and Scope

This paper will examine to what extent the application of NIS concepts in public policy has been able to foster such a transition in a country on the verge of this socioeconomic

developmental threshold. A majority of the research on the application of National Innovation Systems thinking to developing contexts remains largely theoretical, with the transition of innovation systems between levels of development particularly remaining a relatively under-researched topic (Chaminade et al., 2009). This paper contributes to current literature by providing qualitative analysis of policies implemented within a recent time frame to a country on the verge of transitioning into the realm of mature innovation systems, providing a lens on how effectively theoretical recommendations are put into practice.

Malaysia has been chosen as a case study due to its long standing status on the edge of the ranks of high-income, developed countries. Despite having developed a strong base of technological and social infrastructure over the last 20 years that outperforms the majority of its regional peers, Malaysia has nevertheless been unable to match the success stories of recently emergent newly industrialised countries (NIC) like Korea or Taiwan, and has seemingly stagnated within this state of transition.

This paper aims to add to the ongoing discourse of National Innovation Systems thinking as it is applied towards developing contexts, particularly the transition from a Dual to a Mature Innovation System. By evaluating the implementation of these concepts in an upper-middle income country looking to pivot away from efficiency maximising macroeconomic strategies to one based off of creating global competitiveness via innovation, this paper will provide a lens on how effectively theoretical recommendations are put into practice. Outtakes could include possible blocks towards cultivating a successful innovation system in similar contexts.

The paper will cover topics pertaining to the National Innovation systems of Developing countries, including the basic tenets of NIS scholars, STI vs DUI modes of innovation, and NIS policy recommendations.

1.3 Outline of the Thesis

The thesis is outlined as follows. Section 2 will provide relevant background information on National Innovation Systems thinking, beginning with general concepts before specifying their particular application to a developing context, and further into its past integration into Malaysian public policy. A brief outline on the history of Malaysia's National Innovation System is given before describing the measures implemented between 2010 and 2020 within the 10th and 11th Malaysia Plans. Section 3 will then triangulate public policy between 2010-2020 with both domestic and international benchmarking data sets collated during the same time from the Malaysian Science and Technology Information Centre (MASTIC), the Global Innovation Index (GII), the Global Competitiveness Report (GRI), and UNESCO.

2 Theory

This section will cover the main concepts in NIS literature before further specifying how they can be applied within public policy regimes of developing countries. It should be noted that a large proportion of the material referred to on the main concepts of NIS refer to Chaminade's comprehensive 2018 book Advanced Introduction to National Innovation Systems.

2.1 Innovation Systems and Policy

Broadly speaking, Innovation Systems (IS) thinking is characterised by a dynamic approach towards analysing the network of actors within the innovation process. These actors are based in all sectors of the economy, and the NIS approach examines their interactions over time within the multi-faceted process of innovation (Lundvall et al., 2009), while further considering the way these systems are influenced by the socioeconomic context of the nation they reside within. This context is however not held as deterministic, and NIS thinking acknowledges its susceptibility to evolution over time (Chaminade, 2018).

NIS reflects a nuanced approach to innovation, beyond simply equating firm-level investments into R&D with specific innovation outcomes. There exists a clear focus on the idiosyncrasies each system displays and how they may either encourage or hinder innovative efforts. NIS thinking employs a systemic perspective that reciprocally links micro-level behaviour to the larger system, whereby interactions and outcomes at the micro-level result in changes at the system-level, which in turn will influence innovation and competence building at the micro level (Chaminade, 2018). By serving as a link between the ongoing process of development within a country to the development of innovative abilities of domestic firms, NIS acts as a theoretical bridge between development economics and innovation studies (Lundvall et al., 2009 cited in Chaminade, 2018).

NIS thinking at its most basic can be broken down into three components. The first is seeking to understand the way knowledge is created and diffused within a particular system. NIS scholars appreciate a wide diversity of available learning modes, understanding that highly-specific, often tacit local knowledge is married to more universally applied scientific principles within any effective innovation system. Straightforward science and technology (STI) indicators have therefore been criticised when used as a proxy for innovation, being too narrow in scope and not acknowledging the contexts in which innovation results from learning by doing/using/interacting (DUI) modes instead (Kraemer-Mbula and Wamae, 2010). By incorporating these different learning processes into the scope of analysis, NIS remains more readily open to understanding the diversity of learning paths actors can take (Chaminade, 2018).

Second, NIS scholars prioritise understanding the linkages both within and between organisations, referring explicitly to both typical work organisation as well as the various public and private institutions that encircle such organisations. NIS emphasises the importance of acknowledging the motivations as well as the interactions between these different groups of actors in how it informs the innovation process as a whole (Chaminade, 2018).

Finally, NIS highlights the importance of pulling the analytical lens out away from the specific interactions between the involved actors to analyse how innovative processes are influenced by the prevailing socioeconomic structures of their country. For example, innovative processes are most often affected by the economic structure of the country, as industrial specialisations and the existing balance between industries influence how firms will learn as well as which ones are increasingly incentivised to innovate (Chaminade, 2018).

As the concept has been increasingly adopted internationally, NIS literature has strongly dismissed any notion of 'ideal practices' between different settings, stressing a mutual rejection among policy makers of the notion of 'optimalisation' (Chaminade and Edquist, 2006) which policy makers may attempt to glean by comparing the innovative initiatives of a similar, more developed innovation system. NIS scholars point out that aggregative innovation measures mask the nuances (either inefficiencies or proficiencies) existing within particular processes or firms in a country that led to such rankings. Therefore, there is no guarantee that a 1-to-1 imitation of one policy would lead to the same level of success within another context and policy design needs to be conducted in an ad-hoc fashion (Chaminade and Pérez, 2017). This could otherwise be a tempting strategy for a country like Malaysia, whose neighbour Singapore has managed to excel on almost all fronts to become a global innovation and economic frontrunner. While superficial similarities exist in the socioeconomic legacies of the two countries, the practices that have led to Singapore's success could not simply be imported into the Malaysian approach and expected to garner the same results

NIS scholars instead vie for an intelligent benchmarking approach when comparing innovation systems. The policies implemented within another system are analysed, and are subsequently discussed to determine whether they could be fit as 'better' practices than those already implemented (as opposed to 'best') (Lundvall and Tomlinson, 2001; Perez et al., 2009) to the context of the domestic innovation system. This constant assessment and moulding of policies to the given state of an innovation system is is particularly important for dynamic developing countries, as they're institutional and socioeconomic status may be changing just as rapidly. Understanding how innovation policy should be formulated should take then leads to the question about where those who implement those policies fit within an innovation system, and how and when governments should intervene to potentially improve their domestic NIS.

2.1.1 Government Involvement

The OECDs mainstreaming of NIS concepts and its subsequent uptake globally led in many cases to a shift in political discourse around the topic, marking a shift in how innovation policies were conceptualised and justified. Contrary to the Neoclassical approach, NIS views government involvement as prerequisite rather than as a final resort 'for achieving national objectives' (Lundvall and Borrás, 2005, as cited in Chaminade, 2018) when it comes to

developing their innovative capabilities. The argument follows that, the private benefit of firms for investing in innovation-related activities is outweighed by the public good it will create and such a gap should be bridged by public institutions. The wide-range of interdependent and interactive inputs considered by NIS would additionally result in a non-linear approach within policy making.

Neoclassical thinking previously led to reactive policies which were aimed at addressing 'market failures'. Within this view, there is an implicit understanding that innovation is market-dependent and thus strategies were crafted with a 'failure' fixing perspective, that were implemented to overcome such shortcomings without 'disrupting' the natural functioning of the system. Innovation was promoted through policy tools that increased access to funding for R&D as well as investment incentives, such as tax breaks, that would increase the ease with which investment bodies could interact with innovative firms. The system's natural state was seen as a pareto optimum that should be strived towards with minimal government intervention (Chaminade, 2018). Historically, innovation policies have been implemented internationally that have been often based off of this paradigm, and it can still be seen that governments follow this school of thought to rationalise current innovation policy in spite of an outward adoption of NIS concepts (Chaminade, 2018).

This rationale assumed that these policy makers would be equipped with an entire set of information necessary to accurately deliver a fully rationalised solution that would direct firms' behaviours in the correct direction to influence the market.

The NIS approach would ideally see a paradigm shift towards a 'opportunity' perspective in motivating public policy, whereby policy would instead aim to stimulate innovation pathways or configurations that the market would not be able to either support on its own. Mazzucato (2011, as cited in Chaminade, 2018) cites the reduced role of the state as a major blockade towards achieving effective innovation policy and its subsequent positive impact on economic growth. The implication is that the government must take the risk to invest in areas where the private sector would or could not in order to effectively utilise or build the macro STI capabilities present within the innovation system. Old linkages require government intervention to be dismantled to allow for the building of new competences of producers and users, while economic agents themselves need to be properly incentivised to partake in the creation and diffusion of knowledge. If policy makers understand the necessity behind shifting their approach towards their innovation systems and how they justify their actions, another slew of considerations arise which can be used to categorise systemic problems.

Contrary to Neoclassical doctrine, NIS literature assumes that policy makers in reality have a very limited set of information on how their innovation systems function. The systemic approach that NIS inextricably adheres to widens the range of considered factors that may affect a domestic innovation system. Social norms alone can sharply affect the effectiveness of implemented innovation policy. Innovation processes are therefore understood as highly context-specific, and the way innovation policy is tailored to a system needs to be equally specific. NIS scholars insist that policymakers take an experimental and adaptive approach to their innovation policy and utilise a multitude of tools in order to determine what works effectively in their given context (Maloney, 2017). This requires long-term commitment on policy-makers to their policies, as well as an efficient monitoring system to evaluate their

effects in order to consistently fine-tune towards meeting the system's needs. Considering the path-dependency of evolutionary economics, understanding how to sequence when crafting innovation policy is a key concern, as previous inefficient path-dependencies do not necessarily have to carry over into current functioning but can be worked out of over time with the correct blend of institutional pushes.

Long-term coordination of approach is an important consideration for policy makers but, as stressed earlier, it is equally important to understand the context that they aim to influence, as sustainable improvement in any system will warrant specific policy focus. Policy makers can inform their decision making by categorising the domestic IS as one of three categories put forward by NIS literature: emerging/nascent, fragmented/dual, and mature. Each type of system requires a dynamic approach from policy makers, not to 'fix' systemic problems but to create opportunistic spaces that would best be utilised given the particular system's characteristics.

2.1.2 Types of Innovation Systems

Emergent innovation systems are characterised by an institutional structure which lacks basic innovative capability, and as such requires a pragmatic agenda which focuses on building these up through small iterative improvements to the point that it can absorb and utilise technology that has been developed abroad. They require a focus towards building up the abilities of the domestic sectors or industries that naturally have the most advantage to be able to eventually conduct their own innovations and benefit society at large. *Mature* innovation systems on the other hand have already had the chance to develop these strengths. At this point the biggest concern is to avoid stagnation via lock-i. Therefore in these systems government must be wary to continually search for new growth paths, while managing in parallel any persistent problems of already established pathways.

The median between these two systems is the most dynamic and challenging form of innovation system to effectively manage, a *fragmented* or *dual* innovation system.Common in a large proportion of medium to high-income countries, these systems are characterised by the existence of two 'speeds' within their country, containing both particularly innovative clusters with high levels of technological capabilities besides diametrically underdeveloped counterparts. There typically is a critical mass of qualified scientific professionals in particular areas which allows them to engage in STI-based learning modes, but a lack of supportive or efficient institutions domestically can lead to the firms employing these professionals implementing an internationalisation strategy and utilising this talent elsewhere (Stal and Cuervo-Cazurra, 2011, as cited in Chaminade, 2018).

Dual innovation systems simultaneously deal with maximising technology adoption as well as developing their own. Being able to manifest all different combinations of organisation, linkages and socioeconomic structures, this type of innovation system especially requires an ongoing appraisal of the weaknesses and strengths of the system by policy makers as it matures, with strategies simultaneously evolving to meet the system's changing needs at any given time. NIS states that prioritisation within fragmented IS should lie in developing effective networking policies to allow for smooth linkages between the more dynamic sectors and the rest of the system. This could entail establishing networks between universities and industry, developing

industrial clusters or value chains, or improving connectivity with international partners or between local actors.

Within both weak and fragmented IS, special attention must be given to improving the absorptive capacity of firms. It needs to be acknowledged that the system itself is not yet able to only produce its own innovations and will actively be relying on imported technologies and practices. Any alleged benefits of effective innovation, trade, or investment policies will be hard to come by without being paired with policies explicitly aimed at improving the absorptive capacity of actors across the entire system. Ensuring an explicit focus on institutions and socioeconomic structures will best enable capability building and interactive learning within firms over time.

If the shift from a neoclassical perspective is recent, newly NIS-oriented policies can often collide with previous rationales and instruments. This can be overcome if policy makers maintain consistent vertical and horizontal alignment within their policy structures, building up public branches to support and strengthen the innovation ecosystem according to this vision. Vertical alignment consists of tailoring policies to the specific requirements and context of the IS in question. Horizontal alignment on the other hand means ensuring that these priorities, once established, are coordinated amongst each of public bodies that have any influence or jurisdiction over any aspect of the innovation ecosystem. Additional static systemic issues that should be considered in developing policy are: *directionality*, articulating collective priorities and the intended direction of change; *demand articulation*, having to anticipate actual end user needs and improve the efficiency of public procurement; *reflexibility*, how rapidly any of the innovation system's agents can anticipate and mobilise themselves in response to changes; *coordination*, which is the synchronisation of policies of various public bodies in different realms towards one desired direction.

Regardless of the kind of system in question, innovation and STI must be considered as two sides of the same coin, as the latter often defines the potential of the former. Vertical alignment within fragmented innovation systems must therefore prioritise a systemic approach to STI policies to support the innovative activities of their actors, taking into account both STI learning and DUI learning modes. The most critical challenge in such a system is most likely going to be where to invest limited resources to maximise their impact. Paired with the ad-hoc nature of developing these policies, an effective monitoring system must be developed to capture the systemic aspects of STI within the country and evaluate previous efforts.

Horizontal alignment in some way can be seen as a policy system in and of itself, especially in a fragmented system where alignment was previously lacking and public bodies traditionally operated independently of one another. In order to align STI initiatives behind these groups, governments in a fragmented system need to develop a consistent systemic economic model and rationale behind their actions to inform any joint strategy. Recent efforts at new forms of public organisations such as cross-sector councils for innovation and cross-ministerial agencies may also simplify navigating broader policy efforts.

2.1.3 STI vs. DUI

Innovation systems are inherently meant to be centres of knowledge production, be globally breakthrough technologies or iterative improvements in domestic practice. NIS literature however stresses the importance of understanding the different kinds of knowledge that are included in innovative practices and how they each affect the system and can be influenced by policy in turn.

Jensen (2007), in his seminal paper, put forth two contrasting modes of innovation: the Science, Technology, and Innovation (STI) mode based off of codified scientific and technical knowledge; and the Doing, Using, and Interacting (DUI) mode, which focuses on more tacit, informal methods of improving products or building competences over time. In order to effectively improve on aspects of a nation's innovation system, policy makers need to have a comprehensive understanding of how these methods are reconciled and being utilised by the system's various actors.

The more recent understanding of DUI place within an innovation has led to the move away from the bias implied through the utilisation of STI benchmarking variables towards more holistic ways of measuring the specific performance of an innovation system (Jensen, 2007). It cannot be overlooked that DUI processes are a necessary contributor to both a national innovation system's knowledge creation and innovative outcomes (Parilli, 2016) despite a traditional tendency to focus on STI indicators.

STI methods typically rely on knowledge that is available globally rather than specific to one location, and ideally will result in the production of global knowledge (given that the outcome is not protected by intellectual property rights). Alternatively, DUI methods are learnt locally, 'on-the-job' as employees face ongoing challenges that require solutions which may or may not be ultimately codified and widely available (Jensen, 2007). Policymakers that the place both these types of processes have within the overall scheme of innovation will understand the need to realign policies beyond a simple linear approach when promoting domestic innovation (Jensen, 2007).

It is additionally important to recognise not only that there exists a constant dynamic between these two approaches, but that the way they are both used separately and combined will result in different outcomes, as different collaborations will lead to different innovations (Parilli, 2016). Product innovation tends to benefit from a collaboration of both modes, while process innovation leans more towards the DUI mode (Parilli, 2016). Both modes exercise a positive influence on innovation endeavours, whether done internal to a firm or through collaboration with another innovation actor., but the separate influence of 'DUI-only' has been shown to be more pronounced on both process and product innovation than 'STI-only'. Nevertheless, joint implementation stands to be the most beneficial (Parilli, 2016).

Collaboration

Which actors interact with one another additionally will lead to different outcomes, pointing to the diversity of factors that must be considered by policy makers when looking to stimulate innovation. For instance, Parilli (2016) found that firm—university collaboration without the

engagement of other STI and DUI agents typically led to weak results in terms of innovating product (Parilli, 2016).

Policy Implications

Policy choices in the present as well as those implemented previously will affect the broader set of characteristics determining the efficacy of STI and DUI interactions (Fagerberg, Srholec, 2009). Fagerberg and Srholec show the positive correlation between the technological capability of a nation, social capital, and innovation-supporting governance in promoting technological catchup in less developed nations.

In terms of policy, STI mode calls for a supply-driven approach, whereby research results are commercialised, while DUI mode requires a demand-driven approach, such as supporting the development of products or services for a specific market (Isaksen, 2013). Analysis shows that policy makers should focus on implementation capacity to aid STI-firms (e.g. market and process competence) and absorptive capacity for DUI-firms (e.g. scientific competence) (Isaksen, 2013). Absorptive capacity will additionally allow for firms to make better use of foreign subsidiaries based domestically, who provide knowledge through backward linkages and can help develop the technological capabilities of the region they are based in, potentially extending to the capabilities of the host NIS (Pérez et al., 2009).

Beyond improving firms' ability and incentive to invest in R&D and learning on-the-job, policy should therefore aim to encourage the access and collaboration with a wide variety of system actors to increase the number of utilised knowledge sources (Isaksen, 2013). Policy should additionally target the interface between users and producers (Pérez et al., 2009). Emphasis on user-producer interaction finds its basis from the fact that firms often innovate in order to create solutions to specific problems that emerge from this continuous interaction.

Policy within emergent or dual innovation system need to be adapted to the industries they aim to develop and address their respective firms in order to be effective, as a lack of absorptive capacity would impede the benefit of a simple broad increase in scientific learning (Isaksen, 2013).

The absorptive capacity of DUI firms can be increased by improving their linkages to academic institutions, which allows these firms access to more STI modes of innovating, subsequently easing their process of absorbing scientific knowledge without having to invest in a dedicated research branch (Isaksen, 2013). This requires long term commitments for both policy makers and the parties involve with a comprehensible incentive structures for the latter.

NIS scholars stress the importance of recognising variation between regions of a country, and the tailoring of policy towards those Regional Innovation Systems (RIS) as well as the NIS in order to facilitate the catch up of the country as a whole (Pérez et al., 2009). Each are prone to their individual strengths and constraints, being subject to different institutional frameworks and path-dependency of previous policy interventions (Pérez et al., 2009). Accordingly, clustering according to these characteristics is a key strategy that should be utilised by policy makers which allows for idiosyncratic levels of intervention (Pérez et al., 2009). Encouraging an acceptance of DUI modes of innovation may additionally benefit and be more appropriate for a typical non-metropolitan region that is more deficient in science and technology

infrastructure in pursuing their own brand of innovation to improve productivity (Cooke, 2016). Nevertheless, it is also emphasised that the functioning of RIS in question will still be affected by those policies outside of its geographic boundaries and as such a holistic approach at both the macro and micro level is required of policy makers.

2.1.4 NIS Critique

Although the tenets put forth by NIS literature seem to be well-reasoned and largely correct, a fact corroborated by its wide adoption by policy makers around the globe, it does still have its criticisms. These tend to revolve around the pedestal that innovation as a concept is put upon by NIS scholars as an economic panacea for sustainable growth. David (2010) berates the contemporary obsession with innovation, likening the engagement with the subject to reverence practiced in shamanistic rituals, as public policy attempts to summon up "potent quasi-magical effects — notably in the forms of "knowledge spillovers" and "information externalities"" (David, 2010, 512). The main point of contention being against an excessive focus on promoting and investing in innovation in isolation, rather than maintaining a systemic view of its place amongst all economic actors and functions. Seeing that NIS concepts and recommendations can be so comprehensive on their own, it is imperative to avoid incorporating economic and public policy into innovation policy rather than vice versa. David additionally brings up the valid concern about defining what an 'optimal' amount or rate of innovation would be, something typically lacking within the NIS literature. Drawing a parallel to genetic mutations, David points out that innovations can take a substantial amount of time to manifest their full systemic consequences, with a learning process before the 'winners' are fully adapted into the ecosystem. David himself acknowledges the lack of a concrete guiding concepts for public policy behind these statements but nevertheless, these are valid concerns that need to be considered moving forward in any endeavour pertaining to NIS.

2.2 Application to Developing Countries

NIS literature in the 1990's was initially rather empirical in nature and tended to focus on the technologically-based Schumpeterian rents that were found in developed countries (Europe in particular) (Wonglimpiyarata, 2011; Chaminade, 2018). This led to scepticism on its applicability towards developing countries, as the concepts were built 'ex-post' for developed countries while they would have been applied 'ex-ante' to the developing world (Amir, 2013). However, as the topic became increasingly studied it was found that not only that it could be applied, but stood to hold massive benefit for those countries that chose to implement NIS practices appropriately to their corresponding level of development (Amir, 2013).

Innovative practices are an essential means to achieve national economic growth in today's technology-oriented, globalised economy, especially as offspring practices become adopted earnestly by a wider range of industries. Holistic policies targeting a nation's IS are better suited for developing countries than pure science and technology policies as they have the additional tendency of further shaping a country's social capacities (Chaminade & Perez, 2017) and

influencing its competitive position globally (OECD, 2016). The benefit of a well-functioning innovation system also cannot be overlooked for countries further along in the development process, as they seek to pivot away from strategies based on capital-accumulation, industrial-diversification, and low-cost advantage towards those based off of indigenous technological capability and value creation (Suehiro, 2019; Cherif and Hasanov 2019; Wong and Fung, 2019).

2.2.1 Government Involvement within a Developing NIS

Developing countries often have weaker indigenous firm capacities and formal institutions, but one opportunity available to those with a dual innovation system is a lack of bureaucratic precedent, which allows for heavier government involvement. This idea of strong government intervention may seem to go against notions of Western democratic practice, and subsequently the "West-is-best" notion that has been found controversial in development literature. While those practices have in fact shown to be effective for richer countries that have developed these methods of operating naturally over time (i.e. Western), it is often the case that precisely a non-Western institutional arrangement has allowed countries to make the best use of their latent capabilities to catch up with the countries that were further developed. East Asian countries, China in particular, have managed to capitalise upon this and rapidly catch-up to and overshoot many of their developed peers by implementing an explicitly non-Western institutional arrangement that emphasises heavy government direction.

Innovative practices seek to build a nation's knowledge base, but this base only proves useful if diffused properly (Cherif and Hasanov, 2019). Diffusion is a social process that can be either impeded or facilitated by both informal and formal institutions, depending on their approach. Governments in developing nations are therefore given the opportunity to mould the latter to be as conducive as possible to innovative practices and their spread (Amir, 2013).Having been done successfully in Newly Industrialised Countries (NICs) such as Taiwan and Korea (Cherif and Hasanov, 2019), which boasted a heavier government hand, what remains most important therefore seems to be not a particular arrangement of government institutions or policy, but rather consistently maintaining a coherent vision over time in order to implement tailored policies best-fit to a country's idiosyncrasies that upgrade its firms and technological capabilities.

2.2.2 Barriers to Development

This is not to say that these countries are without challenges. Chaminade and Pérez (2017) cite *eight* barriers that developing countries face towards establishing a healthy, and efficient IS that this paper will later use as a framework for analysing Malaysian innovation policy.

Although the NIS narrative has been increasingly adopted in public discourse with the acknowledgement of STI as a central component of achieving economic growth, this outward alignment is rarely accompanied by an increase in allocated budget towards realising that concept. This lack of commitment can be extended to a lack of enforcement intellectual property rights, which are a fundamental channel to make these initiatives commercially viable.

Unfortunately, the public bodies leading STI initiatives in developing countries typically are in a position of limited political leverage and struggle in establishing their initiatives as a national priority. Those in positions of authority above these bodies often fail to give STI the status of a central pillar of economic and social policy.

Political turbulence is often present in developing countries, and can greatly hinder a continuous implementation and long-term strategising of innovation policies. It is unavoidable that most innovation projects will either end in failure or take a large amounts of time and investment before being widely adopted, and the same is true for developing an efficient and well-functioning innovation system. As such, the benefits of any policy implemented towards improving the IS will tend to only take root if followed through over a long enough time horizon. However, the often rapid shifts in political hegemony within developing countries can lead to changing prioritisation, upending previous progress.

There additionally is often a lack of monitoring and evaluation being enacted to establish whether these policies, if maintained, are making any progress towards the intended outcome. This can result either from the lack of financial headroom from an overall lacking budget or a specifically maladjusted institutional culture that deters from investing in such efforts. This is particularly detrimental for innovation policy-making, as the process itself is inherently experimental. Policy makers seeking to fine tune the approach of their policies need to have a deep empirical understanding of the previous policies' strengths and weaknesses, and this can only be determined by having these types of measures consistently implemented.

In NIS thinking, government involvement is seen as required to narrow the gap between public and private benefit. This implies that private actors are often not properly incentivised to partake in the financially risky activity of innovation. This is especially true in a developing system that is from the start characterised by a weak arrangement of institutions supporting innovative activities. Reduced levels of R&D investment from the private sector are additionally aggravated by financial systems that are not built to support innovation. As new firms or entrepreneurs are unable to gain access to funding, a negative cycle is spawned where a lack of profitable projects further disincentivises the financial sector to support such initiatives. In addition academic bodies in weak innovation systems tend to focus more on teaching or performing research, often lacking the linkages to private enterprises required to collaborate on commercially viable innovation projects. Governments of developing countries therefore initially need to bear the brunt of the cost associated with further developing a healthy innovation system.

A term often thrown around within developing countries regarding higher-qualified skill professions is 'brain-drain'. The concept posits that locals who are in a position to build their respective expertise will often leave the country in search of higher paying salaries or environments where there is more opportunity to make use of and build the skills they've acquired. This is often symptomatic of a circular issue within developing economies, whereby a lacklustre educational system leads to a lack in human resources in terms of both quality and quantity, which in turn disincentivises multinationals and otherwise innovative local companies from basing their operations domestically. This lack of a highly qualified workforce within the hard sciences will also impede any ability to craft a conducive ecosystem without outside influence.

A lack of monitoring and experience towards crafting a cohesive vision for innovation systems can lead to reduced coordination among public bodies in implementing an overall STI strategy (previously mentioned as horizontal alignment). The initial structuring of these public bodies often works against their ability to function as a unit, with overlapping jurisdictions and strategies creating confusion and lengthening any bureaucratic process associated with innovation (e.g. seeking funding, filing for patents, etc.). As stated earlier, developing countries often see a lack of funding directed towards STI initiatives, so it can often be the case that these organisations will compete with one another to secure funding for their projects.

Even if these organisations are strategically aligned, there exists another kind of mismatch for governments that have only recently enlisted an NIS approach. Maintaining neoclassical rationale (viewing innovation support as a fixing market failures) beneath overt NIS strategies in the beginning stages of a shift of rationalisation can remain, and policy makers and public bodies can suffer from an ideological inertia. Paired with insufficient monitoring and evaluation, this may mean that the instruments that are enlisted do not match the objectives set forth by bodies leading innovation efforts. Without evaluation mechanisms, these new efforts may themselves be based off a misunderstanding of what the actual needs of the system are. This lack of direction will strain the effectiveness of strategies that are already limited by a lack of funding or prioritisation.

Developing countries within higher income brackets, like Malaysia, face other challenges to those posed by Chaminade and Pérez (2017). As they aim to transition to more developed technological capacities through activities such as an improved innovation system, they lose the cost-based advantage of their export industries that initially made them competitive (Lee, 2013, as cited in Chaminade, 2018). To avoid this becoming a ceiling to the country's progress and falling into a middle-income trap, NIS literature states that these nations should place strategic investments into technologies with a short life cycle, paired with gradual institutional changes.

To summarise, analysis of STI policies that influence innovation systems in developing countries suggest that upgrading is most possible when implemented policies follow three criteria. They must be: comprehensive, being geared towards all elements within the system including the actors themselves, the links between them, and the institutional frameworks they interact within; evidence based, through both domestic data gathering as well as international 'intelligent' benchmarking so that those comprehensive policies affect each component in a way that meets the actual needs of the country; developed and subsequently implemented consistently over time as well as over the various bodies involved (i.e. vertical and horizontal alignment), so that they are implemented effectively and are given the chance for their benefits to develop. Once again, what these policies are specifically will depend on the path-dependent context of the particular system in question and will need to be determined by well-monitored and evaluated, continuous policy experimentation.

2.3 Malaysian Context

Malaysia has long been considered a forerunner within Southeast Asia towards achieving a developed, high-income status. An emerging 'tiger' of the Asian economies (Wonglimpiyara, 2011), Malaysia has achieved tremendous growth and economic success in the short time since establishing its independence in 1957 (OECD, 2016). The developed metropolitan region surrounding the capital, Kuala Lumpur, is contrasted by more rural regions in the rest of the country, rendering what has become a *dual* innovation system.

Malaysia began its transformation as an agriculture-centric economy exporting primary commodities in the 1970s to a multi-sector nation primarily driven by manufacturing (OECD, 2016) in the 1980s (officially classified as an upper-middle income country by the World Bank in 1979 [Suehiro, 2019]), before focusing on modern-services in the 1990's (OECD, 2016; 11th Economic Plan, 2015). Currently Malaysia's economy has found great success along several major growth outcomes (Cherif and Hasanov, 2019) relative to its Southeast Asian neighbours (with the exception of Singapore) as a diversified economy, based off of foreign direct investment (FDI) through export-led manufacturing in the electrical and electronics and natural resource-based sectors (Ng, 2016; OECD, 2015).

Since the mid-90's, the Malaysian government has prioritised the increase of innovative and productive capacities within the country. Technology parks were created with the aim of promoting domestic upgrading, government research institutes (GRI) were established, initiatives to develop the skills of locals were implemented, as well as multiple efforts to encourage MNCs to establish research centres domestically that would potentially lead to spillovers in local industries (Cherif and Hasanov, 2019). Despite successfully attracting a swathe of MNCs through generous incentives and cost-based advantages (OECD, 2016), these spillovers have remained minimal, pointing to a lack of absorptive capacity locally. In many cases, domestic firms did not meet many requirements to receive government incentives, further stagnating any potential development (Cherif and Hasanov, 2019).

As such Malaysia's efforts up to this point to improve the quality of its NIS components have been met with little success, with the country still lagging far behind the innovation scores of its developed counterparts (11th Economic Plan, 2015).This is symptomatic of the Middle-Income Trap that faces many Asian economies and that few have been able to escape thus far. This occurs when a nation that up to this point found success by leveraging low-labour cost and an abundance of natural resources find themselves unable to pivot into an knowledge-intensive and highly skilled economy due to a lack of appropriate infrastructure and social capital (Wong and Fung, 2019; Cherif and Hasanov, 2019; Suehiro, 2019). Malaysia has been faced with mild economic stagnation since the 2000s, blamed on its bias of export products towards E&E (Electrical and Electronic) goods, with little effort put forth to shifting towards high-value-added exports and a lack of upskilling of domestic labour (Suehiro, 2019). Despite dedicated efforts, there is evidence that the Malaysian government has been unable to tackle the market failures that impede the promotion of domestic technology creation, at least to the extent of more successful NICs in Asia such as Taiwan and Korea (Cherif and Hasanov, 2019).

The transitions towards becoming an upper-middle income economy were achieved primarily by consecutively planned government strategies that were able to steer Malaysia's capabilities towards consistent improvement (Bekhet, 2017). Of particular importance were the five-year Malaysia Plans (MP), the first being launched in 1966 and continuing to the current day; the New Economic Policy (1971-1990); the National Development Policy (1991-2000).

Having successfully achieved a status of a upper-middle income nation, Malaysia's next target was to transition into a high-income economy. This intention was cemented in the Wawasan 2020 (Vision 2020) ideal put forth by the then Prime Minister Mahathir Mohamed in the country's sixth economic plan in 1991 (6th Economic Plan). Incubating domestic innovation as such remains at the top of Malaysia's priorities, consequently informing a majority of public policy (OECD, 2015). Throughout the span of the NTP over the last ten years, the Malaysian government has done what it can to dig deeper into the determinants of the country's innovative capabilities to rectify previous shortcomings.

Coming out of the second financial crisis the country had faced in little over a decade, the Malaysian government presented their 10th Malaysia plan in 2010 with the clear aim to further build up the nation's productive capability of its knowledge economy through its individuals and organisations. The successor to the NEP and NDP, the 10th Malaysia marked the beginning of the the National Transformation Policy (NTP) (2011-2020) (11th Malaysia Plan, 2015). This would carry on into the 11th Malaysia Plan, and would be paired with the Government Transformation Programme (GTP) . The NTP marked a change in strategy towards achieving success within a global context, emphasising a holistic approach towards managing the transition towards becoming developed country, including incubating an efficient NIS. In the next section, the methodology used to evaluate the policies within the 10th and 11th Malaysia plans will be outlined before the main policies themselves are described and subsequently evaluated.

3 Methods

This paper utilises a variety of sources to determine the effectiveness of the implementation of NIS concepts into Malaysian public policy. The primary data sources were the 10th and 11th Malaysia Plans, documents published every five years as a means for the Malaysian government to inform the public on future policy strategy. Transparency throughout the dissemination of these plans have been maintained via parliamentary hearings and mid-term reviews involving policy makers around the country that ensure consistency between policies proposed and implemented (10th Malaysia Plan, 2010; 11th Malaysia Plan, 2015).

Concepts from the literature review were used as a framework for categorising the otherwise policies presented in these plans. These included: social and technological capabilities, absorptive capacities (as mentioned in Fagerberg, 2008), as well as the list of barriers for building an effective NIS within a developing context presented by Chaminade and Pérez (2017). Given the broad sense of innovation being covered by that list and the literature in general, secondary sources were elected due to the fact that they cover a larger scope than could be achieved via a self-led research.

A qualitative analysis of the policies mentioned in the 10th and 11th Malaysia Plans (from 2010 to 2020) was done by triangulating domestic sources (innovation surveys conducted by the Malaysian Science and Technology Information Centre (MASTIC)) against various international innovation benchmarking datasets (Global Innovation Index (GII), Global Competitiveness Report (GCR), and UNESCO GERD figures).

First, the policies proposed in the 10th and 11th Malaysia plans are described. Next, context for evaluation was provided through an appraisal of Malaysia's NIS by domestic innovative firms, sourced from MASTIC surveys between 2012 and 2015. Finally, the previously mentioned NIS concepts were used as a frame to select relevant metrics from the GII and GCR to be matched against these policies. The metrics selected were based off of the descriptions behind their design in the latest version of each of these reports. The full versions of these descriptions can be found in Appendix A. The effectiveness of Malaysian policies was determined by measuring the progress of the corresponding metrics over the ten year period being analysed and additionally triangulated against government spending on R&D over the same period provided by UNESCO.

Several shortcomings are acknowledged with the data and applied method. First is that this paper is limited in that it has to rely on a variety of secondary data sources, created separately from one another, meaning that their end focus remains unaligned. Several of the sources (particularly the MASTIC surveys) do not cover the allotted period of study in its entirety. Additionally the GII and GCR, being secondary sources, have not been designed with the topics evaluated in this paper specifically in mind, and thus serve more as approximations for the concepts in question. Nevertheless, even within their limited capacity or scope, these secondary

sources still provide insight on the overall effectiveness of the implementation of NIS concepts into Malaysia's public policy when considered all together, being compensated for by the breadth of scope of these surveys, both in number of participants and factors measured that goes into each score. As such, the paper offers actionable insights for Malaysian policy makers to be found and the conclusions of this paper add to the literature discussing the practical implications of applying NIS concepts to a developing context.

4 Data

4.1 10th Malaysia Plan (2010-2015)

National Key Economic Areas (NKEA)

The Tenth Economic plan emphasised a shift from the previous sectoral diversification strategy towards specialising within the industries that Malaysia demonstrates predilection towards, focusing growth within areas that would have the highest economic impact for the country as a whole. The plan outlines 12 National Key Economic Areas (NKEA) that it aimed to subsequently endorse with the given policies: oil and gas; palm oil; wholesale and retail; tourism; ICT; education; electrical and electronics; business services; private healthcare; agriculture; and the greater Kuala Lumpur (10th Malaysia Plan, 14). The final point standing as a geographical area, highlights the government's understanding the country's economic and innovation system is fragmented (10th Malaysia Plan, 20). The Tenth Plan highlights the fact that agglomerating economic activity into specific urban areas allows for greater network effects and for firms to benefit from economies of scale (10th Malaysia Plan, 116). It is no surprise that the capital serves as additionally as one of the most dynamic and liveable regions in the country, attracting foreign creative and knowledge workers.

Clustering

While building Kuala Lumpur up as a the dynamic hub of economic and innovative activities, remained one of the primary focuses of the plan as a whole, a number of initiatives had been taken up since the 9th economic plan to ensure balanced regional development (10th Malaysia Plan, 118). Five growth corridors were identified in other parts of the country, whose sectoral strengths would be supported by the government. The Tenth plan further extended this strategy by focusing on specific high-density clusters within the corridors to make the most of the sectoral and geographic advantages, creating network benefits such as shared resources, labour market matching and knowledge sharing.

Low Productivity

Within the Tenth Economic plan, the Malaysian government was able to identify the country's major weaknesses. Of particular interest were: a weak base of human capital (10th Malaysia Plan, 4); a lack of effective linkages between the components of the quadruple innovation helix framework (universities, industry, government, and public environment); an inefficient government structure (10th Malaysia Plan, 29), whose components lacked alignment and effective segregation of responsibilities; and a lack of incentive for private investment into innovative activities (10th Malaysia Plan, 38).

Improving labour productivity domestically remained a primary focus of the Tenth plan, as Malaysian levels began drastically falling behind their high-income Asian counterparts. If they were to aspire to join their contemporaries, the Malaysian government understood that upskilling the work force was a top priority in order to further develop local strengths and shift domestic industries up the global value chain.

Education

Beyond simply improving the quality of the local educational system, the plan additionally outlines strategies to improve the linkages between academia and industry, encouraging collaboration and establishing a dialogue that would both focus the development of skills towards industry needs and provide an avenue for gainful employment out of university. This was paired with Malaysia's intention to employ a vocational dual training system and graduate internship jobs. The government aimed to mainstream and significantly increase enrolment for technical education and vocational training (TVET) programs to improve mobility between the academic and technical streams (10th Malaysia Plan, 80).

With the Tenth plan, the Malaysian government continued its efforts to streamline its educational pipeline. Previously being managed by a number of agencies with their own given agendas, the plan established the Department of Skill Development to standardise TVET curriculum in an effort to reduce development costs and improve alignment by reducing the number of interfaces between the educational body and industry (10th Malaysia Plan, 216).

Beginning with the problem of Malaysia's underdeveloped human capital base, in 2010 it was seen that Malaysian students severely underperformed in terms of Maths and Science when gauged against international benchmarks (Trends in International Mathematics and Science Study [TIMSS] 2007), while those further along in their development, the working force, remained largely unskilled, with only a third going beyond basic schooling to work in jobs of a higher skilled bracket (10th Malaysia Plan, 193). Seeing that the underdevelopment of domestically talent was spread along the entire lifecycle of local students' development, the Tenth plan acknowledged that "nothing less than a comprehensive, all-inclusive national effort from the public and private sectors as well as civil society" was requires to "lift the quality of the nation's human capital" (10th Malaysia Plan, 193). The Tenth plan proposed an "integrated human capital and talent development framework" to prop up the educational backbone of the local workforce and provide both domestic firms and MNCs with the skill sets they required to succeed.

The country's national economic plan and STI plans both were motivated to improve Malaysia's education system from the outset up until secondary education. Universities in particular were enabled more autonomy and a stronger performance culture was encouraged (10th Malaysia Plan, 223). The Tenth Economic Plan additionally crafted strategy to improve the quality of the linkages between these educational platforms and industrial firms to create better matches between available human capital and innovative sectors of the economy.

An additional emphasis was placed in the Tenth plan on developing soft-infrastructure aimed at skill development, supporting the development of industrial clusters and the ecosystem enabling specialisation, innovation, and economies of scale (10th Malaysia Plan, 30).

Linkages

The Malaysian government sought to remove any possible factors limiting the ability of domestic firms to pursue specialisation or from foreign firms setting up research branches locally. The Malaysian strategy was to develop a highly competent, flexible work force that directly met the needs of high-capacity domestic firms. This was to be done by enabling and further stimulating practical and commercially viable university-industry links (10th Malaysia Plan, 216). The Knowledge Transfer Partnership (KTP) programme was introduced in 2011 to facilitate a convergence of industrial expertise and research findings into commercially viable innovation projects as well as to provide industrial-based post-graduate trainings. Through this and other measures, greater mobility between industry and academics was encouraged (10th Malaysia Plan, 224). The government as such did what they could to improve their services to both components of the innovation system to remove distortions in the labour market, subsequently reforming and improving its own formulation and services.

Foreign Sources of Innovation

Of particular emphasis in the plan is the establishment of the Talent Corporation (TC) whose explicit mandate is "to drive solutions to attract, motivate and retain the talent needed for a high-income economy" (10th Malaysia Plan, 106) via three roles: "as a catalyst to lead and drive innovative national talent management initiatives; as a facilitator for private sector efforts in attracting, creating and motivating a world class workforce; and to deliver major national initiatives on talent across the human capital development pipeline" (10th Malaysia Plan, 100). The initiatives would be additionally streamlined according to the National Talent Blueprint, whose goal is to align the TC to the needs of the established National Key Economic Areas (NKEA). Beyond attracting highly-skilled individuals, the Malaysian government also sought to implement incentive schemes that would attract similarly knowledge intensive MNCs to establish their research centres within the country

Through the Economic Plan, it would seem that those responsible have a solid understanding of Malaysia's status as a dual/fragmented innovation system, whether that understanding is intentional or not. There is an explicit understanding that, although the end goal is to establish Malaysia as a self-sufficient producer of value-add innovations, it is currently at least in part reliant on foreign talent and organisations. As such, efforts were made to encourage both foreign talent and firms to establish an innovative base locally.

SMEs and Private Sector Investment

It is understood throughout Malaysia's New Economic Plan that shifting towards being a high-income nation requires a shift within its economy to higher value-add and knowledge intensive production, which would in turn require industrial specialisation designated by Malaysia's inherent capabilities and contrastingly limited by its relative size. The end goal was, and continues to be, to shift from an economy ascertaining value from activities based on low cost and natural resources towards one driven by the productivity and innovativeness of its individuals and firms. With the government previously most often being a core strategic investor and driver of the economy, attempts were made to incentivise and stimulate investment

from the private sector and encourage a culture of demand-driven innovation and productivity, as well as simply improve public-private partnerships (PPP) (10th Malaysia Plan, 24). This led to increased investment into enablers of innovation, R&D and VC funding, and several initiatives to develop comprehensive infrastructure around the areas of Malaysia's inherent advantage (such as downstream palm oil, electronics, oil and gas). These efforts were to be aligned with previously delineated priority areas, the NKEAs. For instance, the government proposed a wave of privatisations aimed at forging a more equitable share of risk to reward with the private sector, as well as co-investing with the private sector through the Malaysian Venture Capital Management Berhad (MAVCAP), Malaysian Technology Development Corporation (MTDC) and Ekuiti Nasional Berhad (EKUINAS) (10th Malaysia Plan, 167). An additional PPP was the establishment of the RM20 billion (roughly €4 billion) Facilitation Fund aimed at catalysing private investment in key strategic areas.

As the world converges due to the pressures of globalisation and the opportunities afforded to us via its innovations, increasing amounts of attention have been placed on small-to-medium enterprises (SMEs) as a source of innovation and economic potential. This is recognised within the Tenth Economic Plan which, sought to to boost the nation's productivity by removing previous inhibitions towards and enabling the activities of smaller firms. Initiatives include special financing schemes and skills training for domestic knowledge SMEs (k-SMEs), as well as encouraging foreign firms to establish themselves locally to develop specialised capabilities. One effort aimed at specifically encouraging SME to participate in innovative activities is the 1-InnoCERT certification, which would entail monetary benefits such as tax deductions for R&D activities and priority in government procurement on the basis of innovation and commercialisation achievement (10th Malaysia Plan, 88). The SME Corp. was also established to function as a holistic SME support with the aim of coordinating programs as well as evaluating their impact, in order to reduce redundancy. Their activities included improving skills and capabilities of workers at all levels, providing facilities, financial assistance, advisory services, and market access in order to promote their commercial viability domestically and on the global market. Through the SME Corp., a Skills Upgrading Programme would also be implemented, in which the SME Corp. (10th Malaysia Plan, 232), was set to finance 80% of the training cost paid by employers towards training their employees at accredited training centres. Additional financing for SMEs include the RM150 Million (roughly €30 million) Business Growth Fund aimed at supporting companies until they can generate sufficient commercial value to be sustained by private investment. Additionally InnovationMalaysia would be the body responsible for overseeing and coordinating innovation initiatives in order to improve their quality and contribution to the generation of intellectual properties (IPs), with the key outcome being an increased rate of commercialisation of R&D outputs.

Reformatting Government Structures

There was a clear understanding that a significant transformation of the country's economy could not be achieved without a parallel transformation in the organisation and function of the government to meet the oncoming change in requirements. The Government Transformation Program aimed to take the same holistic approach utilised in the New Economic Plan and integrate an all around restructuring of government organisation to streamline bureaucratic processes and function more as a facilitator and consultant for enabling the risk-taking profiles of the private-sector (10th Malaysia Plan, 92). The government's role was to rather be a

facilitator of emerging specialisations via partnered investments with industry in all aspects of economic output. This meant a refocusing of organisational structuring to overcome overlaps and inefficiencies in program implementation, which would be headed by the Prime Minister's department; attempts to combat corruption, which has been a persistent problem within the all levels of the nation's operations; and an improvement of the talent present within public-sector organisations.

Seeing that improving productivity and increased private sector activity remained the central tenets for the New Economic Plan profile as a whole, it was clear that the government's role would have to be to provide a clear, consistent, and business friendly regulatory environment with policies tailored to the maturity, structure, and needs of each sector. This meant establishing transparent objectives for each sector, creating structures to address areas of overlapping jurisdictions such as cross-agency working teams to cut across silos to achieve national priorities, and improving the capabilities and accountability of public sector workers as in the private sector.

Proper alignment between the efforts of the public sector and the needs of industry and the private sector was highlighted in the Tenth plan as well. In order to ensure this, priority was to be given to continuous monitoring of individual and business perceptions through surveys in order for the government to promptly respond to the stakeholder concerns on the frontline and improve effectiveness of proposed solutions.

While the nearly the entirety of the Tenth Economic Plan's strategies seem to in some way match NIS policy recommendations, there is one agenda item present which seems to stand at odds. Aimed at improving inclusiveness, the Bumiputera development agenda is stated to be "a major thrust of Malaysia's economic policy", and has been since the Second Malaysia plan period. The primary target being attaining a minimum 30% Bumiputera corporate equity ownership at the macro level. Such policy remains a political artefact from the nation's independence that continues to impede both simplified economic and political functioning.

4.2 11th Malaysia Plan (2015-2020)

The Eleventh plan showcased an extension of the precedents set forth by the Tenth plan, but attempting further refinement and decisiveness in the alignment behind implemented policies and was much more detailed and specific about the actual strategy. The government's main focus remained people-centric, building human capacity to enable the continuous pivot from a labour-intensive to knowledge-intensive base of productivity. Specifically, the main agenda saw economic growth being developed along seven areas categorised along three dimensions, as seen in the following chart.

The priority on the labour productivity front was to further develop a comprehensive pipeline between both unskilled and highly-educated labourers to industry via strengthened TVET (11th Malaysia Plan, 30) and university-industry linkages respectively. Despite the previous efforts of the Tenth Economic Plan, industry feedback consistently showed that there still existed a disconnect between the values and skills these graduates possessed from what was required by

industry firms (11th Malaysia Plan, 140). While the Tenth Plan had established major strategy documents for the development of the human capital ecosystem with the Malaysia Education Blueprint 2013–2025 (Preschool to Post-Secondary Education), the Malaysia Education Blueprint 2015-2025 (Higher Education), and the Talent Roadmap 2020, greater pressure needed to be applied on aligning available talent to market needs by increasing the involvement of industry professionals in crafting the curricula and marketing TVET as a desirable career path. It was estimated that 60% of the jobs created during the Eleventh Plan, would require TVET-related skills, putting the program in a position to be a major contribution to Malaysia's effort to transform into a highly developed nation.

Several committees were put together within the Eleventh Plan to improve alignment between TVET programs and industry as well as academia-industry linkages including: an Industry Skills Committee, Industry Working Groups, Critical Skills Gaps Committee, Industry Centres of Excellence, Academia-Industry Graduate Development Centre (11th Malaysia Plan, 144). Although drafted with the purpose of improving efficiency, this is an example of one of the main weaknesses of the Malaysian NIS, whereby emphasis is placed on having a team for every problem rather than focusing on how effectively those branches operate.

The Tenth plan was successful in some part, as the economy grew on the back of increased domestic demand in the form of private investments within services and manufacturing. That being said, it was clear that it was still an ongoing process towards being a self-sufficient as FDI played a key role as a major source of investment and technology transfer.

The Eleventh plan planned to further refine the holistic, 'whole-of-government' approach to encouraging productivity and innovation within the economy. The newly devised five-year Malaysia Productivity Blueprint was set as an ongoing nation-wide productivity agenda, while increasing public sector productivity was incentivised by the enlistment of specific KPI measures (11th Malaysia Plan, 52). A similar initiative was set to develop coordination across agencies for human capital development with the establishment of the National Human Capital Development Council (11th Malaysia Plan, 142). Public sector linkages with academia were streamlined and loosened, and meritocratic funding was installed while relinquishing some of the tighter regulations in favour of public universities establishing autonomy in research and curricula.

Development strategy within the Innovation Ecosystem maintained the holistic approach that was previously established in the Tenth Economic plan, emphasising greater collaboration and integration across the components of the economies quadruple helix. Research, in theory, was to be closely aligned to industry demand with active involvement from the private sector in all aspects of research, development, commercialisation, and innovation (R&D&C&I). Innovation will be targeted at both enterprise level as well as societal level, rather than just operating on the national level as it did in the 10th plan, aiming to improve demand-driven research, researcher-industry collaboration and potentially incorporate incorporate social financing models to assist communities in funding new initiatives.

Efforts at nurturing the 5 previously established economic corridors continued, aiming to make use of each areas individual capabilities and stimulate indigenous productivity. While geographic balance in economic growth remained a priority for the government, additional

efforts at improving productivity at the city level were aimed for via support for agglomerations and knowledge-based clusters that would make use of each city's competitive advantages in a manner formulated by respective local authorities. This was meant to help build not only their productive capabilities but additionally their global desirability and domestic living standards.

The GTP also continued its efforts, with the angle for the government's transformation leaning towards being more citizen-centric, with enhanced productivity and effectiveness of service delivery through a less bureaucratic, hierarchical, and centralised approach. The aim once again is to enable the private sector to step in and perform the investment function that government typically has had the majority input to, taking initiatives to encourage productive and innovative actions across the public sector, industry players and individual enterprises. Five strategies were taken: reducing the cost of doing business via increased provision of basic infrastructure/improved regulation; providing performance-based incentives for high-income and knowledge intensive economic activities; matching talent mismatch by establishing a labour market data warehouse and improving labour market clearance mechanism, and promoting re-skilling programmes; improving access to financing for knowledge-intensive industries by equally incorporating innovation within financing approaches; providing tipping point financing through the Facilitation Fund to serve as a bridge towards commercial viability that attracts private sector investment.

Specific emphasis was placed on building up the innovation system along four general key areas: shaping a supportive ecosystem, creating opportunities, putting enablers in place, and providing funding. This included the development of several specialised agencies to drive the innovation agency including: Agensi Inovasi Malaysia (AIM); National Science and Research Council (NSRC) (11th Malaysia Plan, 246); Khazanah Harta Intelek Malaysia, a centralised repository of Intellectual Properties (IPs) to catalyse commercialisation; and several intermediaries to enhance collaboration and provide advisory services.

Despite the foundations that the Tenth plan laid down for the newfound 'whole-of-government' approach, there remains significant opportunities for improvement within how the government delivers its services. Beyond combatting corruption, transparency and efficiency of said services were highlighted to be improved through more effective engagement with the citizens as well as through better coordination and sharing of data amongst agencies. The Eleventh plan acknowledged the ongoing shortcoming of overlapping functions of government agencies. To summarise the main goals of the GTP remained on retaining better talent, improving communication and connection with relevant stakeholders, streamlining organisational functions, and increasing monitoring of ongoing projects.

4.3 MASTIC National Surveys of Innovation (NSI)

The MASTIC National Survey of Innovation (NSI) testifies to the Malaysian government's pursuit of innovation as a national priority. With the first edition released in 1995 (MASTIC, 2012), the survey has aimed to provide actionable insights into Malaysia's NIS from the perspective of its private sector actors. Based off of the OECD's OSLO manual, the NSI surveys

companies from the manufacturing and services sector, with its main objectives being to study the innovation activities of these firms, measure the knowledge and awareness of these firms of public sector innovation initiatives, profile innovative companies within the country, establish parameters to allow for efficient benchmarking, determine major impediments to innovation and subsequently craft recommendations to be taken up in public policy decision making (MASTIC, 2012).

The surveys however have been conducted at irregular intervals since the project's conception in 1995. As such this paper will only be able to utilise the data presented in the 2012 NSI (its evaluation spanning between 2008-2012) and 2015 (spanning 2012-2015). A more recent report on the country's innovation activities from 2015-2017 was set to be released in December, 2019 but is, at the time of this paper, unavailable. All referenced datasets have been included in Appendix B.

4.3.1 2012 NSI

The 2012 survey sent questionnaires to 5293 firms across manufacturing and service industries of which they received 1682 usable surveys, about a 30% response rate. Of these 1682 firms, around 70% of the firms (1178) had engaged in some form of innovative activity, be it pertaining to product, process, organisational, marketing innovations, or R&D.

Innovative activity was geographically centralised to three states out of the country's fourteen, with the top three constituting more than 40% of all innovation activity: Selangor (22,50%), Kuala Lumpur (11,29%), Sarawak (10,27%). This follows, as geographical clustering of economic activity has continually been a deliberate policy strategy by the Malaysian government over the course of the 10th and 11th Malaysia Plans.

The majority of innovative activities (80%) was performed within the company or within the company group, instead of collaborating with external sources. Most of these activities were self-funded, with government funding lagging far behind even private investments from outside the firm. The most important sources of information for those innovations and what drove them came from within the firms themselves, or from suppliers or customers. Public institutions, universities, or external consultants were rarely collaborated with when innovating.

The most common factor perceived as being impeding towards successfully engaging in innovative activities was cost, followed by closely by market and knowledge factors, yet one of the most telling findings of the 2012 survey was how little respondents made use of government-led innovation support initiatives despite this. Roughly 80% of firms across industries failed to take up any of the incentives offered with the survey showing that nearly 40% of the time this was due to a lack of awareness that such assistance was available.

The recommendations put forth by MASTIC echo NIS tenets: linkages should be increased to promote the development of commercially viable innovations; funding should be increased to allow for more innovative activities in key economic areas; innovation infrastructure, both physical and non-physical, needs to be built up by the government to aid in supporting these efforts; a diversity of sources for innovation information should be built up, both those created

through university-industry linkages as well as through importation via MNCs; Malaysia's human capital base needs to built up; information about government incentive strategies as well as innovation activities in general need to be further disseminated and generated (through efforts like the NSI); and finally, government innovation efforts need to be focused to NKEAs and streamlined.

4.3.2 2015 NSI

The 2015 NSI was carried out in the same fashion as 2012, with a near identical number of usable responses, at 1685. 72% (1213) of these respondents had conducted innovation activities in the time period between 2012-2015.

The 10th Malaysia plan seemed to have found moderate success in encouraging linkages to promote innovation, as the developer of innovations became much more equally spread amongst sources. However, a smaller percentage of firms were participating in many crucial targeted activities. Of particular interest is training, which stood as a key priority within the 10th Malaysia plan to improve human capital ability.

A few trends persisted between the two surveys. Initiatives remained primarily self-funded within the timespan, with public funding remaining the least utilised option. This was mostly due to there continually being remarkably little awareness of government initiatives supporting innovation, cited over half the time between 2012-2015 as the reason for not utilising support.

Internal (within the company group) and market sources (suppliers and customer bases) remained the main sources of information for producing innovations, demonstrating a tendency for firms to pursue a market-pull rather than technology-push strategy for introducing innovations into the market. The biggest factors inhibiting innovative activities remained cost and knowledge factors.

As such, recommendations put forth by the 2015 NSI iterated those set by the 2012 survey nearly verbatim. Collaboration between sectors (particularly university-industry linkages) was highlighted as well as the promotion of a citizen-centric quadruple helix cooperation model (public authorities, academia, industry, citizens) to produce actually useful and commercially viable innovations, paired with a need to increase the amount of funding available for innovations within NKEAs. There was a clear need to improve human capital capacity, an ongoing issue, as well as improving the efficiency and focus of government initiatives as well as the visibility of such efforts across industrial sectors. As mentioned before, the NSI only manages to cover the extent of the 10th Malaysia Plan. It is acknowledged that the inconsistency in datasets stands as one of the major weaknesses of this paper.

Before describing the secondary sources and outlining which measures were chosen, it is worth paraphrasing the barriers outlined by Chaminade and Padilla-Pérez in their 2017 paper towards developing a high-functioning NIS within a developing context. Seven of those have been selected to frame the metrics chosen to evaluate the effectiveness of Malaysian Innovation policy (Chaminade and Padilla-Pérez 2017):

1. *Overt ideological shifts to NIS thinking are not complemented by a match in proposed funding*
2. *Policy makers fail to prioritise STI outcomes*
3. *Political turbulence disrupts long-term commitment to innovation policy*
4. *Lack of monitoring and evaluation mechanisms inhibit effectiveness of policy tools*
5. *Lack of engagement and financing from the private sector*
6. *Lack of highly-qualified domestic labour*
7. *Inefficient structuring of public innovation bodies*

With these in mind, the next section will outline the secondary sources and their metrics deemed to fit one or more of the above aspects, before showcasing their development between 2010 to 2020. Full rankings of the relevant metrics between 2010-2020 can be found in Appendix C.

4.4 Global Innovation Index

The GII is an internationally renowned reference survey for the multidimensional aspects determining a nation's innovative performance and has become a benchmarking tool that informs and allows for effective discourse between public and private stakeholders. Established in 2007, it has developed 80 metrics built around two sub-indices: Innovation Inputs, and Innovation Outputs.

The pillars selected to best reflect innovation outcomes were: *Institutions, Human Capital and Research,* and *Business Sophistication.* Malaysia's development in each of these metrics is shown in the following figure, which is listed out of 129.

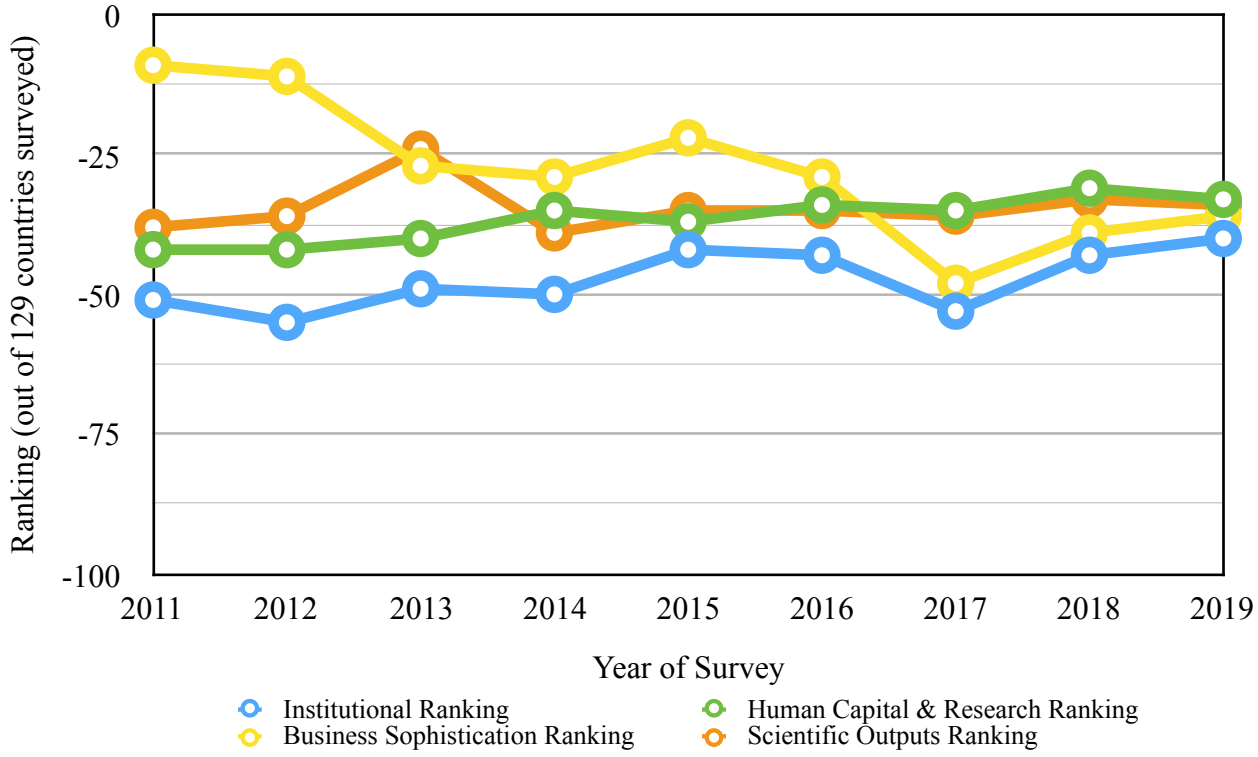

Figure 1 - Sub-Pillar Rankings (Source: Global Innovation Index 2011-2019)

Malaysia's position as an upper-middle income country is reflected well in the data, as most of its scores place it above the median with little variation. There is one exception, its Institutional Ranking remains on the lower end of the middle, reflecting the findings of MATIC, the OECD, and the government itself of its status as a major weakness of the overall system. The pillars are further discussed below. Each constitute of sub-pillars with their scores, which have been filtered for the sake of brevity and relevance before being elaborated upon.

Institutional Ranking

The most important sub-pillar within Institutional Ranking is *Government Effectiveness,* its change in score shown below:

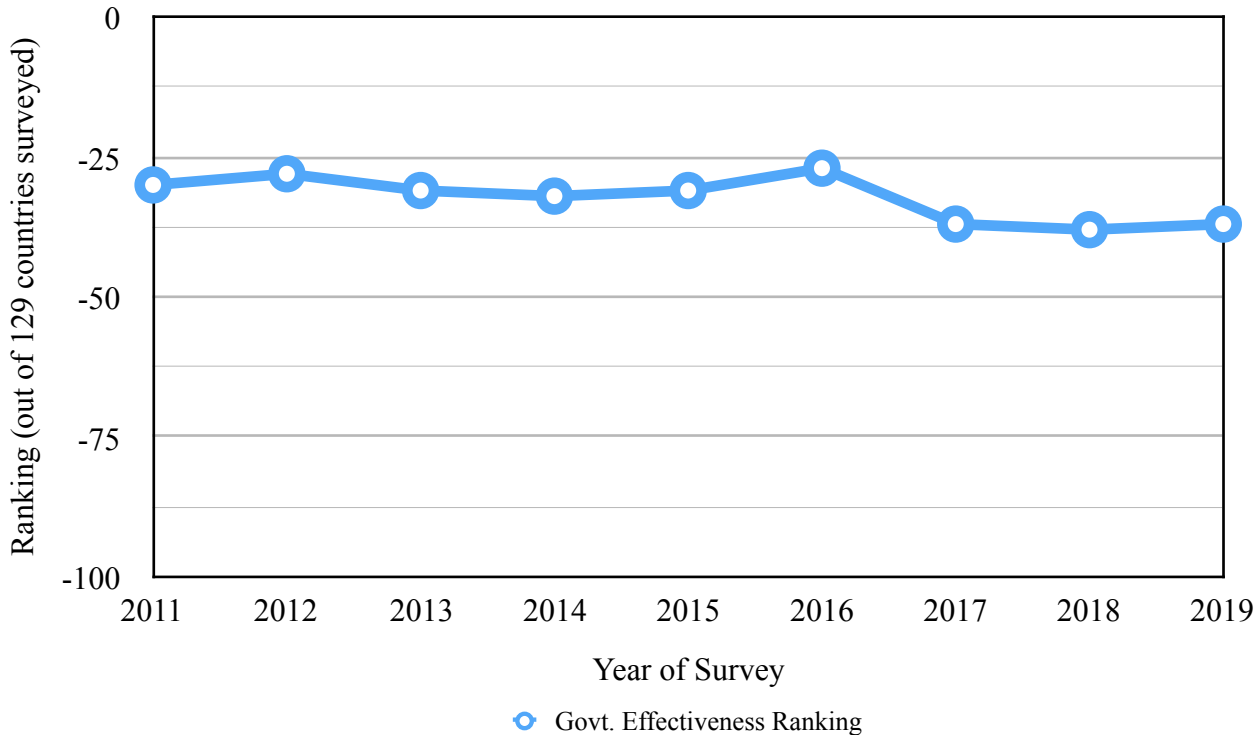

Figure 2 - Government Effectiveness Ranking (Source: Global Innovation Index 2011-2019)

The Malaysian government's effectiveness peaked in 2016, following the conclusion of the 10th Malaysia plan but immediately fell to its lowest score right after.

Business Sophistication

The business sophistication metric contains some of the most relevant sub-pillars in this report, these are *Knowledge Workers Ranking, Innovation Linkages,* and *Knowledge Absorption.* Each consist of their own determinants which are mapped in the figures below:

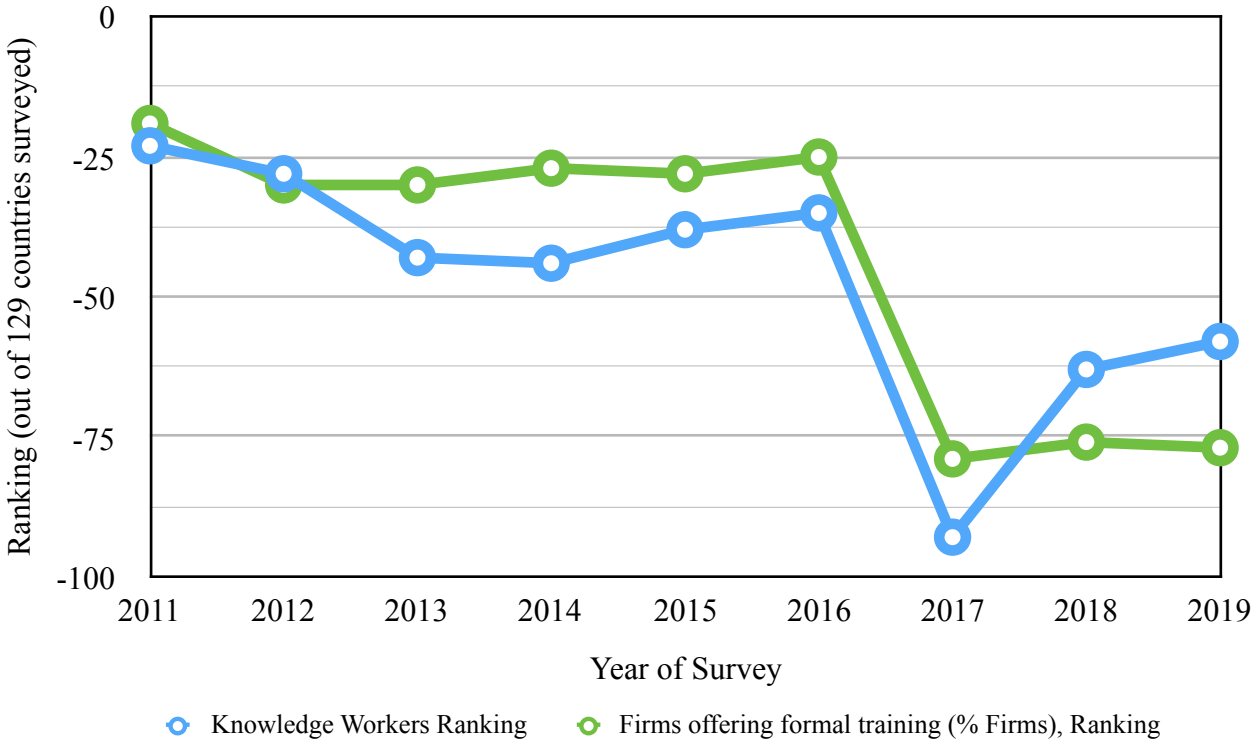

Figure 3 - Knowledge Workers Ranking (Source: Global Innovation Index 2011-2019)

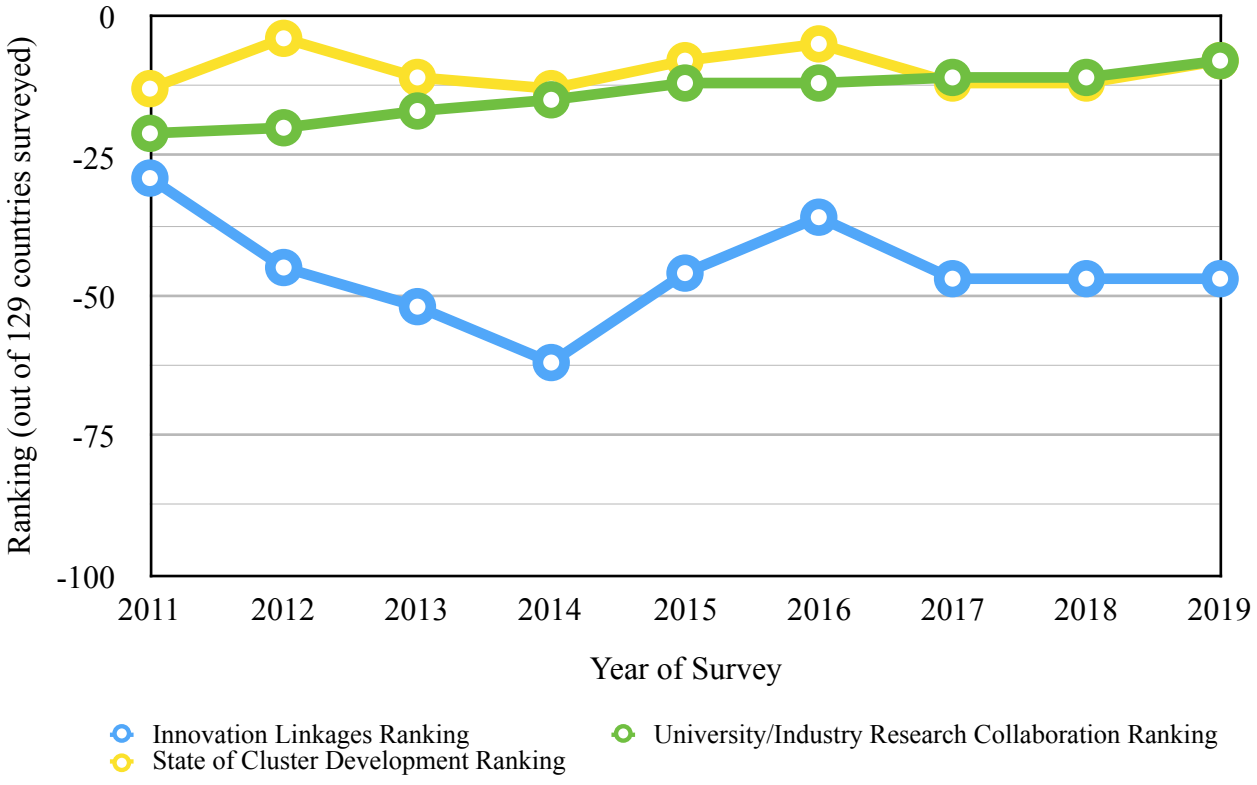

Figure 4 - Innovation Linkages Rankings (Source: Global Innovation Index 2011-2019)

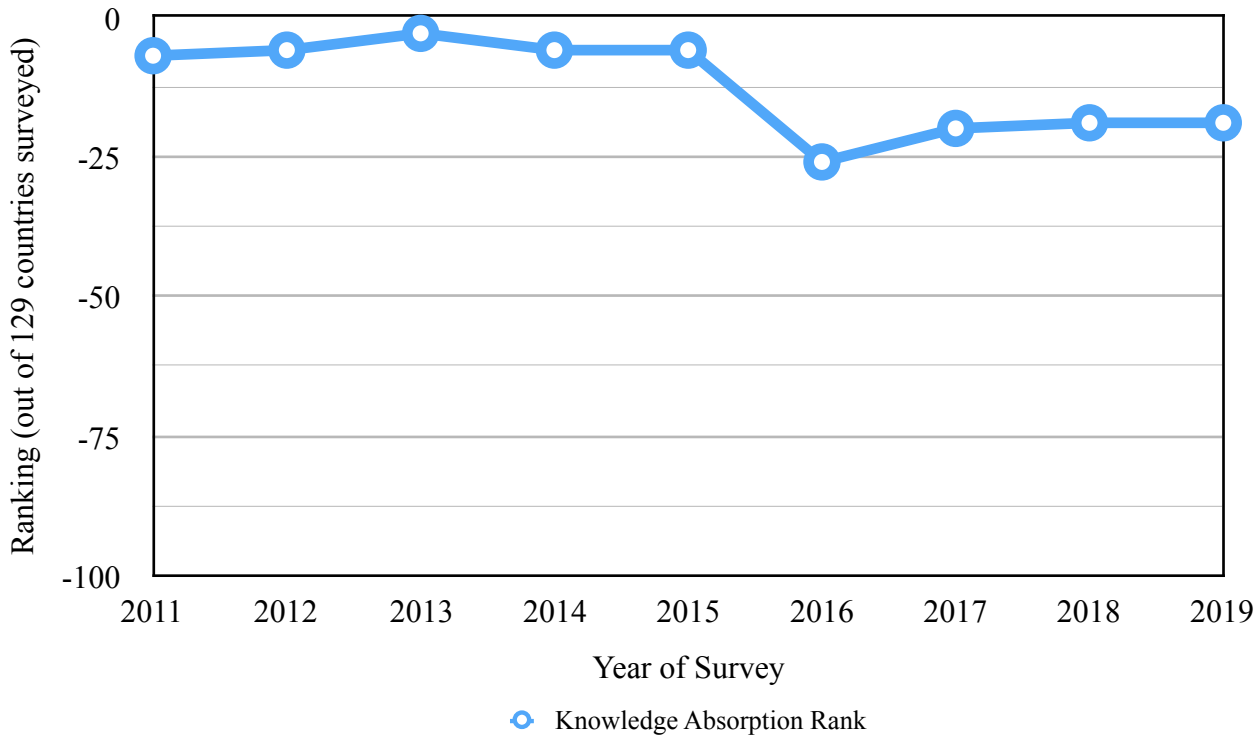

Figure 5 - Knowledge Absorption Rank (Source: Global Innovation Index 2011-2019)

Human Capital & Research Ranking

The GII rankings for Malaysia's human capital has remained rather consistent, as can be seen

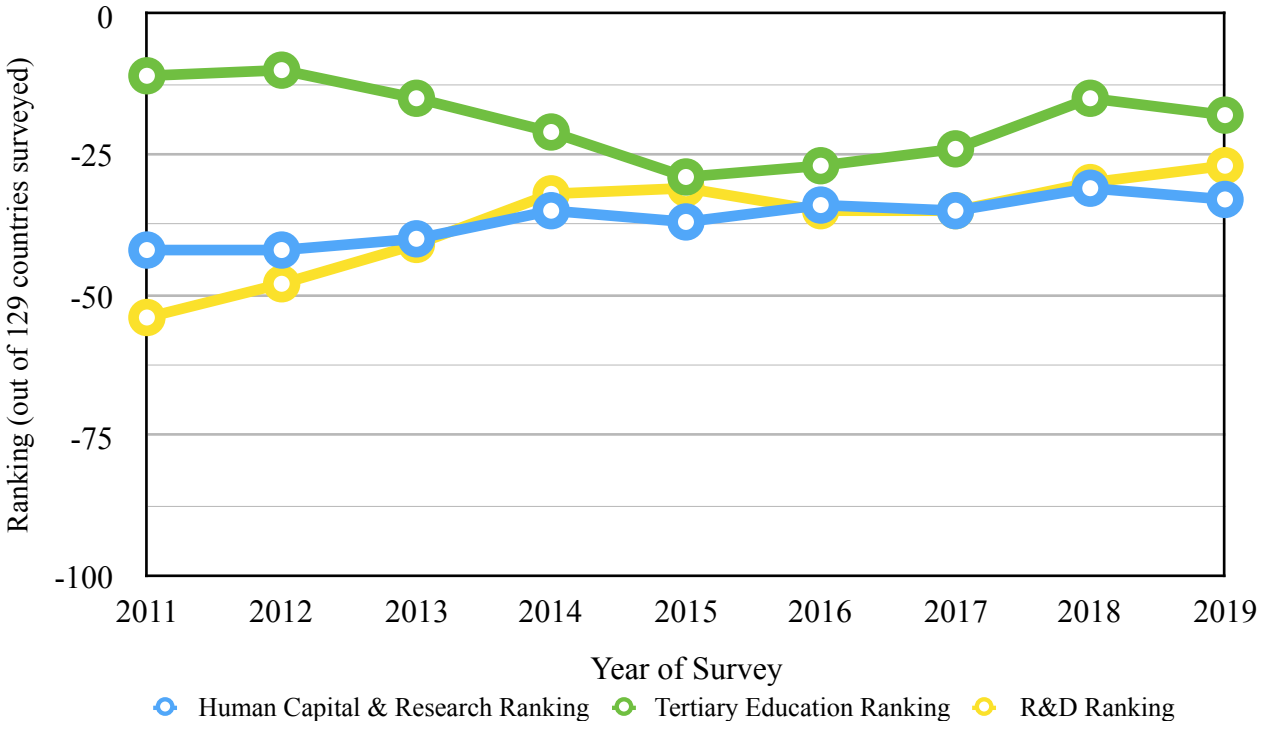

Figure 6 - Human Capital and Research Rankings (Source: Global Innovation Index 2011-2019)

below:

In terms of the country's education level and quality of its labour force, there has been lack of any significant development besides a dip in 2015 before returning to close to 2011 levels by the end of the decade. An upward trend of its R&D ranking is also apparent throughout this time.

4.5 Global Competitiveness Report

The GCR is an index anchored in the growth accounting school of thought and aims to evaluate the drivers of 'total factor productivity' (TFP) within a nation's economy. Composed of 12 pillars, it offers valuable insights into which aspects need to be improved to maximise the effective potential of Malaysia's NIS.

Though not explicitly pertaining to Innovation Systems, competitiveness within the global landscape of the Fourth Industrial Revolution is increasingly associated with innovation capabilities, amking the study highly relevant. Addtionally, the Malaysian government's desire to increase the productive effectiveness of its multifactor productivity (MFP) (a constituent of TFP) as a key strategy to develop as a global innovator makes the GCR's findings an ideal companion to the GII.

Three components in particular were highlighted: *Innovation and Sophistication Factors*, *Business Sophistication*, and *Innovation*. Unfortunately however, due to a change in the format of the datasets, the years 2018 and 2019 do not include the scores for innovation and sophistication factors, so they have been left out. As such, conclusions can only be drawn on the lasting effects of the 10th Malaysia Plan and the beginning phases of the 11th. As an additional visual comparison, Malaysian scores will be presented next to Singaporean scores, which stands as the only regional neighbour that is significantly ahead of Malaysia in terms of innovation and competitiveness. Rankings are usually done out of 137, but for the sake for visual clarity, the minimum has been kept at 30 and Malaysia can thus be seen to be operating well within the top ranks of middle-income economies. The figures are shown below:

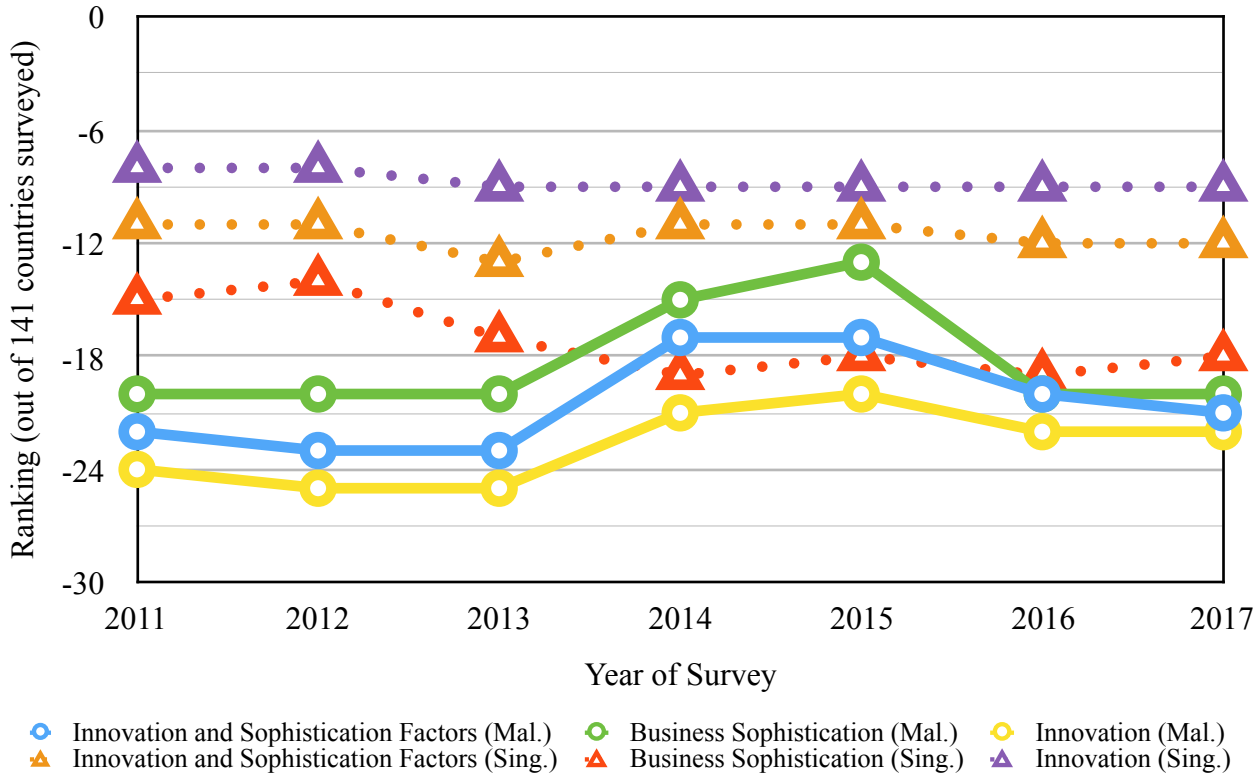

Figure 7 - Sub Pillar Rankings (Source: Global Competitiveness Report 2011-2019)

According to the GCR , 2012 marked Malaysia's shift from being an efficiency-led economy to one transitioning towards being innovation-led instead, which testifies to the success of the early measures of the 10th Malaysia Plan. It can be seen that there is a sharp rise in business sophistication and innovation factors, with Malaysia even surpassing Singapore in terms of the former, between 2013-2015 . This is however followed by a sharp drop afterwards, signifying an inability for the government to consistently maintain their upward momentum through the initiation of the 11th Malaysia Plan.

The GCR additionally provides two metrics worth mentioning here, *Institutions* and *Higher Education and Training*. The graphs are provided below:

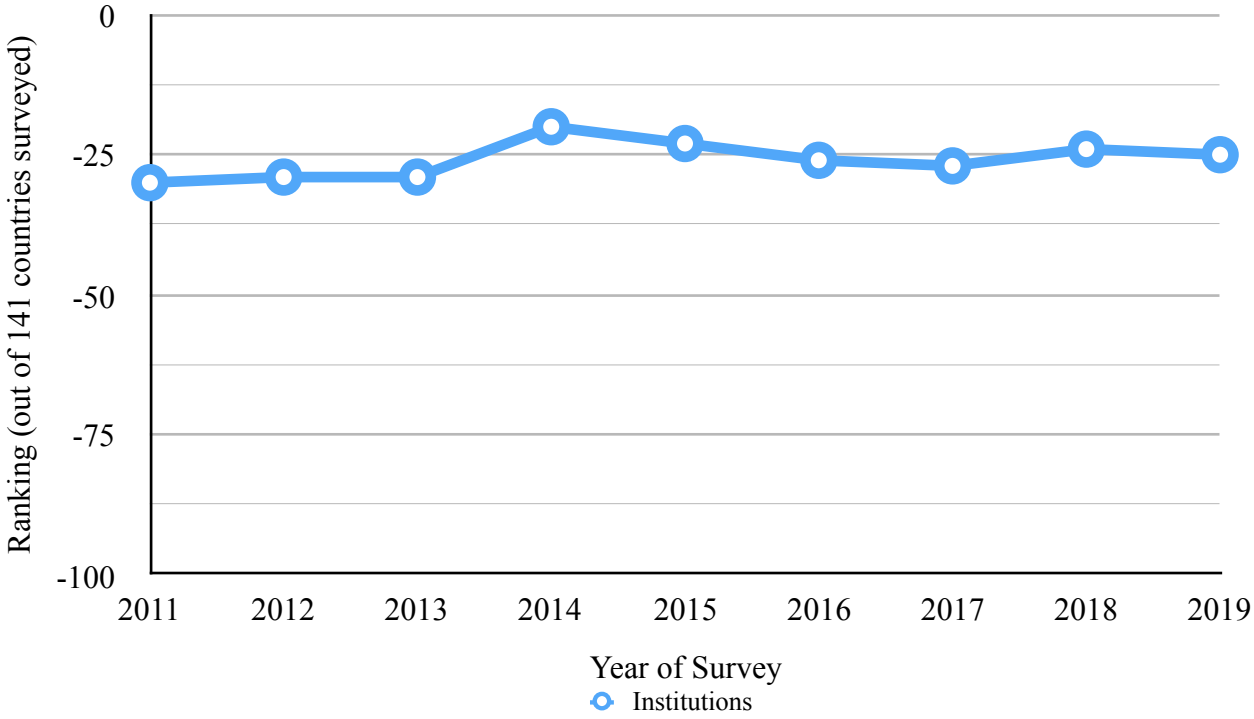

Figure 8 - Institutions Rankings (Source: Global Competitiveness Report 2011-2019)

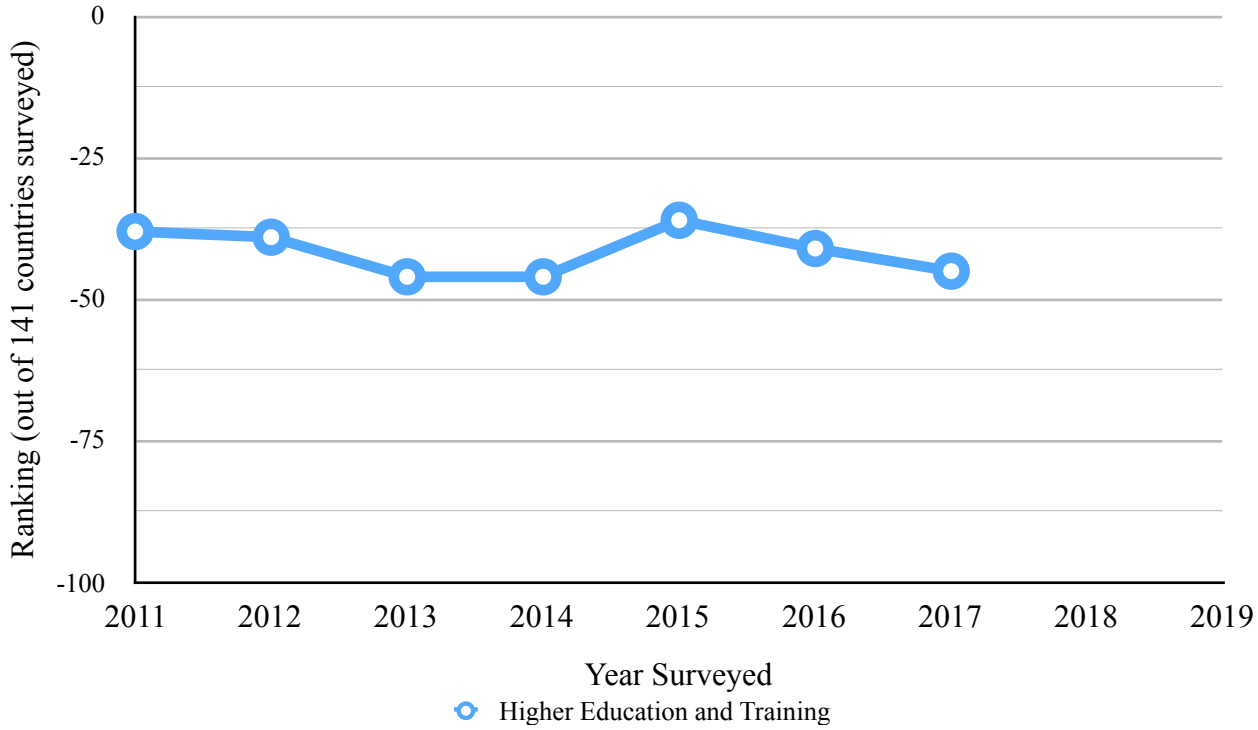

Figure 9 - Higher Education and Training Rankings (Source: Global Competitiveness Report 2011-2019)

These figures highlight a similar consistency with those found in the GII report, with the difference being that Institutionally, Malaysia places higher than it does in terms of higher education and training.

4.6 UNESCO GERD

Gross expenditure on R&D (GERD) is a often utilised indicator of whether a country is science and technology oriented, with 2% required to be considered as such (Annamalah, 2016). According to UNESCO (2020), Malaysia's GERD from 2011 to 2016 (no information past that year is currently available) has not risen above 1,4%. Of this, around 30% was funded by the government each year, the composition of GERD is highlighted below:

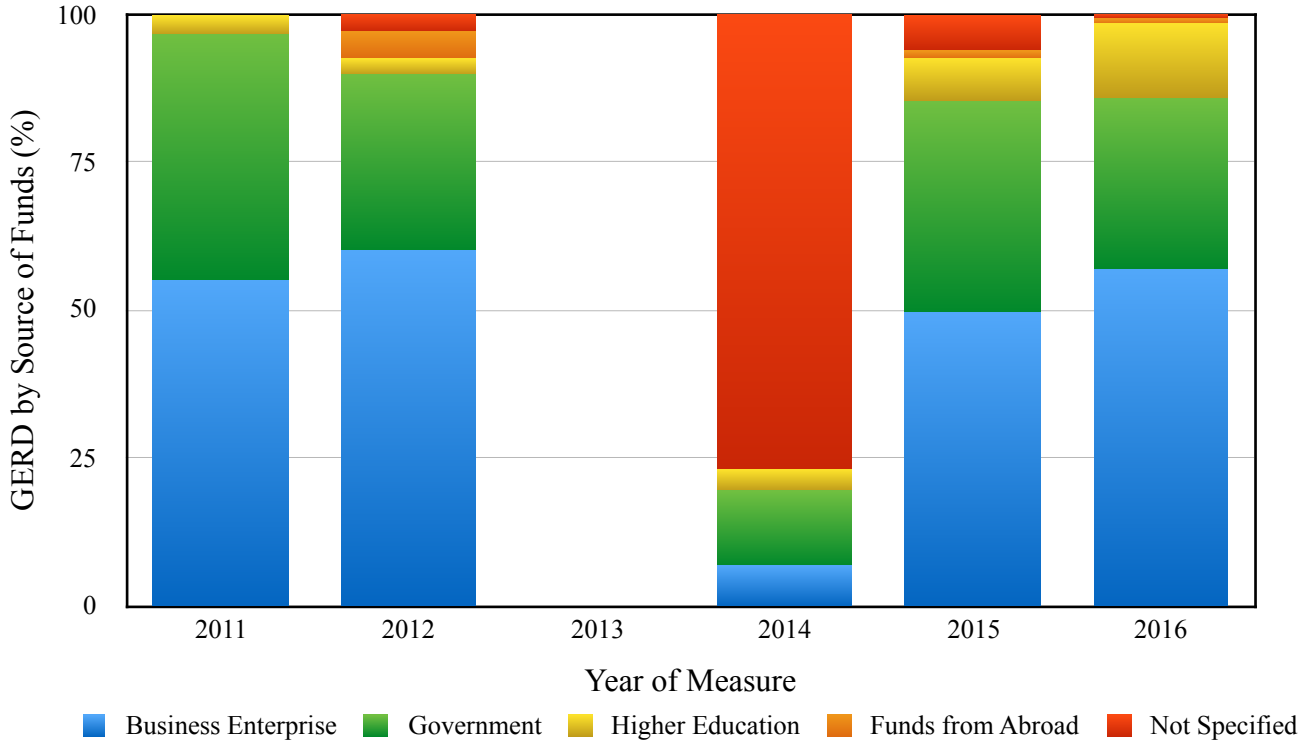

Figure 10 - Sources of GERD, % (UNESCO, 2011-2019)

While private sector investment was a highlight of the Malaysia Plan policy, there is still major room for improvement in terms of government monetary investment into the nation's R&D agenda.

5 Analysis

Firm Performance and Funding

The main findings of the GII are that the strongest aspects of the Malaysian NIS are the development of its firms. By international benchmarks, the government has been adept at implementing its clustering strategies (Fig. 4) and absorbing knowledge from external sources (Fig. 5) (which most often tend to be MNCs located domestically). This can be attributed to the nation's history of encouraging the domestic presence of MNCs as an integral part of the local economy. The effectiveness of local firms is corroborated in Malaysia's ranking within the GCR's business sophistication metric, which between 2014-2016 superseded Singapore's ranking. This points to the success of the Malaysian government's attempts at maintaining growth within its NKEAs.

However, this high ranking paired with low innovation scores imply that Malaysian firms excel at following the status quo well but has so far been unable to leverage these strengths into a pivot towards an innovation-led competitiveness. Iterating the example in Figure 7, this is diametrically opposed to the highly developed Singapore, which finds its strengths first in its ability to innovate. Malaysia seems primed to engage in productive and commercially viable innovative activities, but the major block for this transition remains the government itself.

Despite schemes aimed at building innovative capacities of SMES such as the 1-InnoCERT certification Malaysia has so far been unable to assert itself as a country effectively creating and diffusing its own innovations, with the country's 'innovation and sophistication factors' ranking consistently below its business sophistication, with its 'innovation' ranking remaining its lowest attribute in GCR (Fig. 7). MASTIC found that firms most often cited a lack of funding as the key barrier to innovative activities, simultaneously discovering that most firms were completely unaware of the existence of public funding incentives for innovation (see Appendix B). Knowing the number of initiatives developed during the 10th and 11th plans to increases enablers for innovation (either via financing schemes or the development of infrastructure) showcases that, despite an awareness of the need for such activities, initiatives put forth in the 10th and 11th Malaysia plans were rendered ineffective through a lack of targeted marketing.

Linkages

NIS literature points towards partnerships between the private sector and academia as a major contributor to developing a developed NIS (Chaminade, 2018; Isaksen, 2013; Lundvall et al., 2009). However, despite the constant prioritisation of promoting collaboration across various innovation actors throughout policy formulation and evaluation, academic institutions remain tenuously linked to industry in terms of innovation (Ng, 2016; Iqbal, 2011), remaining as one of the countries weakest aspects (Fig. 4). The contrast between University/Industry collaboration ranking in Fig.4 showcases that the country has been unable to effectively

transform joint research into commercial viable innovations. Lack of innovation-based private-academic linkages are corroborated by the MASTIC survey, which in cited universities as being a key source of innovation less than 1% of the time in 2012, and under 2% on average in the 2015 edition. More often suppliers were listed as the most important partner in innovation followed by clients (see Appendix). This undermines the practical potential of the skills that are being built as well as the chance of producing commercially viable innovations that would serve practical end-uses within the domestic private sector (Iqbal et al., 2011). Inefficient linkages between the sectors of the quadruple helix model have continuously been highlighted in other reports and research papers throughout the last ten years, such as NG, 2016; OECD, 2016, and Wong, 2019.

Education

Despite efforts put forth by the 10th and 11th Malaysia plans through the development of training schemes such as the TVET initiative, Talent Corporation, SME Corp. and heavy investment over the last two decades (Ng, 2016; GCI, 2016; Iqbal et al., 2011; Yap, 2015), human capital and R&D consistently remain some of Malaysia's lowest rankings in these reports. In terms of human capital development, there has been a steep decline since the onset of the 11th Malaysia Plan in the ranking of the country's knowledge workers, which was paralleled by lowered rankings in the percentage of firms offering formal training. Upskilling industry employees was a key strategy in keeping the Malaysian workforce competitive, and this lack of results showcases an inability of the Malaysian government to improve what has clearly been a major impediment to Malaysia's innovative capability through its proposed methods.

Reformatting Government Structures

While scientific output and human capital and research rankings have remained stable over time (albeit at lower levels), it can be seen that public institutions remain the largest barrier towards the progress of Malaysia's innovation system.

While the Malaysian government showcases a comprehensive understanding of its own shortcomings, with detailed plans to improve them, there has been a disappointing lack of results. A rationalisation of public innovation organisations is direly needed (Ng, 2016; OECD, 2016), but efforts have been exacerbated by a lack of effective monitoring (Ramli, 2017; Ng, 2016; OECD, 2016) that would otherwise be able to point the necessary practical steps to improve the interface between the public and private sectors. This is demonstrated by the lack of MASTIC figures since 2015.

The GTP proposed throughout the 10th and 11th Malaysia plans called for battles against corruption and streamlining of government activities in order to increase horizontal alignment. The methods utilised however demonstrated a misunderstanding of how to achieve this well-intentioned aim. Developing more organisations in a bid to streamline engagement with innovative actors led to horizontal alignment being weighed down by a bloated network of overlapping jurisdictions with a lack of focus on end-user oriented outcomes that would assist local firms' innovating (Wong and Fung, 2019). This was reflected in consistent low scores in the GII Governmental Effectiveness ranking (Fig. 2) and was further corroborated by the findings of the MASTIC surveys. Surveying companies on the most problematic factors in

conducting business domestically, the Malaysian government was highlighted the biggest barrier inhibiting innovative activities (MASTIC, 2012; MASTIC, 2015). Inefficient government bureaucracy placed as a resounding forerunner throughout the studies, being first four out of seven years, and was never ranked below the fourth most impeding factor.

Literature

Linking the Malaysian government's efforts to the literature can help additionally frame the strengths and weaknesses of its approach. In terms the government's approach to static NIS challenges, its strength lies in its prioritisation of strategic push across government bodies for innovation, signifying a strong sense of *directionality* or vertical alignment. However this is inhibited by a lack of *coordination* as seen in inefficient overlapping of public bodies and an inability to follow through with these efforts due to a lack of clear connection to private actors within the system. While the GTP has aimed to deal with many of the issues that come with *demand articulation* and *reflexibility,* public bodies related to innovation still show massive inefficiencies in executing policies and adapting to the system. This is additionally hampered by the lack of consistent evaluation mechanisms for any implemented policy.

Though absorptive capacities and technological capabilities of domestic firms have been one of the strengths of Malaysia's NIS (as showcased by Fig.. 1 and Fig. 7), these strengths have dwindled marginally over the course of the last ten years. As the government employed consistent strategic pushes throughout, this would highlight an inability to consistently develop the system, perhaps not reacting to new needs of the actors or a variety of other factors. Chaminade and Pérez (2017) highlight political turbulence as one of the key barriers to developing a strong NIS, which has been an unfortunate constant within Malaysia's recent political landscape as changing regimes, corruption, and vies for political power may have taken the focus away from building domestic capabilities (Lissborg, 2017).

Weak and inconsistent evaluation mechanisms being in place (Ramli, 2017; Ng, 2016; OECD, 2016), a lack of horizontal coordination across public bodies, reduced numbers of highly qualified local talent, and underfunding of R&D from public sources (Thiruchelvam, 2017; Suehiron, 2019; MASTIC, 2012; MASTIC, 2015; UNESCO, 2020) are all barriers that were highlighted in Chaminade and Pérez 2017 paper that continue to persist despite efforts by the Malaysian government. The lack of funding shows a misalignment between proposed action and what has actually been implemented to this point and may be symptomatic of overt shifts in ideology that have not been fully internalised, seeing that they have not met with the same effort or funding such shifts call for.

Over the course of the 10th and 11th Malaysia plans therefore, it can be seen that government initiatives have achieved little in way of incubating an NIS that creates value through domestically developed innovations. The majority of metrics in the analysed reports have shown either stagnation or decline in performance between 2010 and 2020.

6 Conclusion

6.1 Research Aims

This paper aimed to assess how effectively NIS recommendations had been implemented the Malaysian government, a developing country with a dual innovation system aiming to transition into a mature NIS. By analysing the application of NIS thinking in public policy between 2010-2020 through the collation of both domestic and international benchmarking reports, the paper determined the strength and weaknesses of their approach in promoting the development of the domestic NIS.

6.2 Findings

By no means approaching innovation as "shamanistic rituals", the Malaysian government showcases a solid understanding of the concepts put forth in NIS literature on important aspects of building an NIS as one of its major strengths. More than a lack of understanding however, the Malaysian government has showcased an inability to follow through on this understanding over the course of the last 10 years. Government inefficiency through misalignment across its public bodies and an inability to develop meaningful connections to and between the other actors of the system has inhibited the countries growth into an effectively developed NIS.

Upon analysing the available data, Malaysia's greatest impediment towards achieving a globally viable NIS (in terms of achieving competitive value through innovation) seems to be the government's ineffectiveness at improving the factors that it has outlined as impeding the development of the NIS. All sources cited, including the Malaysia plans themselves, have outlined government ineptitude as a one of, if not the largest factors holding back effective innovation, either through a lack of horizontal alignment of its innovation bodies, lack of effective interactions with private sector actors either through funding or communication, or an inability to maintain the effectiveness of implemented policies over a long-term horizon.

The biggest limitation in the Malaysian government's attempts to improve its own NIS is the government itself. Firms are sophisticated and developed enough to shift over into innovation-led competitive advantage from technology absorption but are being held back by a lack of public support. While high-skilled labour is still lagging behind in many regards, it has never been cited as a main impediment to developing innovations. Additionally, the Malaysian government has implemented several initiative that would be able to address these concerns. This is only a given if the government has the ability to effectively follow through with and

promote such efforts effectively in the long-run which seems unlikely given the current state of affairs.

6.3 Limitations

Citing a variety of secondary sources with different measures and ways of defining them serves as the major weakness of the paper. However this was done as a response to the lack of public data made available by the Malaysian government wth regards to its Innovation system and its actors. Addtiionally, with the broad scope of the subject being covered, citing multiple sources from internationally renowned benchmarking reports was deemed more effective towards uncovering viable findings compared to developing a new report.

6.4 Policy Implications

Following the findings of this paper, the main recommendations become rather clear. The first priority for any tangible progress would be a rationalising and improvement of government led innovation programs. If paired with the establishment of a more reliable and consistent evaluation mechanism, the government would be afforded the reflexibility to react to the needs of the NIS as the country transitions into an innovation-led economy. The Malaysian government clearly understands the required improvements for its NIS to properly develop, even with regards to the shortcomings of its own initiatives, but lacks the capacity to follow through effectively on substantially improving these factors.

Additionally, closer linkages need to be formed between universities and industry to stimulate the development of commercially viable innovations that are targeted towards end-user value whose success would in turn aid in the promotion of an innovative culture among firms. Additional incentives could be created on the requirements that such collaboration occurs. As such, additional funds need to be allocated to the pursuit of R&D within the country.

Specialised knowledge needs to be promoted in the development of human capital. As such, a more robust effort needs to be made in the promotion and implementation of efforts such as the TVET.

6.5 Future Research

Malaysia has a complex political history, with racial patronage and corruption being an instituted, albeit unfortunate political norm (Lissborg, 2017). It would be both of value to understand how this impacts the various actors of the innovation system, and the effectiveness of the, thus far, weakly-led government initiatives.

Additionally, while MASTIC covers firms innovative behaviours, specific research should be made to discover the actual end-user needs and what the public institutions can realistically do to meet them. Further research should be done into the effectiveness of policies promoting efficiency within the public sector as it relates to innovative action.

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Appendix A

GII DEFINITIONS

The GII adopts a broad notion of innovation, originally elaborated in the Oslo Manual developed by the European Communities and the Organisation for Economic Co-operation and Development (OECD).

The Innovation Input Sub-Index

The first sub-index of the GII, the Innovation Input Sub-Index, has five enabler pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication. Enabler pillars define aspects of the environment conducive to innovation within an economy.

Pillar 1: Institutions

Nurturing an institutional framework that attracts business and fosters growth by providing good governance and the correct levels of protection and incentives is essential to innovation. The Institutions pillar captures the institutional framework of an economy.

The Political environment sub-pillar includes two indices: the first is the political, legal, operational or security risk index that replaces the political stability and safety indicator, reflecting more on the likelihood and severity of political, legal, operational or security risks impacting business operations; the second reflects the quality of public and civil services, policy formulation, and implementation.

The Regulatory environment sub-pillar draws on two indices aimed at capturing perceptions on the ability of the government to formulate and implement cohesive policies that promote the development of the private sector and at evaluating the extent to which the rule of law prevails (in aspects such as contract enforcement, property rights, the police, and the courts).

Pillar 2: Human capital and research

The level and standard of education and research activity in an economy are prime determinants of the innovation capacity of a nation. This pillar tries to gauge the human capital of economies.

Higher education is crucial for economies to move up the value chain beyond simple production processes and products.
The sub-pillar on tertiary education aims at capturing coverage (tertiary enrolment); priority is given to the sectors traditionally associated with innovation (with a series on the percentage

of tertiary graduates in science, engineering, manufacturing, and construction); and the inbound and mobility of tertiary students, which plays a crucial role in the exchange of ideas and skills necessary for innovation.

The last sub-pillar, on R&D, measures the level and quality of R&D activities, with indicators on researchers (full-time equivalence), gross expenditure, the R&D expenditures of top global R&D spenders, and the quality of scientific and research institutions as measured by the average score of the top three universities in the QS World University Ranking of 2018. The R&D expenditures of the top three firms in a given economy looks at the average expenditure of these three firms that are part of the top 2,500 R&D spenders worldwide. The QS university rankings indicator gives the average scores of the economy's top three universities that belong to the top 700 universities worldwide. These indicators are not aimed at assessing the average level of all institutions within an economy.

Pillar 5: Business sophistication

The last enabler pillar tries to capture the level of business sophistication to assess how conducive firms are to innovation activity. The Human capital and research pillar (pillar 2) made the case that the accumulation of human capital through education, particularly higher education and the prioritization of R&D activities, is an indispensable condition for innovation to occur. That logic is taken one step further here with the assertion that businesses foster their productivity, competitiveness, and innovation potential with the employment of highly quality ed professionals and technicians.

The rst sub-pillar includes four quantitative indicators on knowledge workers: employment in knowledge-intensive services; the availability of formal training at the rm level; R&D performed by business enterprise (GERD) as a percentage of GDP (i.e., GERD over GDP); and the percentage of total gross expenditure of R&D that is financed by business enterprise.

In addition, the sub-pillar includes an indicator related to the percentage of females employed with advanced degrees. This indicator, in addition to providing a glimpse into the gender labor distributions of nations, offers more information about the degree of sophistication of the local human capital currently employed.

Innovation linkages and public/private/academic partnerships are essential to innovation. In emerging markets, pockets of wealth have developed around industrial or technological clusters and networks, in sharp contrast to the poverty that may prevail in the rest of the territory. The Innovation linkages sub-pillar draws on both qualitative and quantitative data regarding business/university collaboration on R&D, the prevalence of well-developed and deep clusters, the level of gross R&D expenditure financed by abroad, and the number of deals on joint ventures and strategic alliances. In addition, the total number of Patent Cooperation Treaty (PCT) and national office published patent family applications led by residents in at least two offices proxies for international linkages. The GII team has been evaluating various hard data-based indicators to measure innovation linkages in an economy. Measuring innovation linkages adequately remains challenging, if not to say, impossible based on existing innovation metrics.

In broad terms, pillar 4 on Market sophistication makes the case that well-functioning markets contribute to the innovation environment through competitive pressure, efficiency gains, and economies of transaction and by allowing supply to meet demand. Markets that are open to foreign trade and investment have the additional effect of exposing domestic firms to best practices around the globe, which is critical to innovation through knowledge absorption and diffusion, which are considered in pillars 5 and 6. The rationale behind sub-pillars 5.3 on Knowledge absorption (an enabler) and 6.3 on Knowledge diffusion (a result)—two sub-pillars designed to mirror each other as much as possible—is precisely that together they will reveal how good economies are at absorbing and diffusing knowledge.

Sub-pillar 5.3 includes five metrics that are linked to sectors with high-tech content or are key to innovation: intellectual property payments as a percentage of total trade (three-year average); high-tech imports as a percentage of total imports; imports of communication, computer and information services as a percentage of total trade; and net in ows of foreign direct investment (FDI) as a percentage of GDP (three-year average). To strengthen the sub-pillar, the percentage of research talent in business was added in 2016 to provide a measurement of professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, including business management.

The Innovation Output Sub-Index

Innovation outputs are the results of innovative activities within an economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the overall GII scores as the Input Sub-Index. There are two output pillars: Knowledge and technology outputs and Creative outputs.

Pillar 6: Knowledge and technology outputs

This pillar covers all those variables that are traditionally thought to be the fruits of inventions and/or innovations. The first sub-pillar refers to the creation of knowledge. It includes five indicators that are the result of inventive and innovative activities: patent applications led by residents both at the national patent office and at the international level through the PCT; utility model applications led by residents at the national office; scientific and technical published articles in peer-reviewed journals; and an economy's number of articles (H) that have received at least H citations.

The second sub-pillar, on Knowledge impact, includes statistics representing the impact of innovation activities at the micro- and macro-economic level or related proxies: increases in labor productivity (three-year average), the entry density of new firms, spending on computer software, the number of certificates of conformity with standard ISO 9001 on quality management systems issued, and the measure of high- and medium-high-tech industrial output over total manufactures output.

The third sub-pillar, on Knowledge diffusion, mirrors the Knowledge absorption sub-pillar of pillar 5, except for indicators 5.3.2 (no longer net imports) and 5.3.5 (on research talent). It includes four statistics all linked to sectors with high-tech content or that are key to

innovation: intellectual property receipts as a percentage of total trade (three-year average); high-tech net exports as a percentage of total exports; exports of ICT services as a percentage of total trade; and net out ows of FDI as a percentage of GDP (three-year average).

GCR DEFINITIONS

1st Pillar: Instituions

The institutional environment of a country depends on the efficiency and the behavior of both public and private stakeholders. The legal and administrative framework within which individuals, firms, and governments interact determines the quality of the public institutions of a country and has a strong bearing on competitiveness and growth. It influences investment decisions and the organization of production and plays a key role in the ways in which societies distribute the benefits and bear the costs of development strategies and policies. Good private institutions are also important for the sound and sustainable development of an economy. The 2007–08 global financial crisis, along with numerous corporate scandals, has highlighted the relevance of accounting and reporting standards and transparency for preventing fraud and mismanagement, ensuring good governance, and maintaining investor and consumer confidence.

5th Pillar: Higher Education and Training

Quality higher education and training is crucial for economies that want to move up the value chain beyond simple production processes and products. In particular, today's globalizing economy requires countries to nurture pools of well-educated workers who are able to perform complex tasks and adapt rapidly to their changing environment and the evolving needs of the production system. This pillar measures secondary and tertiary enrollment rates as well as the quality of education
as evaluated by business leaders. The extent of staff training is also taken into consideration because of the importance of vocational and continuous on-the-job training—which is neglected in many economies—for ensuring a constant upgrading of workers' skills

7th Pillar: Labour Market Efficiency

The efficiency and flexibility of the labor market are critical for ensuring that workers are allocated to their most effective use in the economy and provided with incentives to give their best effort in their jobs. Labor markets must therefore have the flexibility to shift workers from one economic activity to another rapidly and at low cost, and to allow for wage fluctuations without much social disruption. Efficient labor markets must also ensure clear strong incentives for employees and promote meritocracy at the workplace, and they must provide equity in the business environment between women and men. Taken together these factors have a positive effect on worker performance and the attractiveness of the country for talent, two aspects of the labor market that are growing more important as talent shortages loom on the horizon.

9th Pillar: Technological Readiness

The technological readiness pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICTs) in daily activities and production processes for increased efficiency and enabling innovation for competitiveness. Whether the technology used has or has not been developed within national borders is irrelevant for its ability to enhance productivity. The central point is that the firms operating in the country need to have access to advanced products and blueprints and the ability to absorb and use them. Among the main sources of foreign technology, foreign direct investment (FDI) often plays a key role, especially for countries at a less advanced stage of technological development

11th pillar: Business sophistication

Business sophistication concerns two elements that are intricately linked: the quality of a country's overall business networks and the quality of individual firms' operations and strategies. These factors are especially important for countries at an advanced stage of development when, to a large extent, the more basic sources of productivity improvements have been exhausted. The quality of a country's business networks and supporting industries, as measured by the quantity and quality of local suppliers and the extent of their interaction, is important for a variety of reasons. When companies and suppliers from a particular sector are interconnected in geographically proximate groups, called clusters, efficiency is heightened, greater opportunities for innovation in processes and products are created, and barriers to entry for new firms are reduced.

12th pillar: Innovation

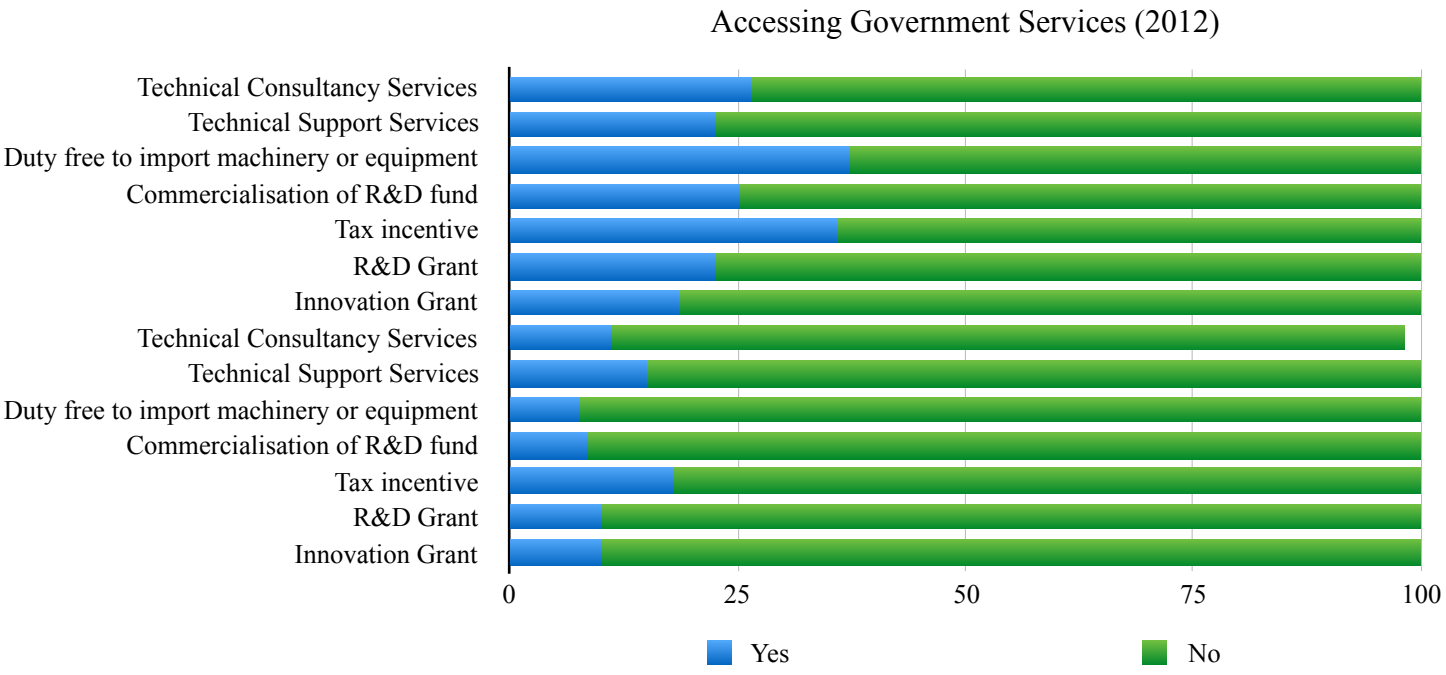
The last pillar focuses on innovation. Innovation is particularly important for economies as they approach the frontiers of knowledge, and the possibility of generating more value by merely integrating and adapting exogenous technologies tends to disappear. In these economies, firms must design and develop cutting-edge products and processes to maintain a competitive edge and move toward even higher value-added activities. This progression requires an environment that is conducive to innovative activity and supported by both the public and the private sectors. In particular, it means sufficient investment in research and development (R&D), especially by the private sector; the presence of high-quality scientific research institutions that can generate the basic knowledge needed to build the new technologies; extensive collaboration in research and technological developments between universities and industry; and the protection of intellectual property.

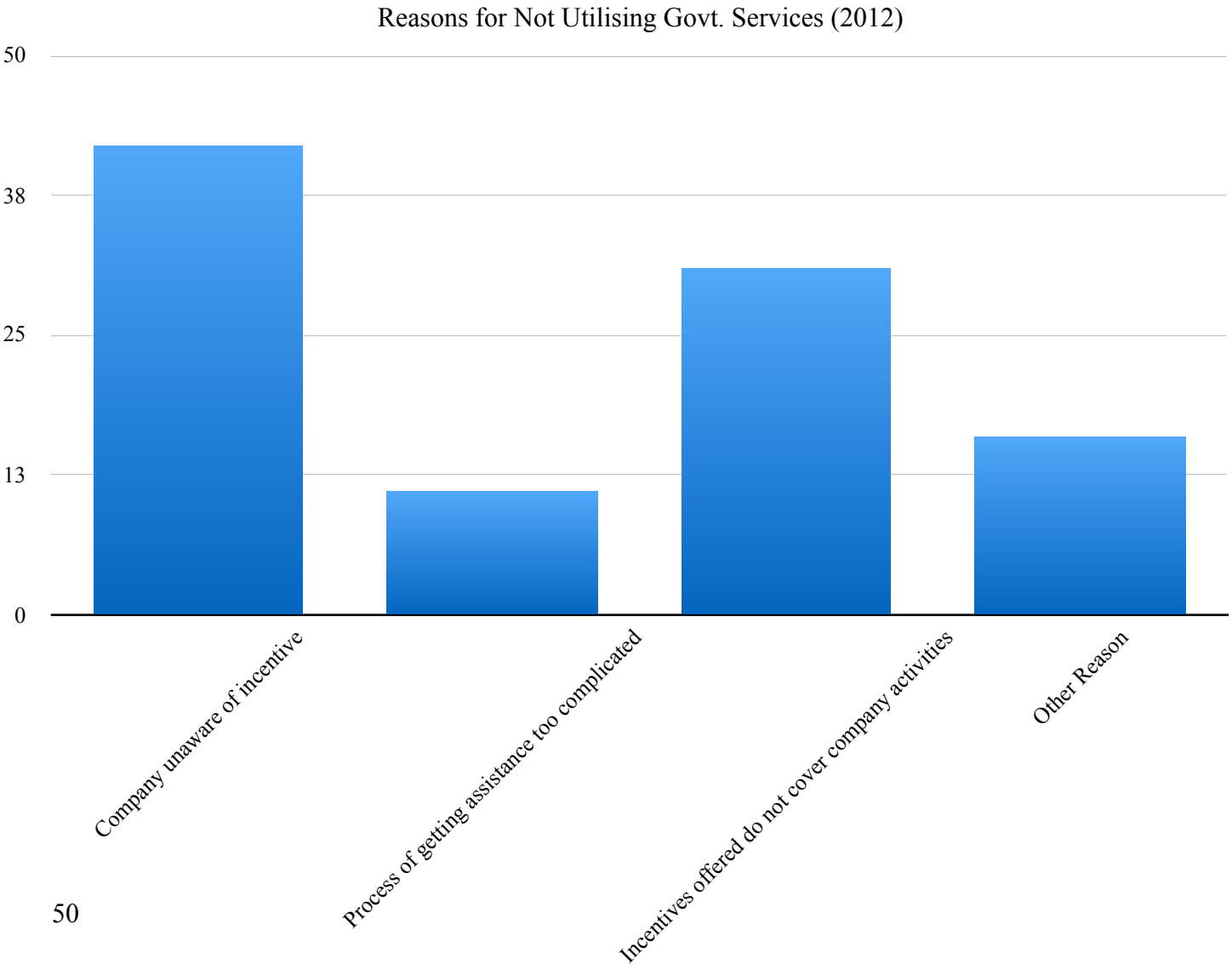
The interrelation of the 12 pillars

Although we report the results of the 12 pillars of competitiveness separately, it is important to keep in mind that they are not independent: they tend to reinforce each other, and a weakness in one area often has a negative impact in others. The detailed structure and methodology used to compute the GCI are presented at the end of this appendix.

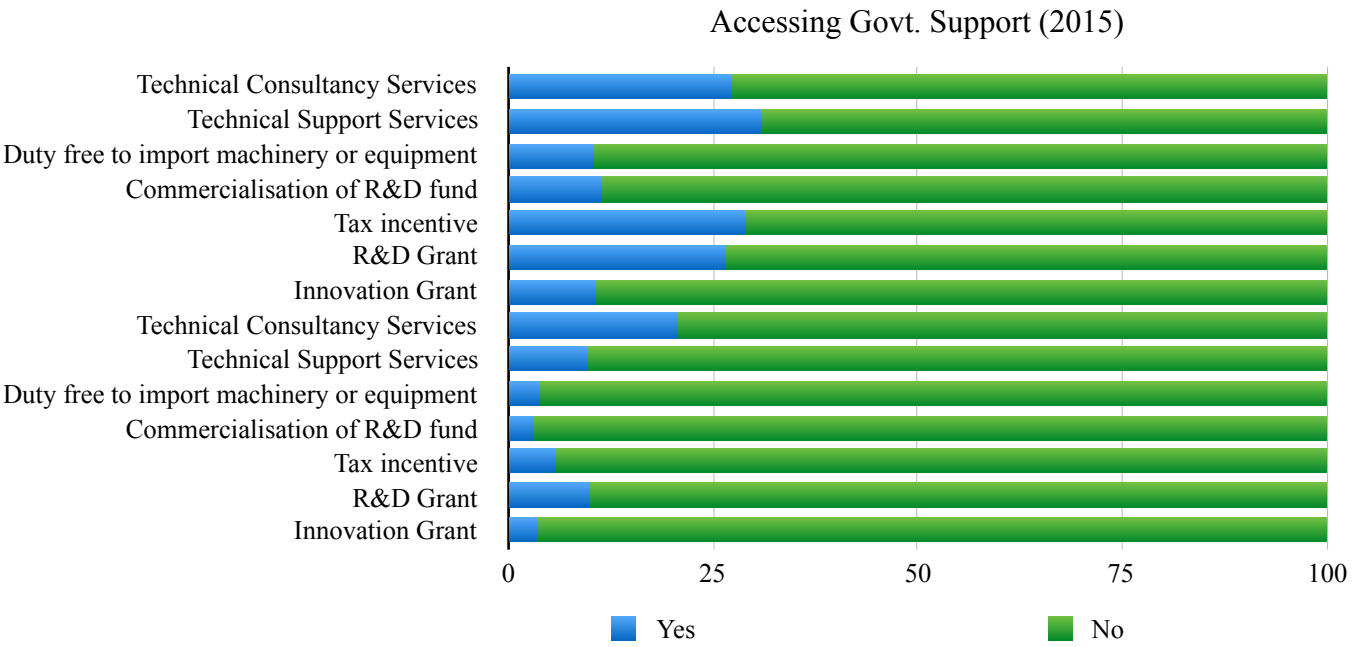
Appendix B

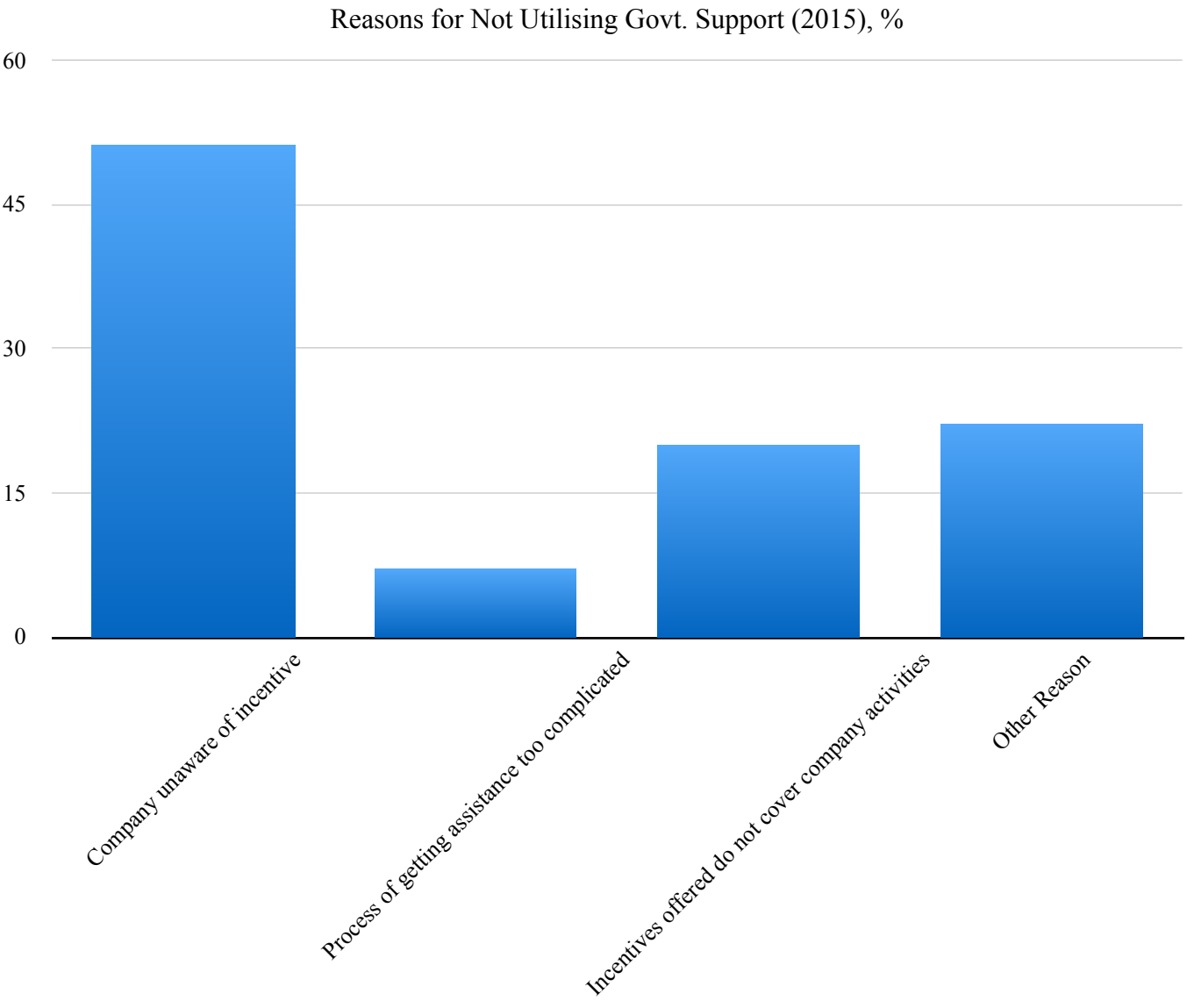
MASTIC Findings (2012)





MASTIC Findings (2015)





Appendix C

MASTIC Survey Data (2012)

Developer	New or Significantly Improved								
	Methods			Logistics			Supporting Activities		
	Manufacturing	Services	Average	Manufacturing	Services	Average	Manufacturing	Services	Average
Closed Innovation	1501	1932	1717	697	244	471	647	389	518
Joint Innovation	174	107	141	74	79	77	95	78	87
Open Innovation	31	55	43	16	52	34	113	54	84

Types of Innovation Activities	Manufacturing		Services	
	Yes	%	Yes	%
In-house R&D	291	65	187	26
Acquisition of R&D	73	16	64	9
Acquisition of capital	251	56	261	36
Acquisition of external knowledge	93	21	85	12
Training	301	68	292	40
Market introduction of innovation	202	45	179	24
All forms of design	194	44	167	23
Prep for marketing innovation	137	31	84	11
Prep for organisational innovation	134	30	82	11

Types of Govt. Support (2012)	Manufacturing										
	Yes		No								
	N	%	a	%	b	%	c	%	d	%	Total "No" (%)
Technical Consultancy Services	119	26,5	141	31,7	79	17,8	68	15,3	38	8,5	73,3
Technical Support Services	100	22,5	142	31,9	84	18,9	73	16,4	46	10,3	77,5
Duty free to import machinery or equipment	166	37,3	152	34,2	39	8,8	52	11,7	36	8,1	62,7
Commercialisation of R&D fund	113	25,4	158	35,5	58	13,0	71	16,0	45	10,1	74,6
Tax incentive	159	35,7	164	36,9	33	7,4	44	9,9	45	10,1	64,3
R&D Grant	101	22,7	162	36,4	65	14,6	75	16,9	42	9,4	77,3

Types of Govt. Support (2012)	Manufacturing										
	Yes		No								
	N	%	a	%	b	%	c	%	d	%	Total "No" (%)
Innovation Grant	82	18,4	170	38,2	82	18,4	66	14,8	45	10,1	81,6
	Services										
Technical Consultancy Services	83	11,3	83	11,3	273	37,2	26	3,5	114	15,6	86,7
Technical Support Services	111	15,1	211	28,8	87	11,9	214	29,2	110	15,0	84,9
Duty free to import machinery or equipment	56	7,6	286	39,0	21	2,9	246	33,6	124	16,9	92,4
Commercialisation of R&D fund	63	8,6	225	30,7	79	10,8	256	34,9	110	15	91,4
Tax incentive	131	17,9	270	36,8	17	2,3	209	28,5	106	14,5	82,1
R&D Grant	73	10,0	218	29,7	82	11,2	257	35,1	103	14,1	90,0
Innovation Grant	74	10,1	288	39,3	19	2,6	247	33,7	105	14,3	89,9

Funding	Types of Innovation/Activity (Manufacturing)				
	Product (N)	Process (N)	Organisation (N)	Marketing (N)	R&D (N)
Own	276	255	245	247	258
Private	56	42	40	38	43
Public	45	49	11	32	82
Other	6	17	3	4	15
	Types of Innovation/Activity (Service)				
Own	200	309	388	302	175
Private	65	79	138	25	44
Public	17	24	117	22	43
Other	16	17	110	19	22

Source of Information	Mean		
	Manufacturing	Services	Overall
Internal Sources			
Within the company	1,50	1,04	1,27
Other companies within the company group	1,07	0,70	0,85
Average Mean	1,29	0,87	1,06
Market Sources			

Source of Information	Mean		
	Manufacturing	Services	Overall
Suppliers of equipment, materials, services, or software	1,36	0,87	1,11
Clients or customers	1,45	0,92	1,18
Competitors and other companies in the industry	1,24	0,77	1,00
Average Mean	1,35	0,85	1,10
Institutional Sources			
Consultants	0,92	0,72	0,82
Commercial laboratories and private R&D institutes	0,93	0,59	0,76
Universities or other higher education institutes	0,83	0,64	0,73
Government or public research institutes	1,00	0,65	0,82
Average Mean	0,92	0,65	0,78
Other Sources			
Conferences, trade fairs, exhibitions	1,29	0,77	1,03
Scientific journals and trade / technical publications	1,12	0,75	0,94
Professional and industry associations	1,12	0,78	0,95
Technical, industry, or service standards	1,22	0,78	1,00
Average Mean	1,19	0,77	0,98
Total Average Mean	1,19	0,78	0,99

Fosters Hampering Innovation Activities (2012)	Mean		
	Manufacturing	Services	Overall
Cost Factor	1,88	1,66	1,77
Knowledge Factor	1,54	1,44	1,49
Market Factor	1,72	1,27	1,50
Organisational Factor	1,51	1,31	1,40
Regulatory Factor / Public Policy	1,20	1,03	1,11
Other Factors	0,73	0,078	0,75
Total Average Mean	1,43	1,12	1,34

MASTIC Survey Data (2015)

Developer (2015)	New or Significantly Improved								
	Methods			Logistics			Supporting Activities		
	Manuf.	Services	Average	Manuf.	Services	Average	Manuf.	Services	Average
Closed Innovation	379	349	364	391	417	404	412	412	412
Joint Innovation	401	426	414	408	487	448	398	403	401
Open Innovation	429	416	423	427	401	414	415	449	432

Types of Innovation Activities	Manufacturing		Services	
	Yes	%	Yes	%
In-house R&D	209	13,52	76	6,08
Acquisition of R&D	107	6,92	47	3,77
Acquisition of capital	245	15,85	191	15,29
Acquisition of external knowledge	108	6,99	104	8,33
Training	228	14,75	211	16,89
Market introduction of innovation	197	12,74	183	14,65
All forms of design	135	8,73	101	8,09
Prep for marketing innovation	180	11,64	179	14,33
Prep for organisational innovation	137	8,86	157	12,57

	Manufacturing										
Types of Govt. Support (2015)	Yes		No								
	N	%	a	%	b	%	c	%	d	%	Total "No" (%)
Technical Consultancy Services	128	27,29	188	40,09	46	9,81	41	8,74	66	14,07	72,71
Technical Support Services	144	30,70	182	38,81	42	8,96	35	7,46	66	14,07	69,30
Duty free to import machinery or equipment	48	10,23	211	44,99	51	10,87	59	12,58	100	21,32	89,77
Commercialisation of R&D fund	53	11,30	211	44,99	55	11,73	48	10,23	102	21,75	88,70
Tax incentive	135	28,78	167	35,61	27	5,766	40	8,53	100	21,32	71,22
R&D Grant	124	26,44	181	38,59	19	4,05	36	7,68	109	23,24	73,56
Innovation Grant	49	10,45	210	44,78	34	7,25	57	12,15	119	25,37	89,55
	Services										
Technical Consultancy Services	154	20,70	313	42,07	26	3,49	124	16,67	127	17,07	79,30

Types of Govt. Support (2015)	Manufacturing										
	Yes		No								
	N	%	a	%	b	%	c	%	d	%	Total "No" (%)
Technical Support Services	72	9,68	358	48,12	25	3,36	159	21,37	130	17,47	90,32
Duty free to import machinery or equipment	28	3,76	326	43,82	34	4,57	211	28,36	145	19,49	96,24
Commercialisation of R&D fund	23	3,09	360	48,39	25	3,36	187	25,13	149	20,03	96,91
Tax incentive	42	5,65	369	49,50	23	3,09	172	23,12	138	18,55	94,35
R&D Grant	75	10,08	328	44,09	75	10,08	128	17,20	138	18,55	89,92
Innovation Grant	25	3,36	367	49,33	36	4,84	175	23,52	141	18,95	96,64

Source (2015)	Types of Innovation/Activity (Manufacturing)				
	Product (N)	Process (N)	Organisation (N)	Marketing (N)	R&D (N)
Own	381	346	289	319	192
Private	115	108	101	104	68
Public	45	44	40	36	34
Other	16	10	26	16	8
	Types of Innovation/Activity (Services)				
Own	381	346	289	319	192
Private	115	108	101	104	68
Public	45	44	40	36	34
Other	16	10	26	16	8

Partners (2015)	Mean	
	Manufacturing	Services
Other companies within the company group	2,07	1,96
Suppliers of equipment, materials, components	2,46	2,40
Client or customers	2,53	1,97
Competitors and other companies in the industry	1,86	1,52
Consultants	1,57	1,44
Commercial laboratories and private R&D institutes	1,71	1,14
Universities and other higher education institutes	1,76	1,47
Government or public research institutes	1,33	1,13
Total Average Mean	1,91	1,63

Source of Information (2015)	Mean	
	Manufacturing	Services
Internal Sources		
Within the company	2,43	2,26
Other companies within the company group	1,78	1,88
Average Mean	2,11	2,07
Market Sources		
Suppliers of equipment, materials, services, or software	2,30	2,30
Clients or customers	2,33	2,38
Competitors and other companies in the industry	1,99	2,24
Average Mean	2,21	2,31
Institutional Sources		
Consultants	1,48	1,46
Commercial laboratories and private R&D institutes	1,42	1,28
Universities or other higher education institutes	1,25	1,31
Government or public research institutes	1,29	1,34
Average Mean	1,36	1,35
Other Sources		
Conferences, trade fairs, exhibitions	1,89	1,62
Scientific journals and trade / technical publications	1,42	1,33
Professional and industry associations	1,48	1,37
Technical, industry, or service standards	1,65	1,48
Average Mean	1,61	1,45
Total Average Mean	1,75	1,71

Fosters Hampering Innovation Activities (2015)	Mean	
	Manufacturing	Services
Cost Factor	2,16	2,22
Knowledge Factor	2,00	2,11
Market Factor	2,00	2,00
Organisational Factor	2,00	1,93
Regulatory Factor / Public Policy	1,78	1,76
Other Factors	1,56	1,60
Total Average Mean	1,96	1,99