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INNOVATION POLICY AND INDUSTRIAL POLICY AT THE CROSS-ROADS: A REVIEW OF RECENT EXPERIENCES IN ADVANCED DEVELOPING COUNTRIES

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Innovation policy and industrial policy at the cross-roads: a review of recent experiences in advanced developing countries

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Table of Contents

List of Tables

List of Boxes

Abbreviations and acronyms

AVIC	Aviation Industry Corporation of China
BNDES	Brazilian Development Bank
COMAC	China Commercial Aircraft Company
CPO	Crude Palm Oil
CTA	Aerospace Technical Center
DSD	Department of Skills Development
EDB	Economic Development Board
Embraer	Empresa Brasileira de Aeronáutica S.A.
FELCRA	Federal Land and Crop Authority
FELDA	Federal Land Development Authority
FINEP	Financiadora de Estudos e Projetos
IIA	Investment Incentives Act
IMP	Industrial Master Plans
INPE	Instituto de Pesquisas Espaciais
IRPA	Intensification of Research Priority Areas
ITA	Aeronautics Technology Institute
KLCE	Kuala Lumpur Commodity Exchange
MARDI	Malaysian Agricultural Research and Development Institute
MIT	Massachusetts Institute of Technology
MITI	Ministry International Trade and Industry
MLP	Medium to Long Term Plan for the Development of Science and Technology
MPOB	Malaysian Palm Oil Board
MPOPC	Malaysian Palm Oil Promotion Council
MRO	Maintenance, repair and overhaul
OECD	Organization for Economic Cooperation and Development
OPGL	Oil Palm Genetics Laboratory
OPRI	Oil Palm Research Institute
PIA	Promotion of Investment Act
PITE	Partnership for Technological Innovation
PKO	Palm kernel oil
PORIM	Palm Oil Research Institute of Malaysia
PORLA	Palm Oil Registration & Licensing Authority
PPO	Processed Palm Oil
PROCEI	Mexico-European Union Competitiveness and Innovation Program
PSI	Presidential Special Initiative
R&D	Research and Development
RDI	Research and Development Institute
RIIAQ	Querétaro Aerospace Research and Innovation Network
RISDA	Rural Industry and Smallholders Development Authority
RSAF	Republic of Singapore Air Force
SAE	School of Aeronautics Engineering
STI	Science, Technology and Innovation
UPM	Universiti Pertanian Malaysia
WTO	World Trade Organization

"Innovation is of importance not only for increasing the wealth of nations in the narrow sense of increased prosperity, but also in the more fundamental sense of enabling people to do things which have never been done before. It enables the whole quality of life to be changed for better or for worse. It can mean not merely more of the same goods but a pattern of goods and services which has not previously existed, except in the imagination." (Freeman and Soete, 1997:2)

1. Introduction

Box 1: Innovation policy instruments: a definition

Innovation policy intervention is a "measure that mobilises resources (financial, human or organisational) through publicly (co-)financed research and innovation programmes or initiatives; and/or funds the generation or diffusion of information and knowledge (studies, road-mapping, technology diffusion activities, advisory services or public-private partnerships) in support of research and innovation activities; and/or promotes an institutional process (legal acts or regulatory rules) designed to explicitly influence the undertaking of research and innovation by organisations. In addition, a policy measure is normally implemented on an on-going (multi-annual) basis, rather than being a one-off 'event' or a single 'project'."

Izsák et al. (2013:16)

This paper builds on and contributes to a framework that is useful for a practical discussion on the application of industrial policy across countries at different stages of industrial development (Weiss, 2015). The analytical framework identifies five policy domains, spanning across markets for products, capital, land, labour or technology, at the origin of factors that can either constrain or favour the growth and competitiveness of manufacturing activities (Section 2). Against this background, we explore the nature and use of different types of public policy instruments—also referred to as policy interventions—intended to address problems that affect a given system of innovation (Box 1). Thus, we document concrete policy interventions used to promote and facilitate structural change, on the one hand, and positive industrialization dynamics, on the other. We address two questions: what can we learn from recent industrialization experiences in developing countries? What kinds of policy interventions or combinations of policy interventions adequately address what kind of challenges?

In dealing with these questions, we document some instances of confluence between innovation policy and industrial policy in advanced developing countries. Based on Borrás and Edquist, (2013), we interpret innovation policy as all combined actions undertaken by public organizations to influence innovation activities – the term encompasses the choice of particular policy instrument and its implementation. Accordingly, we look at how some developing countries have been able, or not, to lay the foundations for strong national and sectoral innovation systems.[1] We show that interventions expected to create innovation systems capable of sustaining dynamic industrialization efforts may, under certain circumstances, exacerbate some of the binding constraints stemming from failures in the markets for products, capital, land, labour or technology.

The heterogeneous economic structures of middle and upper middle income developing countries, characterized by a mix of 'traditional' and 'modern' manufacturing activities, calls for the analysis to capture the complexity of the environments in which both innovation and industrial policies operate. Some developing countries have been able to catch up in terms of the technological content and complexity of their manufacturing structures and productive competencies, a process broadly described as economic modernization. And yet, empirical experience suggests that modernization seems insufficient to ensure long-term sustainability and growth, the internal economic dynamics risks an overexposure to external shocks and dependence on external technology suppliers (Cimoli, 2001). Similarly, notwithstanding the presence of increasingly complex domestic science, technology and innovation systems, emerging countries generally still lack the competencies required to meaningfully contribute to the dynamics of international markets for technology. Public policy is called to address these challenges.

From the above, and consistent with modern theories that explain innovation as both a systemic and systematic activity, we are interested in recent experiences that illustrate the learning and capability building processes that sustain innovation and industrialization. Systemic in this context underscores innovation as an interactive process that involves knowledge exchanges among different knowledge producers and knowledge users (Freeman, 1995; Lundvall, 1992; Nelson, 1993). Systematic, in turn, refers to the consistent commitment of resources to support innovation over a long period of time.

We also acknowledge that innovation and industrial policies confront and interact within complex, multi-level, multi-actor contexts. In some instances, innovation policy authorities—frequently a Council or a Ministry of Science and Technology—can influence and modify such contexts, but in most cases, their powers are severely constrained. The functioning of education

[1] Innovation policy is a recent aspiration for developing countries. The experiences of industrialization reviewed in this document may not necessarily reflect efforts guided by explicit innovation policies. However, by drawing attention to innovation, we establish a link with current literature on innovation systems and more importantly, with current debates on the desirable elements and different approaches to innovation policy and related policy instruments. In effect, there is great interest in understanding how public policy interventions can contribute to the development and performance of systems of innovation. Innovation is therefore interpreted in a broad sense, as a learning and competence building process that spans across different markets including, but not limited to, technology.

and other social and economic systems shape framework conditions within which innovation policy operates (Gault, 2010). Those framework conditions influence not only the achievement of innovation outcomes, but the contribution of innovation to broader objectives of structural change and industrial dynamics and thereby, to the ultimate social, economic and environmental outcomes (Izsák et al., 2013).

The heterogeneity of available innovation policy approaches adds to the complexity and challenges for innovation policy design and implementation, which reminds us of debates about the innovation policy mix. As we discuss below, consensus is missing on the balance and coherence of the strategic tasks for policy, and the range of policy instruments implemented in light of the diverse factors that can constrain innovation and industrialization (Borrás and Edquist, 2013; Flanagan et al., 2011; Izsák et al., 2013; OECD, 2010). Bearing this in mind, this paper discusses policy instruments within the specific environment in which they are implemented, the nature of the challenges they seek to address, the resources available to do so, the political context and the processes by which the instrument was customized for a specific context and/or situation.

From a development perspective we innovation goes beyond technology generation and the adoption of new or improved goods and services. In line with Freeman (1995), we are interested in those institutional and organizational transformations that underpin or block the development of capabilities that sustain the acquisition, mastering and, eventually, the ability to improve upon and produce new technologies. Developing countries face the daunting task of mobilizing, coordinating and even creating the necessary resources to address pressing development challenges. This often requires the introduction and management of incentives that facilitate the convergence of the behaviours and strategies of diverse agents in a given system of innovation. To improve innovation performance, decision makers may need to consider practices that regulate land tenure, the mechanisms to assign and protect intellectual property rights (IPRs) and other idiosyncratic and cultural factors surrounding innovation and industrialization.

Our analysis highlights the demands industrialization imposes on developing countries; strategies to address those demands are often best described from the perspective of mission-oriented programmes. In the spirit of Foray et al. (2012), the development of new technologies alone may not suffice to solve all of the development challenges emerging countries face. Rather, the solution often requires the creation and adoption of effective and appropriate technologies, even if developed elsewhere. Market forces alone cannot induce all the innovations needed to foster industrialization; government programmes facilitate and promote the development of relevant technologies to support the continuous progression of industrial activities (Foray et al., 2012; Joseph and Johnston, 1985).

Mazzucato (2011) argues that the role of the state in the economic system is not limited to fixing markets; rather, governments have the power, actually the responsibility even, to play a proactive role in the creation, governance and functioning of markets. Public policy plays an important coordination and allocation role within systems of innovation (Borrás and Edquist, 2013). This means that public interventions not only provide the conditions for innovation to flourish, but that those interventions may constitute leading factors for the achievement of innovation goals and the mobilization of innovations as the basis for companies, industries and economies to thrive. Vértesy (2011) asserts that carefully designed policy interventions help manage major external macroeconomic or technological shocks that occur in global value and innovation chains, with direct implications on the path and dynamics of emerging industrial activities in developing countries.

2. The analytical framework

According to Weiss (2015), the ultimate goal of industrial policy in any given country is identifying and addressing the binding constraints that inhibit structural change in favour of industrialization and higher productivity (Box 2). He builds on a growth diagnostics approach, using the well-established notion of market failures as the basis for public policy intervention. He proposes a simple framework for the analysis of industrial policy and industrialization along a continuum; industrialization occurs along a somewhat 'linear path' in three subsequent stages, 'early', 'middle' and 'late stage'. Each stage is characterized by regularity in certain factors such as the complexity of market structures, technological content, productivity and degrees of specialization and qualification of the labour force. The nature, scope and objectives of industrial policy reflect the binding constraints and windows of opportunity for the continuous development of manufacturing and related activities along those three stages. Relevant constraints to industrialization relate to low returns on investment, insufficient appropriability conditions and the cost and availability of funding.

Box 2: The rationale for industrial policy

> "The role of [industrial policy] can be rationalised in terms of [addressing] failure of markets and private decisions in response to market signals to generate an adequate level of manufacturing activity. Here action must be coordinated by governments and incentives given to firms that reward them for the external benefits they create for others. Application of successful [industrial policy] can be likened to removing constraints in the 'problem tree' approach to growth diagnostics'".
>
> Weiss, (2015:4)

Weiss (2015) recognizes that industrial policy does not occur in vacuum; rather, it is embedded within a wide set of decisions and initiatives that can potentiate or constrain the functioning of the manufacturing sector. Macroeconomic, environmental and other social, political and economic considerations, which fall under the purview of other kinds of organizations with their corresponding mandates and specific areas of intervention, make for a complex mix of problem trees for decision makers. Here, we argue that technology occupies a prominent role among the complex set of issues that frame industrial policy action.

In addition to a taxonomy that distinguishes five areas or policy domains, Weiss (2015) identifies a series of policy instruments or mechanisms that can characterize interventions across these distinct policy domains (Table 1). According to the author, 'market-based' interventions operate through pricing links; in essence, the goal is to enhance the profitability of manufacturing relative to alternative economic activities. Public inputs, in turn, denote the provision of goods or services which firms themselves would not adequately supply due to constraints resulting from low returns on investment, insufficient appropriability conditions and the cost and availability of funding. Institutions required to implement industrial and related technology fall within this category.

Table 1: Industrial policy taxonomy: where innovation stands

Policy domain	Innovation strategy	Instruments
Product market	Innovating input suppliers	
Labour market	Innovating input users	Market-based
Capital market	Complex systems innovation	
Land market	High science-content technology industries	
Technology		Public goods/direct provision

Source: Weiss (2015)

We would argue that innovation is a third dimension necessary to explain the relationship between policy domains, or sources of market failure, and the choice of specific policy instruments. Different innovation strategies reflect the dominant modes of sectoral innovation, which in turn outline the mechanisms for public intervention as identified with specific sources of innovation market failure. This is captured by Martin and Scott (2000), who propose a taxonomy (Table 2) whereby a country's strategic position relative to innovation depends on the nature of innovation and product market performance across industrial activities. Choices for policy interventions respond to questions relative to the form of innovation, for example, radical or incremental, the extent of appropriability and the appropriation mechanisms available, the degree of product-market rivalry and the importance and complexity of learning mechanisms, including but not limited to R&D and technology transfer.

Table 2: Innovation modes, sources of sectoral innovation failure and policy responses

Main mode of innovation	Sources of sectoral innovation	Typical industries	Policy instrument
Development of inputs for user industries	Financial market transactions costs facing SMEs; risk associated with standards for new technology; limited appropriability of generic technologies	Software, equipment, instruments	Support for venture capital markets; bridging institutions to facilitate standards adoption
Application of inputs developed in supplying industries	Small firm size, large external benefits; limited appropriability	Agriculture, light industry	Low-tech bridging institutions (extension services) to facilitate technology transfer
Development of complex systems	High cost, risk, limited appropriability (particularly for infrastructure technology)	Aerospace, electrical and electronics technology, telecom/computer technologies, semiconductors technology	R&D cooperation, subsidies; bridging institutions to facilitate development of infra-structure
Applications of high-science-content technology	Knowledge base originates outside the commercial sector; creators may not recognize potential applications or effectively communicate new developments to potential users	Biotechnology, chemistry, materials science, pharmaceuticals	High-tech bridging institutions to facilitate diffusion of advances in big research

Source: Martin and Scott (2000)

Below we review some recent catching up experiences in two different industries, namely aerospace and palm oil, with distinct levels of technological complexity. We draw from an extensive, though by necessity incomplete review of secondary sources of information. The discussion does not intend to be a comprehensive account of industrialization processes from a step-by-step historical perspective. Rather, we borrow from history to understand the context of implementation of specific policy interventions. We thus provide examples of policy interventions that have contributed to create positive dynamics in the social, economic and scientific and technological systems across specific developing countries. Learning from the past remains a good practice when it comes to planning for the future. And yet, any attempt to replicate previous experiences should be assessed in light of the broader framework conditions imposed by the modern global economic system.

2.1 Policy instruments: a heterogeneous mix

Literature on innovation policy draws attention to the complex and heterogeneous nature of policy instruments at hand. It captures the growing interest in understanding the effects that different policy instruments have on innovation performance, on how (combinations of) individual instruments interact with market mechanisms and the overlapping or complementary effects that can be associated with different policy instruments within systems of innovation (Borrás and Edquist, 2013; Izsák et al., 2013; Mohnen and Röller, 2001; Nauwelaers, 2009). This diversity reflects the complexity of innovation systems which entail a series of elements or subsystems that can reinforce, but also block each other (Hekkert et al., 2007; Kuhlmann and Arnold, 2001). The underlying innovation-related policy objectives or policy domains subject to specific policy interventions can be grouped around one or more of the following objectives (Borrás and Edquist, 2015; Izsák et al., 2013):

- Support investment in research and innovation
- Enhance innovation competences of firms
- Support services for innovating firms
- Competence building through individual/organizational learning, involving formal/informal education and training
- Demand-side activities involving the creation of new markets
- Provision of constituents or supporting the development of agents within the system
- Strengthen linkages within innovation systems.

This list is not exhaustive, but helps to illustrate the ramifications of the policy-decision tree around innovation and industrialization. Addressing these policy problems calls for a portfolio approach in which a combination of instruments simultaneously targets several objectives and groups of policy problems (Izsák et al., 2013; Nauwelaers, 2009). In effect, as we discuss in the sections below, policy instruments result from policies aimed at facilitating different forms of innovation, including products or services, which denote the acquisition/development of new proprietary technologies protected by patents or other forms of IPRs; yet some others are closer to process innovations in the form of changes in manufacturing techniques, organizational innovation, optimization of workflows and process re-engineering. Whereas some policies aim to support forms of innovation with clear and rapid market potential, some others aim to address more upstream issues with no immediate commercial value.

The possibility of combining policy instruments is what makes innovation policy systemic (Borrás and Edquist, 2013). However, finding 'optimal models' for the combination of instruments, otherwise interpreted as one-size-fits-all solutions, is problematic (Box 3); significant differences result from framework conditions but also from the 'quality' of implementation (Flanagan et al., 2011), the degree of maturity reached by certain agents or the innovation system as a whole (Izsák et al., 2013), and even the particular governance structures around innovation (Dutrénit et al., 2010). Moreover, identifying the impacts of individual innovation policy interventions on social and economic outcomes is extremely difficult. There is a complex chain of direct and indirect, vertical and horizontal effects; the ultimate results may only be perceptible many years after implementation (Padilla-Pérez and Gaudin, 2014; Santiago and Natera, 2014).

Box 3: Innovation policy mix: not a silver bullet

Finding an optimal policy mix is not a one-off exercise, but a continuous process that adjusts to the dynamics of innovation systems. Innovation is rarely a goal in itself, but a means to achieve broader social and economic goals.

Policy mixes are the first layer of direct incentives to research, development and innovation. A second layer lies with the institutions and structural factors that affect growth indirectly, in particular through effects on innovation incentives. Interpreting the effects of policy mixes on innovation and growth performance should consider that only the first layer of effects is detected. Indirect and cumulative effects of policy mixes are present but they cannot be measured without an integrated theory of innovation policy, which does not fully exist at present'.

Izsák et al. (2013:15), Borrás and Edquist (2013)

This paper thus endorses those who advocate the search for instrument combinations and policy models that adequately reflect the history, structural characteristics and conditions of developing countries (Crespi and Dutrénit, 2014), as opposed to tendencies to transpose models and interventions implemented elsewhere based on the notion of 'good practice' (Izsák et al., 2013). Unfortunately, the lack of a culture of policy evaluation in developing countries significantly limits the space for learning from past experiences, and narrows down possibilities for policy experimentation. This paper will illustrate how different instruments have been implemented in different forms and combinations, depending on the state of development of local value and innovation chains in developing countries.

2.2 Catching up in global value and innovation chains

Amsden (2003), Terheggen et al. (2010) and Reddy (2011) document the potentially disruptive power associated with the entry of a set of large and dynamic developing countries as leaders in the conformation and performance of global value and innovation chains. To a significant extent, this successful integration can be explained by these countries' investments in science, technology and innovation (Santiago, 2014). This paper draws attention to such cases for a number of reasons:

- The popular examples of industrial catching up in South East Asia highlight the importance of an explicit export-market orientation. Exposure to external markets is expected to stimulate demand for local goods and provide incentives to innovation. To a large extent, the cases explored here confirm the potential benefits that catching up industries derive from such an outward looking stance.
- Methodologically, the focus on a global value chain obviates the need to discuss in detail the specific conditions that allowed a given country to catch up in specific industries. Different catching up strategies are discussed, bearing in mind the conditions and trends that characterize a global industry.
- The discussion of past experiences of 'successful' industrialization provides a framework to interpret the efforts implemented by a 'second tier' of catching up countries. We take into account any possible changes in the institutional environment and the factors that drive or constrain the catching up process over time.

3. Catching up in a high-technology value chain: the aerospace and aircraft manufacturing industry[2]

3.1 Context of the industry

The global aerospace and aircraft industry is an extreme example of the challenging process of catching up in industrial innovation. The industry remains concentrated in a handful of Organization for Economic Cooperation and Development (OECD) member countries, notably the United States. The share of global output captured by emerging economies is estimated at around 10-11 per cent (Vértesy, 2014). Notwithstanding the efforts undertaken by diverse emerging economies in Asia and Latin America—perhaps with the exception of Brazil—the only developing countries capable of establishing aircraft manufacturing firms are China and Singapore, while the majority of developing countries seeking to catch up in this particular

[2] The introductory paragraphs in this section build extensively on personal communications with Dr Dániel Vértesy, who has been studying catching up processes in the global aerospace industry for nearly a decade. References to his work are included throughout the text.

global industry have achieved only modest results (Vértesy, 2013). Argentina and Indonesia represent experiences with, frankly, disappointing results. These divergent outcomes can, to a large extent, be explained by differences in the structure and functioning of the innovation systems that support the emergence of local aerospace manufacturing industries (Niosi and Zhao, 2013; Vértesy, 2011).Essentially, Indonesia and Argentina were less successful in overcoming technological and investment barriers and in creating strong enough innovation systems around the local industry (Vértesy, 2011).

The aerospace and aircraft manufacturing industry is characterized by a number of factors that make it extremely difficult for latecomer countries to catch up; these include sizable technological and capital barriers, while standards and norms are very high and non-negotiable, and not only for those countries willing to participate in international trade flows[3]. Goldstein, (2002) asserts that successful catching up in this industry requires development of world class design and manufacturing capabilities, being competitive in regards to price and operational costs of the aircraft, and after-sales services provided to an oligopolistic base of customers. Over time, accumulated learning by doing may lead to unusually large cost reductions. To a considerable extent, catching up in aerospace has been led by government initiatives. However, only few of these government-led megaprojects have succeeded in structuring vertically integrated aerospace production activities (Box 4).

A first wave of internationalization saw Brazil emerge as the single latecomer country able to develop manufacturing capacities and technological competencies needed to join the exclusive ranks of countries that possess an aircraft assembly industry. Brazil's Empresa Brasileira de Aeronáutica S.A. (Embraer) had to learn everything about aircraft production before finding an opportunity to specialize in design and system assembly in the 1990s. To avoid technological dependency, Embraer followed the strategy of limiting the use of

Box 4: Key elements in the successful creation of an aerospace sectoral system of innovation in Brazil

- Finding a market niche (commuter aircraft capable of serving airports with poor infrastructure);
- Channelling finance and design efforts to successfully develop a new product for this niche;
- Establishing a company to ensure commercial valorization of innovations (Embraer, 1969);
- Creating new linkages to provide capital (government launch support, government commissioning and acquisition of the bulk of new planes, and a corporate tax incentive scheme channelling private capital to Embraer);
- Creating linkages to access technology (through exclusive co-production contracts, licensing agreements and support for R&D in aerospace and connected activities).

Vértesy, (2011:141)

[3] Vértesy, personal communication.

technology licencing to acquire the competencies required to locally assemble planes; state support was critical to facilitate acquisition of any missing technological and organizational capabilities. Embraer is now the world's fourth largest aircraft manufacturer; it enjoys a solid presence in export markets.

Today we are experiencing what is considered a second wave of internationalization of the commercial aerospace industry. Vértesy (2014) asserts that unlike the first wave, today's dominant catching up strategy is one of integration and specialization in specific segments of the global value chain. This has been possible thanks to cost-reduction strategies pursued by transnational corporations which are increasingly integrating design and engineering, manufacturing, distribution and after-sales support in multiple locations around the world. Export data show a fairly bright picture for dynamic catching up countries, suggesting a need to increase their local value-added content of exports (Vértesy, 2014). According to Perez and Soete (1988), catching up countries face the challenge of tapping into a new window of opportunity to join the global aerospace value chain as specialized tier suppliers.

Measuring the real contribution of the aerospace and aircraft industry to aggregate products in a given country is problematic. However, the expected indirect impacts on an economy are equivalent to three times the contribution of the industry to GDP, on average, 0.2-0.4 per cent with peaks of up to 1.5 per cent in the case of Singapore (Vértesy, 2014). A combination of 'push' and 'pull' factors explain current dynamics of the global industry. On the 'push' side—in addition to the increased cost sensitivity of multinational corporations—we observe a rapidly growing demand for air transport and expanding commercial aircraft fleets, particularly in the Asia-Pacific region (Vértesy, 2014).

Strong 'pull' effects result from politically ambitious governments that seek to create strong domestic aerospace competencies, notably in BRICS and South East Asian emerging countries (Pritchard, 2012; Vértesy, 2011). A notable example is China, where the government adopted explicit industrial policy, science, technology and innovation strategies to promote the local aerospace industry (McGregor, 2012; Pritchard, 2012). The construction of a Chinese jet has been specified as one of the goals for the seven rising industries in the 12th Five Year Plan (2011-2015). This confirms commitments dating back to 2007, when the State Council officialized R&D for a large aircraft as a major scientific and technological project for the country (Pritchard, 2012). The Medium to Long Term Plan for the Development of Science and Technology (MLP) adopted in 2006 documents China's commitment to developing capabilities for 'indigenous innovation' and the achievement of a global leading role by 2020. Aerospace technology is one of eight priority technology fields with two engineering megaprojects: large aircraft and manned aerospace and moon exploration. Recent efforts to develop a Chinese aircraft include the creation of the China Commercial Aircraft Company (COMAC) in 2008 and the establishment of partnerships between Chinese firms and multinational firms such as Parker Aerospace, General Electric, Honeywell and Goodrich; many of those partnerships have been facilitated by the state-owned Aviation Industry Corporation of China (AVIC) (McGregor, 2012).

Countries such as Mexico and Malaysia seem to be following the Japan/Singapore model, rapidly becoming important centres for maintenance, repair and overhaul (MRO) and logistics, with the caveat that the former two countries lack the proximity to other high-tech and heavy industries, and the good governance observed during the early stages of development of the industry in Japan/Singapore (Vértesy, 2011). In effect, Vértesy (2013) asserts that in Singapore, the close collaboration between MRO service providers and parts and component suppliers was crucial for technological learning, especially in the commercial segment of the industry. Finally, notwithstanding India's success in building an outstanding aerospace industry (Mani, 2013), the country remains a promise, particularly in subsystem avionics production.[4]

These experiences have yet to provide conclusive results; however, they corroborate that things are far from becoming any easier. The absence of a clear catching up model to follow is accompanied by the realization that governments, private firms and other relevant agents within a given system of innovation play different roles during the emergent phases. In addition, there is the fact that the industry is exposed to frequent shocks that lead to persistent transitions in the technological regime or the macroeconomic conditions in which it operates (Vértesy, 2011). Below, we explore some of the strategies followed by latecomer countries to overcome a series of product-, labour-, capital-, land- and technology-market constraints.

3.2. Product market

Vértesy (2011) asserts that traditional strategies to develop an indigenous aerospace industry show some regularity across developing countries. Brazil, Singapore, the Republic of Korea and Indonesia, for example, allocated massive public funding and facilitated the acquisition of advanced technology by assembling aircraft under licensing; public procurement, often related to the military, served to promote demand for locally assembled aircraft. Arguably, the factor that gave Brazil and Singapore an edge was the early focus on commercialization with special attention on targeting developed country markets. In addition to increased sales,

[4] Vértesy, personal communication.

commercialization in the civil segment of the industry provided incentives to improve quality and efficiency.

Vértesy (2011) warns that sole reliance on the military push is unsuitable to underpin the development of a local aerospace/aircraft assembly industry; rather, failure to connect with specific long-term technological developments and the development of capabilities required to compete in a dynamic commercial segment is a more accurate interpretation. For example, in the case of Singapore, the specialized MRO firm, SAI, benefitted profoundly from both high public defence spending on the Republic of Singapore Air Force (RSAF) fleet expansion and maintenance, as well as from the proximity of related industrial activities, including electronics and precision engineering, its sibling companies were involved with (Vértesy, 2013). Similarly, some of the challenges Embraer faced in the early 1990s derived from its strong emphasis on engineering—favoured by long-term public procurement—over marketing considerations (Goldstein, 2002). The promotion of industry associations and entrepreneurship down the value chain are additional elements of any policy intended to promote the industry. As we discuss in the context of capital markets, this was possible in Brazil on account of a tax system that facilitated the emergence of a segment of domestic supplier firms around Embraer.

Export-oriented strategies favoured the development of more flexible innovation systems in Brazil; strong education and research systems provided relevant assets to facilitate a smooth adjustment of the emerging aerospace industry in the face of changes in the global environment. The choice of segment specialization was also relevant, with Singapore focusing on MRO services, while Brazil centred on the assembly and commercialization of commuter aircraft. Embraer found a niche in small-sized commercial and military aircraft, well-suited to operate in difficult conditions; at the same time, these aircraft are cheaper and easier to maintain.

At early stages, catching up in aerospace has been characterized by a mix of import substitution and export promotion strategies. Trade- and non-trade related mechanisms, such as export credits, export subsidies, import duties and ‘excessive’ bureaucracies have been common in Brazil, China and other countries. Goldstein (2002) documents the Brazilian government’s explicit policy to promote arms exports and the provision of credits to finance the acquisition of Brazilian aircraft by costumers abroad. In today’s world—with a few exceptions, mostly of large enough countries—the use of high import duties would face serious barriers. Public procurement, both for military and commercial purposes, remains a frequent practice, particularly in countries where the commercial air transport industry remains under public ownership.

In the case of Embraer, the threat of imposing or increasing import duties was used to force foreign commercial aircraft producers into collaboration agreements; they were compelled to provide the technical and organizational know-how necessary to assemble or handle series production of the final product (see our discussion on technology markets below); to some extent, this type of agreement helped Embraer become the sole source of certain parts and components for some major global aircraft manufacturers (Goldstein, 2002).

More recent newcomers are following Singapore's approach of specializing in specific segments of the industry, in particular, as parts and components suppliers. A significant difference relative to catching up strategies during the first wave of internationalization is the fact that today, countries target specialization across specific segments of the industry and consequently, the 'scale of the projects' is much lower and thus more feasible, more economic and sustainable (Vértesy, 2014). One exception is the aforementioned case of China which, similar to Brazil, is exploiting its bargaining power to offer privileged access to local markets in exchange for collaboration and technology transfer as required by local aerospace firms (Pritchard, 2012; Vértesy, 2014). China's 'indigenous innovation' strategy is marked by this inclination to lure multinationals into agreements favourable for Chinese firms (McGregor 2008).

3.3 Labour market

The reader should exert caution when interpreting successful integration and catching up in the global aerospace and aircraft manufacturing industry. Developing countries remain embedded in enclave economies; they import bulk parts and components, while labour upgrading and skilling depend strongly on specialized training provided by leading aircraft manufacturers (Vértesy, 2011). However, although the internationalization of the aerospace industry is no major source of employment in developing countries, the potential for increased qualification requirements may favour some positive long-term effects on local labour markets. The caveat is the competition that exists for highly qualified personnel across industries within developing countries. Even today, Embraer faces difficulties attracting/retaining well-trained graduates, as other industries (i.e. banking) may pay more generously.[5]

Latecomer countries that have captured a piece of the global market, mostly through MRO activities, share in common substantial efforts to develop specialized programmes and training centres, the conformation of dedicated research organizations and policies to facilitate aerospace knowledge assimilation, diffusion, and eventually, generation. Education and research

[5] Vértesy, personal communication.

organizations assist in the creation of competencies needed to deal with recurrent changes in technological regimes and the overall environment in which the emerging aerospace industry operates. A balance between education policies targeting long-term core competencies and the ability to respond to short-term skills requirements or to deal with emerging transitions is necessary. Private consulting firms and industry associations can address short-term training needs in technical and managerial aspects; the added advantage is that these organizations may be more flexible and responsive than formal education systems.

The Brazilian experience illustrates this point. Vértesy (2011) documents that prior to the formal take-off of the local aerospace industry, specialized training was already available at the Army's technical school established in 1939 and at the Escola de Aeronáutica (School of Aeronautics Engineering, SAE) at Campo dos Afonsos. In 1946, SAE was transformed into the Instituto Tecnologico da Aeronautica (Aeronautics Technology Institute, ITA) which, modelled on the Massachusetts Institute of Technology (MIT), was to become the source for major developments in the early stages of the industry. An additional step was the creation of the Centro Tecnico Aeroespacial (Aerospace Technical Center, CTA) as a branch of the military in 1950, with a mandate to conduct and oversee research in aviation and space flight in Brazil. CTA offered post-graduate research positions for engineers from ITA, especially at Instituto de Pesquisa e Desenvolvimento (Research and Development Institute, RDI). RDI was one of four institutes subordinated to CTA. CTA followed a strategy of spinning-off successful projects into aircraft producer companies, one of which was to become Embraer.

In the aerospace and aircraft manufacturing industry, the creation of a strong knowledge base in natural sciences and engineering provides a basis for the emergence of centres of excellence in applied fields required by the industry, for example, aeronautics, material science, electronics, information technologies and management (Vértesy, 2011). Facilitating close collaboration and information exchanges between universities, specialized training institutes and industry is also necessary from the early stages of development of the industry; it allows the education system to adapt as early as possible to the industry's needs. As the industry consolidates, it begins to assume stronger roles in supporting higher education and in conducting applied research; large-scale funding should be provided for basic research and the expansion of a knowledge base for local firms to tap into.

The recent Mexican experience helps illustrate the importance of collaboration between industry education and research organizations. As documented in the official development strategy for the industry, Mexico is undertaking efforts to connect the existing national network of public research centres with the development of new laboratories and certification programmes and the education and research requirements of a rapidly expanding aerospace industry (ProMexico, 2014). At the regional cluster level, for example, in the state of Querétaro, some initiatives include the establishment of the Querétaro Aerospace Research and Innovation Network (RIIAQ) with a mandate to contribute to the development and strengthening of R&D and innovation capacities. Similar initiatives exist for the aerocluster in the city of Monterrey, historically one of the country's leading industrial centres. The Mexico-European Union Competitiveness and Innovation Programme (PROCEI) has supported the conduction of specialized studies on the industry, and the development of certification programmes, supplier identification, consulting and infrastructure specifically for the development of capacities and competitiveness of the local industry.

The literature documents the importance of labour mobility as a form of embodied knowledge for capability building in catching up countries. Singapore has historically been very open and attractive to well-trained experts and engineers, something not many other countries have been able to replicate. According to Vértesy, Airbus complains that it—at least temporarily—faces higher assembly costs in China as expats from Europe have to be hired since China cannot find local workers with sufficient skills.[6]

3.4. Capital market

Public funding has been and remains a necessary, though insufficient, condition to overcome the technological and high capital hurdles in the aerospace industry. Public support is necessary not only at the entry stage but throughout subsequent phases of development. Take-off in latecomer countries has been possible thanks to active government intervention both as investor and customer. As an investor, leading projects have usually been government-driven, including Embraer, which was created as a state-owned enterprise in 1969; training and most R&D efforts initially also took place in public education and research organizations. Brazil, for example, established the Brazilian Development Bank (BNDES) to give credit to innovators, including funding to the start-up Embraer (PwC, 2010); government ownership helped offset the understandable risk-aversion of private investors. Privatization of Embraer was later accompanied by a redesign of government interventions, particularly to facilitate access to capital by the new private firm. Goldstein (2002) documents that while aircraft imports were subject to a 50 per cent duty if a comparable Brazilian product was available, Embraer enjoyed exemptions in production taxes and trade duties, for example, to acquire materials, parts and components otherwise unavailable locally. Discounts in corporate income taxes were also offered to Brazilian firms investing the equivalent of up to 1 per cent of their taxable income in

[6] Vértesy, personal communication.

Embraer assets on which they could even receive dividends. The Brazilian government introduced import duty exemptions for specialized suppliers, especially weapon producers.

A complex set of funding mechanisms has been made available to Embraer through different Brazilian government agencies, including (Goldstein, 2002; Pritchard, 2012):

- Financiadora de Estudos e Projetos (FINEP) for R&D activities and project development. According to Goldstein, (2002), FINEP contributed up to 22 per cent of the development costs of the ERJ-145/135 family of aircraft; BNDES may have fully covered the development costs of the AL-X fighter.
- BNDES: innovation activities and credits and direct financing for Embraer customers.
- Banco do Brasil: Short- and long-term financing, including export promotion instruments such as FINEX (Fundo de Financiamiento à Exportação – Export Finance Fund) or the Programa de Estimulos às exportações - Export Promotion Programme (Proex), which provided up to 3.5 per cent rebate on interest rates on loans to importers of Brazilian aircraft (Goldstein, 2002).
- Sao Paulo Research Foundation: this is an example of provincial government support. The Parceria para Inovação Tecnológica – Partnership for Technological Innovation (PITE) programme supported R&D, notably through the promotion of collaboration between firms and higher education and research organizations (Goldstein, 2002).
- Preferential income tax system to promote production, exports and R&D activities. Pritchard (2012), for instance, suggests that in Brazil, tax breaks for R&D are equivalent to up to 160 per cent of total R&D expenditures.

Additional financial incentives are channelled by governments as customers through public procurement. For instance, previous to the emergence of global value chains in the early 1990s, the Brazilian government's orders of aircraft, particularly for military use, supported the vertical integration of the local aerospace and aircraft manufacturing industry. Public purchases of aircraft represented up to one-third of total sales of Embraer's Bandeirante aircraft before 1980, while federal agencies were required to buy Embraer's aircraft when price differences were less than 15 per cent relative to imported alternatives. Guaranteed purchases and up-front payments served to fund product development activities (Goldstein, 2002).

Government demand in Brazil also helped offset changes in external demand. At the same time, it served a more long-lasting purpose, namely allowing learning throughout different operational aspects. According to Goldstein (2002), although the Xingu executive plane, Embraer's first pressurized aircraft, was a commercial failure, government procurement allowed the firm to accumulate knowledge used later in the development of more successful models, such as the Brasilia. Assumption of this kind of risks is possible when there is some minimum guarantee that the firm will be able to leverage financial support and share the burden of any commercial derailment.

An adequately managed transition in the funding structure towards an increased share of private capital is needed as the nascent industry begins to consolidate; in Brazil, this transition eventually led to the privatization of Embraer in the early 1990s. The transfer to private ownership included a package of financial, fiscal, marketing, regulatory and international responsibilities formerly concentrated in the government through the Ministry of Aeronautics. The government injected new capital, assumed the debt, and retained 6.8 per cent of the company's stock, including a "golden share" carrying the right to veto key decisions resulting in changes of control and corporate purpose, the nature of defence programmes or the share of foreign ownership – the maximum was set at 40 per cent (Goldstein, 2002). By contrast, in Argentina and Indonesia, the sudden withdrawal of public funds, particularly from the military, without accompanying private investment flows contributed to the stagnation of the nascent local industries.

3.5. Land market

Similar to other high-technology industries, aerospace companies tend to concentrate in well-identified clusters with a prominent presence of knowledge-producing institutions (Martínez, 2011). Accordingly, governments in catching up countries increasingly compete to attract firms in the supply chain by establishing aerospace business parks, providing tax breaks and supporting R&D. Investment in infrastructure and proximity to airports and the creation of education and research organizations have contributed to reduce entry barriers for foreign subsidiaries and local start-ups. Tax breaks and other incentives for investment and production signal to potential investors the government's commitment to the industry's long-term development.

An early expression of this strategy is the cluster developed in São José dos Campos, State of São Paulo in Brazil. The choice of this location reflected a strategic one between two of the country's most influential cities, Sao Paulo and Rio de Janeiro, the availability of electrical power, an agreeable climate and propitious topographic conditions (Goldstein, 2002; Vértesy, 2011). In addition to these general environment conditions, the presence or the explicit strategy to create organizations specialized in aerospace education (ITA, for example) and research (Instituto de Pesquisas Espaciais, INPE) played important catalytic roles. Leveraging on the presence of multinational firms in other industries of economic activity favoured investments in complementary activities, including in the components and electronics industries, as well as the consolidation of different tier suppliers.

In Singapore, the government played an active role in the provision of financial incentives and the facilitation of intensive knowledge and technology flows to underpin emergent industrial activities at the Changi/Loyang and Jurong aerospace clusters (Vértesy, 2013). In addition to sales offices of airframe makers, three different kinds of companies were located in Singapore: MRO providers, such as SAI or the engineering department of SIA (later joined by other providers including HAECO of Hong Kong), and parts and component supplier companies from the second and third tiers of the global aircraft industry. Finally, the French helicopter manufacturer, Aerospatiale, represented a top-tier company, which acted as an anchor tenant according to Niosi and Zhegu (2010). The Economic Development Board (EDB) played a critical role as an efficient gatekeeper brokering between government policies and industry needs (Vértesy, 2013).

A more recent example of the strategic promotion of clusters to underpin the development of a local aerospace industry are the rapidly growing aerospace clusters in Mexico (Martínez, 2011). The country's development strategy emphasizes the planning or actual implementation of interventions to expand the mandates of existing public education and research centres and to tap into the accumulated experience and capabilities to deal with highly globalized industries, including automobiles, electronics, medical devices and advanced manufacturing (ProMexico, 2014). The Mexican experience highlights some changes in the notion of 'investment in infrastructure'; increasingly, this implies expanding the base of information and communication technologies according to the needs of aerospace manufacturers. In the case of the Baja California Aerospace Cluster, located in the Northeast region of the country, investment in ICT services to meet design and engineering requirements has accompanied initiatives by ICT-related industry associations to establish training and certification centres; the latter offer clinics on design and engineering software tailored to the needs of the aerospace industry.

The strategy of building organizations specialized in servicing the aerospace and aircraft manufacturing sector, together with the use of existing research and productive capacities and physical infrastructure of broader scope, seems to position Mexico half-way between earlier strategies followed by catching up countries. Vértesy (2013) documents that unlike Brazil or India, which made efforts to acquire the complex technological capabilities required to design and produce aircraft, Singapore did not establish public research organizations or training institutes dedicated fully to aeronautical engineering. Specialization in MRO and parts manufacturing allowed a less demanding strategy. Yet, the government remained actively involved via the provision of incentives for firms to locate in Singapore and to invest in technological capabilities with a view to a long-term presence. The Singaporean government set out to develop the country's strategic location, turning it into a global transportation hub and regional financial centre. A side-effect was the constant demand for air transport-related services and MRO with potential scale advantages. To facilitate the accumulation of advanced technological capabilities, the government resorted to tax incentives for firms, public procurement (including for the military), favourable immigration policies and investment in education and training.

For a country like Mexico, a direct implication from the Singaporean experience is the need to upgrade the overall systems of innovation, national and sectorial, surrounding the aerospace industry. Singapore placed emphasis on the provision of a strong local knowledge base in science and engineering, access to foreign experts and a highly educated and competitive labour force combining vocational, technical and engineering programmes. Strong incentives were provided for start-up companies in the form of tax holidays, investment allowances, training grants and investment guarantees. The Loyang Industrial Estate near Changi airport became the first aerospace industrial park to provide ready-built premises and good infrastructure for new companies (Vértesy, 2013). Against this background, the development of the sectoral innovation system was designed to potentiate Singapore's geographical location, including the rapidly growing economic activity and air transport growth in the Asia-Pacific region, the cultural proximity with China and the cost reduction strategies of airlines, particularly in MRO services (Vértesy, 2013).

3.6. Technology market

From an innovation perspective, aerospace products constitute complex systems (Table 2); the creation of necessary technological capabilities to catch up in the industry, from basic design to the manufacturing of aircraft, is a non-linear process. In many early attempts at catching up, the take-off of the local aerospace industry was possible on account of the convergence of a complex set of political, technological, commercial and military interests. The interplay government-military took the form of state-owned enterprises mandated to develop local aerospace industries (Goldstein, 2002; Vértesy, 2011).

Reverse engineering was a strategy to learn from the West. For example, in the early 1970s, China started the development of helicopter design and manufacturing capabilities based on the acquisition and reverse engineering of imported French helicopters, SA-321Ja. In 1985, the first

Chinese version, the Z-8, flew but had little success due to technical difficulties (Niosi and Zhao, 2013). Although reverse engineering is difficult under the current World Trade Organization (WTO) rules, there is no guarantee that at least some such activities continue to take place in countries like China (McGregor, 2012).

A more viable alternative under current international trade regulations is technology licensing. This practice has served different purposes across different catching up stages. In addition to technology accumulation, licensing has promoted industry-government collaboration and, as in the case of Argentina, the possibility to address market rather than technology needs, for example, employment creation. Licensing for technology acquisition when coupled with local R&D efforts and the increase of absorptive capacities was effective to sustain catching up. An additional success factor for technology licensing was its linking with technological partnerships. Reliance on collaboration helped Singapore and Brazil deal with and adjust relatively quickly to changes in market conditions and technological trajectories within the industry, or to face and recover from any major macroeconomic and political events.

According to Goldstein (2002) and Vértesy (2011), Embraer's productive activities in the 1970s were facilitated by co-production and licensing arrangements with foreign partners; such agreements helped boost market penetration without excessive technological dependence. Embraer limited the degree of vertical integration to minimize the risk of fragmentation of business operations; the focus on designing the aircraft, producing fuselages and assembling the final product was leveraged through the signing of long-term purchase agreements with major suppliers, many of which were located abroad.

Box 5: Organizational innovation to face external economic shocks affecting Brazil's Embraer

"In 1994 Embraer was privatized to a consortium of Brazilian enterprises and pension funds, led by the Bozano Simonsen Group, while the government retained a "golden share" and a seat on the board of governors. Privatization resulted in capital injections as well as greater flexibility to sign partnership agreements to jointly develop a family of regional jets.
Arguably however, the most important organizational innovation 'was the creation of a system of risk-sharing partnerships (an already common practice of leading aerospace producers in Europe and the US who realized the need to cut costs by focusing on core competences and sharing R&D costs with component suppliers.)
'This new form of organization allowed shorter lead times due to parallel manufacturing, but also ensured that Embraer applied the latest technologies, given the fact that many of its partners were suppliers of the leading global producers. Embraer thus redefined its core competence as aircraft designer and system assembler. At the same time, this posed new challenges for other companies in the sector, who needed the capital and technology to compete with major foreign parts and components suppliers to win long-term contracts."

Vértesy (2011:146)

Frequently, collaboration with foreign suppliers has been possible through a combination of state intervention and the ability to spot opportunities to capture market shares. Partner multinational firms have had no option but to accept the deal or loose presence in the Brazilian or the Chinese markets, for example. Vértesy (2011) illustrates this process based on the case of Embraer's entry into the segment of small planes. The Brazilian government offered licenses to one producer and deterred imports from all others. In exchange, the partner firms were expected to: '(1) allow Embraer to progressively manufacture a greater share of the planes' components and parts in Brazil; (2) do not oblige Embraer to pay any royalties; (3) allow Embraer to make modifications on the models; (4) expect collaboration on future aircraft design, production and marketing' (p. 138). Based on these considerations, one can explain the increased market share obtained by Piper in Brazil, whereas Cessna and Beech faced the opposite situation. Similar experiences led to enhanced collaboration with Aermacchi, Northrop and Pratt & Whitney. McGregor (2012) documents similar trends in China: multinationals have entered into technology collaboration agreements as a way to enhance their presence in the local market; the author argues that in a relatively short period of time, the risk is that those same multinationals will have to face competition from the Chinese companies they are helping to create.

Countries in the new wave of catching up should be ready to respond to frequent swings in the industry; a process that Vértesy (2011) qualifies as a pattern of interrupted innovation. The prospects of successfully managing any ensuing transition depend to a large extent on the sectoral and national systems of innovation and the accumulation of technological capabilities among local aerospace firms. Purposive trade negotiations pave the way for the continuous development of the local industry. In Brazil, for example, there is correspondence between Embraer's partnership building with leading aircraft manufactures, the signing of memorandums of understanding (MoU) to promote technology collaboration and higher involvement of private investors in aviation activities (see, for instance, the MoU signed with the United States, or trade agreements with China (Pritchard, 2012)).

We have already mentioned the importance of public funding at early stages of the aerospace industry's development and the subsequent transition towards increased participation of private investors. Again, Brazil offers an interesting example. The privatization of Embraer was accompanied by a steady specialization in certain core competencies and the establishment of joint ventures to acquire additional competencies (Box 5). Along came a process of entry of new firms, many of them created by former Embraer employees and facilitated by a series of public incentives for entrepreneurial activities connected to Embraer's supply chain (see section on capital markets above). The result was dissemination of some core technological capabilities to a broader local aerospace industry.

Niosi and Zhao (2013) assert that joint ventures, subcontracting and wholly owned subsidiaries have underpinned technology acquisition by Chinese aerospace firms. Joint ventures with Boeing resulted in investments for the production of parts, sub-assemblies and services in China. In 1985, Aerospatiale, now part of the Airbus group, 'signed its first subcontracting agreement with Xian Aircraft to produce doors for the A300 and A310 aircraft' (p. 86). In exchange, Airbus has increased market share in China, particularly for large commercial planes. Bombardier has also participated in major subcontracting operations in China, for example, for the production of its CSeries aircraft. While Bombardier seeks to enhance its competitive stance relative to Embraer in the Chinese market, China's AVIC has benefitted from access to cutting edge technologies in regional jets manufacturing. Surely, there are significant differences in bargaining power across developing countries; China has been able to leverage on its large and expanding domestic market for aerospace and aircraft manufacturing and related services.

It is still too early to characterize the recent emergence of Mexico as a rapidly growing location for global aerospace and aircraft manufacturing activities. Positive effects have basically been identified because the country has successfully increased local value added content to exports (Martínez, 2011; Martínez-Romero, 2013; Vértesy, 2014); this was rarely the case in the traditional maquiladora industry. To some extent, however, it seems that the country's accumulated experience with the maquiladora programme may have provided some 'transferable competencies' needed—low-cost, highly qualified labour, experience with global value chains, for instance, in automobiles, and the presence of a modern manufacture structure—to facilitate attraction of global aerospace and aircraft manufacturing firms (Martínez, 2011). The expectation is that the country's capacity to meet tough technical and quality standards, together with an aggressive policy to connect emerging clusters with the public research infrastructure already in place, can assist the move to more complex, innovation-intensive stages in the industry (ProMexico, 2012, 2014).

4. Industrialization of a natural resource-driven industry: palm oil

4.1. Context of the industry

The palm oil industry is a success case of the transformation of an agricultural product into a natural resource-based industry with significant linkages and implications for industrial development in a developing country context (Fold and Whitfield, 2012). The oil palm fruit requires processing within 24 hours after harvesting; any delay is detrimental to the quality of the oil extracted. Two types of oil can be obtained from the oil palm fruit: crude palm oil (CPO) from the mesocarp, and palm kernel oil (PKO) from the kernel. The oil palm is extremely versatile, the fruit and its by-products have multiple applications in the food processing, cosmetics and other industries; increasingly, oil palm is being used in the production of biodiesel (Box 6).

Based on Rasiah and Azmi (2006), a review of this industry is pertinent given its mainly process-based nature; in general, technical change involves efficiency-driven techniques designed to boost quality and speed up delivery. Innovations mostly involve the development of new uses for processed palm oil and by-products such as kernel oil and oil palm waste. Limited empirical evidence suggests that human resources management practices simply focus on reducing injury and raising productivity (Rasiah and Azmi, 2006).

Palm oil is endemic to West and Southern Africa, but it has flourished in South East Asia, notably in Malaysia, steadily becoming a high-value, highly diversified, innovation-driven, export-oriented industry. Malaysia and Indonesia have positioned themselves as the world's dominant oil palm producers and exporters, a significant achievement considering that though the roots of the palm oil industry in Malaysia date back to the colonial period, modernization and rapid development only began in the 1960s (Craven, 2011). Within a few decades, Malaysian plantations, processors and manufacturers have made so much progress that they are considered the technological frontier; the local industry is not only the leading innovator, but the controller of the industry's value chain (Rasiah and Azmi, 2006).

Box 6: Oil palm, a very versatile line of industrial uses

"The oil palm tree bears fruit in bunches, called fresh fruit bunches. The individual fruitlets contain an outer skin, a pulp containing the palm oil, and a central nut consisting of a shell and the kernel. Two kinds of oil are obtained from the fruit. Crude palm oil is produced from the pulp, and palm kernel oil is produced from the nuts. Crude palm oil is used in producing soap and other non-edible products, as well as for industrial purposes. Crude palm oil must be refined before use in food manufacturing processes to produce products such as biscuits and ice cream. Refined oil can be fractionated to produce liquid palm olein and palm stearin fractions, used for cooking-oil and margarine. Palm kernel oil can also be used as an edible fat in manufactured foods. Kernel oil is also used in the oleo-chemical industry to manufacture products such as cosmetics. The palm oil milling process produces several by-products, some of which can also be sold while others can be used in the production process."

Fold and Whitfield (2012:8)

Craven (2011) asserts that Malaysia's experience illustrates the leadership role government intervention can play in fostering the development and functioning of sectoral systems of innovation. Public interventions have played a catalytic role, promoting the growth and active participation of private firms and research communities; interaction between these and other agents have sustained the long-term transformation of oil palm from an agricultural activity into a buoying processing industry. DSD (2008) claims that the Malaysian oil palm industry is one of the most highly organized industries of any national agriculture system in the world. As discussed later, the Industrial Master Plans (IMPs) adopted in Malaysia since the 1980s confirm that the promotion of industrialization and upgrading of oil palm activities took place within a broader industrial development framework and the alleviation of poverty and inequality in the country (Rajah and Azmi, 2006).

By contrast, the development of the oil palm industry in West African countries, Ghana or Nigeria, for example, is considered a less successful experience (Adejuwon et al., 2014; Fold and Whitfield, 2012). Although based on the Nigerian experience, the study of Adejuwon et al. (2014:75) seems to describe the situation in West Africa:

> *"In the area of cultivation, challenges such as insufficient production due to a large proportion of output being dependent on wild and old palm trees, unavailability of land for oil palm plantations because of the land tenure system as well as non-adoption of high-yield varieties by farmers have been acknowledged. The various problems encountered during processing include the closure of most large-scale mills because of capacity under-utilisation, unacceptable product quality of small-scale processed oil by the refining industry, inability of small-scale processors to cope with harvest peak periods as well as high cost of traditional processing systems because of low extraction rates."*

More recently, a small, tropical developing country, Honduras, is seeking to expand its local palm oil industry for the purposes of processing and exporting biofuels. In doing so, Honduras expects to reduce vulnerability in the face of international oil price fluctuations (Abdullah et al., 2009; Craven, 2011). Moreover, the country is seeking to capitalize on a window of opportunity derived from a growing local palm oil industry, expanding cultivation, improvements in irrigation and processing, existing infrastructure and large, established firms and a system of higher education (Craven, 2011). In the short-run, existing plantations and production facilities in Honduras would continue to drive down the price of biodiesel relative to that of sugarcane ethanol. In general, the literature advises to turn to Malaysia as a model to guide the development of the oil palm industry in this and other developing countries (Box 7).

In what follows, we revisit some key lessons from Malaysia's and other developing countries' experiences from the standpoint of the five policy domains proposed by Weiss (2015). Similar to our previous discussion about the aerospace and aircraft manufacturing industry, the development of the oil palm industry highlights the presence, or lack thereof, of coordinated efforts and strategies by farms, firms, government organizations and the interactions between these and other agents within relevant systems of innovation.

Based on Fold and Whitfield (2012), the reader is invited to look at the 'successful' Malaysian experience and the 'failure' of other developing regions, notably West Africa, bearing in mind the complex set of factors that have conditioned the development of the oil palm industry in both these regions. Differences in policy interventions certainly contribute to explain any divergent trajectories; however, factors such as history, geographical and climatic factors deserve consideration. The development trajectories of the palm oil industry in each region corroborate the importance of path dependencies to explain catching up, forging ahead or falling behind (Abramovitz, 1986).

Box 7: Factors that favor catching up in the palm oil industry

- Good governance: comprehensive, multi-level, multi-ministry, multi-year plans.
- Incorporate legislation, research, education policy, financing and investment, legal frameworks, taxation schemes, infrastructure, rural development and land distribution.
- Increased collaboration with funding bodies, NGOs and universities to foster research;
- Fiscal policies to support development of the domestic market;
- Pro-active strategy to promote export orientation and as the industry consolidates, export diversification;
- Pro-active promotion of technological diversification
- Environmental controls to ensure sustainability in the long term.

Craven (2011), Rasia and main text

4.2. Product market

From a historical perspective, Malaysia and Indonesia in South East Asia, and Ghana and Nigeria in West Africa share in common a colonial past, with European settlers being responsible for the establishment of the first commercial oil palm plantations. The strategies implemented by the settlers in the two regions differed radically, particularly in regards to the insertion of local oil palm production to international markets; some of those characteristics continue to influence current structures and performance of the markets for oil palm in both regions.

Practices to allocate property rights are among the factors holding back the development of the oil palm industry in West African countries such as Ghana and Nigeria (Adejuwon et al., 2014; Fold and Whitfield, 2012). More specifically, as we discuss in our section on land markets, the colonial period left practically intact the traditional practices used to determine land ownership (Fold and Whitfield, 2012). The result is a complex ownership structure favourable to the coexistence of a dual palm oil market. A commercial, mechanized processing segment coexists with a traditional segment mostly reserved for domestic consumption.

The presence of a traditional industry reflects what Fold and Whitfield (2012) denote as the 'degree of societal embeddedness' of oil palm in West African culture. In the case of Ghana, particularly in the coastal and forest zones, oil palm is central for the local cuisine; it is the main source of edible oil. Moreover, the production of other traditional oil palm products, for instance, local wine, requires felling down palm trees before they reach maturity (Fold and Whitfield, 2012). The authors argue that the modern and the traditional domestic segments compete for the oil palm fruit; those in the domestic segment tend to favour low-yielding varieties more suitable for domestic consumption. The section on technology markets below will comment on how the informal nature of a large share of smallholder plantations results in barriers to the adoption of processing technologies in Nigeria. By contrast, Asian countries record no relevant non-industrial use for oil palm products.

Differences in scale and degree of mechanization between West African and South East Asian countries are also a reminder of their colonial past. In the former case, the predominance of small holding production eventually surrendered to the more profitable, rapidly growing demand for cocoa cultivation stimulated by the expanding European market for chocolate. By contrast, in Malaysia, oil palm cultivation was large-scale and processing highly mechanized from the very beginning. Colonial land policies favoured large-scale operations in oil palm, with indigenous small holders focusing on rice and other crops. Malaysian oil planters specialized in primary production and received no protection or subsidy from the government; specialization in primary production continued after independence (Rasiah and Azmi, 2006).

The orientation of local production to the domestic or international market was determined early on in the colonial period. Malaysia has consistently focused on external markets, taking advantage of its historical insertion into global rubber trade. As rubber trade began to decline during the 1960s, palm oil found itself in a favourable position to increase its presence in Malaysian exports (Fold and Whitfield, 2012). By contrast, West African countries have tended to concentrate on local markets with sporadic, limited incursions in export markets (Fold and Withfield 2012). This trend continued after both regions gained independence; Malaysia progressively consolidated as a net exporter of oil palm products, while Ghana and Nigeria have become net importers (Adebowale, 2012; Adejuwon et al., 2014).

In Malaysia, the penetration of new export markets has been reinforced by well-concerted promotional strategies, including the creation of what Fold and Whitfield (2012) named a ‘consensus-agency’ with representatives from the whole industry, the Malaysian Palm Oil Promotion Council (MPOPC). MPOPC has been instrumental in offsetting some international campaigns—including one orchestrated by US soybean producers—designed to undermine global demand for palm oil products (Fold and Whitfield, 2012; Rasiah and Azmi, 2006).

4.2.1 The role of public policy interventions

Differences in the consistency, continuity and coordination of public policies targeting the oil palm industry contribute to explaining different performances across developing country regions. In West Africa, policies targeting the oil palm industry have been subject to constant, often abrupt changes. For example, Fold and Withfeld (2012) comment that in the early 2000s, Ghana registered three different government initiatives on palm oil, organized by three different state institutions and with no connections to each other; this was compounded by limited learning from past experiences, almost complete dependence on donor support and limited participation of private investors. The South East Asian experience has been dramatically different, as countries in the region have enjoyed more stability, consistency and to some extent, proper sequencing of government interventions, thus favouring a more steady development of the industry (Rasiah and Azmi, 2006).

The Malaysian experience attracts attention due to the positive results associated with government intervention and the expectation that continued government support will maintain positive dynamics of the local oil palm industry. Initially, government interventions included the acquisition of foreign-owned states by local parastatals and the creation of specialized organizations, both public and private, to promote the development of the industry. Examples of those organizations, many of which continue to operate today even if under a different form, include the Rural Industry and Smallholders Development Authority (RISDA), the Federal Land Development Authority (FELDA) and the Federal Land and Crop Authority (FELCRA) to alleviate poverty (Rasiah and Azmi, 2006). The sophisticated functioning of the Malaysia Palm Oil Board (MPOB) is a direct result of key government-driven investments in the creation of a suitable institutional framework in previous decades (Craven, 2011).

According to Fold and Withfeld (2012), learning from colonial policies in support of the rubber industry informed the strategies targeting the oil palm industry in Malaysia. Those policies included flexible export taxes adjusted according to cycles of expansion and contraction of the rubber industry, the financing of specialized research facilities to serve the industry’s needs, the promotion of local value added and the connection of agricultural and poverty reduction strategies involving investments in physical and financial infrastructure (Rasiah and Azmi, 2006).

In the 1970s, the promotion of the oil palm industry in Malaysia was possible through export taxes that stimulated a shift from CPO to processed palm oil (PPO). In parallel, tariffs on bleaching earth, a key input used in PPO production, were raised, while domestic prices were tied with world prices. In order to attract investment in refineries, the government promoted tax incentives on capital investment and the regulation of the number of facilities established in the country to prevent overcapacity (Rasiah and Azmi, 2006). According to Fold and Whitfield, (2012) the take-off of the industry benefitted considerably from the establishment of oleochemical production facilities in the early 1980s. Important results include the expansion of exports of these products, the establishment of refining capacities and efforts to develop production technologies during the late 1990s. A rapid transformation in the composition of exports in favour of PPO followed; by the early 2000s, the share of PPO products had reached about two-thirds of total palm oil exports (Rasiah and Azmi, 2006).

To move palm oil products up the value added chain, the Malaysian government implemented a series of integrated state-led plans from the mid-1980s, commonly identified as the Industrial Master Plans (IMP). The first plan, IMP 1, adopted in 1986, identified oil palm as a priority industry, setting goals for the development of different segments of the value chain (Rasiah and Azmi, 2006). Specific targets included the provision of institutional support to improve refinery technology, stimulate palm oil R&D and develop complementary domestic industries, including biofuels (Abdullah et al., 2009). Rasiah and Azmi (2006) document that the IMP 1 supported oil palm refineries with reductions in corporate income taxes equivalent to 50 per cent of export sales; they also enjoyed the double deduction tax benefit on export sales. According to the authors, in some extreme cases, by combining these two provisions, export-oriented firms managed to avoid paying income tax altogether. As the industrial capacity to process and export palm oil products increased—something interpreted by government authorities as a sign that the processing segments were already competitive and world class—the government initiated a gradual reduction on export duties on CPO (Rasiah and Azmi, 2006). A direct consequence was that Malaysia began importing CPO from neighbouring Indonesia, thus creating some dynamics for the growth of the palm oil industry at a regional scale.

By 1996, a second IMP, or IMP 2, was adopted, this time with an emphasis on productivity growth and the search for input suppliers as the local processing capacity of CPO surpassed local production. Indonesia became a major supplier of raw materials (Rasiah and Azmi, 2006).

At the same time, in order to overcome shortages in labour and land reserves in Peninsular Malaysia, the industry began a geographical expansion towards other regions within Malaysia; incentives were granted to labour-intensive and agro-processing firms in East Malaysia, for example, through the opening of export-oriented processing and assembly plants in the region (Cramb, 2011; Rasiah and Azmi, 2006). The IMP 2 also had important effects on import substitution and the development of complementary industrial activities, including packaging, machinery and equipment and related services. The IMP 2 focused on enhancing downstream activities with an impact on value added, for example, biotechnology, and in the provision of training, R&D and marketing promotion (Rasiah and Azmi, 2006). To facilitate job and industry expansion, the Malaysian government has subsidized factory/processing plant space, and established free trade zones/export processing zones near major freeways and ports (Craven, 2011).

Palm oil and related products continue to feature prominently in Malaysia’s development strategy. The Ninth Malaysia Plan, concluded in 2015, placed emphasis on ‘new agriculture’ which involved large-scale commercial farming, the wider application of modern technology, production of high quality and value-added products, biotechnology, convergence with ICTs and the participation of entrepreneurial farmers and skilled workforce (DSD, 2008:8). The Tenth Malaysia Plan identified as key objectives addressing challenges related to low productivity among smallholders and the rising cost of production and dependency on foreign labour in upstream activities. Some remedial strategies include the attraction of foreign investments in oleochemical-based products, bulking facilities and R&D; the development of palm oil industrial clusters for the promotion of activities such as biofuel, oleochemicals, biofertilizers, specialty food products, biomass products, nutraceuticals and pharmaceuticals; improving agricultural practices and mechanization, particularly among smallholders; and implementation of centralized procurement of agricultural inputs such as fertilizers and pesticides to lower input costs (EPU, 2010:124).

4.2.2. Price controls

Malaysia is an example of how public intervention may alter market prices in ways that it induces positive incentives for structural change in a given industry, in this case, palm oil. The use of price, export quantity and domestic allocation promoted the expansion of industrial activities without being detrimental to the dynamics of the agriculture sector. A major driver for Malaysian firms to move away from CPO exports and into PPO products was the already mentioned exemption of export duties on processed products; the exemption represented a duty difference of 7.5 per cent in 1968, sufficient to stimulate first-stage processing (Rasiah and

Azmi, 2006). The intent of the exemption was not to transfer government revenue from non-oil-related products, but rather, to promote a cost differential between CPO and PPO products, in favour of the latter.

Rasiah and Azmi (2006) argue that the duties on CPO pursued four goals: (1) to make palm oil processing attractive; (2) to avoid overburdening crude palm oil producers; (3) to protect duty revenue; and (4) to avoid cross-subsidizing the industry even though it was not yet profitable. By the late 1980s, as domestic firms had successfully shifted from CPO to PPO, the Malaysian government gradually removed the mechanisms that changed relative prices so as to favour the movement of domestic firms up the value chain. Although the shift from the more volatile CPO to the more stable PPO implied a reduction in CPO exports during the 1980s, this effect can to some extent be explained by the increased share of CPO production processed domestically and transformed into PPOs. As PPO exports consolidated, CPO exports eventually rebounded by the early 2000s. The rebound was promoted, at least in part, by bilateral barter trading agreements with China, India and Myanmar (Rasiah and Azmi, 2006). The expansion in oil palm cultivated land ensured that imports of CPO to cover domestic demand remained in check at low levels.

A different story originates from Indonesia. Starting in the early 1970s, the Indonesian government implemented a series of interventions to keep the domestic supply of cooking oil stable and at reasonable prices (Rasiah and Azmi, 2006). Citing a study by Larson (1996), Rasiah and Azmi (2006:32) report that the scheme was effective in keeping down the price of cooking oil but led to market distortions that failed to promote local palm oil processing. This disincentive can be explained by the fact that CPO and PPO were similarly taxed, independently of the margin between milling and refining palm oil. Thus, the intervention failed to alter the expected profitability of PPO over CPO. Moreover, the controls led to a wealth transfer from the government and palm oil producers, 22 per cent of which were rural poor smallholders off the Java Island, to the intermediaries and the more affluent consumers on the Java Island. Inconsistent and oscillating export and control policies resulted in increased risk and uncertainty, thus inhibiting the investment climate around oil palm (Rasiah and Azmi, 2006).

4.2.3. Palm oil-based biodiesel, an expanding new market for the Malaysian industry

The use of palm oil in biofuel production has resulted in a new boost to the expansion of Malaysia's oil palm industry. The industrial and economic ability to process imported CPO is interpreted as a notable shift in the local industry and a successful upgrade of the CPO segment of the domestic market (Craven, 2011; Lim and Teong, 2010). Craven (2011) argues that this step marks the country's full shift away from basic agricultural commodities towards a sophisticated and valuable product.

Box 8: Malaysia's National Biofuel Policy

- Formulated after extensive consultation with all stakeholders and as a result of research findings by Malaysia Palm Oil Board (MPOB) since 1982;
- Considered the development, feasible use, sustainable supply and spin-off effects of biodiesel in short, medium and long terms according to Malaysia's contribution to the global renewable fuel objective;
- Envisioned the use of environmentally friendly, sustainable and viable sources of energy to reduce dependency on depleting fossil fuels;
- Expected to enhance the prosperity and well-being of all stakeholders in agriculture and commodity based-industries through stable and remunerative prices;
- Spelled out a comprehensive framework with concrete initiatives in line with the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) to which Malaysia is a signatory party;
- Implementation spearheaded by the Ministry of Plantation Industries and Commodities;
- Called for the production of biodiesel for use in the transport and industrial sectors at a wide scale. The transport industry is priority sector, prone to high subsidies. The intention is to use 5% processed palm oil (biodiesel) and 95% petroleum diesel (B5) in land and sea transport;
- Promoted the production of biodiesel for export purposes.

Abdullah et al. (2009)

Lim and Teong (2010) assert that Malaysia has potential to benefit from the growing environmental concerns associated with the excessive reliance on fossil fuels and the global search for alternative energy sources. The huge potential of biodiesel coupled with the abundance of palm oil, a most cost-effective feedstock for biodiesel, is a major driver for the country's emergence as a leading producer of high quality biodiesel. By 2008, the total approved installed capacity of biodiesel production in Malaysia represented nearly 92 per cent of the world palm-based biodiesel production output (Lim and Teong, 2010).

As part of a comprehensive national development plan for the industry, the Malaysian government began experimenting with biofuel production in 1982 (Abdullah et al, 2009). However, it was not until 2005 that the Ministry of Plantation Industries and Commodities launched the National Biofuel Policy (Box 8). The policy aims to continue the expansion of Malaysia's biofuel exports, particularly targeting the European market (Abdullah et al., 2009; Craven, 2011). In addition, the Eighth Malaysia Plan, introduced in 2001, identified renewable energy as the ‘fifth fuel’ behind the four primary energy sources: oil, gas, hydropower and coal (Ng et al., 2012). As a leading producer of palm oil, Malaysia has launched a comprehensive palm biofuel programme. It has successfully established the use of palm biodiesel blend (B5) as a suitable fuel for transport and industrial sectors.

Ng et al., (2012) document the potential for the emerging palm biomass industry to contribute significantly to Malaysia’s development dynamics. Such dynamics would be fuelled by the increasing use of palm oil residue in the production of palm biomass and various other green products and biochemicals. Research on palm biomass by both private and public institutions is expected to drive product development and contribute to policies that promote the implementation of green technologies in Malaysia. The authors report that the National Biomass Strategy 2020 provides a roadmap for the oil palm biomass to contribute to the development of national clusters in the biofuel and bio-based chemical industries. The oil palm industry is recognized as one of the National Key Economic Areas in the Economic Transformation Programmes.

4.3. Labour market

In the early stages of development of the oil palm industry, Malaysia lacked a specialized training institution with national coordination power. The situation changed with the adoption of the IMP 1 and IMP 2 which introduced incentives to stimulate training. Between 1988 and 1992, firms with at least 50 employees enjoyed double tax deductions for approved training expenses. Eventually, the programme was replaced by the Human Resource Development Fund (HRDF), introduced by law in 1992 and implemented in 1993. HRDF had the mandate to developing quality human capital and a world-class workforce as the basis for a high income economy driven by knowledge and innovation (Rasiah and Azmi, 2006). Currently, the HRDF is responsible for promoting the up-skilling of Malaysian workers via financial incentives for employers who can claim financial assistance for up to 100 per cent of training costs incurred. Employees with no formal education but with ample practical experience and knowledge can be certified based on their competency levels under the Recognition of Prior Learning Scheme (HRDF).

These measures supplemented some previous actions undertaken, without necessarily being connected to the oil palm industry. In the 1970s, the Malaysian government established the Kolej Serdang, which became the Universiti Pertanian Malaysia (UPM) and was eventually renamed the Universiti Putra Malaysia (UPM) in 1997; the UPM was responsible for training agricultural and agro-industrial and agro-business graduates (Rasiah and Azmi, 2006).

The Palm Oil Research Institute of Malaysia (PORIM), established as a public research centre by an Act of Parliament in 1979, has been the key public and privately coordinated institution for advanced training in the industry. PORIM has conducted trainings on chemistry, quality, analytical techniques, processing operations, transportation and handling palm oil-related products (Rasiah and Azmi, 2006). PORIM expanded its role into R&D following the adoption of the IMP 1 in 1986. In addition to marketing functions, support was expanded to include training and R&D in oleochemicals, specialty fats and processed palm kernel oil (Rasiah and Azmi, 2006).

Abdullah et al. (2011) suggest that the development of the palm oil industry in Malaysia has had significant influence on labour and immigration policies. The Malaysian oil palm industry is labour intensive, especially in the oil palm plantations; the estimated number of workers in local oil palm plantations in 2010 was about 446,368 persons. The share of foreigners[7] is significant, with 69 per cent of the total workers in local oil palm plantations. These workers perform various crucial, labour intensive activities, particularly field jobs such as harvesting and collecting fruits, weeding work and other general work. The composition shows that the majority of foreign workers were Indonesians, followed by Bangladeshi, Thais, Myanmars and others. It is expected that the oil palm industry will continue to attract migration flows, as the lack of local skilled workers remains a factor that affects the development of the industry (DSD, 2008).

4.4. Capital market

In regards to financial support for the development of the domestic palm oil industry, Malaysia illustrates the use of sequential incentive schemes, through the tax system, research funding and other mechanisms depending on the stage of the industry's development (Box 9). To promote a shift away from the production of basic commodities, the Malaysian government introduced the Pioneer Industries Ordinance in 1958, which provided tariff protection and income tax reductions for both domestic and foreign firms in the manufacturing sector, including palm oil processing. Depending on the level of investment, these incentives were available for two to seven years. Within ten years, firms with "pioneer status" increased from 18 to 148 (Craven, 2011; Rasiah and Azmi, 2006). Between 1969 and 1974, nine palm oil refineries obtained this status. Biofuels is one of those key eligible industries that conferred firms with pioneer status. This policy was discontinued after 1974 as the industry moved towards maturity. The investment tax credit, eventually transformed into the investment tax allowance, granted tax

[7] Foreign workers in Malaysia are those who are not Malaysian nationals working in the country under a Temporary Employment Visit Pass granted by the Malaysian Immigration Department (Abdullah et al., 2011).

exemptions through capital spending; between 1969 and 1978, exemptions amounted to a minimum of 25 per cent, with at least one firm obtaining a 100 per cent tax exemption (Rasiah and Azmi, 2006).

The export-oriented Investment Incentives Act (IIA) of 1968 is considered the first major scheme granted to oil palm firms (Rasiah and Azmi, 2006). Beneficiary firms received a 40 per cent abatement of corporate income tax for two years, with the possibility of extension, and on excess profit and development taxes over eight years. A shortcoming of the IIA 1968 was its application based on ethnic criteria from the mid-1970s; a process reinforced by government economic plans intended to fight poverty and promote economic restructuring (Rasiah and Azmi, 2006). The Industrial Coordination Act of 1975 introduced ownership conditions on the basis of export-orientation and new economic plan (NEP) criteria. Exporting firms enjoyed some flexibility in regards to the ethnic criteria of the NEP; the share of equity owned by participating Malay indigenous people (Bumiputera) varied with the share of exports relative to sales targeting the domestic market. This arbitrary implementation of incentives remained until the promulgation of the Promotion of Investment Act (PIA) of 1986. Additional export allowances amounted to 5 per cent (FOB value) of gross income, which was considered redundant, used only by a small fraction of refineries in 1982. Arguably, an export credit refinancing scheme that offered export-oriented firms loans with preferential interest rates was more widely taken up by processed oil producers.

Box 9: Factors that explain success in the provision of financial incentives to oil palm

- The main beneficiaries were large processors, well-coordinated with the Ministry of International Trade and Industry (MITI), the authority responsible to manage the incentives.
- The major firms were vertically integrated, from oil palm cultivation to processing. This encouraged upgrading into higher value added segments and opportunities to capture higher export rents.
- Firms received strong support—technical and market know-how—from MITI, the Standards and Industrial Research Institute of Malaysia (SIRIM), the Malaysian Palm Oil Promotion Council (MPOPC) and PORIM to expand into processing activities.

Rajah Rasiah, (2006)

Starting in 1978, the generous incentives for most kinds of oil palm processing were withdrawn. Palm oil refining and fractionation in developed areas, not owned at least in part by Bumiputera, were not eligible for support. Fractionated products and cooking oil continued to qualify for a 50 per cent investment tax credit, but others like margarine, vanapasti, and shortening qualified for higher tax credits. The qualifying criteria included location in underdeveloped areas and Bumiputera ownership, but even there, incentives were removed by the early 1980s (Rasiah and Azmi, 2006). Notwithstanding the reduction in direct incentives, Rasiah and Azmi (2006) argue that Malaysian oil palm producers were assisted by the founding of the Kuala Lumpur Commodity Exchange (KLCE) in 1980, which acts as an instrument for price setting, hedging and dissemination of market information to reduce market risk.

Foreign direct investment (FDI) in the Malaysian palm oil industry was relatively low in the 1960s and 1970s. However, the 1970s saw the entry of new agents into the Malaysian palm oil industry (Fold and Whitfield, 2012). Foreign capital was dominated by Japanese and Indian interests seeking to capture a share of the PPO exports. Japanese capital brought in specific technical and management capacity in marketing and production, often through joint ventures with Malaysian state capital. Indian investors also formed joint ventures with local private capital, taking advantage of ethnic links and existing trade relations in India and the region. Finally, local Chinese capitalists joined Singaporean investors.

The 1986 PIA promoted increased FDI flows to attend key technological investments (Craven, 2011). The government was able to guide FDI flows via state-sanctioned restrictions to export-oriented industries, including palm oil. Furthermore, increased levels of FDI throughout the 1960s to 1990s corresponded to increased domestic investments; the latter doubled as a share of GDP, from 14 per cent to 28 per cent, in roughly the same period (Craven, 2011).

Increased competition and a disorganized increase in refinery capacities led to a restructuring of the industry in the early 1980s, with the closure of less efficient producers, and the consolidation and modernization of physical refining technologies. Subsequent cycles of expanding capacities and restructuring have followed, leading to a constant change in the strategies pursued by producers in the industry. The export credit refinancing facility coordinated by the Bank Negara was continued under the IMPs (Rasiah and Azmi, 2006).

According to Fold and Withfeld (2012), the current structure of Malaysia’s palm oil industry shows a split between processors, refineries and producers, plantation companies and groups. The capital structure in the refining segment is either downstream-expanded plantation capital with considerable state interest or private without any financial interests in plantation activities. The autonomous refineries, particularly the foreign-owned ones, were the largest in terms of processing capacity; they cover the major part of exported palm oil in bulk. This segment seems to be in a constant competition to obtain economies of scale with a strong dependence on marketing power in specific import markets.

In Indonesia, a mechanism that helped the development of the oil palm industry was the presence, between 1994 and 2004, of the ‘Primary Cooperative Credit for Members’ scheme (Koperasi Kredit Primer untuk Anggota, KKPA), which allowed transmigrants to obtain subsidized bank loans (Pacheco, 2012). Under this initiative, a private sector developer was required to partner with a cooperative formed by a group of smallholders; the intention was to promote scale economies and efficiencies. In practice, a contract is signed between the company and the cooperative of smallholders and banks under the supervision of the government. Farmers entrust their land to the company which plants, manages and harvests the crops. In exchange, landowners receive a percentage of the harvest revenue after deducting plantation establishment and management costs. Local governments participate through facilitation of discussions between the partners and land titling. Banks keep land titles as collateral and the company is responsible for collecting the repayments from farmers. Farmers are charged for these services. Usually, the deal includes the handing over from the village to the company of a percentage of the total land to be developed. This land taken over by the company constitutes the nucleus of the plantation (Pacheco, 2012).

According to Pacheco (2012), the KKPA has resulted in a significant expansion by more than tenfold of the area under oil palm cultivation, from about 210,000 hectares in 1980 to 2,420,000 hectares in 2002. Hence, oil palm plantations have exceeded that of coconut – Indonesia's traditional oilseed crop. Oil palm, which constituted only 6 per cent of total major oilseed planted area in 1980, reached 43 per cent by 2005.

4.5. Land market

Fold and Whitfield (2012) argue that differences in colonial land tenure arrangements contribute to explain the divergent development of the oil palm industry in South East Asia and West African countries. In the case of Ghana, for example, independence left land tenure practices pre-dating the colonial period intact; ownership is established based on traditional seniority and kinship relationships within the community. Rights are defined rather loosely and property can be subject to constant ownership claims and litigation, even when a formal transaction between two contracting parties exists. Land tenure has evolved in ways that favour small capitalist holders specialized in cash crop products; rent seeking behaviour is common, as the elimination of restrictions to private capital ownership accompanies a system where land cannot be sold but rented for extended periods of time. Land owners have rights to a share of the revenues from production.

Limited access by the Ghanaian government to ready stocks of available land after independence meant that any attempt to promote large-scale plantations required some unpopular, forced expropriations often without proper compensation. As a result, large-scale, state-owned plantations built on expropriated land were subject to constant land litigation, protests and open confrontation with the farmers; moreover, it became a major barrier for the privatization of plantations and estates during the 1980s and 1990s (Fold and Whitfield, 2012).

A different situation occurred in Malaysia where British settlers had ample control over local Malaysian landholders eager to encourage development investment. According to Fold and Whitfield (2012), after independence, land ownership was better defined, including ample access to land by the Malaysian government. Moreover, the new independent government was able to capitalize on some earlier investments in infrastructure, the organization of large-scale production activities and public investments in irrigation initially intended to promote rubber production.

A notorious application of accumulated learning relates to the FELDA. During the period of expansion of the rubber industry, FELDA gained experience in the promotion of new settlement schemes for landless rural households to start large-scale cultivation of rubber trees and oil palms on virgin land. FELDA provided housing facilities and titles to land. In addition to positive impacts on income among rural smallholders, the initiative contributed to economic diversification. At the start of the decline of the rubber industry in the early 1960s, the oil palm industry was ready to respond based on a very explicit strategy of export diversification and reduced dependence on narrow product lines (Rasiah and Azmi, 2006). New policy measures to stimulate large-scale agricultural diversification and exports included subsidies for the transfer of rubber land to palm oil cultivation. FELDA was responsible for the adoption and dissemination of some organizational innovations, including pooling or bulking to achieve scale economies (Rasiah and Azmi, 2006).

A major initiative was FELDA's decision to condition future settlement schemes on commercial oil palm cultivation; this promoted the creation of large palm oil states where small farmers worked under state-led management. According to Rasiah and Azmi (2006), land development schemes involved the plotting of large plots of land appropriated by the state and distributed among poor Bumiputera tenants to work on smallholdings. This mechanism to favour equity and fight poverty was intended to be neutral in the market, as smallholders and large estates faced a similar environment in the marketplace.

In Ghana, the fragmentation of land ownership meant that initiatives similar to those instrumented by FELDA were unfeasible; collaborative programmes trying to bring together adjacent small holdings to form oil palm processing companies contributing land and labour were rejected by existing large and medium states/mills which refused to accept the government's terms. The initiative's implementation followed political agendas, was underfunded and disconnected from MITI and the Ministry of Food and Agriculture (Fold and Whitfield, 2012).

The expansion of oil palm plantations in South East Asia is not free of obstacles. Wicke et al. (2011) and Craven (2011), for example, assert that the continued development of oil palm in Indonesia and Malaysia raises concerns about environmental sustainability. Wicke et al. (2011), in particular, document significant land use changes (LUC) that occur when natural rainforest, peat swamp forest, cropland or other land types are converted into oil palm plantations. The rapid expansion in palm oil production and its implication on LUC have potentially negative social and environmental implications, including the loss of biodiversity, forest fires as well as land tenure and human rights conflicts.

4.6. Technology market

Malaysia controls the oil palm value chain from raw materials to final consumer goods. It is the engine for new product development in the industry; local firms have developed capacities to become internationally competitive based on value added, product development and not merely on price differentials (Rasiah and Azmi, 2006). The local industry is an example of successful incremental innovation – PORIM and local universities have been responsible for most R&D activities. PORIM, in particular, has been critical in the provision of training and some added value services such as market prospecting, upgrading and product development; PORIM has developed capacities to adapt and respond to the needs of private firms (Rasiah and Azmi, 2006).

The diversification of Malaysian palm oil exports owes a great deal to the intervention of the Palm Oil Registration and Licensing Authority (PORLA) which has been responsible for implementing government interventions in favour of the palm oil industry very early in its development. PORLA has the mandate of overseeing that exports meet some minimum quality requirements (Fold and Whitfield, 2012; Rasiah and Azmi, 2006). The mandate includes licensing and governance of local companies responsible for quality assurance of exports.

The complex set of organizations completing what Rasiah and Azmi (2006) call the Malaysian oil palm cluster includes PORIM and the MPOC. These two organizations, created under government ownership and control, eventually merged in 1990 to become the Malaysian Palm Oil Board (MPOB). The MPOPC is a privately registered company owned by the government. In its early days, PORLA played an administrative role, while PORIM helped address collective action problems by deepening and broadening oil palm-related R&D activities. MPOC is devoted to improving the image of oil palm by stressing the techno-economic advantages and environmental sustainability of the product (Ng et al., 2012); it has been instrumental in promoting oil palm market expansion and the development of the value chain in coordination with other government entities, for instance, the Ministry International Trade and Industry (MITI) (Rasiah and Azmi, 2006).

In Malaysia, R&D has significantly contributed to increased agricultural productivity as derived from improved planting material and agronomic practices. Large plantation companies, regardless of ownership type, established research centres early on in the development of oil palm cultivation. Inspired by the previous Rubber Research Institute, the government supported the creation of PORIM as a leading centre for research and training activities for the local oil palm industry. A portion of PORIM's funding derives from a duty levied on local CPO production. The creation of PORIM added to the existing activities in support of R&D, many of them dating back to the 1960s; R&D activities then began to expand into oil palm breeding after the establishment of exchange programmes with West Africa. Private plantations, in turn, set up the Oil Palm Genetics Laboratory (OPGL).

The IMPs had positive effects on PORIM. In particular, IMP 2 mandated it to intensify R&D activities, including downstream products; joint venture R&D was encouraged to facilitate commercialization. The Institute expanded its activities to include R&D and technician training in a variety of palm oil products, including oleochemicals, specialty fats, processed palm kernel oil and biofuels (Rasiah and Azmi, 2006). As mentioned earlier, PORIM was eventually incorporated into the MPOB. According to Craven (2011), PORIM's current organizational structure demonstrates the efficacy of IMP investments in universities; more than half of MPOB managers and leaders are PhD holders. In addition, PORIM provides financial support to private research centres (Fold and Whitfield, 2012; Rasiah and Azmi, 2006).

The different IMPs have kept financial incentives for firms relatively unchanged over time (Rasiah and Azmi, 2006), while R&D activities have undergone notable changes. PORIM, the Malaysian Agricultural Research and Development Institute (MARDI) and universities have received increased funding for palm oil R&D, while domestic firms have benefitted from a policy of open access to research results. The IMP included generous incentives for manufacturing R&D, including tax credits of up to 50 per cent of qualifying R&D expenditures over a 10-year period. Eligible expenses include personnel, buildings, machinery and equipment, contract R&D and materials (Rasiah and Azmi, 2006). In 1991, the Intensification of Research Priority Areas (IRPA) established a five-year palm oil research fund of more than RM 1 billion (USD 370 million) for universities and research institutes. Because of its positive results, the IRPA was extended for an additional five-year period to 2001. Rasiah and Azmi

(2006) assert that R&D efforts in Malaysian institutions expanded from oleochemical by-products to environment-friendly cultivation and manufacturing methods, productive recycling of waste and raising value added in existing products.

According to Fold and Whitfield (2012), dissemination of innovations from plantation companies in Malaysia took place through subsidiaries selling producer services or through other formal and informal channels. Examples of these include virtual 'guidebooks' explaining all aspects of oil palm growing and participation of research staff and plantation management from Malaysian state organizations, parastatals and private companies at conferences and workshops organized by institutions with an affiliation to the industry. Information exchanges among 'planters' have promoted dissemination of technical and managerial knowledge. This spirit prevails today. Innovation in biofuels, on the other hand, has followed a somewhat different path. Product innovations 'are rarely firm-based but rather emerge from an institutional framework and are shared by the participants in the processes. Although that dampens profit levels it increases diffusion through the value chain' (Rasiah and Azmi, 2006:39).

West African countries have lacked consistent support to technology diffusion and R&D more specifically. The lack of support to R&D has undermined the development of the oil palm industry in Ghana. According to Fold and Whitfield (2012), the Oil Palm Research Institute (OPRI), the public research institution specializing in oil palm, has been severely neglected over the years; consequently, capacities for research and for the provision of seedlings and technical assistance to small farmers are weak. In the early 2000s, a Presidential Special Initiative (PSI) to promote the development of the oil palm industry identified the industry as one of four pillars for growth. The OPRI received increased funding to produce improved seed nuts and germinate them into seedlings for PSI nurseries and eventually given to smallholders. The results proved disappointing, as large estates complained about the poor quality of seed nuts and their continued preference to source outside Ghana. The authors further claim that support from the PSI fell short relative to the Institute's needs; it failed to upgrade capabilities to serve either the industrial or the small-scale palm oil sub-sectors.

Our discussion on land markets mentioned that current land ownership practices in West Africa make the adoption of more efficient modern practices for the operation of the region's oil palm industry problematic. This includes technology absorption and innovation. Adejuwon et al. (2014) assert that strategies that emulate the successful trajectories of Malaysia and Indonesia in oil palm trade, focused on large-scale cultivation and processing, are problematic for a country such as Nigeria. The land tenure system in use in the country limits the space for the establishment of large plantations, while innovations in oil palm fruit processing have concentrated on machinery for large-scale oil palm fruit processing. Countries such as Nigeria face the challenge of finding their own paths and strategies to catch up based on altogether different models; their local oil palm industries remain centred on small holdings and processing technologies. To a large extent, the informal nature of these productive organizations undermines opportunities for technological acquisition; activities are performed mostly based on doing-using and interacting (DUI) modes requiring limited scientific and technological inputs (Jensen et al. 2007; Adebowale, 2012; Adejuwon et al., 2014).

5. Concluding remarks

This paper addressed two questions, namely: what can we learn from recent industrialization experiences in developing countries? What kinds of policy interventions or combinations thereof can address what kinds of challenges? To answer these questions, we benefitted from an analytical framework that builds on the common wisdom that public policy intervention is justified by the existence of market failures. We looked, in particular, at factors that affect the functioning of markets for products, capital, labour, land and technology, and the related policy interventions that developing country governments have implemented over time. We used the cases of the aerospace and aircraft manufacturing industry and the oil palm industry as examples.

Authors such as Joseph and Johnston (1985) oppose the notion of market failures, arguing that it is neither a sufficient nor necessarily an adequate explanation, as it misses the complex political process that characterizes policymaking processes. Borrás and Edquist (2013) agree by noting that path-dependent and political processes underpin policymaking, while Dutrénit et al. (2006) and Grossmann (2012) remind us of the possibility of policy capture by specific interest groups. Vested interests may be economic, environmental, social or be related to national defence. Policy implementation likewise reflects national traditions sometimes inherited from a colonial past, the nature of state-society-market relations and the degree of legitimacy or social acceptance of particular instruments (Borrás and Edquist, 2013).

Our intention is not to solve the debate. However, our review of industrialization processes in two completely different activities across different developing country contexts clearly indicates that public policy intervention has done and can do more than simply fix markets. Policy interventions have been instrumental in the emergence of national and sectoral innovation systems capable of sustaining robust, dynamic industrialization processes, even in industries traditionally dominated by more advanced countries. Thus, we have learned that industrialization requires strategic choices, combined with the capacity to identify and tackle opportunities to develop particular economic activities. The discussion illustrates the different policy approaches and corresponding policy instruments associated to those dynamic processes in the context of their implementation. In effect, we have found instances in which the alignment between innovation and industrial policy facilitates the achievement of industrialization goals.

Our intention is not to advocate that developing countries should industrialize in similar industries or use the same policy instruments in exactly the same ways. The modern economic system induces different opportunities, but also different constraints as compared to earlier catching up experiences. Mexico's bid to catch up in aerospace and aircraft manufacturing provides an example. The country's strategic positioning, i.e. specialization in the concrete segment of MRO, within the global industry tends to reflect the Singaporean experience. However, some interventions are more in line with strategies followed by countries that have tackled the more ambitious goal of building a national aircraft assembly industry, namely the creation of training programmes specifically designed to meet the needs of global aerospace firms. The promotion of clusters involving links between different agents in a triple helix, industry-government-firms, has been instrumental for catching up (Etzkowitz and Leydesdorff, 2000).

To simplify the presentation of our findings, Table 3 and Table 4 summarize the characteristics of different policy instruments implemented by countries that have, with some degree of success, built favourable conditions for the development of a strong local aerospace and aircraft manufacturing industry or oil palm industry. Table 3 presents policy interventions according to different markets for products, land, capital, labour and technology. For each policy dimension, the table elaborates the characteristics and context of implementation for each instrument or combination of instruments. In some instances, it is possible to see the sequencing and packaging of interventions depending on the needs of the industry; alternatively, the choice of instrument reflects the evolving goals or specific approach chosen by governments to guide developments in the industry.

Take, for example, the reliance on public ownership to promote the development of markets for products. In the case of Brazil, the founding of Embraer as a public entity was the basis to promote the emergence of the local aerospace and aircraft industry. As the industry reached maturity, the decision was made to privatize Embraer while the government retained control over key operations and business decisions. This approach reminds us of the well-documented experiences of Japan and the Republic of Korea (Freeman, 1995; Kim, 1997; Lee, 2001). By contrast, in the context of a declining rubber industry in Malaysia, the scope of publicly-owned firms was to take over ownership of existing oil palm plantations and promote further development of the industry according to renewed national development goals.

We also observe that latecomers to the industries under review have started by improving productive and technological capacities according to strict standards and norms as required by global industry players or to meet the demands of international markets. The use of technology licensing and technological partnerships has been instrumental for technological learning, particularly capacities associated with process rather than product innovations (Freeman, 1995). As indicated in Section 2.2, the selective use of trade-related policies has been instrumental for success. They have promoted the desired industrial structures based on combinations of import substitution and export promotion interventions.

Table 3: Policy interventions implemented to address market failures affecting the emergence of selected industries in advanced developing countries

Policy domain	Aerospace	Palm oil
Product market	Creation of state-owned firms to spearhead development of the local industry Public procurement, particularly from the military, to boost local demand Establish links with commercial segment of the industry to minimize anticompetitive incentives as firms tie operations to public procurement Public ownership of parts of the commercial segment (air transport) Tax incentives to favour the emergence of local supplier firms linked to the final aircraft assembly firm Export orientation and mix of import substitution and export-oriented strategies at early stages of development, using trade (high import duties, export credits/subsidies) and non-trade (excessive bureaucracies) related mechanisms Facilitation of military-related exports Hand-holding after privatization of former state-owned firms (injecting	Creation of local parastatals to take over control of the industry Creation of specialized organizations, both public and private, to promote the development of the industry Export orientation with support from specialized export promotion government agencies Introduction of export taxes consistent with industry cycles to favour production and export of increasingly value added products (from raw agricultural products to processed products) Creation of standard and normalization organizations to guarantee product quality according to international standards Linking industrial development to poverty reduction strategies Pegging domestic prices for local products, particularly for inputs for palm oil processing, to keep the local industry competitive

Policy domain	Aerospace	Palm oil
	capital, assuming debts, retaining share ownership, controlling decision-making bodies, imposing restrictions on FDI)	Import tariff for selected oil processing inputs Tax incentives on capital investment Managed expansion in oil refining capacities Integrated industrial development plans with consistency and continuity over long periods of time Reduction in corporate income tax, including exports Gradual phasing out of tax incentives and subsidies as the industry matures Promotion of complementary activities upstream to support some degree of vertical integration of local value chains Barter agreements to facilitate acquisition of necessary inputs
Labour market	Incentives for training as upgrading and skilling depend to a great extent on leading aircraft manufacturers Development of specialized programmes and training centres Balancing between long-term education needs (through traditional organizations, universities) and short-term needs (vocational training, specialized short-term training by industry associations or specialized private organizations) Favour labour mobility, including migrations, even in the case of large countries but with low levels of qualification of the labour force	Facilitate job and industry expansion through subsidies for investment in factory/processing plants and free trade zones/export processing zones near major freeways and ports Subsidies and tax credits for up to 100% of expenditures in the provision of training Programmes for the certification of competencies and on-the-job qualification Promotion of targeted immigration to compensate for labour shortages, particularly in labour-intensive activities and where specific skills for upstream segments are still lacking in the country
Capital market	Credits/subsidies for foreign/local customers to acquire locally assembled	Attraction of FDI to strategically selected value added activities:

Policy domain	Aerospace	Palm oil
	aircraft Subsidies and other financial transfers to state-owned firms Subsidies/direct funding/tax credits for exports, production or R&D activities through science granting councils, ministries of industry and trade or other industry-specific organizations Discounts or credits on income tax for the emerging segment of local suppliers/investors in the industry Exemptions on import duties for specialized suppliers Public procurement and guaranteed government purchases to promote vertical integration or to offset product development risks	oleochemicals, for example Promotion of product diversification, particularly to incorporate smallholder producers Adoption of sequential incentive schemes depending on stage of industry development: Tax exemptions or credits for emerging activities. These were applicable to exports, capital investments or training, for example Dedicated research funding Soft loans for certain production and export activities Incentives for the production and investment in underdeveloped areas and/or those with predominance of poor, indigenous populations Use of commodity exchange markets to facilitate price setting, hedging and dissemination of market information to reduce market risk Controls on FDI flows into the industry, directed towards specific areas, often matched by local investments Promotion of collaboration between private land developers, smallholders and financial organizations under government supervision
Land market	Policies to promote the creation or to facilitate expansion of emerging regional clusters for the industry Creation of specialized business parks Provision of tax breaks for long-term investments, including plans to set up R&D facilities Investment in general physical infrastructure, increasingly in the form	Promotion of new cultivation areas through incentives for delocalization (housing, land titles), creation of export zones, immigration. Some incentives included some form of coercion by public entities Transfer of organizational practices from other successful products, from rubber to oil palm, for

Policy domain	Aerospace	Palm oil
	of highly-specialized information and communication technologies Establishing direct links between clusters and airport infrastructure	example Investment in general purpose infrastructure (irrigation, transportation and processing facilities) Subsidies for the transfer of declining agricultural activities to new, potentially more profitable activities
Technology market	Technology transfer via: Assembling aircraft under licensing agreements Conditional access to local markets Co-production agreements Facilitation of reverse engineering in public R&D centres Technology licensing/knowledge transfer/knowledge sharing agreements upstream and downstream the value chain Favouring local firms to become the sole source of specific parts and components for major aircraft manufacturers Investments to expand local technical and higher education and research capacities to attend to the needs of the industry Support to spin-off projects from publicly funded research (Embraer) Funding mechanisms to facilitate university-firm interactions Improvement or development of national laboratories/programmes for certification and norms according to international standards Ensuring external certification for local efforts on standards and norms	Creation and funding of specialized R&D organizations with public support Establishment of specialized education or training programmes to attend the needs of the industry Establishment of specialized public research centres to serve the needs of the industry and provide support for private R&D activities Policy of open access by private entities to government supported research Establishment of local certification and normalization of organizations. These will be responsible for certifying local production and promoting and regulating the emergence of local certification organizations according to internationally accepted standards Promotion of FDI for technological upgrading in specific sectors. Controls where possible via state sanctioned restrictions on export-oriented activities Facilitate incremental innovation, focused on improving existing products Tax credits for R&D, including personnel expenses, investment in infrastructure, machinery and equipment, contract R&D and

Policy domain	Aerospace	Palm oil
	Promotion or specialized research and innovation networks within clusters Signing of general purpose or specialized cooperation agreements with foreign governments to facilitate 'umbrella programmes' for the provision of training and certification, technology transfer, know-how and investments in specialized infrastructure Investment in ICT infrastructure, including specialized services, training and certification activities Facilitation of skilled labour mobility, including immigration	materials

Source: Author

Table 4 proposes an arrangement that complements Table 3. Again, distinct policy instruments are arranged according to the specific market failures they intend to address (columns). This time, however, we consider the specific structure or objective within an innovation system where those interventions may have more visible results (rows) –see discussion in Section 2.2. Hence, we identify policies that promote the acquisition of specific innovation competencies, for instance, technological licensing for the assembly of parts and components in the aircraft and aerospace industry as compared to policies that induce 'deeper' structural changes in the system of innovation, for instance, investment in general research infrastructure or formal education. Bearing this in mind, Table 4 shows that the traditional concentration of innovation policy on promoting R&D fails to consider the broader challenges local innovation systems face; this traditional linear supply-push perspective has been criticized elsewhere in the literature (Borrás and Edquist, 2013).

Consistent with our discussion in preceding sections, the mix of policy instruments needs to fit national conditions and, arguably, those of specific industries (Izsák et al., 2013). A given instrument or combination of instruments may adopt distinct forms across countries or industries; in effect, single instruments or combinations of instruments may be suited for different purposes.

For example, although labour mobility and attraction of foreign workers has underpinned the development of both aerospace and aircraft manufacturing and oil palm activities, in the former case, the emphasis has been on attracting highly qualified personnel, while in the latter, the focus has been on overcoming labour shortages, particularly for low skilled jobs in the plantation industry. By contrast, whereas public procurement, particularly from the military, and the establishment of links with the commercial segment of the industry helped boost demand for Brazilian-made aircraft, such level of intervention was not needed in the case of oil palm. In some other cases, interventions that would seemingly belong to industrial policy may lead to the achievement of some innovation goals, for instance, co-production agreements in the case of aerospace and aircraft manufacturing activities.

Table 4: Policy instruments by type of market failure and policy problems in a system of innovation

Innovation system element	**Instrument**	**Policy domain**				
		Product	**Labour**	**Capital**	**Land**	**Technology**
Enhancing skills for innovation	Human resources for R&D		◆ ●			◆ ●
	Innovation-related skills		◆			◆ ●
	Specialized, industry focused training centres / education programmes		◆			◆ ●
	Labour mobility including immigration		◆			◆
Investment in research and technologies	(Competitive) funding for research			◆ ●		◆ ●
	Direct business R&D			◆		◆
	R&D infrastructure				◆	◆ ●
	Centres of Excellence				◆ ●	◆ ●
	Tax incentives			◆	◆	◆ ●
Enhance innovation competencies of firms	Direct business innovation		◆ ●			◆ ●
	Open access to public research findings					●
	Start-ups	◆				◆

Innovation system element	Instrument	Policy domain				
		Product	Labour	Capital	Land	Technology
	Networks / platforms				◆	◆
	Innovation support services		◈ ●			◈ ●
	Co-production agreements	◆	◆			◆
	Technology licensing		◆			◆
Strengthen systemic linkages	Collaborative R&D					◈ ●
	Clusters				◆	◆
	Interaction academia-business, including labour mobility		◈ ●			◈ ●
	Collaboration agreements (general or specific for the industry)					◆
	Technology transfer	◆	◈ ●			◈ ●
	Spin-offs					◆
	Joint ventures	◆		◆		◆
	S&T/business parks				◆	◆
Demand and framework conditions	State-owned firms (industry and connected activities)	◈ ●			●	◆
	Specialized agencies, public/private, to promote the industry	●		◈ ●		◈ ●
	Specialized agencies' norms and standards	◈ ●	◈ ●			◈ ●
	General infrastructure		◈ ●	◈ ●	◈ ●	◈ ●
	General upskilling labour force		◈ ●			◈ ●
	Labour mobility, including		●		●	

Innovation system element	Instrument	Policy domain				
		Product	Labour	Capital	Land	Technology
	immigration					
	Price controls (domestic market)	●			●	
	(Managed) privatization	◆				
	E-society				◆	◆
	IPR	◆				◆●
	Loans and guarantees	◆		◆●	●	◆●
	Public procurement	◆		◆		◆
	Export-promotion agencies		◆●	◆●		
	Export taxes/credits to orient export composition	◆●		◆		
	Trade-related barriers (import tariffs)	◆				
	Non-trade barriers	◆				
	Barter agreements	●		●		
	Free trade zones/Export processing zones		●		●	
	FDI controls	◆●		●	●	◆●
	Tax incentives for emerging local suppliers (capital investment, income, exports)	◆●		◆●		◆
	Subsidies/tax incentives for local production, capital investment, exports	◆				◆
	Promotion of vertical integration	●				

Innovation system element	Instrument	Policy domain				
		Product	Labour	Capital	Land	Technology
	Commodity exchange markets	●		●	●	

Notes: ◆ Aerospace ● Palm oil
Source: Author

Some concrete interventions commonly found in recent contributions to the literature, such as incubators or business accelerators, are absent in Table 4. Whereas these instruments may have not been used extensively during the earlier development of the aerospace and the oil palm industry, there is nothing to prevent its adoption in future development strategies. The scope for policy learning and policy experimentation remains significant. One can only hope that some more systematic efforts at documenting experiences and capturing learning will guide future innovation and industrial policies in developing countries.

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