DOI 10.1179/030801806X103343

INTERDISCIPLINARY SCIENCE REVIEWS, 2006, VOL. 31, NO. 2

Cold War politics and scientific communities: the case of Silicon Valley

MARGARET PUGH O'MARA

Department of History, Stanford University, Stanford, CA 94305–2024, USA

Many cities, regions and states have sought to replicate the economic success achieved by the high-tech industrial cluster of 'Silicon Valley' in northern California. While Silicon Valley's success is commonly attributed to particular entrepreneurs, firms and institutions, historically-specific political and economic frameworks underpinned its development. Policies and programmes of the US government during the early decades of the Cold War created new economic opportunities for people and organisations engaged in scientific research, yet the influence of public funding streams can be obscured because of the devolved and privatised way in which the programmes were structured and implemented. Exploring these political frameworks, particularly the way in which they altered the fortunes of Silicon Valley's major research institution, Stanford University, helps explain why Silicon Valley grew where it did, and why its economic ecosystem has proved so difficult to replicate elsewhere.

Silicon Valley is one of those few places in the world whose name has become shorthand for an entire industry. For half a century, this cluster of suburban communities in northern California has produced successive waves of globally significant innovation in electronics and computer technology, and been an incubator for countless entrepreneurial enterprises and a generator of astounding levels of wealth. Its success has prompted many imitators – one computer-industry titan remarked during the internet boom of the late 1990s that 'Silicon Valley is the only place on Earth not trying to figure out how to become Silicon Valley'[1] – but none has been able to replicate fully the physical and institutional ecosystem that exists there. Even as serious challengers to its industrial dominance rise elsewhere in the world, Silicon Valley often remains the benchmark against which these other scientific and technological communities measure their progress. In an era when the commercialisation of increasingly complex technologies **has made 'scientific communities' and 'high-tech regions' increasingly synonymous**, Silicon Valley has shaped cultural and economic assumptions about what such communities are, how they function, and who they serve.

The Valley's success has spawned a powerful creation mythology whose iconic figures are quirky but brilliant 'garage entrepreneurs', a type embodied by HP founders William Hewlett and David Packard, who began their company in a Palo Alto garage in 1939. Alternatively, debate centres on what one observer calls the 'chicken-and-egg problem' of whether the presence of entrepreneurial firms, or the presence of a major research university (Stanford), accounts for the Valley's ascendance.[2] Yet these interpretations can oversimplify or ignore altogether the broader political and economic conditions present at the Valley's mid-twentieth-century creation – at global, regional and local levels – that allowed technologists like Hewlett and Packard, or universities like Stanford, to be so successful.

Silicon Valley, despite standing as a symbol of the twenty-first century knowledge economy,

is a Cold War creation, its institutions and paths of opportunity shaped fundamentally by that era's political institutions and imperatives. And, although Silicon Valley has become a global model for scientific and technical communities, the forces underlying its development were distinctively American, rooted in particularly American systems of governance, market structures and educational institutions. Grounding Silicon Valley's development in the Cold War political economy – and identifying the essential *American*-ness of its institutional structures – reveals why its economic and social structure has proved so difficult to replicate elsewhere, and forces further reflection on the global quest to build 'the next Silicon Valley'.

Very simply defined, scientific communities could be said to consist of scientific workers, the institutions and industries that sponsor their work, and the physical infrastructure that surrounds and supports these people and organisations. In 1940, the place that became known as Silicon Valley encompassed something of a scientific community, but a relatively small and remote one. Largely a rural landscape of fruit orchards and grazing pastures, many of the area's white-collar residents clustered in the college town of Palo Alto, home of Stanford University. Its blue-collar citizens, a good number of them Latino and Asian, worked in the orchards or the canneries. An intrepid few took the thirty-mile-plus journey on the train to work in San Francisco, but the area was less a dormitory community than an agricultural one. Stanford itself was a land-rich institution, owning close to nine thousand acres of the surrounding countryside, but it was often cash-poor and was known more for its football team than its physics laboratories. The University of California at Berkeley, across the San Francisco Bay, had far more visible research accomplishments and more notable faculty in the hard sciences.

Nonetheless, even at this early stage, the area was a magnet for the scientifically creative and entrepreneurial, home to groundbreaking early experiments in motion photography, wireless technology and electronics. The temperate weather, open-minded business culture and university presence in the area supported a small but vibrant scientific community whose collaborative and informal approach to research and production would become a hallmark of Silicon Valley's business culture. Yet there was little capital available to turn this scientific tinkering into business enterprise, and the Valley remained a sleepy place, at a far remove from the centres of commerce and politics.[3]

National policy changes resulting from the Second World War, and the Cold War that followed, changed the terms on which all dimensions of Silicon Valley's embryonic scientific community operated, transforming its people, its institutions and its landscape. Before the war, scientific research in the US – both industrial and university-based – was funded almost entirely by private sources; public funding or public policy had a minimal impact on most American scientists and their laboratories. Afterwards, driven by the demand for strengthened military defence and the development of ever more powerful nuclear weapons, the US government made an unprecedented investment in both basic and applied research, which spurred an attendant increase in trained scientific manpower. Addressing Congress exactly one month after atomic bombs fell on Japan, President Harry Truman put forth a new call for public investment in science: 'no nation can maintain a position of leadership in the world of today unless it develops to the full its scientific and technological resources … no government adequately meets its responsibilities unless it generously and intelligently supports and encourages the work of science in university, industry, and its own laboratories.'[4]

In the fifteen years that followed, the annual federal government investment in research and development grew to over nine billion dollars, coming close to taking up ten per cent of the entire US budget.[5] With scientific and technical innovation a high public priority, federal

agencies sent new streams of money to scientific people and institutions not only through defence contracts and research grants, but also through new programmes to boost the teaching of science and mathematics, and increase the number of MAs and PhDs in engineering and the hard sciences. The new expenditures on the research and development of new technology turned the federal government into the private sector's most important customer in a number of industrial categories, aerospace and electronics chief among them, and increased market demand for trained scientific professionals. American research universities, which had previously operated at a certain remove from public life, were transformed not only in size but in political significance. In an era when Washington's leaders looked worriedly at the Soviet Union's robust output of scientists and mathematicians and rationalised educational investments as a matter of national security, American universities and the scientists within them became important agents of national policy. 'With all their irritating faults,' wrote President Dwight D. Eisenhower's science advisers in 1960, 'universities are essential agencies of our national hopes, and they must be treated accordingly.'[6] For the people and institutions in the business of researching cutting-edge science and technology, the US government was the original venture capitalist.[7]

Yet the new bounty of what Eisenhower rather ominously labelled 'the military-industrial complex'[8] was not shared equally by all scientific people, places and institutions. A disproportionate amount of defence spending overall – from military installations to aerospace factories and research laboratories – went to the American South and West, drawn by favourable climate, cheap land and abundant labour, and political pressure from powerful members of Congress. California found itself a particularly fortunate recipient of federal defence largesse. Its proximity to the Pacific theatre made it a hub for war work in the early 1940s, and in the immediate post-war years its mild weather, plentiful land, new infrastructure and growing population increased its geographic desirability for defence contractors.[9]

In similar fashion, the vast majority of university-based research monies went to a remarkably small pool of major research institutions. In 1939 and 1965, exactly the same group of twenty-five universities (fifteen private and ten public) was responsible for producing two-thirds of the nation's PhDs in science; by the mid-1960s, sixty per cent of all federal funds for university science went to this exclusive group.[10] While there was a good deal of political rhetoric flying around at the national level about the importance of university expansion in winning the Cold War, public officials usually failed to note that only a select few universities were being transformed by the new political order.[11] Those that were either entered the Cold War period having large research facilities (state institutions like the University of California) or as the pre-eminent private US institutions of science (Harvard and MIT), or were aggressive and entrepreneurial about building their science programmes and attracting top-flight faculty. Stanford University fell into this last category, giving the surrounding area a further competitive advantage.

Cold War spending changed the people and institutions of science in the US; simultaneously, new public infrastructure and housing programmes transformed the physical landscapes in which they grew. The quarter century after 1945 was the heyday of the low-density, car-dependent American suburb. Millions of middle-class whites left city neighbourhoods for new developments on the urban outskirts; thousands of industrial facilities and their jobs made a similar exodus. Housing and highways, the principal drivers of this mass outward movement, were both heavily subsidised by the US government. Federal tax breaks for home mortgages made buying a new suburban home cheaper, in many instances, than renting an apartment in the city. The federal interstate highway programme (itself conceived as a defence measure to allow for quick evacuation of cities) poured millions of dollars into the

creation of road networks that connected city and suburban hinterland.[12]

Once again, the area that became Silicon Valley found itself on the favourable side of broader economic and political trends. Two major highways ran down the spine of the San Francisco Peninsula from the city through the valley's small towns; as California's population exploded, real estate developers bought up the orchards and farms of the area and built thousands of acres of residential subdivisions. Due in part to the amount of defence related research under way in the area, the demographic profile of these new suburbanites was markedly white-collar and affluent, particularly in the towns adjacent to Stanford's campus.[13]

The geographic and institutional favouritism of the defence complex made practical sense – capacity built by previous federal grants made the grantees better qualified applicants for federal funding – but it also was an outcome in keeping with a federalised American political system that implemented policy through devolution and privatisation rather than through centralised planning. Even during an era of massive government expansion, American fears of 'big government' remained. While the expansion of the state was readily evident to anyone observing the huge military installations and government laboratories of the Cold War era, an even more fundamental and long-lasting state expansion came more stealthily, through the government contracts that turned private industries and universities into sites for military research and development. This pattern of devolved and indirect policymaking is a hallmark of American political culture, and it helps to explain why observers have often failed to recognise the extent of public-sector influence on the development of Silicon Valley and places like it.

However, not all American cities with defence economies, university communities and suburban locations managed to become Silicon Valley. If the first part of the explanation here is the economic opportunity created by national defence and infrastructure investments, the second is the way in which these opportunities were seized by those on the ground. Devolving and privatising policy implementation made the American state-building process into one that was simultaneously top-down and bottom-up, and some firms and institutions were better equipped to become policy actors than others. Home-grown assets – some deliberately cultivated, others accidental strokes of luck – were crucial in allowing the San Francisco peninsula's people and institutions to maximise the economic benefits of the new Cold War order.

Stanford University stands at the centre of this dimension of Silicon Valley's story, a place presented with remarkable new opportunities but also seizing these chances in ways that radically changed it, within and without. Entrepreneurial university administrators, most notably Stanford's Dean of Engineering (later its Provost) Frederick E. Terman and its long-serving President, Wallace Sterling, presided over a transformation of the institution from regional respectability to international prominence – and a huge volume of federal research dollars.

After a wartime stint working in Washington, Terman had returned to Palo Alto with a determination to expand Stanford's physics and engineering programmes and a new appreciation of the benefits of government-sponsored science. He made some frank comparisons with other institutions in a 1943 letter to a colleague: 'The years after the war are going to be very important and also very critical ones for Stanford. I believe that we will either consolidate our potential strength, and create a foundation for a position in the west somewhat analogous to that of Harvard in the East, or we will drop to the level somewhat similar to that of Dartmouth, a well thought of institution having about 2 per cent as much influence on national life as Harvard.'[14] Not having the Washington ties of the elite universities of the eastern US, Stanford established a lobbying office in the nation's capital in

1945 to build new government contacts and win important contracts that gradually elevated its political stature and academic reputation.[15]

Terman's approach to building Stanford's research capacity demonstrated a pragmatic and market-minded approach to academic research that reflected the university's (then rather bold) openness to profit-making partnerships with private enterprise. He had some disdain for scholars who stayed isolated from the non-academic world –'going to seed' was one way he chose to describe it – and felt that research could advance knowledge regardless of whether it took place in a university or in a commercial laboratory.[16] Terman did not consider basic research as being above applied research; he seemed to sense early on that the postwar economy would be driven by 'the exploitation of science by industry' and that universities could profit from this.[17]

The pragmatism and entrepreneurial sympathies of Stanford's administrators allowed them to grasp quite quickly the degree to which the university as an institution was becoming a more potent force in American cultural and economic life. Their postwar approach to building Stanford's reputation focused not only on strengthening certain of its academic departments, but on making them more conducive to the promotion of innovation and entrepreneurship, working in concert with the private sector and with government. Federal grants and contracts not only contributed to the national defence effort, Terman and his cohorts reasoned, but these funds also served as seed money for industrial innovation. At Stanford, the commercial potential of academic science was celebrated and encouraged to a degree that was sometimes found excessive by certain members of the faculty. But it proved to be immensely valuable to the university in the long run, particularly in financial terms.[18]

Stanford also sought to beef up its postwar reputation by aggressively recruiting faculty from the Ivy League colleges of the East. Good pay, plentiful research dollars, strong ties with high-tech industry, a good climate and natural amenities, and a pleasant, family-oriented community were all powerful selling points in luring talented junior professors to Stanford. The exodus that resulted from the university's recruitment effort was noticeable enough by 1961 to merit an article in *Newsweek*, in which one new professor was quoted as saying that he left Harvard to come West 'because interesting things are happening … there's excitement in the air.'[19] Through these strategies, over the course of the 1950s Stanford's income from federal grants and contracts rose steadily, from less than $2 million in 1951 to $8.3 million in 1960.[20] Within fifteen years of the end of the Second World War, Stanford had launched itself into the elite ranks of major Cold War research universities, ranking just behind Harvard and MIT in its receipt of federal research dollars.

Stanford was not alone among American universities in reorganising itself to create what Terman called 'steeples of excellence' in the sciences and engineering during the early Cold War decades. However, it did possess one asset that no other university of its calibre had: suburban real estate. This home-grown asset played a catalytic role in making Silicon Valley into the high-tech centre it became, and into an international model for what a modern community of science should look like.

The university's founders, the Gilded Age railroad baron Leland Stanford and his wife Jane, had deeded thousands of acres of surrounding countryside to the school on the condition that the land could be leased for other uses, but never sold. Stanford's land grant was immense and unmatched by any other major American university; as one contemporary magazine article observed, its acreage was one-third the size of the City of San Francisco, and two-thirds the size of the island of Manhattan.[21] Before the Cold War era, Stanford's landholdings had been of little financial benefit. But as the orchards and farms of the peninsula turned into affluent suburban subdivisions, the land's value changed dramatically, and the university

embarked on an ambitious land development programme. While building scores of residential subdivisions might have been the easiest and most immediately remunerative development strategy, Sterling, Terman and other administrators had more high-flying goals in mind. They recognised that California's defence economy was fundamentally changing the industrial profile of the metropolitan region and that the San Francisco peninsula was particularly well situated. Stanford's presence clearly served as a significant draw for the inventors and scientific entrepreneurs moving to the peninsula, and the presence of such industry was immensely valuable to students and recent graduates of the university's science and engineering programmes. As Terman noted, 'location near a center of brains … is more important than location near markets'.[22] With that in mind, in the early 1950s Stanford developed an industrial park for scientific industry on a part of its lands adjacent to the main campus, easily accessible from new highways, and close to the suburban neighbourhoods where white-collar workers lived.

This was no ordinary industrial development, however. While 'industrial parks' were on their way to becoming a common feature of the American suburban landscape by the mid-fifties, Stanford's administrators decided that the university's park would be one with higher architectural and planning standards, highly selective in its tenants, and designed specifically to be a home for the advanced scientific industries that desired proximity to Stanford's 'brains'. To those ends, the university instituted stringent architectural and planning restrictions on the front end, and reserved the right to approve or disapprove of any alterations to the facilities. Many of the features of the park are now common practice in various types of commercial parks across the US and the globe: wide setbacks from the street, green lawns and landscaping throughout, low-rise modern construction, hidden parking, regular tenant maintenance of clean buildings and grounds.

Stanford's choice to develop its land sought not simply to create isolated and unconnected real estate developments, but to form a 'community of scholars' that would be a centre for scientific production and innovation. In order to do this, Stanford administrators – the same men who were simultaneously building up the scientific community within the university – employed architecture and community design to accomplish social and cultural ends. Like other landowners, Stanford may have got into the real estate development business because it saw the opportunity for a quick profit, but its administrators also saw that the university could provide an alternative to the sprawling and unplanned suburban tracts growing up across the Californian landscape during the postwar era. As a real estate developer, Stanford saw itself as an important counterbalancing influence; because the university owned so much land, its choosing to develop carefully and sparingly would preserve land values over the long term. Interestingly, a university whose leadership often embraced entrepreneurial, free-market economics not only eagerly accepted large amounts of federal grant monies but also saw that comprehensive planning (of the kind usually practised by the state) could be a way to control social and economic outcomes.

The architectural and landscape standards employed at what would eventually become known as the Stanford Research Park were intended to make the place more than merely a high-class industrial development, but a space where form deliberately disguised industrial function. Some tenants chose to articulate their connection and proximity to the university campus through architecture that evoked the colonnaded sandstone of Stanford's main quadrangle; others chose to blend into the residential landscape around the park by incorporating the modern and distinctly Californian suburban ranch-house architecture. The architecture and design of the park reflected its creators' belief that the new scientific and high-tech industries of the Cold War age were a dramatic departure from what had come before. Such industry was 'smokeless', not dirty, and its workers were not only white-collar professionals but

scientific people of exceptional creative abilities. Discussions of workers in the park often played off the prevailing stereotypes of scientists as quirky but brilliant. Discussing his park facility, one executive quipped: 'we don't have any set working hours for our scientists … If a man works better from midnight till morning it's all right with us. We're working with gifted individuals and we try to encourage them to have bright ideas. We don't care what time of day they have them.'[23]

In mandating such high standards for its tenants, Stanford violated nearly every cardinal rule of economic development. 'We didn't know what the hell we were doing', one Stanford leader admitted to a group of real estate developers in 1958. 'If we knew how hard it was to get industry, that you've got to give tax exemptions, cheap labor and free buildings, we probably wouldn't have tried.' But instead of struggling to find tenants, university officials found that companies were very interested in coming to the park. 'We were as tough as we could be,' the administrator said, 'and we couldn't discourage them.'[24] By the late 1950s, the development's tenants included the headquarters of Hewlett-Packard and Varian Associates, and research arms of major aerospace and electronics companies like Lockheed and General Electric. As Stanford's administrators had predicted, companies were drawn by the proximity to defence installations, the many natural and community amenities, and by the growing concentration of scientific minds working at Stanford and its spin-off companies. The *San Francisco Chronicle* echoed Fred Terman in noting that 'one of the greatest single attractions for the new – and highly desirable – smogless, light industries that make exotic products is brains. The electronics and missile industries as well as the less novel, more familiar varieties, must have a large pool of deep thinkers from which to draw new ideas, push ahead of competitors in the mad research scramble.'[25]

The desires of scientific workers to be near communities of other scientists and be in places with the right amenities for them and their families gave the Stanford park a huge advantage in luring industry, as it was located in the sort of community that offered all these advantages. The campus-like look and feel presented an additional plus for firms who were attempting to lure workers away from university jobs and into industrial research. By locating in the park, firms could potentially have their pick of some of the best scientists and engineers in the country – not only faculty but Stanford graduates as well. The particularly Californian atmosphere, communicated through architecture, planning, and the internal culture of the entrepreneurial and innovative young companies that populated the park, also was a compelling asset in an era when the Golden State was the favoured destination for so many migrants.[26] By 1960, Stanford's effort had been so successful and so influential upon its neighbours that the local newspaper editor commented: 'The research centers of the Midpeninsula, with their architectural buildings and landscaped lawns, look more like college structures than factories. In fact, I've seen many college buildings, and attended classes in a few, that resembled those factories of old more than do the industrial plants of today.'[27]

An added incentive for businesses to move to the park was the close relationship they and their employees could have to Stanford. The businesses that leased land in the park gained access to Stanford faculty and laboratory facilities, as well as the cachet of the Stanford name. These opportunities included an honours cooperative programme that offered company employees part-time enrolment towards advanced degrees in scientific disciplines. 'The program is fully self supporting through a combination of the tuition paid by the students and supplementary grants made by the participating companies', Terman noted in 1959. 'This is also a good deal for the employer on the San Francisco Peninsula because it is such an attractive fringe benefit that, with this to offer, the employer is able to recruit the cream of the crop graduating from colleges all over the country in a market which is highly competitive for men.'[28]

The honours cooperative programme complemented another ingenious fundraising tool, the 'Industrial Affiliates Program' of the Department of Aeronautical Engineering. Companies like Lockheed paid $10 000 annually for the privilege of being Industrial Associates, getting in return an enhanced relationship with the researchers at Stanford and, again, the cachet of a close affiliation with the university.[29] Ancillary benefits like these increased tenants' allegiance to Stanford and resulted in additional revenue through corporate donations. High-technology companies, who benefited most from access to Stanford's faculty and research laboratories, were the most willing to give, and this in turn influenced the university's choice of tenants for the Stanford Research Park.

The research park's success was also related to the fact that industry and white-collar employment was already in the process of decentralising significantly in the 1950s. While the university was the first to introduce a planned industrial development into Palo Alto, there already was abundant evidence that jobs were following people out into the northern California suburbs. By the early 1960s, the region's population had suburbanised to a degree that the ratio of population between the suburbs and the core cities (San Francisco and Oakland) was 'well over' two to one, noted one local survey.[30] Regional decentralisation was mirrored in business decentralisation within suburban towns as well; a 1960 publication found that 'even in suburban communities some dispersion of trade and service establishments is taking place in accordance with the trend in the entire Bay Area toward a broader distribution of economic activities'.[31]

The commuting patterns of Stanford Research Park employees attested to the shifting live–work patterns in the metropolitan area. A 1962 survey showed that the majority of the park's 10 500 employees did not live in San Francisco nor the immediate mid-peninsula area but commuted from communities south of Palo Alto. Employees overwhelmingly depended on cars to get to work, an outcome perhaps unsurprising given the restrictions on mobility put in place by the design requirements of the park, which despite their numerous specifications on setbacks and landscaping made no mention of sidewalks.[32] They also might have raised some warning signals about the ability of high-tech employees to find or to afford housing in the immediate area. Because of developments like the Stanford Research Park, Silicon Valley was on the leading edge of the trend towards living in one suburb and working in another. The residential and commuting patterns seen in the 1962 survey also presage the later housing shortages that would face the San Francisco Bay area, particularly Palo Alto, where by the end of the twentieth century few professionals could find available and affordable places to live.

Over time, there were many firms that eventually grew up in Silicon Valley that had little, if anything, to do with Stanford. Some of the Valley's greatest early innovators were neither Stanford graduates nor tenants of its industrial park. Yet Stanford – in its internal transformation and its external land development schemes – was a key driver of Silicon Valley's growth by creating unprecedented kinds of partnerships between industry and university that capitalised on and fully leveraged the scientific resources of the Cold War. Without Stanford, high-tech industry may have made a home in the San Francisco peninsula, but the size and extent of its innovation and influence would have likely been much smaller.

Importantly too, the Stanford Research Park – and the university–industrial partnerships associated with it – set a standard by which future efforts to build scientific communities would be measured. By the beginning of the 1960s, the people, institutions and places that made up the scientific community of the San Francisco peninsula had become a widely recognised model for high-tech economic development strategies under way in other parts of the US and the world. As other local economic development authorities embarked upon their

own schemes for industrial development – high-tech and otherwise – they repeatedly invoked Stanford and Silicon Valley. The Stanford Research Park itself was a feature in the American exhibit at the 1958 Worlds' Fair in Brussels. During a visit to the US in 1960, Charles de Gaulle specifically asked to see the park; other foreign dignitaries followed. Economic development officials from Scotland to Japan proposed research-park building schemes that alluded to the Stanford example. This process of imitation solidified a long growing association between science based economic development and a low-rise, low-density environment in the minds of public policy makers and business leaders. Whether in cities or in rural areas, the developers of these new-style communities of science felt that they had to be similarly exclusive and suburban in look and feel in order to replicate what one observer had drily labelled 'the miracle of Palo Alto'.[33]

Yet in their enthusiasm to develop high-tech centres of their own, Silicon Valley's imitators could easily fall into emphasising style over substance; their efforts focused on replicating the low-rise aesthetics and amenities of the Stanford Research Park and other elements of Silicon Valley's built environment rather than fully reckoning with the institutional structures that underlay it. Few of the area's imitators, then or now, have recognised the historically-specific political and economic assets that allowed Silicon Valley to grow and thrive: huge public investments in science and engineering professions and related industries, a desirable suburban location in an era of mass suburbanisation, a major research university with large and undeveloped landholdings at its disposal, political and economic institutions that supported innovation and entrepreneurship. The degree to which Cold War investments and suburban location functioned as an advantage becomes clear by comparing Stanford's case with those of peer institutions located in regions of the US with fewer Cold War defence investments, with campuses in economically declining city neighbourhoods, and with business cultures that were less hospitable to small start-up companies.

Harvard and MIT, both located in the Boston metropolitan area, provide a good case in point. Although the two institutions were by far the most prestigious and largest federal grantees during this Cold War period, both were located in dense city ~~neighbouhoods~~ NEIGHBOURHOODS with little available land on which to build research parks or other kinds of industrial facilities. Located on the eastern seaboard, Boston had neither the volume of defence-related industry of California (although it had a MORE THAN respectable amount), nor financial or corporate institutions that were as entrepreneur-friendly as those in California. Smart young engineers looking to make their mark on the technology world may have fared better by leaving the bureaucratic culture of Boston for the more nimble and networked environment of Silicon Valley. While a significant high-tech corridor emerged along Route 128, on Boston's outskirts, the large firms that dominated its landscape were less able to weather the vicissitudes of the technology marketplace and less quick to innovate than their counterparts in California.[34]

Outside of the Boston example, a good number of other elite research universities embarked upon science-focused economic development efforts as a means by which to 'save' these surrounding neighbourhoods from economic deterioration and racial change. Yet in doing so these institutions met with what one observer described as 'frustration after frustration'.[35] The research park form, with its low density and functional exclusivity, was ill suited to denser and more diverse urban neighbourhoods. Unlike the ease with which Stanford and its peer developers in Silicon Valley could build new industrial facilities on undeveloped open acreage, establishing a research park on already occupied urban land often involved significant regulatory hurdles and daunting, racially charged political problems.[36]

In the last three decades of the twentieth century, private capital replaced public defence

R&D spending as the major funding source for US high-tech industry, but the competition for coveted high-tech companies and workers did not diminish. Significant high-tech clusters emerged in Asia, Europe and Latin America, their growth driven not only by the globalisation of American companies but also the emergence of homegrown firms managed by native-born talent. As the global high-tech economic base expanded and diversified, the Silicon Valley-style research park became a prerequisite to any effort to build a high-tech economy. The sandstone buildings and red tile roofs of Stanford and its adjacent research park were themselves inspired by the Spanish mission architecture of colonial California, but the frequency with which these architectural motifs appear in research parks elsewhere in the world indicate a deliberate attempt on the part of local promoters to evoke the look and feel of Silicon Valley.

The appropriation of these architectural traditions has become one way for growing high-tech clusters in other nations to communicate their credibility as high-tech producers. Yet the globalisation of the low-density, space-eating research park ~~brings replicas~~REPLICATES a form that is, at heart, a means of disguise. The park is a bucolic setting for industrial activities that not only have a sharply polarised workforce – a white-collar professional class that rests at the tip of a very large iceberg made up of a vast workforce of blue-collar employees – but that also often pollute the parkland on which they sit. Silicon Valley, filled with research parks heralded as 'clean' and 'smokeless', has one of the United States' highest densities of 'Superfund' sites, designated as highly polluted by the US Environmental Protection Agency.[37]

Yet the international reinterpretations of Silicon Valley's scientific community have often differed in two important respects. The Valley itself developed as a result of a complex bundle of public and private forces, its success as a development type fostered in part by the fact that it was planned in a decentralised and privatised manner. Government financing may have had a lot to do with the American geography of knowledge and the ascendance of Silicon Valley as the nation's pre-eminent high-tech community, but this influence was often indirect and *sub rosa*; there remains little awareness among the high-tech entrepreneurs who populate these spaces that public policy played a role in the development of these industries and the places that house them. In contrast, research park development overseas has often been a public-sector project, with national and regional governments acting as major sponsors of research park construction and sometimes retaining management control for the duration of the development, from construction to tenancy and beyond.[38]

The fundamentally different political and economic structures underlying would-be Silicon Valleys in other countries beg a question: is it possible to create comparably productive scientific and technological ecosystems without the rather unique – and distinctly American – political underpinnings that benefited Silicon Valley in the early Cold War era? Are there comparably large streams of capital available, and is the disbursal of this capital flexible enough to allow for maximum innovation by firms and institutions? Are there on-the-ground local assets on which a region can build a distinctive and intellectually vibrant scientific economy? These questions must be kept in mind by any region embarking on the quest to build a community to rival Silicon Valley, and they must also take into account the often indirect and unseen, but incredibly important, role of the public sector in this market success.

NOTES

1. Robert Metcalfe, as quoted in G. Gromov: 'The view from Internet Valley', *Infoworld*, 2 March 1998.
2. P. G. Audia and C. I. Rider: 'A garage and an idea: what more does an entrepreneur

need?', *California Management Review*, 2005, **48**, (1), 6–28; J. Seely-Brown: 'Foreword', in *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region*, (ed. M. Kenney), xvi; 2000, Stanford, CA, Stanford University Press.

3. For more on the early history of Silicon Valley, see C. Lecuyer: *Making Silicon Valley: Innovation and the Growth of High Tech, 1930–1970*; 2006, Cambridge, MA, MIT Press; G. Matthews: *Silicon Valley, Women, and the California Dream: Gender, Class, and Opportunity in the Twentieth Century*; 2003, Stanford, CA, Stanford University Press; M. Kenney (ed.): *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region*; 2000, ~~Standford~~STANFORD, CA, Stanford University Press; R. Lowen: *Creating the Cold War University: The Transformation of Stanford*; 1997, Berkeley, CA, University of California Press.
4. Address to Congress, 6 September 1945, quoted in 'Appendix to report from the Subcommittee on War Mobilization to the Committee on Military Affairs, United States Senate pursuant to S. Res. 107 (78th Congress) and S. Res. 146 (79th Congress) authorizing a study of the possibilities of better mobilizing the national resources of the United States', Washington, DC, US Government Printing Office, 1945, 1.
5. National Science Foundation: 'Federal funds for research, development, and other scientific activities', Washington, DC, US Government Printing Office, 1972, 3.
6. 'Scientific progress, the universities, and the federal government', statement by the President's Scientific Advisory Committee, 15 November 1960, Washington, DC, US Government Printing Office, 11.
7. Worry about competition in science played out in the national media as well, with publications warning that Soviet schools and universities were 'grinding out double the number of technically trained people that ours are producing' ('Why the White House worries', *Business Week*, 27 January 1962, 82–83). For more discussion of the expansion of federal education and defence programmes, and the changes in the political role of American scientists and American universities, see chapters 1 and 2 of M. P. O'Mara: *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley*; 2005, Princeton, NJ, Princeton University Press; J. Wang: *American Science in an Age of Anxiety: Scientists, Anticommunism, and the Cold War*; 1999, Chapel Hill, NC, University of North Carolina Press; D. J. Kevles: *The Physicists: The History of a Scientific Community in Modern America*; 1995, Cambridge, MA, Harvard University Press; S. W. Leslie: *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford*; 1994, New York, Columbia University Press. For discussion of one key educational expansion, the National Defence Education Act of 1958, see B. Barksdale Clowse: *Brainpower for the Cold War: The Sputnik Crisis and National Defence Education Act of 1958*; 1981, Westport, CT, Greenwood Press.
8. 'Farewell radio and television address to the American people', 17 January 1961, in *Dwight D. Eisenhower, containing the public messages, speeches, and statements of the President, 1953–61*; 1961, Washington, DC, US Government Printing Office.
9. See K. Starr: *Embattled Dreams: California in War and Peace, 1940–1950*; 2002, New York, NY, Oxford University Press; R. W. Lotchin: *Fortress California, 1910–1961: From Warfare to Welfare*; 1992, New York, NY, Oxford University Press; B. J. Schulman: *From Cotton Belt to Sunbelt: Federal Policy, Economic Development, and the Transformation of the South, 1938–1980*; 1991, New York, NY, Oxford University Press.
10. 'Federal support of research and development at universities and colleges and selected nonprofit institutions, fiscal year 1968', National Science Foundation, Arlington, VI, 69–

33, 15–17.

11. For further discussion see M. P. O'Mara: *Cities of Knowledge*, pp. 75–95 (see Note 7).
12. For discussion of highway programmes and financing, and the spatial consequences for cities, see M. Rose: *Interstate, Express Highway Politics, 1939–1989*, rev. edn; 1990, Knoxville, TN, University of Tennessee Press; K. T. Jackson: *Crabgrass Frontier: The Suburbanization of the United States*; 1987, New York, NY, Oxford University Press. For in-depth discussion of tax incentives for suburban commercial construction, see T. Hanchett: 'U.S. tax policy and the shopping center booms of the 1950s and 1960s', *The American Historical Review*, 1996, **101**, 1082–1110. The suburban bias of infrastructure provision is discussed in M. Orfield: *Metropolitics*; 1997, Washington, DC, Brookings Institution Press.
13. J. F. Levy: 'San Francisco Bay region industrial study: final confidential report to the Executive Committee and the Technical Advisory Committee', 28 January 1946, San Francisco, CA, San Francisco Bay Area Council, 18; 'Census of population: 1960, volume i, characteristics of the population, part 6, California', 1961, Washington, DC, US Government Printing Office, Table 5.
14. F. E. Terman: letter to Paul Davis, 29 December 1943, FF2, Box 1, Series I, SC 160, Stanford University Archives.
15. E. Keister: *Donald Tresidder, Stanford's Overlooked Treasure: A Biography of the University's Fourth President*, 70–74; 1992, Stanford, CA, Stanford Historical Society. The most comprehensive account of Stanford's internal transformation is R. Lowen: *Creating the Cold War University* (see Note 3); see also S. W. Leslie: *The Cold War and American Science* (see Note 7).
16. F. E. Terman: 'Administrative policies and objectives of research in engineering colleges', *Journal of Engineering Education*, 1947, **38**, 281–285.
17. R. Henle: 'Oral history interview with Frederick E. Terman, Ph.D.', Stanford, 17 January 1970, 19–20, 0900/TERM/1971, Stanford University Archives.
18. Stanford fostered innovation among its students and faculty, and in return it reaped the benefits of commercially marketed inventions. One of these was the klystron microwave tube invented in the 1930s and licensed to Sperry Gyroscope Company. Stanford had a steady stream of income from this invention well into the 1950s. In fiscal year 1955 the total royalties paid to Stanford by Sperry were over $83 000; in 1956 they were nearly $90 000 (T. W. Ford: memorandum to Alf E. Brandin, 15 November 1955, 5. FF 5, Box 12, Series III, SC 160, Stanford University Archives; undated and unsigned memorandum (presumably by same author), 29. FF 5, Box 12, Series III, SC 160, Stanford University Archives). For extensive discussion of the klystron and Stanford's sometimes difficult relationship with Sperry, see R. Lowen: *Creating the Cold War University*, pp. 37–42 (Note 3).
19. 'Deck the halls with ivy', *Newsweek*, 20 February 1961, 59.
20. Stanford University's Actual Budget 1951–58, quoted in 'Background data for a discussion of Stanford University's financial needs for the next ten years', Special Meeting of the Board of Trustees on Planning and Development and Finance, 10 October 1959. Subject File 228 (VP Finance), Stanford University Archives.
21. F. O. Baker: 'City on the campus', *Saturday Evening Post*, 31 December 1955, quoted in 'Stanford building a model city to cost 20 millions', *Corona Independent*, 3 January

1956, Stanford Lands Scrapbook I, 1950–55, Subject File 1300/9, Stanford University Archives.

22. F. E. Terman: 'Higher education and training in a research community', in *Research and the Community*, 13–14; 1962, Albany, NY, Department of Commerce, State of New York.
23. R. K. Sanford: '"Think tanks" contain far-out ideas', *Kansas City Times*, 21 June 1961.
24. M. Wax: 'Stanford park – weird success', *San Francisco Chronicle*, 16 November 1958.
25. 'Brains are bait', *San Francisco Chronicle*, 18 June 1961.
26. The California climate was a factor often emphasised by Stanford administrators, park tenants and the press (see for example 'Stanford bringing old vision to life', *Los Angeles Times*, 25 March 1956). The actual climatic advantages of this sunny and temperate region were further magnified by the prominence of the state in American popular culture during this period, when the television and radio airwaves were dominated by quintessentially Californian icons like the Mouseketeers, Gidget and the Beach Boys. See K. Granat May: *Golden State, Golden Youth: The California Image in Popular Culture, 1955–66*; 2002, Chapel Hill, NC, University of North Carolina Press.
27. A. Bodi: 'Memo from the Editor: they're different now', *Palo Alto Times*, 17 February 1960.
28. F. E. Terman: 'Education for growth industries', paper prepared for San Francisco Regional Technical Meeting of the American Iron and Steel Institute, 6 November 1959, FF 60, Box 1, Series X, SC 160, Stanford University Archives.
29. Various memoranda, FF1, Box 38, Series III, SC 160, Stanford University Archives.
30. San Francisco Bay Area Council: *Economic Guide to the Bay Area*, 1961, San Francisco History Center, San Francisco Public Library.
31. M. Scott: 'The San Francisco Bay Area: a metropolis in perspective', quoted in *Trends*, 1960, 53, San Francisco History Center, San Francisco Public Library.
32. The office parks and industrial 'campuses' that became the prevailing form of suburban commercial development by the end of the twentieth century demonstrate the influence of many of Stanford's design requirements, among them being the lack of sidewalks. This of course particularly disadvantages low-income workers who may not have access to a private car and take public transport to work. See M. Pugh: *Barriers to Work: The Spatial Divide Between Jobs and Welfare Recipients in Metropolitan Areas*; 1998, Washington, DC, Brookings Institution.
33. 'Pilgrimage held to "miracle of Palo Alto' site', *Berkeley Review*, 20 July 1961. For more on the Stanford park's international audience, see M. P. O'Mara: *Cities of Knowledge*, pp. 127-132 (see Note 7).
34. A. Saxenian: *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*; 1994, Cambridge, MA, Harvard University Press.
35. University of Pennsylvania official Jean Paul Mather, described in 'Dr. Mather's summing up', Editorial, *Philadelphia Evening Bulletin*, 26 June 1969.
36. See chapters 4 and 5 of M. P. O'Mara: *Cities of Knowledge* (see Note 7).
37. See US Environmental Protection Agency, National Priorities List, www.epa.gov/superfund/sites/npl/ca.htm (accessed 10 March 2006). Two compelling

recent monographs address the labour inequities in the high technology industry, G. Matthews: *Silicon Valley, Women, and the California Dream* (see Note 3) and S. J. Pitti: *The Devil in Silicon Valley: Northern California, Race, and Mexican Americans*, esp. 173–201; 2002, Princeton, NJ, Princeton University Press.

38. See T. Bresnahan and A. Gambardella (ed.): *Building High-Tech Clusters: Silicon Valley and Beyond*; 2004, Cambridge, Cambridge University Press.

Margaret O'Mara (momara@stanford.edu) is Deputy Director of the Center for the Study of the North American West and Acting Assistant Professor of History at Stanford University. She served previously in the White House and the US Department of Health and Human Services as a political aide and policy analyst, working on healthcare, welfare and urban economic development programmes. Her research interests include metropolitan growth and industrial suburbanisation, universities and urban economic development, and politics and governance in the twentieth century North American West. She is the author of *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley* (~~2004~~2005, Princeton University Press).