What is beneath Singapore's integration to the global HE system?

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1) Introduction

Singapore's Higher Education and Research (HER) have faced major transformations including becoming an education and knowledge hub in Asia (Sidhu et al., 2014). In order to explain those transformations in education, some authors have focused on the government's education policy, in particular the Global Schoolhouse initiative, launched in 2002 in order to position Singapore as an education regional hub. That policy aimed to turn Higher Education into a business, and to lift the education sector's contribution to GDP from 1.9% to 5% by 2015 (Gopinathan and Lee, 2011; Mok, 2011; Ng, 2013; Olds, 2007; Sidhu et al., 2011; Tan, 2017, 2016; Waring, 2014).

Instead, other scholars have analysed the governments initiatives to transform Singapore into a Knowledge Hub (Sidhu et al., 2014). Concerning research and globalization of HER, special attention has been paid to the experience of the National University of Singapore (NUS) (Olds, 2007; Sidhu et al., 2014, 2011). The Nanyang Technological University (NTU) has also called recent attention (Sidhu et al., 2014). The NUS scaled from the 30th to the 12th position in the QS World University Ranking between 2009 and 2015, while the NTU went from the 73rd to the 13th position in the same period, challenging Hazelkorn's (2015) explanation that the same institutions are always at the top positions.

Part of the literature have also studied the entrepreneurial or market dimension of the Singaporean local universities concentrating on how the state has promoted university-industry collaborations as well as universities' commercialization of their research results (Lee and Win, 2004; Sidhu et al., 2011). From a National System of Innovation approach, Won et al. (2007) also analysed how the NUS, Singapore's flagship university, was transformed into an Entrepreneurial University (Clark, 2015, 1998; Etzkowitz, 2008; Etzkowitz et al., 1998).

Although the previously mentioned literature focuses on different aspects of Singapore's HER transformations, they all share one feature: they all place public policy as the main responsible of Singapore's HER transformations. Our article goes one step further and asks: **what is beneath Singapore's integration to the global HER system, in terms of global dynamics and sustainability perspectives?**

In order to do so, we have relied on the analysis of a wide range of literature including scientific articles on the Singaporean HER system, governmental plans and reports, as well as internal documents from the main universities. We have also interviewed various actors in the country (see list in Annex 1) in November 2016: (i) managers of the main local universities; (ii) managers of overseas Higher Education institutions settled in Singapore; (iii) researchers; (iv) a responsible for the scientific cooperation at the French embassy in Singapore. For confidentiality issues we will refer to the interviewees using consecutive numbers. Finally, our work has used different available databases to analyse and illustrate the rise of the Singaporean HER system: National Survey of Research and Development (R&D) in Singapore, Education Statistics Digest, Small and Medium Enterprises Development (SMED) Survey, and bibliometric data taken from Scopus and Web of Science (through the Leiden Ranking available information).

Section 2 analysis the policies followed by the Singaporean government for HER defined as an industrial policy strategy. Section 3 provides the main results of our analysis. Finally, Section 4 opens a discussion on whether Singapore's integration to the global HE system is sustainable in the long term.

2) An Industrial Policy strategy for HER

Singaporean government's policies for HER have been synthesized in the Global Schoolhouse initiative and the formerly called "Science and Technology" (S&T) Plans, later called "Research, Innovation, Enterprise" (RIE) Plans. Through analysing the specific policies for HER we have observed that they can be considered as an industrial policy strategy based on two main objectives: converting Higher Education into a business and transforming the NUS and the NTU into World Class Universities (WCUs). The latter is actually considered as one necessary condition to accomplish a broader knowledge economy strategy. The industrial policy followed by the Singaporean government in order to fulfil those two objectives consisted of a set of industrial policy instruments all of which included high public funding to assure their viability. Briefly, those instruments have been: attracting Foreign Direct Investment (FDI), boosting imports and exports, performing both a vertical and horizontal industrial policy approach and ameliorating and increasing local supply by learning by imitation. In other words, the government's industrial policy included the objective of developing local Dynamic Competitive Advantages (Amsden, 1997). In the rest of this section we explore how these instruments were implemented to accomplish both mentioned goals.

2.1. How industrial policy encouraged Higher Education as a profitable business?

- **Attracting FDI to fulfil market demands that cannot be fully covered by domestic institutions**

Singapore has managed to attract FDI through its very well developed infrastructures, its security and political stability, as well as through its geographic position in the heart of Asia (Belderbos et al., 2014). Concerning HER, Singapore has also been very opened to FDI, encouraging the settlement of overseas Higher Education institutions (Tan, 2017).

Leading foreign universities were supposed to occupy the top of the government's proposed tier system of universities. Their role was to give branding to Singapore, training a small elite of students: 1,000 undergrads, 2,000 postgrads. The Global Schoolhouse initiative included the development of, at least, 10 branch campuses of foreign leading higher education institutions (HEI) as well as to encourage joint diplomas and other partnerships between those foreign HEI and public universities (Ministry of Trade and Industry, 2002). However, in fact, by the time when the policy was launched (2002), there were already 7 leading foreign HEI offering degrees in the country through branch campuses or in partnership with the NUS or the NTU (Ministry of Trade and Industry, 2002).

The Massachusetts Institute of Technology's collaboration with the NUS and the NTU was announced by the end of 1998. In the same year, Johns Hopkins Singapore was established. Two years later they opened the Johns Hopkins –NUH International Medical Centre devoted to academic medicine. It must be said, though, that John Hopkins closed its Singaporean operations in 2006 because it failed to meet its performance benchmarks, even though it received more than US$50 million from the Singaporean's Economic Development Board (EDB) since 1998 (Tan, 2017, 2016).

In 1999, the Logistics Institute – Asia-Pacific (TLI-AP) was launched between the Georgia Institute of Technology and the NUS, and the Wharton School of the University of Pennsylvania set up the Wharton – Singapore Management University (SMU) Research Centre.

In 2000, the leading French Business School INSEAD inaugurated its $60 million Branch Campus. In the same year, another business school, the University of Chicago Graduate School

of Business, settled in Singapore choosing the country as their Asian base (Ministry of Trade and Industry, 2002). The Singaporean government provided funding to restore the building where they installed the branch campus and also contributed easing all the paperwork. However, they moved to Hong Kong in 2013.

In 2001, the NUS established its Design Technology Institute in partnership with the Technische Universiteit Eindhoven, and in 2002, it established a joint master's degree in Industrial Chemistry with the Technical University of Munich.

As by the time when the Global Schoolhouse was launched, all the previous initiatives already existed, the 10 branch campus objective was actually exceeded during the following years. FDI continued to flow to Singapore. According to the Cross-Border Education Research Team (C-BERT) there were 15 Branch Campuses in Singapore by January 2017. Moreover, the NUS has 70 double, joint and concurrent degree programmes with world's top universities (including MIT and Yale), and the NTU has 20 joint or double degrees with leading foreign universities (with UTT France, Karoliska Institute, ParisTech, South Hampton UK, etc.).

- **Boosting exports**

One of the goals of the Global Schoolhouse was to reach a target of 150,000 international students in Singapore. Those students were attracted to do **full tuition paying degrees** whether through E-learning, executive education, undergraduate degrees in domestic and foreign universities or professional Master courses. Visa issues were simplified and students were given health insurance facilities. Moreover, in all fields the government committed to implement quality assurance mechanisms in order to upgrade the existing offerings and guarantee the quality of foreign suppliers (Ministry of Trade and Industry, 2002).

The 150,000 international students' objective was never reached and it was abandoned after the 2011 elections. The government asked all autonomous universities to reduce those figures as they understood the lower support received in those elections as a sample of the Singaporean citizens' discontent regarding immigration policies (Tan, 2017).

Thus, the NTU reduced its 20% of international undergraduate students and, by the end of 2016, they represented only 13% (Nanyang Technological University, 2016). As there is no restriction concerning postgraduate students, international ones represent 44% of total masters students. At the SMU, by September 2016, international students were only 10% in the undergraduate programmes and 61% in postgraduate programmes, coming from 44 different countries.[1]

Finally, according to the Times Higher Education Ranking of 2016, international students represent 32% of total NUS students' population of whom a non-official source said that almost three quarters were postgraduate students. However, research oriented programmes, in particular PhDs, are aimed to attract talent rather than doing business.

- **Ameliorating and increasing local supply**

This instrument included the foundation of new autonomous universities in niches areas, all of them highly internationalized, and increase the supply of existing universities. Those niche areas as well as the new disciplines that should be incorporated to existing universities were defined by the government following a vertical industrial policy.

An early transformation in the local supply was the foundation of the recently renamed **Singapore University of Social Sciences** (until March 2017 called SIM University) in 2005 and focuses on lifelong learning for working adults. Continuing or lifelong education is, in fact, one of the horizontally differentiated goods that was supposed to be further developed in order

[1] https://www.smu.edu.sg/smu/about/university-information/quick-facts (consulted on April 1, 2017).

to transform the industry into a profitable business (Ministry of Trade and Industry, 2002). The Singapore University of Social Sciences provides practice-oriented and applied educational courses.

A clear example of how the government's vertical industrial policy was deployed is the creation of the Committee on the Expansion of the University Sector (CEUS) in 2008. Its goal was to formulate recommendations in order to increase student's participation rate from 25% to 30% by 2015. They defined three changes: the creation of two new autonomous universities and widening the offer of the NUS (Waring, 2014).

As Waring (2014) explains, the CEUS suggested the government to subsidise undergraduate students in niche degrees created jointly with foreign universities. To do so, the **Singapore Institute of Technology (SIT)** was created in 2009. It offers degree programmes in partnership with overseas universities (such as University of Manchester, Newcastle University, the University of Glasgow, DigiPen and the Culinary Institute of America) in the following sectors: engineering and applied sciences, health sciences, design, and interactive digital media, etc. SIT also offers its own applied degrees: sustainable infrastructure engineering, pharmaceutical engineering, information & communications technology, hospitality, and accountancy. Catering mainly to polytechnic graduates, the university has 36 programmes - some offered by renowned partner universities and others run solely by SIT. The programmes include culinary arts management, criminology and security, game design and naval architecture. For Singaporean students admitted in the academic year 2014/2015, annual fees ranged from S$10,100 to S$15,300.

The second CEUS's recommendation was to found a new autonomous university with an interdisciplinary approach. Hence, the **Singapore University of Technology and Design (SUTD)** was established in 2009 in collaboration with the Massachusetts Institute of Technology and Zhejiang University. This is a small, top-tier research-intensive university focusing on design education in engineering and architecture, and catches-up its partner universities' strong tradition of engineering excellence and entrepreneurial spirit. Its five degrees include architecture and sustainable design, engineering product development, engineering systems and design, and information systems technology and design. For Singaporean students admitted in the academic year 2014/2015, fees were S$11,650 per year.

Waring (2014) observes that the third recommendation given by the CEUS was to consider the NUS proposition to establish a liberal arts college which finally, in 2013, was created as a Yale-NUS partnership, in spite of Yale's faculty concern regarding academic freedom constraints in Singapore in a country that historically lacked from civil and political rights.

Beyond the CEUS's recommendations, the leverage and increase of supply also included transforming the NTU from a mainly engineering school into a multi-discipline university. Between 2001 and 2006 they established several new disciplines: Biological Sciences, Humanities & Social Sciences, Physical & Mathematical Sciences and Art, Design & Media. The Lee Kong Chian School of Medicine was launched in 2010. Finally, in 2014 they established the Asian School of the Environment. They also developed 5 MOOCs that, according to NTU (2016), by the end of 2016 had been already taken by more than 250 thousands people.

At the NTU, university's quality was also a central issue. Concerning students experience they developed pedagogical innovations (such as flipped classrooms where contents are given online and then students present the topics in the classroom with the guidance of faculty, which demanded a S$45 million investment) and made huge investments in their campus (more than S$1.8 billion in new infrastructure) (Nanyang Technological University, 2016).

As a result of the former policies, the government expected to cover the whole market (through vertical and horizontal differentiation) taking advantage of every business possibility while at

the same time a broader competition (foreign and local) had an effect on leveraging quality. According to Ziguras and McBurnie (2011, p. 118) quality improvements in domestic institutions squeeze out lower quality foreign programmes, and this was the case in Singapore.

2.2. How industrial policy contributed to transform the NUS and the NTU into WCUs?

- **Attracting FDI → learning by imitation (developing DCA).**

Attracting FDI was not only used to fulfil market demands, but also as a learning by imitation strategy for the local universities. The learning by imitation strategy relied on joint diplomas, partnerships and student exchanges with world top universities.

Concerning joint diplomas, as was stated by the NTU's authorities during our interview, every WCU has a School of Medicine. Both the NUS and the NTU created Schools of Medicine with top foreign HEI. The Duke-NUS Graduate Medical School was launched in 2005. The Singaporean government approached Duke University following 2001 Oxburgh Report on medical education aimed at contributing to define ways of transforming Singapore into a biomedical sciences and industry hub. This graduate school received a US$ 350 million from the Singaporean government to construct this school's building, pay staff salaries and give start-up research funds among other expenses (Sidhu et al., 2014).

In the case of the NTU, despite initial disapproval, the NTU authorities told us that they convinced the Singaporean government to establish their own medical school when the Imperial College London appeared as an interested partner; the resulting undergraduate's Lee Kong Chian School of Medicine, as we have just said, was launched in 2010. In this case, the government committed an endowment fund of approximately S$400 million for this school (Sidhu et al., 2014). Both schools of medicine are top elite institutions accepting around 50 students a year in the case of Duke-NUS and around 100 in the Lee Kong Chian School of Medicine, though they expect to increase enrolments up to 250 students per cohort.

Learning by imitation was also the strategy applied to transform public universities' governance structures. As most world top universities come from the United States, they followed the American model of HE and, in 2006, the Singaporean government "corporatized" public universities. This meant that they were assured the kind of autonomy enterprises enjoy in capitalism even though they remained non-profit. Since then, public universities are called autonomous universities. They are governed by a president and a board of trustees integrated by public government high rank functionaries, academics with management responsibilities (such as the Chairman of the National University Health System who is part of the NUS board of trustees) and business/industry leaders.

Furthermore, in 2012 the "Campus for Research Excellence And Technological Enterprise" (CREATE), an international research and innovation hub inside the NUS campus, was launched. It hosts joint research labs with other universities (such as the MIT, Berkeley and Pekin University) and industrial partners. It has capacity for 1,000 researchers (RIE, 2015). This is a clear example of an environment where local universities can learn from foreign ones which are supposed to share both their research skills and their experience on university-industry collaborations.

A way of measuring the results of joint research collaborations with international partners is to analysed co-authored publications. According to the 2016 Leiden Ranking, 58.7% of the NUS' and 56.3% of the NTU's core publications in Web of Science were coauthored with at least another international organization. Actually, since the 2000's both universities show a sharp increase in their publications in Scopus (Graphs 1 and 2). It is possible to think that international collaborations were a channel to learn how to publish in international peer-reviewed journals.

Furthermore, publishing with authors that were already highly recognized might have also contributed.

- **Importing talent: faculty and graduate students.**

This instrument included both a national and a university dimension. The concern about a lack of talent appears in every public policy document related to HER. In the S&T 2010 plan, for instance, A*Star was supposed to attract foreign scientists, among other initiatives, through the Visiting Investigatorship Programme aimed "to bring top scientists to Singapore to help develop new capabilities in key areas" (Ministry of Trade and Industry, 2006, p. 18). Following the RIE 2015 plan, the government launched the National Research Foundation's (NRF) Fellowship (Ministry of Trade and Industry, 2009, pp. 12–13).

At the university level, the NTU is an extreme example. From our interviews, it appears that after being corporatized, autonomous universities were authorized to reevaluate all their tenured faculty members between 55 and 65 years old (65 is the retirement age in Singapore). As a result, 200 tenured faculty were fired from the NTU because their performance was not in line with the university's new research benchmarks. Furthermore, with the savings made from firing those faculty, they hired 10 top senior researchers chosen worldwide by the impact factor of their papers and other related Key Performance Indicators (KPI). They also hired 85 promising top young researchers, also found worldwide and according to KPIs, through the NRF Fellowships (37) and the Nanyang Assistant Professorships (48) programs. Each of them was awarded with grants from the NRF of up to S$3 million. By the end of 2016, 68% of total PhD students were foreigners and the NTU had 70% (3,185) international faculty and research staff (Nanyang Technological University, 2016).

- **Vertical industrial policies concerning research activity**

Throughout the whole process there has been a strong steering of the HE policy in order to work on strategic issues for the country.

The government initially defined, through the NRF, electronics and engineering as Singapore's research priorities. These sectors would be particularly promoted. In 2000, Life Sciences (later called biomedical sciences) was identified as another key sector. In the S&T 2010 plan they added Interactive and Digital Media (later called infocomms & media) and Environmental and Water Technologies (then called cleantech). Inside each research priority they also defined particular research lines to develop (RIE 2015, p.20 and 21). By 2015, Biomedical sciences, Digital Media and Environmental, and Water Technologies were supposed to double jobs, reaching 80,000 jobs, while tripling their value added to S$27 billion. Among the chosen priorities, Health and Biomedical Sciences is the privileged one. It received S$1,030.3 million (33%) in 2013, and $1,156.1 million (35%) in 2014 of total public R&D funding.

In the RIE 2020 plan those research priorities were further developed into four strategic technology domains (in line with the general shift of the plan focusing on technology and valorisation): (i) Advanced Manufacturing and Engineering (AME); (ii) Health and Biomedical Sciences (HBMS); (iii) Services and Digital Economy (SDE) and (iv) Urban Solutions and Sustainability (USS).

The Singaporean government also encouraged interdisciplinary approaches. For instance, for the S&T 2010 plan the government identified "integrative themes that have high potential to impact inter-cluster industry development" (Ministry of Trade and Industry, 2006, p. 35) and encouraged multidisciplinary research in all the identified priorities. In the RIE 2015 plan, the

Joint Council Office expanded its budget to S$250 million. This office gives grants through competitive calls to multidisciplinary research among the physical and biomedical sciences.

Multi-disciplinary approaches were also fostered in the RIE 2020 plan. One of the funds promoting basic research in this plan, the NRF Competitive Research Programme, is aimed to cutting-edge multi-disciplinary research. Also among the basic research's funds, the Ministry of Education (MOE) offers the Academic Research Funding (AcRF) Tier 3 for multidisciplinary research projects proposed by Singapore's autonomous universities. This fund provides each selected project between S$5 to S$25 million over five years.

Among their transformations to become a WCU, the NUS created 8 Integrative Research Clusters: Asian studies, Biomedical science and transnational medicine, Ageing, Finance and risk management, Integrative sustainability solutions, Maritime, Material science and Smart nation (National University of Singapore, 2016).

- **Horizontal industrial policy**

In order to challenge the quality and capacity of their researchers, the government introduced competitive allocation of funds. Between the S&T 2010 and the RIE 2015, the NRF's Competitive Research Programme was expanded from S$350 million to almost S$1 billion. Other competitive funding that were launched under RIE 2015 are the Biomedical Sciences open collaborative fund (S$590 million) and the National Innovation Challenge (aiming to solve complex city problems, such as the need of clean water). Competitive funds are divided between fully competitive (everyone can participate) (S$2.8 billion in the RIE 2015) and competitive among a subset of research performers (S$2.695 billion in the RIE 2015). The latter includes funds that are only available for Public Research Institutes, others also include Universities and others are only destined to Universities and Academic Medical Centers. All the competitive funds that were committed in the RIE 2015 plan represented 34% of total public investment in R&D. The RIE 2020 plan further increased the importance of competitive grants to 40% of funding for research.

According to the interviews, there are around 12 public competitive calls for grants per year. Some of them (for example concerning aging and clean water) are targeted to specific areas and others, like the white fund, are broad or open. Moreover, the NUS and the NTU have their own preselection processes before sending them to the agencies offering the funds (generally NRF and A*Star). This ensures that they are not sending projects that will not have chances to win. When applying for competitive grants the government demands to predefine the expected KPIs in order to evaluate the project once the grant's period ends. A good evaluation in terms of accomplishing those KPIs is essential for winning future grants.

According to our interviews, including industry collaborations or commercial potentialities of the project are required to apply for major grants which corresponds to the requirements of the RIE 2015 and, specially, RIE 2020 plans. Furthermore, in the interviews we have been said that even if researchers enjoy academic freedom, the structure of highly targeted research assigned through competitive mechanisms may have an impact.

> "Researchers tend to go where they believe they can get funding, prestige and the support that they need. A lot of academics probably chose not to go into the niche areas because they now they are going to a dead-end." (Interviewee number 3)

Concerning university-industry collaborations, the NUS and the NTU have multiple ongoing and long term partners to include as interested private partners in their public grants' applications. A particularly important case in terms of investments is CREATE, as we have already mentioned. Furthermore, the Corporate Laboratory@University Scheme launched in 2013 supports industries to establish laboratories in autonomous universities. The NUS

currently hosts the following corporate laboratories: Keppel-NUS[2], Sembcorp-NUS[3] and the NUS-Singtel Cyber Security Research and Development Laboratory. In 2016, the NUS and Microsoft opened the Institute of Data Science. The NTU has 4 corporate laboratories: Rolls-Royce@NTU, ST Engineering-NTU, SMRT-NTU Smart Urban Rail Corporate Laboratory, Delta-NTU Corporate Laboratory for Cyber-Physical Systems. Rolls-Royce@NTU was established in July 2013 with a total funding of S$75 million for manpower with a target KPI of 30 patents and 260 publications over a 5 year period. Finally, the SMU has the Urban Computing and Engineering Corporate Lab @ SMU while the SUTD host the ST Electronics-SUTD Cyber Security Laboratory.[4]

3. What is beneath Singapore's integration to the global HE system?

Singapore's success cannot be understood without considering **capitalism's global transformations**. Asia's astonishing economic transformations demand an increasing number of higher education graduates. Furthermore, offshoring and outsourcing are trends that do not only explain commodities production process recent transformations, but can also be applied to explain transformations in innovation circuits (Contractor et al., 2010; Gereffi et al., 2005; Levín, 1997, 1977; Piqué, 2016).

Innovation circuits are defined as the framework of actors and institutions that participate, through several stages, in the process of creating an innovation (Aristimuño et al., 2014; Levín, 1977; Piqué, 2016). Among the participants of innovation circuits, Global Value Chain (GVC) leaders –called by Levín (1997) enhanced capital enterprises- monopolized the capacity to innovate. They innovate systematically, thus widening the gap between them and non-innovative firms. By dominating the capacity to innovate, enhanced capital enterprises have a higher profit rate because the innovation profit is renewed by the constant flow of innovations.[5] According to Levín (1997), another type of enterprise that participates in the innovation circuits is the 'technological capital enterprise', which produces one or more phases of the innovation process. Nevertheless, it loses the benefits that derive from its creative or innovative activity which are appropriated, through unequal market exchanges, by the enhanced capital enterprise. Indeed, the latter retains the capacity to organize and plan the whole innovation circuit, while the technological capital enterprise is aware of only a portion of it. A third type of enterprise identified by Levín (1997) is the simple capital enterprise. This type of firm produces the outsourced portions of the enhanced capital enterprise's production process and has lost the capacity to innovate. They adopt always late the new production technics.

GVC leaders also outsource and offshore phases/stages of their innovation processes to universities and public research institutes (Angell, 2004; Khanna, 2012; Rikap, 2016; Santos, 2009). For instance, this has been the case in the biomedical sciences (particularly pharmacy) (Abecassis and Coutinet, 2006; Khanna, 2012) as well as in computing, media and electronics (Dedrick et al., 2009; Kraemer et al., 2011; Linden et al., 2009; Xing and Detert, 2010). These

[2] Since April 2016 one of the NUS board of trustees' members is Mr LOH Chin Hua. Chief Executive Officer and Executive Director of Keppel Corporation Limited.

[3] Dr TEH Kok Peng is Chairman of Azalea Asset Management Pte Ltd. He is a Board Member of Overseas Chinese Banking Corporation, Sembcorp Industries Ltd and Taikang Life Insurance Ltd. Since 2011 he is part of the NUS board of trustees.

[4] For more information on the Corporate Laboratory@University Scheme see : https://www.nrf.gov.sg/programmes/corporate-laboratory@university-scheme

[5] There is actually empirical evidence of GVC leaders' innovation capacity and higher profit rates (Dedrick et al., 2009; Kraemer et al., 2011)

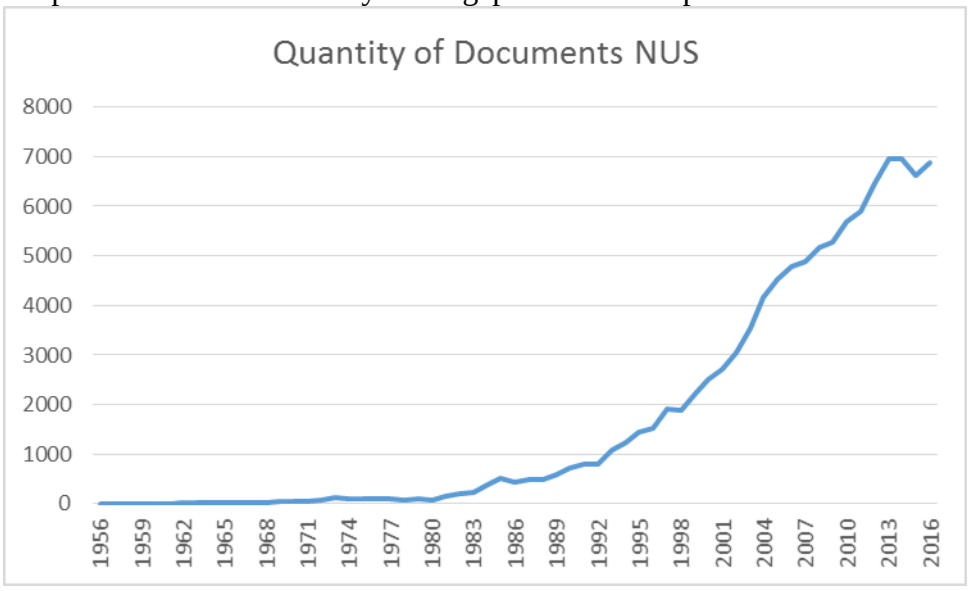
two sectors were identified by the Singaporean government as strategic for Singapore's transformation. With this respect, HER aimed to fulfil the global enterprises' demand for trained manpower and the outsourcing of stages of their innovation circuits.

Why was Singapore able to fulfil this demand and become a knowledge and education hub with the best successes among HE hubs in developing economies as highlighted by global rankings?[6]

Part of the answer comes from Singapore business-friendly environment. Singapore has a central location (between India, China, Japan, Australia, etc.) and the necessary infrastructure. Moreover, this country is like an alien because it is a developed country surrounded by less developed ones. It is a nice place to live in; it works fine as a city. It is a safe bet in terms of political, institutional and safety reasons. Furthermore, as the Singaporean government recognized, they had already achieved a reputation for educational excellence in primary and secondary schools and as a business hub (Ministry of Trade and Industry, 2002). Probably this is why, in a context of globalization of Higher Education and, more in general, a context of further development of GVC in Asia, some institutions were already developing branch campuses before the Global Schoolhouse initiative was launched. Furthermore, in the interviews we verified that some branch campuses' authorities actually were not even familiar with the name "Global Schoolhouse".

Actually, it is possible to consider foreign HE supply as an answer to an already existing unfulfilled demand in Singapore. In the 1980s and 1990s increasing numbers of Singaporean students travelled abroad to study in higher quality institutions (Ziguras and Mcburnie, 2011). So there was an unfulfilled demand of high quality HE in Singapore. Furthermore, concerning the NUS and the NTU transformations into WCU, their research activity started to grow exponentially before the government's policy to transform them into WCU started (Graphs 1 and 2) offering interesting perspectives of collaborations to global enterprises.

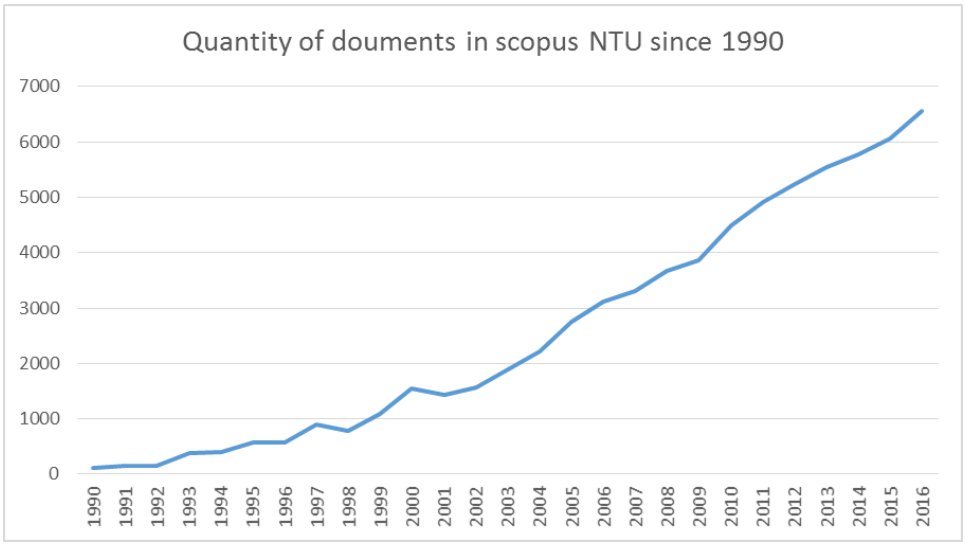
Graph 1. National University of Singapore scientific publications.



Source: Scopus.

Graph 2. Nanyang Technological University scientific publications.

[6] The NUS is the first Asian university in THE (24th worldwide) and the QS rankings (12th worldwide, followed by the NTU in the 13th place).



Source: Scopus.

This process was boosted by the government's industrial policy but also by WCU's from hegemonic countries collaborating with the NUS and the NTU. Since the end of the 1980's universities in hegemonic countries started to be evaluated according to quantitative Key Performance Indicators (KPIs), particularly regarding publishing and patenting activity (Neave, 1988). Research projects between these WCUs and the NUS and/or the NTU induced a transfer of this "ways of doing research" including the need to publish and/or patent the joint achieved results.

Furthermore, Singapore not only has a business-friendly environment but also has a **Higher Education Confucian model, which is more akin to university-industry collaborations as it is not built upon the academic freedom value** (Marginson, 2011). This may have also contributed to increase the appeal of Singaporean autonomous universities, in particular the NUS and the NTU, among global corporations. Actually, contrary to traditional world class universities (WCU) from hegemonic countries that were already internationally recognized as prestigious institutions before globalization, the NUS and the NTU became WCUs at least partly due to (or responding to) two main globalization trends: commodification of Higher Education and the integration of university's research to innovation circuits.

In other words, both Higher Education as a commodity and university research as an indispensable actor of innovation circuits were transformations that took place in the NUS and the NTU. At NUS, CREATE is a major example of this joint process as it includes both research catch-up by learning by imitating foreign WCUs, and the development of University-Industry collaborations. Besides the examples we have already mentioned along this article, we may add that the NUS and the NTU have joint research collaborations with main pharmaceuticals like Roche, Merk, AstraZaneca, Novartis and Glaxo Smith and Kline as well as with other powerful multinationals such as Hewlett Packard, Fujitsu, IBM, Danone, Boing, Shell, Toyota, Exon Mobil, Alstom, Vestas, BMW, Siemens, etc. Actually, some of these multinationals are leaders of their GVC, benefiting the most from the innovations introduced to the GVC.[7] The possibility to profit from WCUs' innovation capacity is a process that exceeds the NUS and the NTU particular experiences as well as the Singaporean government's policies, even though the

[7] Apple, Microsoft and Intel are examples of multinationals that dominate the GVC in which they participate, keeping the major part of the share of total value (Apple) and grabbing a large share of PC's gross profits (Microsoft and Intel). At the same time, other multinationals participating in the GVC but which are not innovation leaders (such as Hewlett Packard, Flextronics, Solectron, Foxconn, Quanta, and Compal) enjoy smaller shares of total value and share/rate of profits (Dedrick et al., 2009).

specificities of the Confucian model for HER and the encouraging industrial policy of the Singaporean government undoubtedly contributed to magnify the NUS and NTU's integration to innovation circuits.

Summing up, beneath Singapore's integration to the global HE system we found not one factor (public policy as identified by most authors) but three factors:

- The first one was the need of global capitalism, particularly the need of GVC leader companies to outsource and offshore part of their production and innovation processes. The Singaporean government attracted (especially through tax exceptions) those enterprises, which pulled Singapore's development (Wong and Goh, 2013). This had two effects on HER. On one hand, it contributed to increase Higher Education's demand and attracted WCUs from hegemonic countries to open branch campuses as well as to keep on developing joint diplomas in those regions. On the other hand, multinationals in Singapore also seek for collaborations with universities (and public research institute) as part of their outsourcing strategy for innovation.
- The second factor is the particularities of Singapore's capitalist society. Singapore's specificities (business-friendly country and a Confucian model of HER) definitely played a necessary role in explaining why it was Singapore a privilege destination of GVC leader corporations and HER branch campuses and other global activities. So capitalism's transformations and Singapore's specificities are essential to understand why Singapore and explain why the observed transformations started before the Singaporean government's major initiatives.
- The third factor was the Singaporean government's industrial policy. Being aware of the previous conditions, industrial policy (as was explained in Section 2) highly encouraged Singapore's integration to the global HE system as part of the government's knowledge economy strategy. Hence, **it is possible to think that the industrial policy was not the trigger but a highway that encouraged an ongoing process**.

It must also be added that this industrial policy was deployed in a favourable regional context because it started before China, the hegemonic country of the region, launched its own initiatives concerning HER and before it became a more FDI-friendly country. However, China has launched its own strategy for HE including the aim to develop WCUs and to scale up in the Global Value Chain (Pan, 2013; Sidhu et al., 2014; Singh et al., 2015). This new context poses a challenge for Singapore as a HER hub and is one of the reason that encourages us to discuss about whether Singapore's knowledge and education hub is sustainable in the long term.

4. Is Singapore's situation sustainable in the long term?

We began our investigation identifying the two main goals of Singapore's industrial policy for HER: converting Higher Education into a business and transforming the NUS and the NTU into WCUs. While analysing the role of industrial policies in the transformations of the Asian Tigers and the lack of analogous changes in Latin American countries, Grinberg (2011, p. 24) explains that "to produce self-sustained outcomes, state policies have to be validated by markets; they have to allow capital's normal valorisation.". Considering the Singapore government's two main goals for HER, we may say that in the HE industry market validation allowing capital's normal valorisation means that students need to attend to HEI and, most important, enterprises operating in Singapore and worldwide should demand their graduates. Otherwise, in the short term, students' attendance will decrease. Furthermore, in the case of the NUS and the NTU, industrial policies were also implemented to transform them into WCUs. Hence, following

Grinberg's (2011) reasoning, research outcomes (and research itself) should be validated in terms of publications but also in the "knowledge markets".

Concerning the first objective, it is possible to conclude that Higher Education industry, so far, is a growing business in Singapore. Students' attendance to Higher Education has increased (enrollment in local universities grew 78% and enrollment in total public Higher Education institutions grew 67%, between 2000 and 2015 (Ministry of Education, 2016)) and international full-tuition paying students have also significantly augmented (in spite of the government's decision to limit their access to undergraduate degrees in autonomous universities). Concerning graduates' employability, according to the NUS, 100% of their graduates get employment and most of them as soon as they are graduated. The NUS is the 17th university worldwide in terms of graduate's employability. Moreover, there is a 93.8% employment rate within six months in the SMU according to their Joint Graduate Employment Survey 2016. In the case of the SUTD, more than 90% of their 2nd cohort of fresh graduates were employed within six months of completing their final examinations.[8]

Nevertheless, the advantage of being the first to install an Education Hub in the region is not necessarily enough to remain in a privilege position. In fact, we mentioned that the Chicago Business School moved to Hong Kong in 2013. This business school realized that half of their students were coming from Singapore, and they were not getting the expected diversity of nationalities to cover the whole region. Moreover, when they opened up in Asia, China was not the world power it already was by 2013: distance to China was not an issue. By the time they moved, they wanted to be closer to the Chinese market. Hence, when they had to move from the building where they initially settled in Singapore, they looked for opportunities considering the previously mentioned constraints of remaining in Singapore. They found in Hong Kong public support regarding property standpoint and financial opportunities. They won an open competition which gave them access to a property in an inexpensive cost and additional financial support.

The influence of capitalism in China in the near future is already challenging Singapore government's long term objective of becoming the major knowledge and innovation hub in Asia. Countries like Singapore with strong R&D development and Gross Expenditure on R&D (GERD) are currently unable to match China's "competitive spending and R&D growth programs." (Industrial Research Institute, 2016, p. 29).

Actually, concerning R&D activities results in Singapore have not been entirely in line with the objective of becoming a powerful innovative economy or, as they call it in the RIE 2020 plan, to become a Smart City. One of the main objectives of the RIE 2020 Plan is to:

> "Sharper Focus on Value Creation. Strengthen flow through from research to its eventual impact in society and economy, through additional budget allocation towards public-private research collaborations and increased efforts in helping companies expand their absorptive capacities for new technologies, so as to support our Future Economy and Smart Nation efforts." (Ministry of Trade and Industry, 2016, p. 3).
>
> "Under the RIE2020 Plan, Singapore is implementing four major shifts that build on the progress achieved under the RIE2015 Plan to create greater value in Singapore from our investment in research, innovation and enterprise" (Ministry of Trade and Industry, 2016, p. 3).

What is beneath the government's search for more value creation derived from R&D activity in the RIE 2020 plan, and what does "value creation from R&D" mean? Value creation from R&D means to increase capital's accumulation as the result of successful innovative activity. In the case of Singapore, two existing indicators can be used to measure it:

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8 http://www.sutd.edu.sg/About-Us/News-and-Events/Press-Releases/2017/3/High-Employment-Rates-and-Starting-Salaries-for-SU (Consulted on April 3, 2017).

licensing revenues and sales revenues from commodities that were produced as the result of R&D activities.

Historically, in Singapore, multinationals were the main R&D performers and the ones that led to the country's industrialization (Wong and Goh, 2013). Actually, studying if there is a causal relationship between outward foreign direct investment[9] and the principal component of external trade in Singapore, Wong and Goh (2013) concluded that this country's success as an international hub for business, financial and knowledge-based services relied on foreign expertise. The S&T Plans, in fact, considered initially foreign multinationals as a central actor while the government tried to leverage R&D in local companies.

> "Going forward, the aim is to anchor more flagship R&D projects and attract multinational companies (MNCs) to locate more corporate R&D activities in Singapore. Greater efforts will be also put in to help Singapore local companies to upgrade and develop depth through R&D capabilities, in order to stay competitive in the next 5 years and beyond. (Ministry of Trade and Industry, 2006, p. 41).

Concerning the business enterprise sector as whole, the S&T Plan 2005 defined among its KPIs that it should reach a 67% share of GERD, figure that was reaffirmed in the S&T Plan of 2010. Since those plans no further key indicators for business enterprises' share of GERD were defined as goals to achieve, as actually that goal was never accomplished. Actually, the share of the business enterprise (local plus foreign) expenditure in R&D decreased between 1994 (62%) and 2013 (58.2%) in Singapore (OECD data). Business Enterprise (or Private) R&D expenditure, in absolute terms, increased during the period, but not as much as the government expected, and not as much as to reach the levels of benchmark countries like Korea (75.9% in 2014) or Germany (58.2% in 2013). Inside the business enterprise sector, it is interesting to distinguish between types of enterprises in order to analyse if Singapore's development story directly dependent on foreign multinationals was overcome, considering the efforts made by the Singaporean government in terms of public expenditure in R&D. Actually, the Singaporean government's share of GERD increased since 1994 (first year with figures).

Chart 1. Sources of Research and Development expenditure in 2014 (S$ million)

Source	R&D Expenditure	Proportion inside enterprise sector	Proportion of total R&D Expenditure
Local SMEs	795,38	15,2%	9,3%
Local LEs	870,89	16,7%	10,2%
Foreign Companies	3549,4	68,1%	**41,6%**
Total private sector	5215,67	100,0%	61,2%
Government Sector	972,1	-	11,4%
Higher Education Sector	1349,32	-	15,8%
Public Research Institutes	989,39	-	11,6%
Total	**8526,48**	-	100,0%

Source: Compilation based on National Survey of Research and Development in Singapore

From Chart 1 we confirm that **foreign companies are still the main responsible of the R&D performed in Singapore and we will see that they are also the main beneficiary in terms of incomes coming from R&D activity** (Chart 3). Regarding the share of SMEs in GERD, it should be considered that SMEs (particularly start-ups which tend to concentrate innovation among SMEs) enjoyed different public incentives since the 1990s when the government started the grant called R&D Incentive for Start-Up Enterprises: "since 2010, firms have been able to

[9] Meaning the investment of capital enterprises operating in Singapore in other countries.

deduct 400% of their expenditure from their income, subject to a cap of 800,000 Singapore dollars (S$), from innovation activities, including not only R&D but also design, registration and acquisition of intellectual property rights, and acquisition of automation equipment." (Intarakumnerd and Goto, 2016, p. 9). Thus, SMEs' actual investment in R&D is smaller than what figures from Chart 1 shows as a significant proportion comes from the public government.[10] According to the 2015 SMEs development survey, 47% of SMEs operating in Singapore showed no turnover growth and 6% a declining turnover; similar figures were observed in the previous years (DP Information Group, 2015). In this scenario, it is hardly probable that they will expand their R&D investment.

Foreign companies also benefit from the Singaporean government's funds for R&D. The funding invested for them by the government is less critical for these foreign companies (but more critical for the sustainability of the Singaporean HER hub, as we will argue next) than the funding received by SMEs because if the government reduces or ends its financial support to private enterprises' R&D, foreign companies can move their operations to other countries offering better relative conditions which is not the case of SMEs.

Chart 2. Licensing and sales revenues per type of enterprise in 2014 (S$ million).

	Local SMEs	Local LEs	Foreign Companies	Total
Licensing Revenue	86,87	**256,32**	122,52	465,71
Proportion of total	18,7%	**55,0%**	26,3%	100,0%
Licensing Dollars per patent	**75 539,13**	**267 000,00**	39 357,53	89 165,23
Sales revenue	763,4	2632,56	**21811,59**	25207,55
Proportion of total	3,0%	10,4%	**86,5%**	100,0%
Sales revenue Dollars per patent	663 826,09	2 742 250,00	**7 006 614,20**	4 826 258,86
Patents Owned (Cumulatively until 31 Dec 2014)	1150	960	3113	5223
Total Dollars due to Patenting activity	850,27	2888,88	**21934,11**	25673,26
Proportion of total income due to patenting	3,3%	11,3%	**85,4%**	100,0%

Source: Compilation based on National Survey of Research and Development in Singapore

Another difference that shows the different situation of local and foreign companies in Singapore is that foreign companies do not license their patents as a main activity, but use them to gain more money by commercializing commodities that resulted from their R&D activity (Chart 2). On the contrary, Singaporean enterprises license their patents. It is thus possible to think that patents are licensed because they cannot profit directly from them as much as foreign companies do. Though more research needs to be done with this respect: the difference between global and local players might be a hint about a dominated place of Singaporean companies in GVC.

Chart 3. Research and Development Revenue Indicators in 2014

[10] There are no detail figures on the proportion of public R&D monies that are received by type of enterprise. Thus, we cannot calculate the share of SMEs' R&D expenditure that is actually funded by the Singaporean government.

Revenue Indicators	Private Sector	Government Sector	Higher Education Sector	Public Research Institutes	Total
Licensing Revenue from Patents and New Technologies Developed in Singapore	465,71	0,29	1,76	3,23	470,99
Proportion from total	98,88%	0,06%	0,37%	0,69%	
Sales Revenue from Commercialised Products/Processes Attributed to R&D Performed in Singapore	25207,55	0,02	0,25	29,51	25237,34
Proportion from total	99,8820%	0,0001%	0,0010%	0,1169%	
Patents Owned (Cumulatively Dec 2014)	5223	52	687	617	6579
Share of total patents	79,4%	0,8%	10,4%	9,4%	100%
Dollars per patent	89165,23	5576,92	2561,86	5235,01	71589,91

Source: Compilation based on National Survey of Research and Development in Singapore

As a whole, private enterprises hold almost 80% of the patents and almost 100% of the associated incomes (Chart 2). But as we have just shown, actually foreign companies are the main enterprises profiting from R&D inside the private sector, which means that, as a whole, foreign companies are the ones profiting from the R&D done in Singapore. The other side of this story is that universities are not creating much economic value from their research results. They have a 10% share of total patents but less than 0.5% of the incomes associated to R&D activity results (Chart 3). It seems that all the instruments that the government created, particularly since the RIE 2015 plan aimed at contributing to the commercialization and transfer of knowledge to the market (including the University Innovation Fund), are still not enough. Moreover, concerning R&D invested in the HE sector, private investment increased in the period, from 2.9% in 1994 to 6.1% in 2013, but in 2000 it was already in the level of 2013. This shows that the policies implemented during the 2000's did not trigger a significant increase in business enterprise funding of HE's R&D. In fact, 80% of total R&D done in the HE Sector in 2014 came from the Singaporean government.

Analysing incomes from R&D results, it is of course possible to say that HE patents are more focused on basic research and that this is a reason why it is harder to profit from them. Actually, studying USPTO data, Singh et al (2015) concluded that universities' share of total volume of intellectual property in East Asian countries (including Singapore) is low and that patent quality[11] is lower in universities than in non-university sectors which, according to the authors, is a sign of weak technology commercialisation impacts.

This situation may be a central reason why the government plans to reduce basic research's share in total public R&D expenditure between 2015 and 2020 to 15%, compared to the 34% of public R&D expenditure destined to basic research in 2014 (11.8% in pure basic and 22.2% in strategic basic). But even considering that there is a significant share of basic research patents in the public sector, the patents' related income indicators show that only enterprises (and mostly foreign companies) are profiting from all the R&D done in Singapore, even if the public

[11] It is defined by the authors considering two measures: The average number of forward citations received per patent and the Relative Citation Index which is calculated as the ratio of each country's share in total citations received to its share in the world's total patents.

government investment in R&D represented 39.3% of total R&D in 2013. Furthermore, public research institutes, which are industry-oriented and undertook a full spectrum of science (as is explained in the RIE 2015), did not perform much better than the HE sector (see Chart 3).

Considering Rikap's (2016) three-types typology of market-universities we may say that the NUS and the NTU are Technological Universities. Briefly, the Technological University loses the profits of its commodified research activity, which are gathered by powerful enterprises that dominate the innovation circuits where this type of university is involved. In fact, through the interviews we could verify that, in spite of a growing number of patents, the NUS is facing serious problems concerning their commercialization. The NUS is having hard times to license their patents (which is absolutely in line with Chart 3 general figures) when it shares property rights with private enterprises. The private enterprise that co-owns the patent uses it without paying royalties to the NUS and have no obligation of sharing the profits with the NUS. The NUS tries to licence these patents to other enterprises but, as could be expected, there are not interested buyers because the private co-owner is already offering the resulting product without the costs of paying royalties, a cost that any other private enterprise aiming to produce would have to pay. Thus, even if formally the patents are shared, enterprises owning them are the ones enjoying the economic profits.

In Rikap's (2016) typology, another type is the Enhanced University, which dominates innovation circuits, keeping a significant part of its innovation's profits. As it enjoys more own resources and has a leading position, is capable of balancing the external market need with its internal academic priorities. For instance, this type of university may use part of its endowment to fund social sciences and humanities, as top elite universities in the United States (Taylor et al., 2013), fields that are less appealing for integrating innovation circuits but that are indispensable for remaining as a leading university worldwide.

As we have said, the RIE 2020 plan is focused on the valorisation of research, acknowledging that the increasing R&D public expenditure (even if it contributes to explain the growing number of publications and patents) is not reporting the expected economic returns in terms of licensing and sales revenues for the HE sector. Nor it has eliminated Singapore's dependence on foreign companies' (particularly multinationals) R&D expenditure. It is possible to analyse the aim of the RIE 2020 plan concerning WCUs as an attempt to transform them into Enhanced Universities; a strategy to contribute to eliminate that foreign powerful enterprises' domination.

Additionally, in the Enhanced and the Technological Universities fundamental, research is jeopardised and investigations end up subordinated to the fulfilment of capital's accumulation because research is focused on fostering the relationship with enterprises and the creation of own enterprises to commercialize their outcomes (Rikap, 2016). Furthermore, the need to fulfil market demands curtails academic freedom both in the Enhanced and in the Technological Universities and negatively affects fundamental research (Rikap, 2016). We have observed that in the RIE 2020 plan, there is a greater emphasis on creating value from academic research. Thus, could this process lead to the actual subordination of fundamental research in the NUS and the NTU? Which could be the consequences concerning academic freedom in universities with a Confucian tradition (Marginson, 2011) that differs from the western idea of university's autonomy?

Going back to the RIE 2020 plan as a whole, there is still an open question. Whose capital's accumulation process will be most benefited? Will it be enough to assure that multinationals stay and amplify their direct and indirect operations and their R&D in Singapore? Even if they do so, it is possible to consider that the Singaporean government will be compelled to maintain the levels of indirect subsidies to those enterprises so that Singapore remains as a chosen country and they do not move those operations to another, probably cheaper country.

The Singaporean case shows that it is possible to transform universities into WCU and to transform Higher Education into a business (the social consequences of these processes in terms of increased polarization have not been discussed in this article but cannot be neglected). However, the former achievements were not enough to transform the place of Singapore's local enterprises and market-universities in global capitalism in terms of market value creation from R&D. R&D in Singapore still depends on foreign multinationals which, at least in part, choose Singapore because of the government's subsidies and funding for R&D.

The sustainability of Singapore's integration to the global Higher Education system may also be at risk considering that Wong and Goh (2013) observed that outward foreign direct investment in Singapore is explained mainly as an outsourcing process and is partly dominated by Singapore-based foreign-controlled firms (35% in 2003). Local enterprises and, especially, foreign enterprises based in Singapore already outsource their labour-intensive activities to lower cost-production countries. If we take into account that relatively high wage levels discourages multinationals R&D investment in Global Cities like Singapore (Belderbos et al., 2014; Wong and Goh, 2013), it is possible to consider that foreign enterprises operating in this country could follow the same outsourcing and offshoring strategy for R&D activities, endangering the sustainability and further development of Singapore as a knowledge and education hub. This threat reinforces the dependence on public R&D expenditure for foreign enterprises (either through direct subsidies or through allowing them to profit from the NUS and the NTU discoveries), compensating higher wages and assuring that foreign enterprises, on which the Singaporean knowledge and education hub replies on, do not offshore R&D.

Summing up, we may say that the state's policy has not been enough so far to reshape the amplified capital's accumulation process inside Singapore. In fact, our conclusion reinforces GVC theory because it is a sign of how, in the most global capitalism ever, GVC leaders are the ones deciding which areas of the planet will be the major producers of R&D, and which will be the factories of the world. As long as the Singaporean government assures these companies higher rates of profit than other countries (with similar institutional, political and economic stability) in the region, it is likely to observe that Singapore remains as a knowledge and education hub. Yet, how long can the Singaporean government support the current situation? In fact, considering the results of our investigation, Singapore's knowledge and education hub seems to be unsustainable in the long term.

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Annex 1. List of interviewees

- Prof. Dr. Philip Moore, NUS Executive Director, NUS Graduate School for Integrative Sciences and Engineering
- BA Sean Flanigan, Director of NUS Industry Liaison Office (ILO)
- Asoc. Prof. Anne Pakir, Director of NUS International Relations Office

- NUS tenured faculty: Dr. Rachel EE and Dr. Lifeng Kang
- Prof. Lalit Goel, NTU Director, Global Education and Mobility
- Dr Toh Kian Lam, NTU Director, Office of International Affairs
- Bertrand Sulpice, ESSEC Managing Director
- Martine Bronner, Chargée de mission Marketing ESSEC Singapore
- David Dubois, Assistant Professor INSEAD Singapore
- Anaïs Doladille, Regional Development Manager Sorbonne-Assas International Law School, Singapore
- Bill Kooser, Chicago Business School Associate Dean for Global Outreach
- Mariana Losada, Université Sorbonne Paris Cité representative in Singapore
- François-Xavier Lannuzel, Attaché de Coopération Scientifique et Universitaire (French Embassy in Singapore)