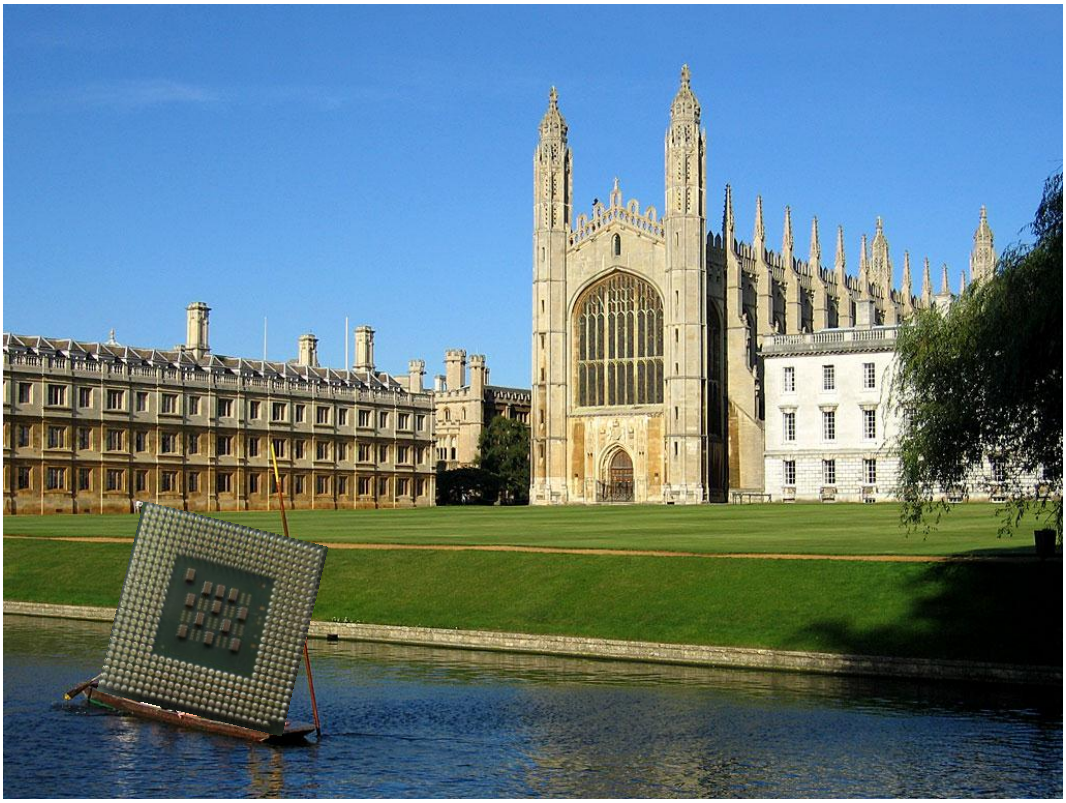
IT Hardware cluster: Cambridge, United Kingdom



Final Paper

Microeconomics of Competitiveness, Harvard Business School

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[*] Required disclosures: Three of the five team members are British citizens, no non-public information has been used in preparing this report, no member of the team has travelled to Cambridge during the project period.

Executive summary:

This paper examines the competitive positioning of the IT hardware cluster in Cambridge, United Kingdom. We find that despite the continued presence of a number of global firms, such as the processor designer ARM, the cluster is struggling to reach the scale or sophistication to be competitive. We identify that the cluster's niche focus on R&D because of a lack of cost competitiveness for basic assembly and manufacturing has prevented it from achieving substantial employment growth. We also identify financing constraints which have made it difficult for successful start-ups to grow.

While the UK provides a relatively strong place to do business more generally, we find that recent macro-imbalances have undermined growth prospects for small and medium sized firms both because of a shortage of capital due to deleveraging and because of concerns about inflation. This has exacerbated underlying low productivity growth over the last decade which we find was linked to a weak innovation infrastructure and low business investment rates.

We make a number of recommendations to upgrade the competitiveness of the cluster, including that the UK government reconsider its abolition of the Regional Development Authorities which has deprived the UK of the tier of government best placed to foster cluster competitiveness. We further recommend that Cambridgeshire County Council take on a more active role in improving local infrastructure and relaxing planning regulations to allow the cluster to grow. We also recommend that the leading IFC in the cluster, Cambridge Enterprise, establish contracts for collaboration with relevant parties to increase R&D expenditure and to build stronger linkages with London VC funds so as to increase access to growth capital.

Table of Contents:

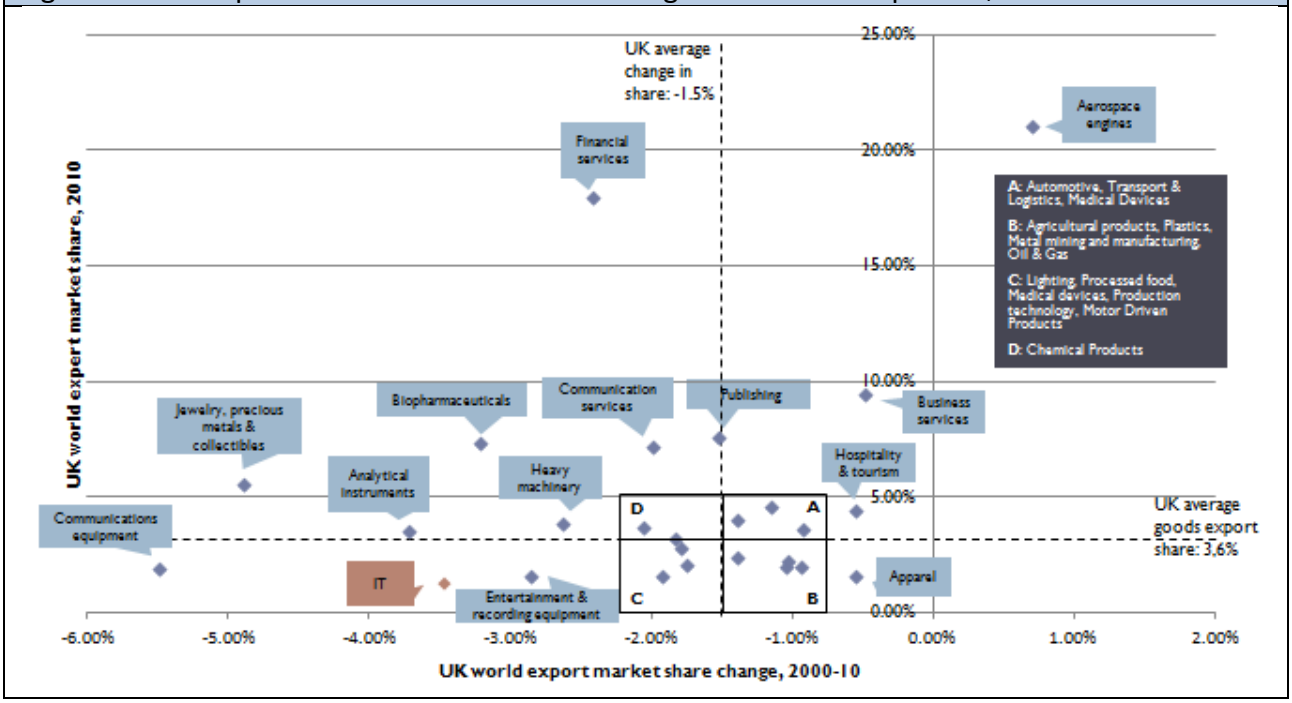
List of figures:

1. United Kingdom economy and competitiveness:

1.1. Overview of United Kingdom economy:

A EU member state, the UK has a flexible economy with strong and stable political and legal institutions as well as world-leading universities. The UK is open to FDI and has seen significant inflows of investment in recent years. It has also seen substantial immigration, particularly from the new Eastern European EU members. However long-standing problems with productivity remain; business investment in R&D lags competitor nations and infrastructure bottlenecks inhibit development. The economy suffered during the financial crisis and is still deleveraging.

Figure 1 – UK exports value share and share change 2000-10 for exports >$5b in 2010[1]



The UK economy is heavily services dominated; services have increased from 74% to 78% of GDP between 2002 and 2010.[2] Unsurprisingly, given London's reputation as a leading financial center, financial services and business services are particularly important contributors.

This is also reflected in the UK's export portfolio (see Figure 1): financial services are the sector (apart from aerospace engines) in which the UK has the biggest share of global exports at around 18%.[3] Pharmaceuticals and business services are also important sectors. Export performance has been disappointing in recent years and the UK's total share of world exports declined by 1.5% between 2000 and 2010. Despite a surplus in services trade, the overall balance of trade has been over 2% of GDP for most of the past decade.[4] A strong currency may have partially contributed to this contraction, however despite sterling weakening by around 25% since 2008, export growth has not improved suggesting wider competitiveness problems.

1.2. UK macroeconomic performance:

Figure 2 – UK economic performance 2000-2011[5]

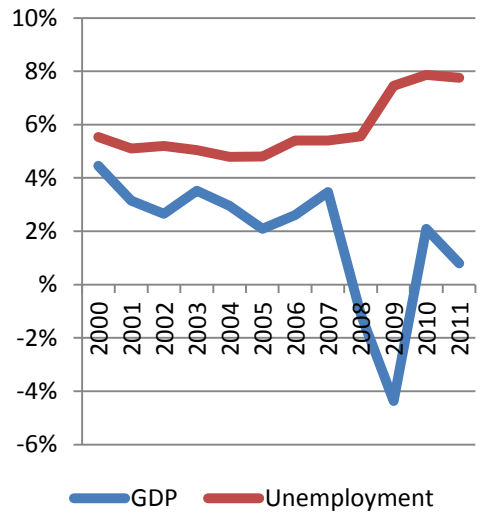
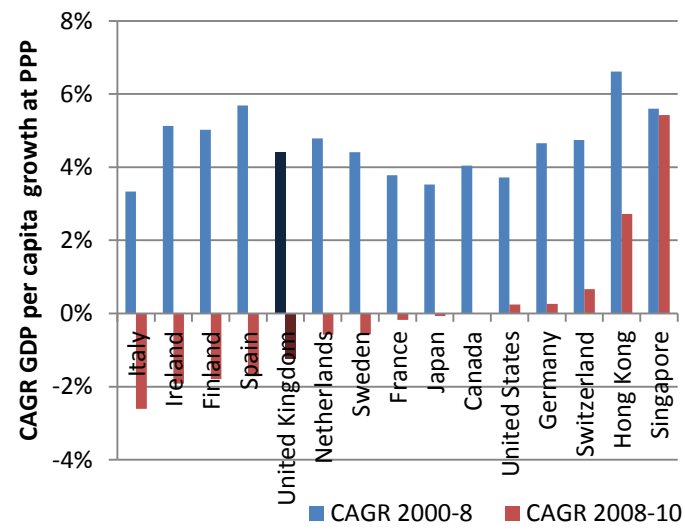


Figure 3 – UK growth pre and post crisis[6]



Between 2000 and 2010 the UK grew by an average of 3.2% per year.[7] This was around the average for advanced economies: above US rates but below Germany. Until 2008 UK unemployment was consistently lower than in the Eurozone, at around 6% on average (see figure 2).[8] But the UK was hard hit by the financial crisis. Growth fell by over 2% in 2008. Apart from the peripheral European economies suffering from the sovereign debt crisis, the UK has

had one of the weakest growth performances in Europe since the onset of the crisis (see figure 3). High debt levels leading to deleveraging across the public, private and financial sectors continue to restrain growth. Total combined debt now exceeds 450% of GDP – the highest ratio among the major economies (see figure 5).[9] Public sector austerity programs combined with private sector deleveraging and a weak external export environment are depressing growth prospects, and recovery has been slower with the UK reentering recession in Q12012. Unemployment has risen to over 8%, and is especially high amongst the young and unskilled.[10] Social unrest has been visible, most notably during the riots of summer 2011.

1.3. Competitive analysis:

1.3.1. National endowment:

The UK is geographically well positioned near the core of European economic activity, and benefits from a time zone between the US and Asian markets. The English language is also a major strength. The EU provides important market access to major trading partners and the UK also benefits from historic global ties including to South Asia, Africa and Australasia. London is a leading global city and a magnet for talented migrants, tourists and students.

The UK's major natural resource endowments are now being exhausted. The major finds of North Sea oil and gas discovered in the 1980s are now past their peak in terms of production.[11] In contrast with the 1990s, The UK is now a net importer of energy. However, the long coastline and windy weather conditions means that the UK is relatively well positioned for investment in renewable energy sources like wind.

1.3.2. Social Infrastructure and Political Institutions (SIPI):

With regard to Social Infrastructure and Political Institutions, the UK generally slightly underperforms for a country with its GDP level. Inequality, as measured by the gini coefficient, at 0.34 is substantially higher than the OECD average.[12] Disparities in educational attainment, poor performance in some healthcare metrics and high incidences of social problems result in a poor score for the UK on the UN Human Development Index where the UK ranks 28th overall.[13] Despite, the presence of world-class universities like Oxford and Cambridge, the UK also performs below OECD average in basic education as measured by PISA averages.[14]

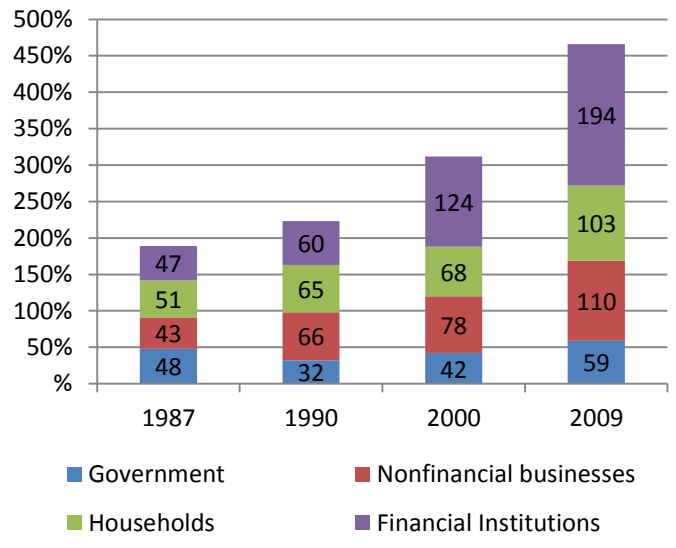
1.3.3. Quality of National Business Environment:

According to the World Bank's Doing Business indicators, the UK business environment remains competitive with peer nations and was ranked 7th overall in 2012 (see figure 4). However, there has been some slippage in performance since 2011 with declines in some categories. Registering property and getting electricity are key weaknesses.

Figure 4 – World Bank 2012 Doing Business Rankings[15]

	Rank
Overall	7
Starting a business	19
Construction permits	22
Getting electricity	60
Registering property	68
Getting credit	1
Protecting investors	10
Paying taxes	24
Trading across borders	13
Enforcing contracts	21
Resolving insolvency	6

Figure 5 – UK debt as % GDP across sectors[16]



Until the financial crisis, UK macroeconomic policy was widely admired on account of low and stable interest rates, and a low debt to GDP ratio in comparison with major European economies. However, since the crisis the outlook for UK macroeconomic policy has deteriorated faster than any other single indicator: the UK has slipped 28 places since 2001. Large structural deficits revealed by the crisis mean that a prolonged period of public austerity will be required to return the budget to a sustainable position. Low interest rates indicate that investors retain confidence in UK public finances for now, but this cannot be assumed.

1.3.4. State of Cluster Development:

Clusters help drive competitiveness across three dimensions. They help spur increases in the level of productivity with which firms operate; they raise the capacity for innovation; and they foster new business formation. The UK has strong clusters in financial services and business services which collectively comprise just under 20% of total exports by value.[17] Other notable clusters include bio-pharmaceuticals, transport and logistics and aerospace engines (see Figure 1). The national government presently lacks a cluster oriented development strategy although some specific efforts are being made to spur a renewal of hi-tech manufacturing. Strong regions and regional institutions are often associated with competitiveness.[18] The recent abolition of Regional Development Authorities, which previously spent £1.3bn per year on skills and business development strategy, risks removing the level of government best placed to support cluster development.

1.3.5. Sophistication of Company Operations and Strategy:

Success depends on high quality, innovative management. UK companies have access to sophisticated international management but business investment and uptake of managerial

practices lag competitors. Particularly relevant for the IT industry is the innovation system. This has some considerable strengths when compared to European competitors. For instance, human capital as measured by new doctorates scored 147 to an EU average of 100, likewise access venture capital scored at 243. However, there are weaknesses in the introduction of innovations in SMEs and in intellectual assets such as patent applications.[19]

1.4. National Diamond Analysis:

Figure 6 – UK National Diamond Analysis

Factor input conditions + World-class educational and research institutions + Flexible labor markets ± Immigration policy making recruitment harder ± Mixed educational outcomes − Underinvestment in key infrastructure	**Context for firm strategy and rivalry** + Sophisticated legal and regulatory institutional structures + Open to trade and foreign investment ± IFCs underdeveloped in some sectors − Competition insufficient in certain key sectors e.g. retail banking
Related and supporting Industries + Diversified economy with sophisticated business services sector − No institutional structure for regional economic cluster policy − Lack of support for business investment and research	**Demand conditions** + Sophisticated consumers in both national and international markets ± Regulatory standards high, though in some cases risk stifling activity − Lack of active government involvement in upgrading and introducing technology

1.5. Key issues facing UK competitiveness:

Several key issues are preventing the UK from being more competitive:

- **Lack of Institutions for cluster development** – To reduce public spending the government recently announced the abolition of regional development agencies. This, however, may mean the absence of an institutional locus for cluster development and competitiveness policies going forward.

- **Low levels of business investment** – The UK has traditionally had low business investment rates, especially in R&D.[20] Business investment post-crisis has been especially low at only around 10% of gross financial expenditure in 2011, the lowest since 1955.[21]
- **Skill levels** – Despite the presence of world-class universities and research institutions, the UK is lagging peer nations in basic skills development. The UK placed 34th in rankings of reading attainment at primary level.[22]

As a result of these weaknesses, productivity remains lower than in most major competitor countries (see Figure 7). Although the UK managed to close the gap with France, Germany and the US up until 2004, since then catch up has ceased (see Figure 8).[23]

Figure 7 – GDP per worker, 2010 (UK=100)[24]

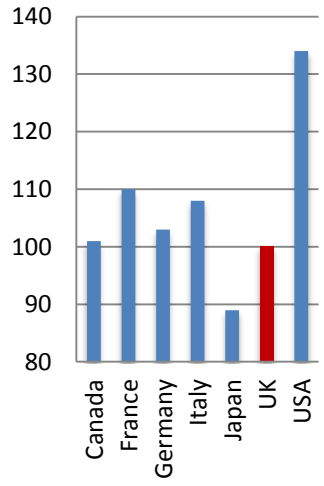
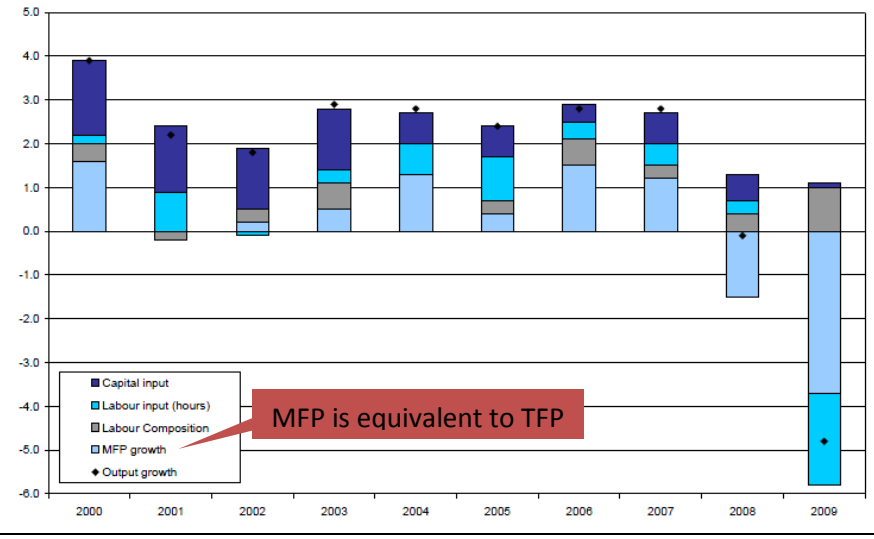


Figure 8 – Decomposition of annual output growth for the whole economy, 2000-9[25]



2. Overview of East of England and Cambridge:

The East of England contains around 5.8m people (11% UK population) and is the third wealthiest part of the United Kingdom after London and the South East.[2627] The region has historic roots in agriculture but has also attracted significant light manufacturing since the Second World War despite the overall decline in UK manufacturing.

Figure 9 – East of England population density by local authority, 2005[28]

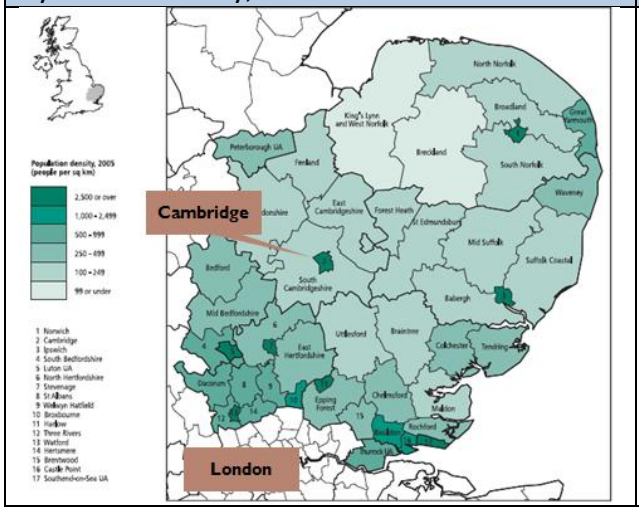
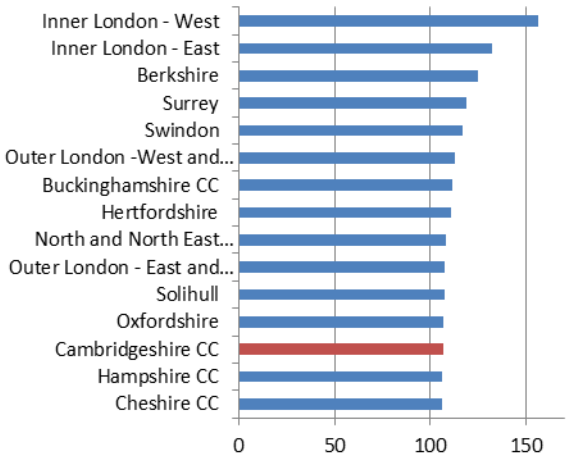
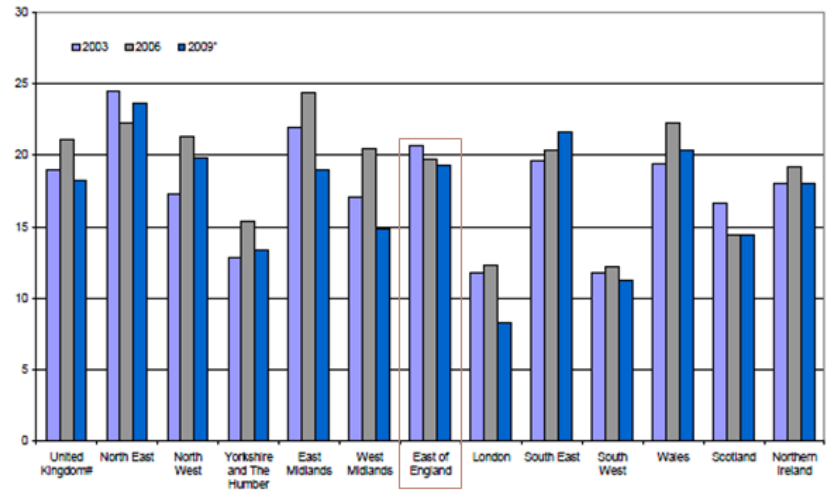


Figure 10 – Gross Value Added per hour worked –top English sub-regions, 2008 (UK = 100)[29]



Cambridge is a major town in the East of England (see Figure 9) and is approximately 75 minutes by train from London and has a population of around 125,000.[30] The Cambridge sub-region is one of the most productive sub-regions in the UK (see Figure 10). The University of Cambridge is the heart of the sub-region, and as the fifth best university in the world provides access to world in high R&D spending; businesses in the East of England have historically spent around 3.2% of GDP on R&D compared to a UK average of only 1.7%.[31] While the East of England number is high compared to national averages in the US of 2.3% and Germany of 2.6%, it is low compared to states with strong university-industry links like Massachusetts (5.5%) and California (4.2%).[32]

Figure 11 – Value of total export goods as % workplace Gross Value Added by NUTS1 region, %[33]



Despite this significant level of R&D spending, only 20% of the Gross Value Added in the East of England is generated by producing export goods (see Figure 11), roughly in line with the UK average. This is driven in part by relatively high labour costs (even if labour has above average skills) and high land and housing costs. Cambridgeshire average house prices are £234k compared to a UK average of £228k. Houses in the city of Cambridge itself average £318k.[34] When compared on a ratio of house price to salary basis Cambridgeshire is one of the most expensive places to live in the UK.[35] Industry reports that accessing land for light industry and assembly is also difficult due to high cost.[36] There is also consensus that transportation infrastructure could be improved, in particular by widening the A11 dual carriageway and improving road access to the West. Public transport could also be strengthened to improve 'backwards' commuting from London to the Cambridge Science Park area by extending the London-Cambridge rail link

The UK's highly centralized government means that local councils have limited scope to change their business environment, however planning and transport policy are areas over which Cambridgeshire County Council has significant influence. The council also has a small Inward Investment team which seeks to attract FDI.

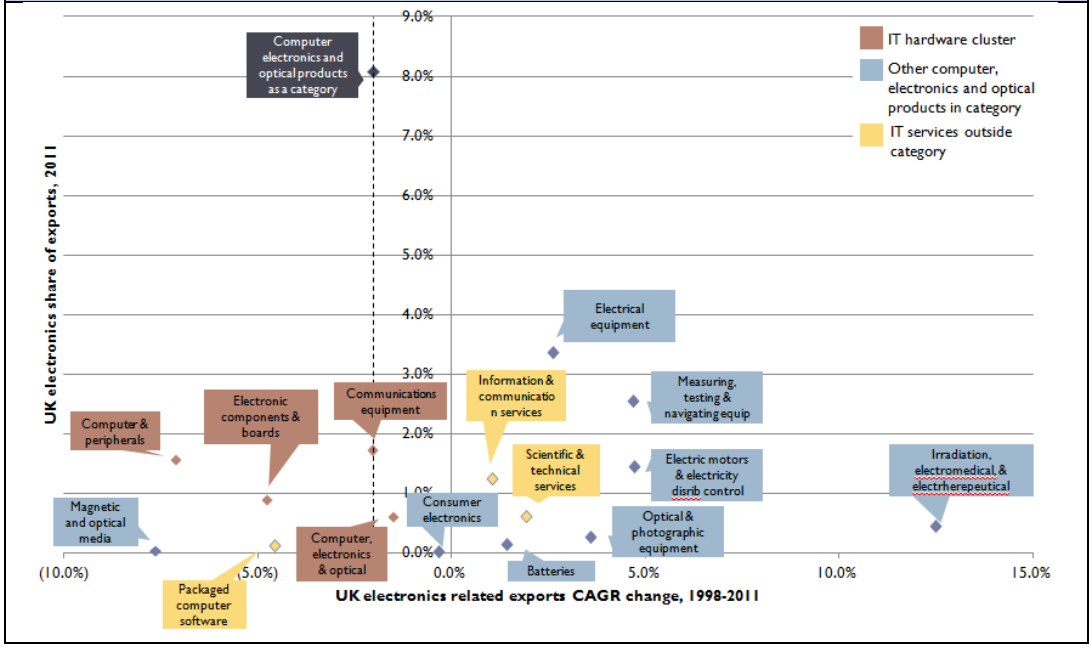
3. Competitiveness of the Cambridge IT Hardware Cluster

3.1. Overview of IT hardware sector:

The IT hardware sector is made up of three sub-sectors (see Figure 12). All three sub-sectors have been researched, developed, manufactured or assembled in and around Cambridge over the course of the history of the cluster. For example, in the late 1970s and early 1980s Eicon Research Limited produced the floppy disk drive components for the Apple II, '1' Limited developed the world's first truly digital computer speaker, and Acorn produced finished computer.[37] At a national level, recent performance has been weak in all three sub-sectors (see Figure 13).

Figure 12 – Product categories of IT hardware

Figure 13 – UK export performance of IT hardware, IT services and other computer electronics, 1998-2011[38]

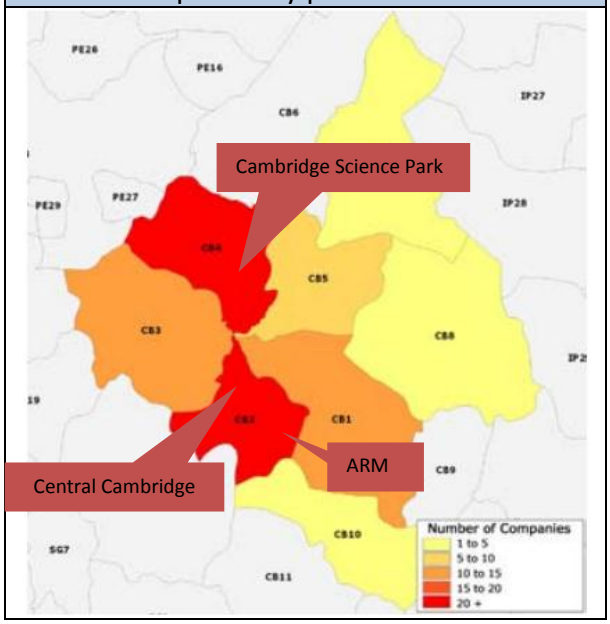


3.2. Overview of Cambridge IT hardware cluster:

3.2.1. Introduction to cluster:

The IT hardware cluster in Cambridge emerged in the 1970s around the Cambridge Science Park (see Figure 14) and continued to grow, in fits and spurts, until the dot-com bubble of the early 2000s, from which it eventually recovered. Since its inception, it has depended on the University of Cambridge as a source of ideas, talent, and even premises since the Cambridge colleges built science and industrial parks on their own land holdings.

Figure 14 – Density of Cambridgeshire VC backed companies by postcode[39]

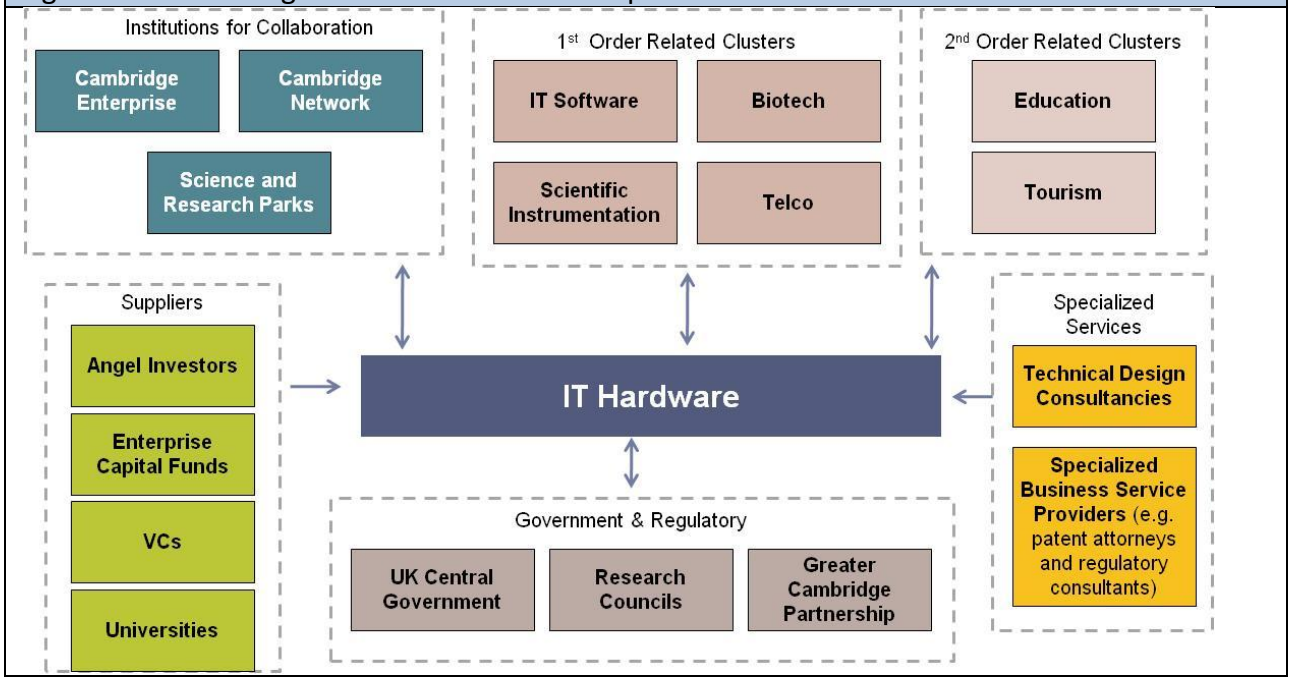


In the last decade assembly operations have increasingly been outsourced while design and research has remained in Cambridge (see Figure 15). Leading sub-component manufacturers include ARM and CSR. Related industries like software have gained prominence, resulting in increased competition for the key inputs of talent and capital.

Figure 15 – IT hardware value chain

3.2.2. Cluster map:

Figure 16 – Cambridge IT Hardware Cluster Map

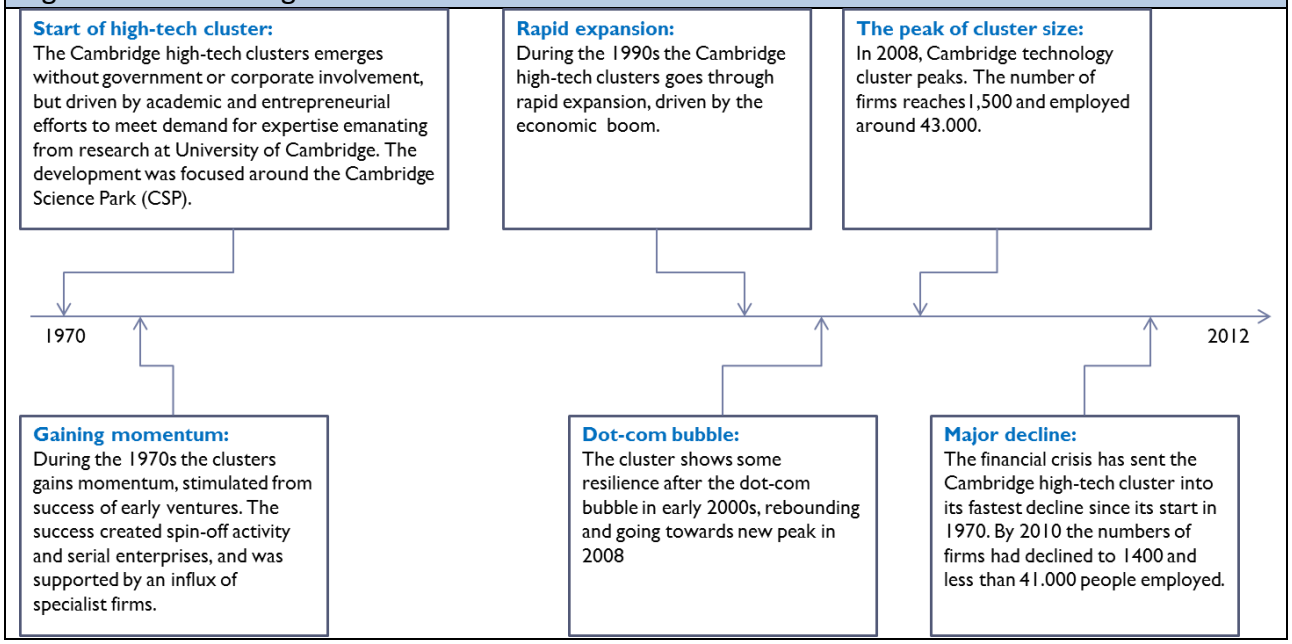


The Cambridge IT hardware cluster has organizations in each of the expected areas (see Figure 16), with government and regulatory being the only area where support is weak. Some of the Institutes for Collaboration have stepped in to fill this void, with Cambridge Enterprise being a key partnership between public and private sector bodies. Other key institutes for collaboration include Cambridge Network, a local networking organization, and the many local science and research parks. Related clusters have helped the cluster to build the critical mass necessary for a funding ecosystem to develop, and have also been a key source of talent and intellectual property. The cluster has a number of suppliers of capital, critical to the development of early stage companies, and specialized services including technical design consultancies and providers of specialized business services.

3.2.3. History and timeline of cluster:

Cambridge University has long been a centre of science and technology. Spin-offs from the university such as Cambridge Instruments date to the 1920s. During the Second World War major research into computer hardware took place at Cambridge. However it was not until the Labour government under Harold Wilson and its industrial policy that structure was put around the Cambridge cluster. The Mott Report of 1970 recommended that the university develop a science park on the edge of the city. The Cambridge Science Park became the linchpin for a wave of start-up spaces and industrial facilities on the edge of Cambridge which were the heart of the cluster. It was during the late 1970s and early 1980s that the area was nicknamed 'Silicon Fen' in recognition of the large number of IT hardware companies that had been created. The 1990s saw continued growth, but despite surviving the Dot-com collapse, the cluster has struggled to survive since the 2008 financial crisis (see Figure 17).

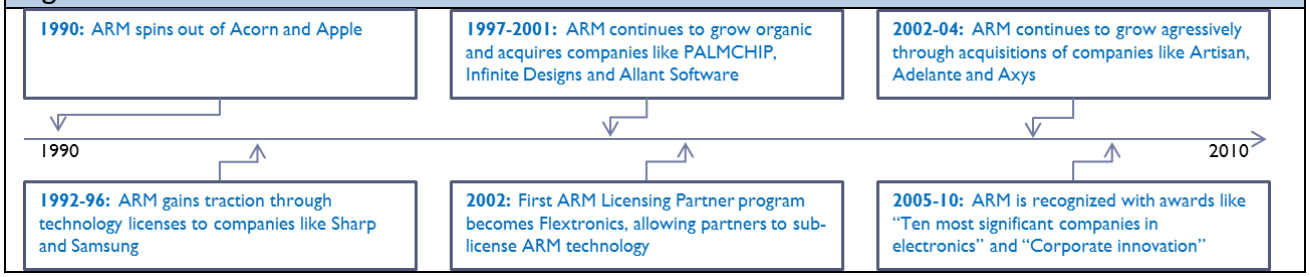
Figure 17 – Cambridge IT Hardware Cluster Timeline



3.2.4. Example of core participants in cluster:

While several IT hardware companies from the cluster have had global success for a time, ARM is arguably Cambridge's greatest success story (see Figure 18). ARM's largest businesses are in processors, and system-on-a-chip infrastructure.

Figure 18 – ARM Timeline



The majority of ARM's revenue comes from licensing of processor designs to third party manufacturers for use in tablets and smartphones. ARM has no significant proprietary manufacturing facilities. Most research and administration is still based out of Cambridge, however they have expanded beyond the UK to reach additional human talent and to develop overseas sales presences. ARM growth has been heavily based on acquisitions, which has limited the impact of their growth on the Cambridge cluster (see Figures 19 and 20).

Figure 19 – Total ARM, Autonomy, CSR and Domino (largest 4 firms) job impact on Cambridge[40]

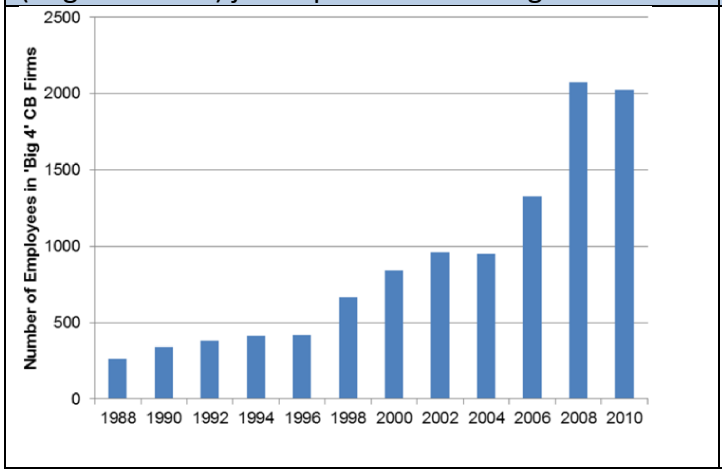
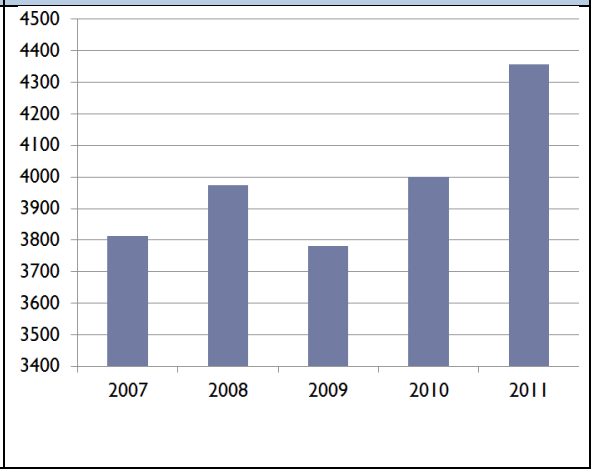


Figure 20 – Total ARM and Domino jobs worldwide[41]



3.3. Cluster diamond analysis:

Figure 21: Cambridge Cluster Diamond Analysis

Factor input conditions + University of Cambridge provides world-class talent pool + University also ensures pipeline of ideas that can be commercialized ± High quality of life attracts talented workers but cost of living is a problem ± Underdeveloped venture capital presence but three active angel investors and two Enterprise Capital Funds − High labor costs lead to outsourced manufacturing	**Context for firm strategy and rivalry** + Developed and established IFCs − Lack of regional government or other sub-national actor limits policy responsiveness to cluster's concerns
Related and supporting Industries + Established software cluster + Presence of scientific instrumentation cluster + Telco cluster in Cambridge + Emerging biotech cluster + Advanced specialized business service providers ± Presence of limited number of technical design consultancies	**Demand conditions** + Internationally-adopted standards mean Cambridge-developed innovations are valuable to buyers worldwide − Few major IT MNCs have operations nearby, making it harder for small firms with innovations to access the major players (Apple, Dell, Hewlett-Packard, etc.)

3.3.1. Factor conditions:

The University of Cambridge, as well as being the genesis of the cluster, has an important continuing role as a provider of highly trained human capital and market-ready innovations. Indeed, many of the cluster's most successful firms stem directly from work undertaken at the university. Retaining talent in the Cambridge area, however, remains a challenge, in part because of London's strong pull due to its outsized role in Britain's economic and cultural life. Although the quality of life in Cambridge is high, costs are comparable to the capital, reducing the area's attractiveness. Also on the labor side, the cost of employing low-

skilled employees is such that virtually no manufacturing takes place in Cambridge, leading to R&D and assembly functions being separated by thousands of miles. Finally, Cambridge has an underdeveloped venture capital scene, making access to capital difficult for many firms. Recent attempts to improve access to capital have been met with only limited success.

3.3.2. Context for Firm Strategy and Rivalry:

The cluster's institutions for collaborations (IFCs) are well established and provide plentiful opportunities for firms to establish partnerships and share best practice. One notable weakness is government's small role in creating a favorable context for the cluster, since regional government is not in place in the East of England and the cluster attracts little attention from central government.

3.3.3. Demand Conditions:

The primary customers for the cluster's products are IT hardware manufacturers, a market dominated by a small number of global players, none of whom has a meaningful presence in the cluster. However, because the industry's standards are global and products integrated, innovations developed in Cambridge can seamlessly be transferred to overseas firms, compensating for the absence of domestic demand.

3.3.4. Related & Supporting Industries:

Cambridge plays host to a number of related clusters, each of which is well established. Software firms have a long presence in the area, as do designers of scientific instrumentation and telecoms hardware. Biotech is also a growing presence in the area. Each of these sectors relies heavily on hardware and, linked through cross-cutting IFCs, there is considerable

integration between the sectors. They also share similar policy concerns, allowing them to band together and speak with a louder voice in front of central government. Supporting industries have a well developed presence, most particularly in the professional services sector, which is highly developed in the London region; key industries include law (including patent law) and finance. Another important set of players is the reasonably extensive network of Technical Design Consultancies (TDCs), although their numbers are well below competing clusters like Silicon Valley or Greater Boston.

3.4. Cluster performance analysis:

Over the last 20 years, the Cambridge IT Hardware cluster has been very successful. However, the last few years of financial crisis have sent the overall cluster into decline.

Strengths:	Weaknesses:
• Major university at its center, constantly generating new ideas and skilled workers • Established brand name and reputation • Location: part of southeast England super-region; 60 miles from London • High quality of life and attractiveness to high-skilled labor	• Access to finance: less VC activity than strongest competitors • Relocation: firms have been moving to Silicon Valley/ Boston once they reach a certain size • High cost of living • Lack of transportation capacity; high congestion • Absence of regional government limits coordination and policy flexibility

3.4.1. Cluster performance data:

The IT Hardware cluster has diminished, which in recent years can be seen especially in the number of firms. This fell from ~900 in 1996 to less than 500 in 2010 (see Figure 22). While employment remained strong, driven by growth of successful companies like ARM, CSR and Domino, few new companies have been introduced in IT hardware since 2003 (see Figure 23).

More growth has been seen in adjacent clusters like biotechnology and pure R&D, with limited spillover benefits to the IT hardware cluster.

Figure 22 – Employment in IT hardware sector[42]

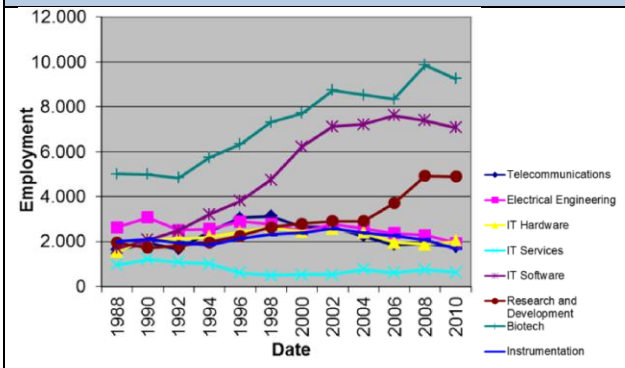
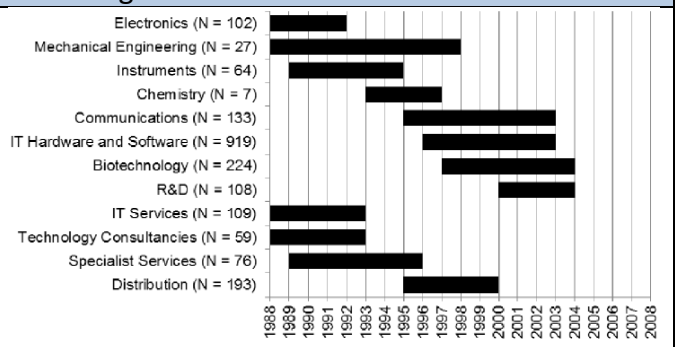


Figure 23 – Company start / entries in Cambridge[43]



Another indicator of vitality in the cluster has been the number of firms reaching sufficient scale to need outside financing either through an IPO or through being acquired (see Figures 23 and 24). Of particular note is that CSR and ARM have made acquisitions of other Cambridge IT hardware cluster firms which suggest strong ties within the cluster.

Figure 23 – Acquired firms[44]

Year of acquisition	Target company	Acquirer	Acquisition value (£m)
2008	nCipher plc	Thales plc	51
2007	Cambridge Display Technology plc	Sumitomo Chemical	142
2005	I2 Ltd	ChoicePoint Inc	53
2005	UbiNetics	CSR plc	27
2005	Apama Ltd	Progress Software Corporation	14

Figure 24 – IPOs[45]

Year of IPO	Company	IPO value (£m)
2007	Sepura plc	99.54
2004	Cambridge Display Technology	142
2004	Cambridge Silicon Radio (CSR) plc	434.45
2004	Arnino Technologies plc	31.8
1998	ARM Holdings plc	1,424.60
1985	Domino Printing Services plc	325.25

3.5. Role of policy, Finance and IFCs:

3.5.1. Policy conditions:

Government involvement in the Cambridge cluster has been weak, as the UK has no regional government. While the Wilson government may have given impetus to the formalization of the cluster in 1970, UK central government largely took a laissez-faire policy once the cluster was in place. The greatest contribution made by the central government was the relaxation of certain rules on the acquisition of British companies by foreign firms. Historically, new small-size enterprises received limited support from large British enterprises. Access to foreign capital was therefore key to the development of these enterprises, and this was enabled by the more relaxed regime.

Another important contribution from central government came in the form of research councils. These are bodies are responsible in the UK for investing public money to "advance knowledge and generate new ideas which lead to a productive economy, healthy society and contribute to a sustainable world". In 1986, UK universities were granted the rights to the intellectual property arising from work funded by the research councils. The University of Cambridge was unusual in vesting this entitlement to inventors on its staff and did not prevent faculty members from developing commercial applications or starting new businesses as long as they carried out their teaching and research duties. This decision was critical to the development of many new startups in Cambridge, and indeed to the development of the cluster itself. [50]

Finally, although there is no strong regional government in the UK, in Cambridge, the Greater Cambridge Partnership emerged to fill the void. The partnership was formed with the

aim of bringing together local firms and community groups to help develop business in the area. Among its key activities was sourcing funding for infrastructure critical to the development of the cluster.[51]

3.5.2. Universities conditions:

The two Cambridge based universities, the University of Cambridge and Anglia Ruskin University, play an important role in the cluster, between them educating over 49,000 students. While both universities provide a significant undergraduate resource, the University of Cambridge is especially valuable in providing postgraduates, with almost 11,000 postgraduate students, 6,635 of which are undertaking research only degrees. This provides a highly skilled labour pool that can feed into the companies in the Cambridge cluster, as well as providing a source of entrepreneurs who may end up forming companies of their own.[47]

The income from universities can also be used towards academic research which helps to increase the knowledge-base of the cluster, and new technologies which can be commercialized through licensing or the creation of new companies. The formation of many companies active in the Cambridge IT hardware cluster can be traced back to the Computer Laboratory or Department of Physics at the University of Cambridge – companies like Acorn, ARM and ANT draw heavily on an understanding of microelectronics developed at these facilities.[47]

3.5.3. Finance conditions:

Cambridge has a reasonably well developed financing system, however sources of capital become more difficult to come by as investment size increases. At the early stage level,

Cambridge is in the advantageous position of having three main angel groups to provide financing.

NW Brown manages the GEIF Ventures Early Growth Fund, a £5m co-investment fund that invests in promising early growth businesses. Since it was founded in 2003, GEIF Ventures has invested in 22 companies, mostly within the healthcare, life sciences and information technology sectors. They invest an average of £70,000 per funding round (thereby meeting a critical need for companies requiring smaller chunks of capital). Their key investments in IT Hardware include Inkski, a novel printing technology that has the potential to overcome the limitations facing both inkjet and offset printing and create a new revolution in digital printing, and Artimi, a developer of ultra wideband chips. [47]

Cambridge Capital Group has made 25 investments, mostly in technology and lifesciences, many of which have been University of Cambridge spin-outs. Their key investments in IT Hardware include Gen Drive, a company that has developed groundbreaking, real-world technology that is able to capture energy from any renewable power source and then feed that energy into the grid. [47]

Cambridge Angels, which was established in 2001, have invested over £11.5m in 33 start-up companies, primarily in the hi-tech and biotech sectors. Their recent investment s include Neul, developers of the world's first, and as of now only, fully FCC compliant white space wireless system. [47]

Cambridge is also a great location for companies seeking "in between" amounts of capital (i.e. more than angel investors can provide, but amounts that are too small to pique the

interest of VCs). Enterprise Capital Funds (ECFs), two of which are in Cambridge, were set up by the government to address the market weakness in providing funding to SMEs. These vehicles use government money alongside private sector funds, to target investments of ~£2m. Only five funds were set up initially, so it is a significant coup for Cambridge to have two of them (the "IQ Capital Fund" and the "Amadeus and Angels Seed Fund")[47]

There are only 2 VCs located within Cambridge itself, Amadeus Capital and DJF Espirit, however the cities close proximity to London means that local firms can also avail of the larger financing ecosystem there. [47]

Amadeus Capital invests across the technology spectrum in industries that include communications and networking, media, e-commerce, computer hardware and software, medtech, and cleantech. The firm was started in 1997 and manages £460m in a portfolio of around 40 companies. They are an investor in Cambridge Silicon Radio, one of Cambridge cluster's biggest success stories. DJF Espirit manages a portfolio of 35 companies. It has $500m of capital under management and invests in technology, media, telecoms and cleantech. [47]

3.5.4. IFC conditions:

Cambridge has a long history of Institutions for Collaboration, and these were critical to the development of the cluster.

Science and research parks provide space for new start-ups side by side with more established firms, helping the development of the new firms and allowing them to take full advantage of the clustering effect. Two of the most important of these are Cambridge Science Park and St. John's Innovation Center. Cambridge Science Park was founded by Trinity College in

1970 as an incubator for spin off companies. It was the first of its kind in the UK and was home to over 100 companies. St. John's Innovation Center was founded in 1987 by St. John's College and is home to over 60 companies. The incubator provides management support in addition to premises and also offers conference facilities and a rented address to 265 other companies without permanent space onsite.[47]

Another important institute for collaboration is Cambridge Network, a networking organization for business people and academics working in technology fields in the area. It boasts 1300 member organizations, as well as a number of individuals, and is entirely funded by membership subscriptions and sponsorship. Its key activities and benefits of membership include: access to discounts on products and services; more than 40 networking events per year; a Linkedin group for referrals and discussions; the region's most visited website for jobs, news and events; a comprehensive directory of company profiles; the Cambridge Corporate Gateway - an information website dedicated to matching external organization's technological requirement to companies in the Cambridge area; and a learning ecosystem where local companies can pool training resources. [47, 49]

The final key institute for collaboration is Cambridge Enterprise, a wholly owned subsidiary of the University of Cambridge responsible for commercialization arrangements for university discoveries. The organization operates in three areas: technology transfer services, consultancy services and provision of pre-seed and seed stage funds for members of the University of Cambridge. [48]

3.5.5. Specialized services:

The main source of specialized services in the cluster is the technical design consultancies. Major consultancies include Cambridge Consultants, TTP, Sagentia and the PA Consulting Group. These firms provide a breeding ground for entrepreneurship, as technology innovators are developing products from concept through to market success. They typically engage in prototyping and small-scale production as well as in an advisory role. In additional to technical design consultancies, the cluster also has an ecosystem of patent attorneys and other providers of specialized services of importance to the IT Hardware cluster. [36]

3.6. Related clusters:

A number of what we call first order related clusters are present in Cambridge. These include IT Software, Biotechnology, Scientific Instrumentation and Telecommunications. The most significant contribution of these related clusters is that they provide critical mass to enable a VC ecosystem and other support services to develop in the cluster. There is also some talent transfer between clusters. [47]

We term tourism and education second order related clusters, however they are also vital to the development of the IT hardware cluster. The education cluster, as outlined above, provides a key source of intellectual property and human capital. Also because of the tourism cluster, Cambridge is a more attractive place to live than many other UK cities of comparable size. Significant investment has been made in improving the city centre environment (e.g. in the Grand Arcade retail district and in leisure amenities around the old cattle market site) and cultural offerings (inc theatres, concerts, festivals etc.) are more diverse than in other cities of similar size [47, 36]

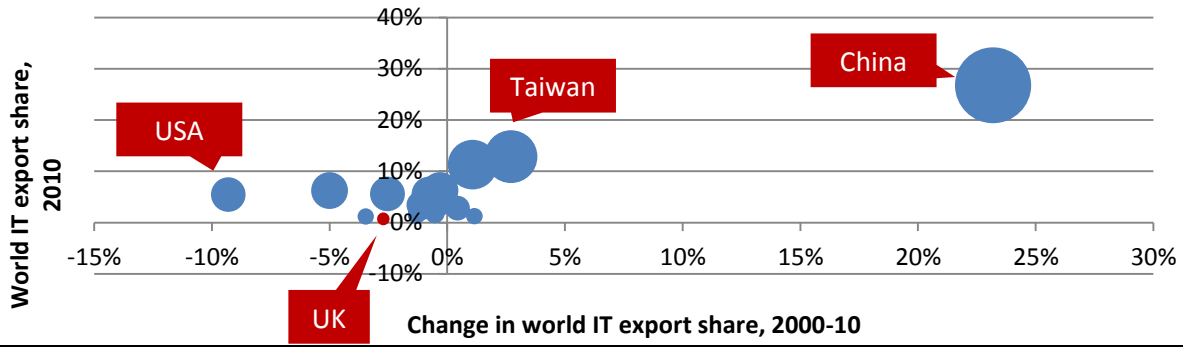
London, as a neighboring location of many important clusters, is also critical to the success of the Cambridge IT Hardware cluster. In many respects, Cambridge shares London's labour market and this is a source of tremendous competitive advantage. Firstly, London provides a more vibrant living environment. Certain people would be impossible to recruit if they were forced to live outside a major city – reverse commuting allows Cambridge based start-ups to continue to recruit people for whom the buzz of living in London is a major draw. Secondly, London gives Cambridge based companies access to additional specialized skills. Some areas of expertise, such as in highly specialized disciplines of marketing or management, are next to impossible to source locally in Cambridge. [47]

Cambridge also benefits from London's highly developed transportation cluster (5 major airports, high speed rail link to Paris and Brussels) which facilitates quick and easy access to suppliers, customers, investors and talent located overseas (e.g. in Silicon Valley). Finally, Cambridge benefits significantly from London's financial cluster. Although Cambridge does have two local VCs, the financial sector in the UK is very London centric with the vast majority of VCs operating there. [36]

4. Description of competing clusters:

Measured by global export share, the IT hardware industry is now dominated by low-cost assembly locations, notably China and Taiwan (see Figure 25). In the short-term, however,

Figure 25 – World IT export shares[46]



these Asian clusters are likely to remain focused on assembly rather than design: they are therefore not Cambridge's direct competitors. This may change over the medium term as China in particular benefits from technology transfer and increasing investment in domestic R&D.

However, for the time being, Cambridge's primary competitors are the U.S. and European clusters that conduct significant IT R&D. The foremost among these by a considerable distance is Silicon Valley, which includes more IT hardware companies, employees, venture capital activity and IFCs than any other. Below Silicon Valley is a second tier of IT hardware clusters that includes more meaningful comparators (see Figure 26). Many of these have been successful in integrating both R&D and assembly in one cluster location.

Figure 26: Comparing Cambridge to its competitors

Cluster	Key segment(s)	Performance and competitiveness
Silicon Valley	Strength across high-tech industries	Much more developed in all the key areas (size, access to capital, depth of talent pool, IFCs, reputation) giving it an unmatched competitive position across IT sub-sectors

Boston/ Rte 128	Biotech, robotics	High VC presence, strong talent pool, and number of university spinoffs have created highly-developed R&D sector and very competitive firms
NC Research Triangle	Hardware, Software, pharma	Presence of numerous large firms (IBM, GE, Glaxo, Pfizer) gives cluster a very different feel to Cambridge; absence of top-10 global university is a weakness although strong talent pipeline from further afield
Eindhoven-Leuven-Aachen	Systems and materials	Strong expertise in IT hardware for the automotive industry combined with sustained government support have provided critical mass; unclear if cluster can grow beyond its current (small) size
Sophia-Antipolis	IT, biotech, aeronautics	Europe's largest technology park, S-A lacks a top-10 global university and generates fewer start-ups but attracts inward investment at much higher rates

4.1. Risks facing the cluster:

The Cambridge IT hardware cluster is at a critical point; it was already struggling to maintain momentum going into the 2008 financial crisis and took a major hit during that period. Despite the booming global success of ARM, the smaller start-ups that the cluster relies on to grow and thrive have been facing challenges growing and accessing finance. It is also not clear if the R&D-focused strategy of most of the firms operating in the Cambridge cluster today is sustainable over the medium-long term in the face of rising global competition. Just as China and Taiwan have consolidated assembly and manufacturing, it is likely that through technology transfer and skill upgrading be in a position to lead on R&D as well.

The Cambridge cluster needs to pre-empt these macro shifts by upgrading its competitiveness. In particular it needs to address the challenge of its small size and its lack of success in attracting a significant number of MNCs to establish their primary R&D centres in the cluster. It also needs to identify which niches of component production might still be appropriate for manufacturing in the cluster.

The cluster also faces challenges with its labour supply, both in terms of rising wages and in terms of skill shortages. Both of these challenges are being exacerbated by central government caps on skilled non-EU immigration which is bidding up wage rates for IT engineers. However there is an underlying challenge that many young engineers are opting for software training instead of hardware, and courses at technical universities are adjusting to meet this demand. The cluster has few on-the-job apprenticeship programs to fill this gap directly.

Even where firms are able to find talent and a niche in the R&D space, they are struggling to grow to scale in part because of challenges with finance. While London has a reasonably strong VC network, the Cambridge cluster is often ineffective at accessing it. Deleveraging by banks across the UK has made them unwilling to lend to SMEs in general and many firms in the Cambridge cluster are finding debt financing difficult.

The lack of government support for the cluster is also a challenge, in particular given that the abolition of the Regional Development Agencies has left regional development strategy in unclear hands. Government has provided no overall strategy for competitiveness beyond deficit reduction and tax cuts for businesses. Given that these policies have not translated into greater lending to businesses or dealt with the underlying problems of high costs and poor infrastructure a change of approach is needed.

Finally on the local level, Cambridge is an increasingly expensive area both for workers and for firms to operate in. High land prices, an unwillingness to relax planning regulations, and inadequate transport infrastructure are challenges to the growth of the cluster.

5. Recommendations for the cluster:

Challenge	Priority	Timing	Recommendation	Resp. actor
Cluster is too small	High	ST	Integrate Cambridge IFCs with similar bodies in London and Oxford to create a 'Golden Triangle' super-cluster	Cambridge Enterprise
Successful companies' local growth have been limited (e.g., ARM)	High	ST	Work more closely with companies like ARM, Domino and CSR to understand what they need to expand locally given their global growth	Cambridge Enterprise
Limited VC funding	High	ST	Build stronger links between London based VCs and Cambridge	Cambridge Enterprise
Immigration cap blocks entry of skilled workers	High	MT	Lobby central government to abandon immigration cap on non-EU workers, or at least to create an exemption for IT hardware engineers	Cambridge Enterprise
Lack of government support to clusters	High	MT	Lobby central government to adopt a cluster strategy	Cambridge Enterprise
No Regional Development Agencies	High	MT	Lobby central government to reinstate Regional Development Agencies, or equivalent bodies with a new name to support cluster growth	Council
Too few MNCs	Med	ST	Approach other MNCs using ARM, CSR, etc. both as success stories and endorsements of the cluster's vitality	Council investment team
Lack of on-the-job technical training	Med	ST	Work with central government to encourage the uptake of the new apprenticeship program by companies	Council investment team
Limited growth capital lending by banks	Med	ST	Encourage central government to continue pressuring banks via Project Merlin to increase SME lending for growth capital	Council investment team
Training programs focused on software	Med	MT	Work with Anglia Ruskin to redesign their engineering curriculum to boost talent supply for IT hardware	Cambridge Enterprise
High cost of land and housing	Med	MT	Relax planning restrictions to allow more housing to be built and drive down costs	Council
R&D spending relatively low compared to other IT hardware clusters	Med	LT	Develop contracts for collaboration between firms, university, and government to boost overall R&D spending to over 4% GDP to catch up with MA and CA	Cambridge Enterprise

Start-up firms ill equipped to pitch to VCs	Low	ST	Encourage business schools in London, Oxford and Cambridge to work more closely with IT hardware start-ups to assist with fundraising	Cambridge Enterprise

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