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# Clusters – Typology and Public Policy

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**Abstract:** Clusters, especially high-tech, are important economic phenomena in modern society. As the archetype, Silicon Valley drives governments over the world to initiate their own cluster. Likewise, the cluster policy has also become a major policy tool in the urban planning field. Based on approaches to initiate and promote clusters, the current cluster policy can be divided into three models, the American model, the Asian model, and the European one. This paper focuses on the sustainability of clusters, reviews the literature about high-tech clusters, cluster policy, and the developments of selected clusters, including Silicon Valley, Silicon Fen, Hsinchu Science Park, Singapore Science Park and One-North, and Akademgorodok; discusses their developments and challenges, and aims to explore the role of government and possible approaches. Based on the data analysis, the research concluded that governments are essential to a cluster's sustainability. The approach of mixing bottom-up and top--down intervention might be the final direction for all countries, and the only difference lies in timing, which varies with local resources, social environments, and especially culture. For governments, its role should be identifying the right timing to implement the adaption in policy, coordinate, and lead the battle for sustainability in practice.

**Keywords:** cluster, Silicon Valley, Silicon Fen, Singapore Science Park, public policy, urban planning

## 1. Introduction

Clusters play a vital role in the development of economics in modern society. However, 'cluster' is not a new historical phenomenon and can be traced back to urban clusters along the Middle Niger (West Africa) in the first centuries B.C. (Mcintosh, 1991). There also exist many geographically concentrated industrial districts, such as textile in northern Italy and wine clusters in California.

In the 1990s, M. Porter posited the cluster theory, which described business clusters as a geographic concentration of enterprise in a particular field, where the participants within the cluster shared a "competitive advantage through economic scale and reduced transaction costs concentration" (Engel, 2015, p. 37).

Nevertheless, it was not until the emergence and success of Silicon Valley that the theory of clusters became well-known to the public, and its definition took the form of a creative cluster or cluster of innovation.

In the last four decades, Silicon Valley has become the most prominent innovation and entrepreneurial cluster in the world, hailed as a haven of start-ups, the global innovation engine, and the world's greatest wealth-generation machine.

Koepp (2002) claimed that Silicon Valley's success is not just in "producing technological and scientific advances, having a pool of skilled management and personnel to facilitate an entrepreneurial attitude", as well as the capability of serving as an ongoing hub for both IT and bioTechs, which makes Silicon Valley "more an economy of concepts than products, more of entrepreneurship than technology".

Research based in Silicon Valley has become a hotspot in the academic field. Researchers have explored the factors that drive the success of Silicon Valley and its potential further applications. At the same time, the extraordinary economic wealth provided by Silicon Valley for the US and its unprecedented creativity stimulates other countries to build their creative clusters. They dream of replicating the success of Silicon Valley, not only in wealth but also in innovation and technological advancements that help drive society forward. The government plans and promotes the cluster's creation and development. Typical examples are Singapore's Science Park, China's Zhongguancun, Hsinchu's Science-Based Industrial Park (hereafter Hsinchu Science Park), the Soviet Union's Akademgorodok, and Japan's Tsukuba Science City. However, many of these have floundered, and even the successful clusters only led innovation centres in their sphere of activity, and have not attracted the global attention and market share that Silicon Valley enjoys. No other cluster has drawn and retained the number of companies or people as Silicon Valley does.

Compared to Silicon Valley with its followers, there exists a significant difference, worthy of attention. Unlike most of the late-comers, Silicon Valley was neither what the government intended to create nor did the government intervene during its development. Nevertheless, nowadays Silicon Valley faces a series of serious challenges, including the shortage of electricity and water supply, an imbalanced social structure, rising living costs, and high taxes, all of which became accentuated by COVID-19, leading to a stream of outward migration of companies and manpower.

Regarding this, many public policy-related problems emerge, including: What is the relationship between urban planning, public policy-making, and a cluster's operation? What role should the government play? Why have so many well-planned clusters failed? How to gain the self-sustaining capability that Silicon Valley possesses?

Answering those questions needs further investigation. Some researchers have deployed their research in this field, including theoretical discussion and empirical analysis. However, the literature review based on 1259 papers about cluster theory from 20 economic geography journals from 1990 to 2015 showed that government and policy-making were fourth from the end among the TOP 10 groups of research questions (Lu et al., 2018). There still exist many research gaps that need further exploration.

Therefore, this study aims to review the current research and cluster applications, examine the impact of public policy on the functioning of innovative cluster structures, discuss the challenge that public policy faces, and explore the possible optimal approaches to initiate a cluster and maintain its vitality in the long run.

The rest of the paper is organized as follows. Section 2 reviews the literature regarding cluster theory, public policy, and an empirical analysis of practical cluster applications, including Silicon Valley, Silicon Fen (Cambridge Park), Hsinchu Science Park, Singapore Science Park and One-North, as well as Akademgorodok. Section 3 presents urban planning challenges. Section 4 concludes this research and provides recommendations.

## 2. Literature Review

### 2.1. The Development of Cluster Theory

According to Koepp (2002), Marshall is the first economist to write "in depth about clusters (which he referred to as 'industrial districts')". Continuing with the legacy of Marshall, Porter (2000) defined a cluster as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (Motoyama, 2008, p. 354). However, Porter's theory is fairly broad; from the perspective of Porter, "clusters occur in many types of industries, in smaller fields, and even in some local industries such as restaurants, car dealers, and antique shops" (Porter, 2000). Koepp (2015) mentioned that "Porter has updated and extended his conceptualisation of clusters to claim that they are the basis for 'the new economics of competition".

According to Engel (2015), Saxenian popularized the concept of an "innovation-centered business cluster" through his research on two successful models of innovation clusters, Boston and Silicon Valley. Engel and del-Palacio (2009) focused on Silicon Valley and posited a Global Cluster of Innovation Framework that "describes business clusters defined not primarily by industry specialization, but by the stage of development and innovation of the cluster's constituents". They believed the distinctive feature of the cluster was "the rapid emergence of new firms commercializing new technologies, creating new markers, and addressing global markets", instead of merely "industry concentrations". They also identified that such a cluster should consist of some key components, including entrepreneurs, venture capital investors, mature corporations and strategic investors, universities, government, R&D centers, and specialized service providers and management". Thus, the definition of clusters is derived from the traditional business cluster progressing to the current specific cluster of innovation (COI), creative cluster, or high-tech cluster.

As the archetype of clusters, the success of Silicon Valley promoted the popularity of cluster theory in academic fields. Researchers have since discussed the mechanisms that drive the success of Silicon Valley, and how to replicate it. Koepp (2002), in *Clusters of Creativity*, explored the "enduring lessons on innovation and entrepreneurship from Silicon Valley and Europe's Silicon Fen". Wonglimpiyarat (2005) believed that "the clusterings of collaborative institutions are (an) important mechanism catalyzing the economic development at Silicon Valley". Specifically, the collaboration between universities, government, and entrepreneurs had a key role in the creation of Silicon Valley as an innovative cluster. Engel and del-Palacio (2015) listed the key modes of behaviour that they believed favour the development of clusters: a heightened mobility of resources (principally people, capital, and information–including intellectual property); an entrepreneurial process (the relentless pursuit of opportunity without regard for resource limitations); increased velocity of business development; a strategic global perspective; a culture of alignment of interests and transaction structures that reinforced that alignment; incentives and goals that lead to an affinity for collaboration; and finally, the development of global ties and bonds.

In order to research cluster policies, Lu et al. (2018) collected 1259 cluster papers from economic geography journals, management journals, and economics journals and found that the top ten groups of research questions include economic development, location selection, research and development, international business, labour, knowledge spillover, government policy-making, cluster measurement, Mar & Jacbos debate, and networks. Based on the data analysis, they concluded that one of the progressions in cluster theory is "the knowledge about clusters, such as why and how clusters emerge and decline and how to utilize cluster policy to improve economic development".

However, just as Motoyama (2016) mentioned, the current cluster theory does not answer some fundamental questions. Firstly, it focuses more on "describing how a cluster is organized today rather than how a cluster emerged". Secondly, the theory neither provides a practical measurement mechanism to evaluate the interconnectedness of a cluster nor explains how the public sector can strengthen this aspect. Much of the research emphasised the history of Silicon Valley, listing all the factors that contributed to its emergence and growth, but no research satisfied the question "how does one make it happen? Can one make it happen? If it is best that emergent forces dominate rather than prescriptive governments dictates, how do we proceed? Who should take the lead" (Engel, 2015, p. 61). Hence, the current empirical analysis is more like hindsight, instead of an action guideline.

### 2.2. Public Policy

What does public policy concern? Brown et al. (2009) stated that it is "the actions and directions of the government", while Considine (1994) specified that "Public policy not only comprises actions and decisions of government, but includes the commitment of providing financial and service related resources" (as cited in Brown et al., 2009, p. 2).

According to Motoyama (2018), Porter's cluster theory brought "a major shift in policy focus… to a firm-level attraction and retention strategy". Since then, cluster theory has become a key policy tool for governments to enhance economic competitiveness through planning and initiating interdependent clusters or sectors.

Hospers and Beugelsdijk defined cluster policy as "all efforts of (a) government to develop and support clusters in a particular region" (Sopoligová & Pavelková, 2017). The distinct features of cluster policy lie in the following aspects: "improving the generalized business environment, providing information and data, providing infrastructure, education, and training, fostering inter-firm networking and collaboration, providing business services, investing or business attraction policies and foster community building" (Sopoligová & Pavelková, 2017, p. 37-38).

Based on the approaches to initiate and promote clusters, the current cluster policies can be divided into three models: the American, the Asian, and the European one (see the detailed comparison in Table 1). Sopoligová and Pavelková (2017) suggested that the American model is characterised by the high level of relations between companies, research centres, and universities. The Asian model is distinctive for its active government support for the creation of conditions for cluster development. The European model ensures economic success through the development of centres of excellence, including initiatives to encourage transnational clusters which facilitates access of clusters to new markets.

Furthermore, they also explored the characteristics of cluster policy, and stated that cluster policy strategies vary with government involvement and intervention. Government involvement determines the approach which might be bottom-up, top-down, or mixed. Within the bottom-up approach, the private sector is largely involved, "cluster emerge due to an initiative of groups of parts of the Triple Helix Model, i.e. university, industry, and government without a concrete political impetus" (Sopoligová & Pavelková, 2017, p. 40). The top-down approach refers to the measures to support clusters initiated by the government and fits better to new clusters characterised by a lack of material assets, entrepreneurs, and cooperation (Fromhold-Eisebith & Eisebith, 2005); clusters emerge as

a result of the activities of public policy, and the mixed-approach as a combination of both top-down and bottom-up model (Hendry et al., 2000).

Asian countries favour the top-down approach, and their clusters serve as a tool for "establishing the basic infrastructure to narrow the regional gaps or on the other hand encourage the development of highly specialised towns'', whereas the leading policy in Europe is bottom-up, "to fit the needs of industries while removing market imperfections'' and the role of government is a kind of laissez--faire approach. Comparing Asian and European policies, it is noticeable that Asian policies are typically low-incentive accompanying the top-down selection of targeted clusters with full funding, whereas European policies feature a "high-incentive policy based on hard competition among clusters with a complete matched funding scheme".

Essentially, the American model is a high-configuration version of the European model. Silicon Valley and other clusters in the USA can also be classified as a type of bottom-up policy.

Brown et al. (2009) focused on the implementation of public policy, reviewed the current public policy, and discussed how public policy can enhance cluster development on different levels. According to their descriptions, the mechanisms of policy consists in "the political process, institutional structures, decision-making processes, administration and implementation, the enormous range of substantive matters that government must deal with, and the philosophical issues that arise in the process of deciding how to deal with those matters" (Fenna, 2004, p. 32, as cited in Brown et al., 2009), as well as their resources.

Based on Brown et al. (2009), there exist three types of implementation of public policy in terms of the degrees of intervention, i.e. voluntary, incentives, and mandatory mechanisms. Examples of voluntary policies include providing a network for members of a cluster. An incentive policy provides subsidies that encourage relocation, while a mandatory policy forces companies to act. The authors claimed that the emphasis of cluster policy should be "paving the way for creating conditions conducive to people's engagement in joint efforts and realising mutual benefits". Thus, public policy may influence either the individual firm level or cluster level.

Table 1. The three cluster policy models

| | American model | European model | Asian model |
|---|---|---|---|
| Government-Initiative | no | yes | yes |
| Government-Intervention | no | less | heavy |
| Degree of intervention | voluntary | high-incentive | low-incentive |
| Interrelations between companies, research centres and universities | high | middle | low |
| Approach | bottom-up | mixed but leading with bottom-up | top-down |
| Sustainability | high self-sustaining | self-sustaining | low self-sustaining |
| Typical instances | Silicon Valley | France Sophia-Antipolis | Singapore Science Park and One-North |

Source: authors' own study based on the literature review.

In the actual practice of public policy, there exist some arguments focused around the role of government. Hospers et al. (2009) examined Europe's policy and posited the government's core role is to "facilitate cluster emergence as opposed to design it". They believed that resources are limited, and if the government instead of the market decides which cluster/firm to help and which not, then the policy falls into the "pick-a-winner" category. They claimed this was the reason why the French high-tech policy failed, and suggested that the government should not interfere in the cluster, but only offer information and contacts on demand of the business community, and do the marketing after the cluster emerges.

Another example comes from the Asian model that is represented by the Singapore Science Park, the Beijing Zhongguancun, and the Hsinchu Science Park, which features "government-directed mechanisms, in the form of infrastructure provision with perhaps a signaling motive" (Koh & Tschang, 2003, p. 224). A detailed discussion follows in the next section.

Engel (2015) investigated 11 countries and 13 distinct economic regions that spread from America (Silicon Valley), Europe, the Middle East, and Asia, to Latin America. Based on these diverse collective inquiry data, he concluded that government plays an important role, no matter if it is "direct or indirect, intended or unintended, beneficial or detrimental". He claimed that "government [is] effective as a source of coordination, a convener of community, a provider of critical resources".

Similar to Hospers et al. (2008), Engel (2015) also reminded the public that governments "cannot be relied upon to provide the answers for a cluster of innovation development, but rather they must focus on providing enabling environments and allow the answers to emerge". He also mentioned that "leveraging and enhancing existing local capabilities is critical", instead of simply duplicating "best practice" is the correct method for development. Engel believed that "encourage innovation in existing business is often more effective than new greenfield construction", though it still requires "exploration through individual entrepreneurial, opportunity-seeking behaviour", and moreover claimed that " Top-down policies can help articulate a vision, but government initiatives are most successful when they focus primarily on incumbent stakeholders, not on emergent elements of society and the economy".

For more evidence, Sopoligová and Pavelková (2017) chose Denmark, France, Germany, China, Japan and South Korea from Europe and Asia as data samples, and compared their cluster policies. They found that "in the context of autonomy, all selected countries implement the cluster concept with strong government support and as a part of government policies", and concluded that "the government involvement may be a guarantee of cluster policy sustainability".

### 2.3. The Applications of Cluster Theory Around the World

'Siliconia' is a term referring to Silicon Valley and the other over a hundred clusters of technology--based industries spread globally with the prefix of Silicon, such as Silicon Island, Silicon Hill, Silicon Sandbar and so on, which showed the governments' significant attempts to apply cluster theory and duplicate the success of Silicon Valley in practice (Koepp, 2002). There exists much empirical research about observing Siliconia's initiative and growth. This section presents a discussion from three perspectives: initiative, growth, and organization mechanism.

Focusing on the development process of a cluster, especially its initial status, it is natural to divide Siliconia into two types, one is 'without governmental intention', such as Silicon Valley and Cambridge Silicon Fen, while the other is 'with government intention', such as the Soviet Union's Akademogorak, the Beijing Zhongguancun (Negro & Wu, 2020), the Singapore Science Park, and the Hsinchu Science Park. A comparison of the selected ecosystems is presented in Table 2 and detailed characteristics in the subsequent points of this section.

**Silicon Valley**

According to Koh et al. (2005) and Engel (2015), Silicon Valley was not created with the intention of developing an innovative cluster. Since World War II and the Cold War, military research has funded universities, national government laboratories, and private companies in Silicon Valley. Abundant military contracts for radio and radar defence led to the growth of pillar Silicon Valley companies such as Hewlett-Packard, Lockheed Missiles, and Space, which is regarded as "a crucial catalyst for the subsequent emergence of this techno-centric innovation cluster" (Engel, 2015, p. 40).

At the same time, policies such as the Bayh-Dole Act of 1980 and the Federal Technology Transfer Act of 1986, also cultivated spin-offs from government-sponsored research that "permitted universities to pursue ownership of their inventions in preference to government ownership of the patents" (Engel, 2015, p. 45). In addition, the US government also stimulates "the venture capital industry and

Table 2. Selected clusters

| | Silicon Valley | Silicon Fen | Hsinchu Science Park | Singapore Science Park and One-North | Akademgorodok |
|---|---|---|---|---|---|
| Founding period | 1950 | 1970 | 1985 | 1980 | late 1950s |
| Type of clusters | ICT and biotech | high-tech in the fields of biotech, electronics and software | semiconductor & electronic manufacturing | ICT & biotech | high-tech in software fields |
| Government--Initiative | no | no | yes | yes | yes |
| Government--Intervention | no | less | less | heavy | heavy |
| Degree of intervention | voluntary | mandatory | low-incentive | | mandatory |
| Interrelations between companies, research centres and universities | high | high | high | high | high |
| Approach | bottom-up | bottom-up | mixed | top-down | top-down |
| Sustainability | high self-sustaining | self-sustaining | partly self-sustaining | low self-sustaining | very low self-sustaining |
| Area | 1854 Square miles (source: Silicon Valley Indicators) | 0.24 Square miles (source: Cambridge Science Park) | 5.18 Square miles | 0.21 Square miles (SSP)(source: Singapore Science Park) 1.56 Square miles (One-North) (source: SSP) | 0.77 Square miles |
| Political-liberty | Yes | yes | yes | yes | no |
| Number of companies | 1,630,346 employees, over 40,000 startup companies (in 2022) (source: Startup Genome) | 130 firms with 7250 employees (source: Cambridge Science Park) | over 530 companies with 152,000 employees (source: NTSC) | 350-375 firms & institutions (Krishna & Sha, 2015) | 300 companies with 9000 employees (source: wikimedia) |
| Prominent Companies | Tesla, Apple, Intel, Google, Oracle, Cisco etc. | PIPEX, Muscat, Zeus, HP Autonomy, ARM, Pye, CCL, Acorn | TSMC, Zyxel | Det Norske Veritas | Intel, Schlumberger; Novosoft |
| Involved Universities & Research institutes | Stanford, UC Berkeley, Santa Clara, San Jose (State), MIT, UCLA (Wonglimpiyarat, 2005) | University of Cambridge, Anglia Ruskin University | Industrial Technology Research Institute of the Foundation, National Tsinghua University, and the Jiaotong University | National University of Singapore, NTU | Siberian Branch of the Russian Academy of Sciences |
| Structures of talents | diversity | local talents | local talents & returning personnel from Silicon Valley | depend on global talents (more than 70%) | local talents |

Source: authors' own study based on the literature review.

entrepreneurial innovation through tax policy (lowering tax rates on capital gains)" (Wonglimpiyarat, 2005, p. 205).

Reviewing the development of Silicon Valley, it is clearly seen that the US government did not provide direct funding and implement specific intended policies to promote the growth of a cluster. On the contrary, there exists a set of developed, dynamic transformation mechanisms between universities, entrepreneurs and Venture Capitals (VC) that catalysed the boom of innovation and make it run in the way of self-directed and market-oriented. For example, Silicon Valley has the "most developed venture capital industries model in the world" (Wonglimpiyarat, 2005). According to Engel (2015), the resources (money, people and know-how/technology) are continually moving effectively and efficiently in the whole environment. Serving as stage financing, VC funds the start-up companies to address tough problems early, and lowers the risk of the founders. They combine actions to achieve the next major milestone, die or successfully exit with the rewards to the success of entrepreneurs, then step into the next cycle – typically not exceeding 12-18 months. The progress of entrepreneurs depends on recruiting people and money within a resource deficient context, which drives entrepreneurs to continually create value to feed VC, just as Engel (2015) mentioned, "mobility balance by commitment, generated by compensation mechanisms that tie employees and founder rewards to success of the enterprise and good outcomes for venture investors".

Such an environment attracts a globally-trained workforce. The mature equity compensation structures (e.g. incentive stock compensation, investing typically at four years) motivate entrepreneurs and employees to frequently move to new ventures, taking an investor's perspective, and speeding up portfolios of potential equity returns (Engel, 2015).

Apart from these, the effective use of university resources and a culture of willingness to accept risk also contribute to the success of Silicon Valley. In the past half a century, Silicon Valley has spawned organically a bottom-up method that kept evolving through five waves of development from defence, integrated, personal computer, and Internet, to ICT and Nanotechnology (Wonglimpiyarat, 2005). The new generations of globally influential companies, from Hewlett Packard, Intel, Apple, Google, and Facebook (Meta), to the most recent Tesla, have also continuously emerged. Such an ability to continually renew and sustain itself through the continuous creation of new companies, i.e. self--sustaining, is the distinctive capability that makes Silicon Valley stand out from other Siliconia, and has not been surpassed so far.

**Silicon Fen-Cambridge Park**

According to Koh et al. (2005), Silicon Fen (Cambridge Park) is also an instance of a bottom-up cluster that was started by Cambridge University in 1970. The British government did not intentionally create Silicon Fen as a cluster, rather it traditionally ignored high-tech startups and has only recently started investing and encouraging its growth. During Silicon Fen's development, Cambridge University played a key role, mainly focusing on basic scientific research to control and select a limited number of tenants. Compared to Silicon Valley whose majority of startups were focused on commercialisation, Silicon Fen is science-oriented. The main type of R&D in Silicon Fen is the pure science research output of Cambridge University and other national-sponsored research institutes in the region. Many companies were led by "research scientists who were first-time entrepreneurs". Silicon Fen initially focused on electronics and software, then extended to biotechnology, R&D consultancy, and software in 1990. Compared to Silicon Valley, Koh et al. stated that Silicon Fen has acted as "a magnet for technology startups keen to take advantage of the facilities it offers", which has a limited role in global production, and there are few national or global level large technology firms emerging. However, Silicon Fen still is "one of the global clusters of intellectual development and research".

**Taiwan's Hsinchu Science Park**

The previous examples were both clusters that experienced little governmental involvement. It is interesting to look at the applications in Asian countries which have different cultures and policy

preferences. The first example is Taiwan's Hsinchu Science Park which possesses a very important position in the global production chain of semiconductors and other electronic technologies.

Hsinchu Science Park is a fully government-oriented high-tech community that was established in 1980. The government provided "public land with infrastructure facilities; efficiently supported one--stop service; domestic and international network; automated customs service and on-the-job training etc.", and invested more than US$583 million in software and hardware facilities for the park by 1998 (Lee & Yang, 2000). However, its subsequent developments are driven by the private sector and aided by returning know-how talents from Silicon Valley.

The success of Hsinchu Science Park is greatly owed to attaching itself to Silicon Valley's extended global network, and becoming one part of the production chain of Silicon Valley, though it "lags behind in the capabilities to develop cutting edge technology" (Koh et al., 2005, p. 13).

**Singapore Science Park and One-North**

If Hsinchu Science Park received a more hands-off policy, then Singapore's application of Singapore Science Park and One-North is a classic example of how a country built "a small but vibrant science community in a relatively short span of time" (Krishna & Sha, 2015, p. 390) with heavy governmental intervention and direct policy implementation, to counter "a backdrop of limitations: a weak local talent base, a feeble research culture, inadequate investment in time, money" (Hang et al., 2016, p. XVII).

Singapore Science Park (SSP) has been a core component of Singapore's economic strategy that was introduced in the late 1970s to complement the implementation of an economic restructuring and technology upgrading policy, which formally opened in 1984[1], was one of the first science parks in Asia. The SSP implemented a top-down approach focused on huge spending, incentives, and investments from foreign companies. The government provided physical facilities, tax breaks, and other supporting infrastructures, including "domestic supplies, service providers and potential business partners". Apple, Seagate, and other multinational companies came into SSP. According to the website of SSP, it has become a home to over 350 laboratories, multinational companies, as well as global leading tech companies.

However, during the development of SSP, the government was the main driving force, private sector participation was restricted, and the interaction between company-company within SSP and companies–universities were lesser and inattentive (Koh et al., 2015). Furthermore, the small domestic market size and local talent pool, as well as feeble resources for exploring the overseas markets, led to the following: the spin-offs from government-funded research institutions and universities within SSP had been relatively modest; many start-ups declined rapidly, and closed down within a few years, and most local companies survived as a support to multinational companies.

According to Koh et al. (2005), the Singapore government built a new One-North Science Habitat to extend and complement SSP in 2000, with estimated investments of about US$ 8.6 billion over 15 years, focusing on bio-science and information technology. Many targeted policies and programmes implemented to directly address the past deficiencies in SSP, included offering a superior intellectual property regime and gateways to other Asian marketing to attract research companies from overseas (especially those from Australia and New Zealand), deploying a dense technological metropolis to promote the spillovers and agglomerative effects as well as the interactions between different sectors within One-North and out of One-North. Since the SSP became the part of Great One-North, the general usage One-North refers to Great One-North which includes the SSP. However, for the sake of clarity, they will be referred to separately in this paper.

Krishna and Sha (2015) claimed that the unique Singaporean approach to building a scientific community is attracting global talents through the implementation of Singapore's national science, technology and intervention (STI) strategy starting from the 1980s. This programme supported

[1] Source: from F.S. Yip, PhD, who led the National Science Council (NSC) from 1980 to 1989.

multinational companies to conduct research in Singapore. The National University of Singapore (NUS) also plays a key role to attract global talents, such as leading scientists, students, and faculty through the internationalisation strategy.

Thus, aided by global talents, Singapore's application can successfully transform its economy into a knowledge-driven modern industry in the context of limited resources decades. This is a good analysis sample worth observing in the long run.

**Akademgorodok**

Many countries dreamt of creating their own Silicon Valley, yet many of them floundered. Hospers (Hospers & Beugelsdijk, 2002) listed some policy failure cases, and the Soviet Union's Akademgorodok is a famous one. Akademgorodok, or "City of Science'', was created from nothing in the late 1950s with the full support of Khrushchev, who visited Silicon Valley and was inspired to create their own high--tech cluster in the middle of Siberia. The government poured abundant funds to cultivate this city, part of which was used to make life easier due to the extremely cold weather and remote area. In its first 30 years, there were 37 institutes and thousands of scientists working together at Akademgorodok, and it became the important science centre of the Soviet Union. However, with the collapse of the Soviet regime, Akademgorodok has come to mirror "the disastrous decline of Russia's academic tradition" (The Guardian, 2000) with the dwindling government funding. Both institutes and scientists struggled for survival due to the lack of sufficient funding and income.

Akademgorodok is a typical example of how the loss of outsourced labour and investments could make a cluster unsustainable. Thus, the way to build up and solidify the self-sustaining ability of a cluster no doubt is a vital challenge that policy-makers and urban planners have to face and work on.

## 3. Challenges of Urban Planning in Selected Ecosystems

In the urban planning field, sustainable development is a key concern, yet difficult to implement in practice. As mentioned in the previous section, while cluster theory is an important policy tool, it is more like hindsight that neither satisfies the answers of "Who takes the first step?", "Who leads?" (Engel, 2015, p. 61), nor offers the guidance and practical mechanism to lead the government or any other entity on how to do so.

Taking a look at all the implementations around the world, including the iconic Silicon Valley, Siliconia faces challenges to maintain its prosperity and survive. This section addressed Silicon Valley, Silicon Fen, and Singapore as samples in different levels of government intervention to analyse the challenges they meet.

**Silicon Valley**

Koepps (2002) described the problems "looming just beneath the surface of their high-tech paradise" that exist in Silicon Valley but have been overlooked, including vulnerable electricity supply disruption, labour supply crisis involving lower-income workers, imbalances between enterprises and their economic infrastructure, as well as poorly performing public schools. He described these problems as an example to expose the bigger issues: high-tech companies had become the main sector of growth with heavy consumption of electric power due to big data processing and storage, but what could influence the details of "atrociously designed energy policy" was the old economy business. In Silicon Valley, more than 80% of electricity was outsourced, but San Jose City Council "unanimously rejected an application for constructing a new power-generation facility in the city" in November 2000.

After twenty years, all the problems Koepp (2002) mentioned have become worse. If the electric--supply crisis had not caught sufficiently the public's attention, the rising cost of living, high taxes, and poor public education have directly influenced the people's daily life in the Bay area. Cupertino, a small city in Silicon Valley where the author lives, and where Apple's headquarters are located, permanently

closed three elementary schools due to insufficient funding in 2021. The average budget of each student in the Cupertino school district is the lowest in California. Many young teachers have had to leave school due to limited budgets. Such a plight in education should not happen in Silicon Valley, nor anywhere else.

For any community, a diversity of occupations, including teachers, nurses, firemen, salespeople, gardeners, etc. are essential for its livability. However, except for well-paid personnel, for ordinary residents, life in the Bay area is becoming more and more unaffordable. Since 2020, the pandemic of Covid-19 has created a trend to work from home which accelerates the migration from California. According to the San Francisco Business Times, census data showed that California experienced the largest domestic outward migration in history, almost 1% of Californians, namely 367,299, left California in the year ending 1 July 2021 (Calvey, 2021). On the other hand, for companies, the rising cost and high taxes have already led to a relocation of companies such as Tesla, Oracle, and Hewlett Packard.

Faced with these problems, how to keep the attractiveness of Silicon Valley both to companies and talents? In fact, what Silicon Valley currently faces is not the problem directly related to itself, but it is rather about the environment and underlying conditions that it engages in. This is a systemic problem, and one cannot use a simple approach that treats the symptoms rather than gets to the root of the problem to resolve it. It is obvious that no entity is capable of solving it alone, neither the government, nor the private sector, and instead it requires the cooperation of the whole of society. However, Silicon Valley does not have a mechanism to execute this project.

Although the government does not have more knowledge than others on leading, who does? Noone is better than the government to take the role of initiator and coordinator, to lead the actions seeking a solution and put it into practice. It needs long-lasting endurance to overcome factionalism and political profits, the wealthy and elite class, and the big companies to generously contribute their wealth, wisdom, and energies to involve, as well as the efforts of all members of society.

However, the first step for all the governments is to put aside political benefits and agree on the singular goal of creating a sustainable and innovative cluster that can benefit the economic needs of the country. This is especially difficult, considering the divided nature of American society today. Only then it becomes possible to discuss coordinating resources to find or create a suitable niche for post--Silicon Valley clusters.

**Silicon Fen**

Like Silicon Valley, Silicon Fen has a similar problem with its infrastructure and urban planning, but with more severity and urgency. Its current physical infrastructure configuration leads Silicon Fen “close to reaching saturation point”, which is “not dying, but leveling off” (Koepp, 2002, p. 235).

According to Koepp (2002), Cambridge as an old historical town, and the regulations for expansion along with the protest of residents against commercialisation have frequently prohibited commercial and residential development. Furthermore, Silicon Fen relies upon the railway to connect with the outside world and lacks not only well-planned local roads for a commute to London but also global transportation and interconnectedness. Yet, the town does not have an airport, its closest major international airports, Stansted and Luton respectively, also lack transcontinental flights, which prevents Cambridge Park’s further growth as a global cluster. Just as Koepp (2002) commented, “For a center of advanced technology that relies on global mobility, compared with other major Siliconia, the airport infrastructure connecting Silicon Fen to the world outside provides more drag than stimulus”. Koepp believed that there would be no substantial room for growth if local and national governments did not take action to solve the problem of excessive traffic.

Unlike Silicon Valley, Silicon Fen suffers from the *folie de grandeur* culture. The public pride in the fact that “Trinity College has produced more Nobel prizewinners than all of France” (Koepp, 2002, p. 237), is common from the gossip of taxi drivers to scholarly discussions. The collective consciousness of the cluster does not realize that “the resilience and vibrancy of the Cambridge cluster today results from

practical management, not cerebral knowledge". In addition, "the amount of land people are willing to give over to development is diminishing". Such a culture is an obstacle to the further development of Silicon Fen.

Apart from "the increased interactivity, improved business facilitation, and the growing personal wealth" (Koepp, 2002, p. 241), the author also indicated that the further progress of Silicon Fen also relies on the adaptation of "management strategies and innovation methods". He also believed that such a revolution 'from within' will continue, although probably running at a more moderate pace and being difficult to discern 'from without". To some extent, the plight of Silicon Fen can be seen as a mirror for clusters that emerge and grow from the bottom-up, including Silicon Valley. One cannot help thinking about whether low-government intervention is always good.

**Singapore Science Park**

Asian countries that used to accept a top-down approach in their cluster have another story. Compared to clusters with a historical culture such as Silicon Fen that affects its development, Singapore is a city state that features a short history and small size, so it is easy to observe and analyse in a span of time as an ideal sample.

Singapore has sufficient reasons to execute the top-down approach. Firstly, it is greatly limited in both natural resources and human resources. Secondly, Singapore lacks a local culture of entrepreneurship and willingness to take risks, as most Asian countries do. The flaw of hardware might be covered up quickly by outsourcing, but the core issue of culture, which is the software, has to take a long time to nurture. With such a background, it is hard to imagine that a cluster can emerge and grow spontaneously in a short time without the government's initiative and direct intervention. That might explain why Asian countries prefer the top-down approach. Thus, it is culture and available resources impact the selection of a government, instead of a form of government.

It is interesting to compare the style of the facility in SSP and One-North, as SSP is low-density like Silicon Valley, while One-North is dense which is utilised to promote the connection between companies in One-North that was lacking in SSP. Such a difference also can be seen as a metaphor to indicate the Singapore government's adaptation from simply copying the best practice to fitting for itself.

However, One-North did not change the primary character of Singapore's cluster which depends on foreign investments, multinational companies, and global talents. The government of Singapore spends billions of dollars yearly on attracting global talents and focuses on foreign companies, while the local firms do not benefit much from this exchange and lack a connection with the university. This greatly impairs the self-renewal ability of One-North and limits its scope of success compared with the amount of money spent.

It is easy to recall Akademgorodok as a comparison, which similarly has heavy government intervention and huge government funding support, and which once contributed importantly to the Soviet Union. If it lacks vitality that comes from the private sector, once the government cannot feed money, could One-North survive and succeed? Such a question is what Singapore and other Asian countries have to answer.

For a government that is used to 'parenting' their clusters, another challenge is to suppress the desire for intervention, and result-oriented favouritism, rather than facilitating effective approaches to foster and enhance the self-sustainability of clusters. Silicon Valley could be a source of inspiration.

## 4. Conclusion

Based on the literature review and case study of selected clusters, and looking at the previously unanswered questions, it is evident that the relationship between urban planning, public policymaking, and a cluster's operation are mutually interwoven and shaped, but no single factor dominated in the

long run. Whether a cluster is a government initiative or not, effective policy and urban planning are essential to the sustainability of clusters, in which the government plays an important role as a leader to initiate the planning and resource-coordinator in the following action. However, the real challenge for a government is how to discern the right timing that it involves and select the appropriate level that it intervenes. Incorrect timing or/and intervention will lead to the failure of a well-planned cluster, though the correct selection cannot guarantee the success of a cluster either.

Taking a look at the selected clusters, it is natural to conclude that all the approaches, top-down, and bottom-up have their reasons to present, evolve or fade. No one size fits all clusters anytime and anywhere. The environment is changing, and society is evolving. What governments should do instead is adapt themselves to their varying local environment, and take on the duty to lead the activity to seek sustainable clusters and their engaged societies.

Furthermore, the authors believe that the approach of mixing top-down and bottom-up might be the new direction of urban planning. Even for clusters that possess a combination of resources, optimal culture, and develop organically such as Silicon Valley and Silicon Fen, when it reaches a certain stage of development, it still benefits from the top-down intervention. For countries that do not currently have an environment qualified to grow a cluster spontaneously, such as Singapore, this requires government initiative and top-down nurturing. The eventual vitality of the cluster will depend on the operation of the private sector, which means the approach must switch ultimately to the bottom-up.

In conclusion, mixing the top-down and bottom-up approach is the final direction for all countries; the difference only lies in timing, which varies with resources, social environments, and in particular with cultures. For a government, the role should be to identify the right timing to implement the adaptation of policy, and coordinate and lead the endurance for sustainability in practice.

## References


Anttiroiko, A. V. (2004). Science cities: Their characteristics and future challenges. *International Journal of Technology Management*, *28*(3/4/5/6). https://doi.org/10.1504/IJTM.2004.005295

Audretsch, D. B., Lehmann, E. E., & Menter, M. (2016). Public cluster policy and new venture creation. *Economia e Politica Industriale*, *43*(4), 357-381.

Brown, K., Burgess, J., Festing, M., Keast, R., Royer, S., Steffen, C., & Waterhouse, J. (2020). Public policies to enhance cluster development. In *Business clusters* (pp. 260-280). Routledge.

Calvey, M. (2021). *Census finds almost 1% of Californians left the Golden State in the past year*. https://www.bizjournals.com/sanfrancisco/news/2021/12/21/census-finds-almost-1-of-californians-left-golden.html

Derlukiewicz, N., Mempel-Śnieżyk, A., Mankowska, D., Dyjakon, A., Minta, S., & Pilawka, T. (2020). How do clusters foster sustainable development? An analysis of EU Policies. *Sustainability*, *12*(4). MDPI. http://dx.doi.org/10.3390/su12041297

Engel, J. S. (2015). Global clusters of innovation: Lessons from Silicon Valley. *California Management Review*, *57*(2), 37.

Engel, J. S., & del-Palacio, I. (2009). Global networks of clusters of innovation: Accelerating the innovation process. *Business Horizons*, *52*/5, 493-503.

Hang, C. C., Low, T. S., & Thampuran, R. (Eds.). (2016). *The Singapore research story*. World Scientific.

Hospers, G. J., & Beugelsdijk, S. (2002). Regional cluster policies: Learning by comparing? *Kyklos, 55*(3), 381-402.

Hospers, G. J., Desrochers, P. & Sautet, F. (2009). The next Silicon Valley? On the relationship between geographical clustering and public policy. *Int Entrep Manag J*., 285-299. https://doi.org/10.1007/s11365-008-0080-5

Ketels, C. H., & Memedovic, O. (2008). From clusters to cluster-based economic development. *International Journal of Technological Learning, Innovation and Development*, *1*(3), 375-392.

Koepp, R. (2002). Clusters of creativity: Enduring lessons on innovation and entrepreneurship from Silicon Valley and Europe's Silicon Fen. John Wiley & Sons.

Koh, F. C., Koh, W. T., & Tschang, F. T. (2005). An analytical framework for science parks and technology districts with an application to Singapore. *Journal of Business Venturing*, *20*(2), 217-239. https://ink.library.smu.edu.sg.soe_reseach/383

Krishna, V. V., & Sha, S. P. (2015). Building a science community by attracting global talents: The case of Singapore Biopolis. *Science, Technology and Society*, *20*(3), 389-413.

Lee, W. H., & Yang, W. T. (2000). The cradle of Taiwan high technology industry development – Hsinchu Science Park (HSP). *Technovation*, *20*(1), 55-59.

Lu, R., Reve, T., Huang, J., Jian, Z., & Chen, M. (2018). A literature review of cluster theory: Are relations among clusters important? *Journal of Economic Surveys*, *32*(4), 1201-1220.

McIntosh, R. J. (1991). Early urban clusters in China and Africa: The arbitration of social ambiguity. *Journal of Field Archaeology*, *18*(2), 199-212. https://doi.org/10.2307/530257

Motoyama, Y. (2008). What was new about the cluster theory? What could it answer and what could it not answer? *Economic Development Quarterly*, *22*(4), 353-363.

Ooms, W., Werker, C., Caniëls, M. C., & Van Den Bosch, H. (2015). Research orientation and agglomeration: Can every region become a Silicon Valley? *Technovation*, (45), 78-92.

Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, *14*(1), 15-34.

Sopoligová, M., & Pavelková, D. (2017). Cluster policy in Europe and Asia: A comparison using selected cluster policy characteristics. *Journal of International Studies*.

The Guardian. (2000). *Town where a Soviet dream turned sour*. https://www.theguardian.com/world/2000/jul/24/russia.ameliagentle

Wang, T., Wang, L., & Chen, T. (2014). Secrets of success: Innovation in the Silicon Valley: Business development and innovation of tech companies. In *2014 International Conference on Behavioral, Economic, and Socio-Cultural Computing (BESC2014)* (pp. 1-5).

Wiryomartono, B. (2020). Urban planning and development. In *Livability and sustainability of urbanism*. Palgrave Macmillan. https://doi.org/10.1007/978-981-13-8972-6_4

Wonglimpiyarat, J. (2005). What are the mechanisms driving the success of the US Silicon Valley? *International Journal of Technology, Policy and Management*, *5*(2), 200-213.

## Klastry – typologia i polityka publiczna

**Streszczenie:** Klastry, zwłaszcza *high-tech*, są niezwykle istotne we współczesnej gospodarce. Jako archetyp Dolina Krzemowa inspiruje rządy na całym świecie do tworzenia lub pomocy w formowaniu lokalnych klastrów technologicznych. Polityka klastrowa stała się również jednym z głównych narzędzi polityki w dziedzinie planowania urbanistycznego. Bazując na podejściach do inicjowania i promowania klastrów, obecną politykę klastrową można podzielić na trzy modele: amerykański, azjatycki i europejski. W artykule dokonano przeglądu literatury na temat klastrów zaawansowanych technologii, polityki klastrowej oraz rozwoju wybranych klastrów, w tym Doliny Krzemowej, Silicon Fen, Hsinchu Science Park, Singapore Science Park and One-North, a także Akademgorodok. Autorzy opisali rozwój wybranych klastrów, wskazali główne wyzwania i zbadali rolę rządu w poszczególnych ekosystemach. Na podstawie przeprowadzonej analizy stwierdzili, iż wsparcie władz rządowych i lokalnych jest niezbędne dla trwałości klastra. Podejście polegające na łączeniu interwencji oddolnych i odgórnych może być ostatecznym kierunkiem dla wszystkich krajów tworzących klastry, a jedyną różnicą jest czas, który różni się w zależności od lokalnych zasobów, środowiska społecznego, a zwłaszcza kultury. W przypadku rządów jego rolą powinny być określenie odpowiedniego czasu na wdrożenie adaptacji w polityce, koordynowanie i prowadzenie w praktyce zrównoważonego rozwoju.

**Słowa kluczowe:** klastry, Silicon Valley, Silicon Fen, Singapore Science Park, polityka publiczna