CENTRE FOR GLOBAL HIGHER EDUCATION

AN ESRC & HEFCE INVESTMENT

Centre for Global Higher Education working paper series

The role of the state in university science: Russia and China compared

Simon Marginson

Working paper no. 9
December 2016

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

HIGHER EDUCATION FUNDING COUNCIL FOR ENGLAND hefce

Published by the Centre for Global Higher Education,
UCL Institute of Education, London WC1H 0AL

www.researchcghe.org

ISSN 2398-564X

The Centre for Global Higher Education (CGHE) is the largest research centre in the world specifically focused on higher education and its future development. Its research integrates local, national and global perspectives and aims to inform and improve higher education policy and practice.

CGHE is funded by the Economic and Social Research Council (ESRC) and the Higher Education Funding Council of England (HEFCE), and is a partnership based at UCL Institute of Education with Lancaster University, the University of Sheffield and international universities Australian National University (Australia), Dublin Institute of Technology (Ireland), Hiroshima University (Japan), Leiden University (Netherlands), Lingnan University (Hong Kong), Shanghai Jiao Tong University (China), the University of Cape Town (South Africa) and the University of Michigan (US).

The support of the Economic and Social Research Council (ESRC) and the Higher Education Funding Council of England (HEFCE) is gratefully acknowledged.

This working paper is part of Research Programme 1. ‘Globalisation, UK higher education and the public contributions of HEIs’.

The role of the state in university science: Russia and China compared

Simon Marginson

Contents

The role of the state in university science: Russia and China compared

Simon Marginson

Simon Marginson is Professor of International Higher Education at the UCL Institute of Education and Director of the Centre for Global Higher Education. He is Joint Editor-in-Chief of *Higher Education*. Email: s.marginson@ucl.ac.uk

Keywords

Research, Universities, Globalisation, International comparisons, University rankings, Policy, Russia, China

Abstract

Research is now organised on the basis of a global science system, articulated by English language journals, which partly subsumes national systems and is the source of most innovations. To be effective, national science institutions must be closely and continually engaged in, and contributing to, this global system. 'Science and technology in one country' is no longer a strategic option. Russian science is characterised by very low rates of publication, citation and joint international authorship, relative to system and university size. The total number of papers produced each year is declining. Only Lomonsov Moscow State University (LMSU) is ranked in the top 750 universities in the world on the volume of published science in English. Between 1995 and 2012, the number of internationally co-authored papers increased by 168 per cent worldwide but only by 35 per cent in Russia. The closed door to international links is a legacy of the Soviet period. The situation in Russia contrasts with the spectacular growth of science in China and East Asia, powered by active and focused states with an internationalisation drive. The article discusses the trajectory of East Asian science. While Russia cannot replicate the East Asian family or political culture, a vigorous internationalisation policy would kick-start the transformation of national science.

Introduction

The advent of the internet in the early 1990s brought with it major changes in science and university-based research (Peters, Marginson and Murphy, 2009). The last two decades have seen considerable development of what can be called 'global science', organised in the form of a single accessible research system articulated by worldwide English language journals, collaborative networks and cross-border projects, the growing mobility of personnel, two large-scale data repositories focused on publication and citation metrics that are managed by Thomson-Reuters and Elsevier respectively, and the research ranking of institutions and national systems (Marginson, 2014). National research systems continue – and across the world have become increasingly active sites – while at the same time they are partly subsumed into the global science system, to which they relate with greater or lesser effectiveness. Simultaneously, in policy circles there has been growing emphasis on investment in R&D and in some countries 'world-class universities' (Altbach and Salmi, 2011), and programmes designed to enhance industry innovation. States now pursue R&D and university research policy in the manner of the 'global competition state' (Cerny, 1997). They are constantly aware at both local/national and global/regional levels, focused on global comparisons, and consider strategy and programmes with an eye on what their competitors are doing; much as they have long done in relation to military technology and energy sources (Bayly, 2004). Strategically, they mostly parallel and imitate each other, like cautious conglomerates maneuvering for an incremental advance in their market share. More rarely they innovate, hoping to differentiate themselves to secure advantage. Whether it is grounded in reality or not, national capacity in science and technology are now seen as key 'causes' of economic growth and prosperity, seen, in fact, as basic to modernity itself.

This paper compares and seeks to explain two differing responses to this common ecology: trajectory of the state, its research institutes and universities in Russia, and the trajectory of states and university systems in East Asia and Singapore (principally but not only in China) in the last two decades. In this article, 'East Asia' refers to the North East Asian zone of Japan, Korea, China, Hong Kong SAR, Taiwan and Vietnam. It is coupled with Singapore in this analysis for historical-cultural reasons, as discussed below.

Russia and China entered the 1990s with a similar Soviet-shaped structure in science and higher education. After the 1949 revolution in China, Russian science and technology was far in advance of that of China. China was much poorer than Soviet Russia, and Soviet policy always saw capacity in science and technology as central to long-term survival. Until the Sino-Soviet split in 1960, Soviet aid and Soviet models played a strong role in China's development. China's higher education and research systems were closely influenced by Soviet forms. Under the Soviet model in China, science was concentrated in academies and specialised institutes associated with a range of ministries, while universities were predominantly teaching-focused, except for a small number of comprehensive institutions (Smolentseva, 2014; Hayhoe, Li, Lin and Zha, 2011). Path dependence was established, so that the legacy of Soviet influence persisted even after the Sino-Soviet split, up until China's reforms to education and science in the 1990s. To an extent, vestiges of the old Soviet model survive in China, in the form of instances of specialised universities under particular ministries, and in the major role played by the Academy of Science in China.

However, in the last two decades pathways have fundamentally diverged. First, while both countries have moved universities in the direction of comprehensive teaching/research institutions, and moved some specialised researchers from separate institutes into higher education, this process has gone much further in China than Russia. Second, investment patterns have been fundamentally different. The end of the Soviet period in Russia triggered the complete or partial collapse of many research organisations and the exit of a large number of trained personnel. This was just before China made the mid-1990s decision to invest heavily in science and research, and build an R&D sector on the American scale – an ambition once harboured by Soviet Russia, but, it seems, is less important to post-Soviet Russia, which has shifted its economic trajectory from a defence-driven military industrial state, to a predominantly resource- and finance-driven state.

Arguably, the Soviet system is still running down and the next Russian science system is yet to emerge. In Russia, in the last two decades, in contrast with almost every other research system in the industrialised world, published scientific outputs have declined, and there has been little progress in science infrastructure. In the same time period in East Asia and Singapore there has been a rapid and massive growth in research infrastructure and scientific outputs, and in the extent of internationalisation of science and universities. This happened in Japan earlier, between the 1960s/1980s. The dynamic growth of science spread to Korea, Taiwan and Singapore in the 1990s and to China in the last 15 years. The achievements of Chinese policy on science and universities are reviewed below. Japanese research is no longer improving, in terms of the quantity of science papers, the rate of citations, and the ranking of universities, but in the other East Asian countries rapid improvement continues, in all three categories, with no end in sight to the upward progress.

The role and character of the state has been key to the dynamic developments in East Asia and Singapore. These system share a common cultural foundation in Chinese civilization (Holcombe, 2011, pp. 1-10), and are conventionally labeled 'Sinic'. Regardless of whether they are single party states or electoral democracies, countries shaped by Chinese civilization share a common mode of state and pursue similar policies on science and universities in the present period. This state tradition is distinct from the differing English-speaking, Western European and Russian state traditions. These differences between regional political cultures inhibit the potential of science policy transfer from, say, China to Russia, but perhaps there are still lessons to learn from East Asia.

Global developments

In the past, prior to the internet, science was something of a global conversation, but it was primarily organised in national systems. The global science and technology system now overshadows all national systems, even the gigantic American system. While that nation continues to play the leading world role, and sets many of the rules of global science – world journals are mostly US-edited – there is growing pluralisation as many other countries strengthen their capacity. The proportion of all science that is produced in the United States is falling (NSF, 2014), an unstoppable tendency but one that generates concern in American circles. However, the point is that science is a single largely open system. There are pockets of secrecy, especially in relation to technology, for strategic military and industrial reasons, but the vast bulk of *strategic* knowledge – knowledge that is powerful and useful for states and companies – is in the open space and flows freely around the world. It is a remarkable change in human affairs. It calls up the need for new strategies and behaviours.

Table 1: Nations publishing more than one thousand science papers in 2011

ANGLO-SPHERE	EUROPEAN UNION	NON-EU EUROPE	ASIA	LATIN AMERICA	MIDDLE EAST
USA 212,394	Germany 46,259	Russia 14,151	China 89,894	Brazil 13,148	Iran 8176*
UK 45,884	France 31,686	Switzerland 10,019	Japan 47,106	Mexico 4173	Israel 6096
Canada 29,114	Italy 26,503	Turkey 8328	South Korea 25,593	Argentina 3863	Saudi Ara. 1491*
Australia 20,603	Spain 22,910	Norway 4777	India 22,481	Chile 1979*	
New Zealand 3472	Netherlands 15,508	Ukraine 1727	Taiwan 14,809		
	Sweden 9473	Croatia 1289*	Singapore 4543		
	Poland 7564	Serbia 1269*	Thailand 2304*		
	Belgium 7484		Malaysia 2092*		
	Denmark 6071		Pakistan 1268*		
	Austria 5103				**AFRICA**
	Finland 4878				
	Portugal 4621*				
	Greece 4534				S'th Africa 3125
	Czech Rep. 4127				Egypt 2515
	Ireland 3186				Tunisia 1016*
	Hungary 2289				
	Romania 1626*				
	Slovenia 1239*				
	Slovakia 1099				

* = countries that have entered the one thousand papers group since 1997
Source: Adapted from NSF, 2014

Features of this world science system include the explosive growth of web-based global publishing in English, both in the form of major disciplinary journals, and open source circulation of papers, ideas and data; the continuing growth in the number of science active nations; the great increase in and publications with international co-authors; the fact that two thirds of citations in the global English-language science literature are international (i.e. they are citations of work that originated in a different country to that of the authors doing the citing); and the central role now played by collaborative research grant programmes such as the European Research Area. Between 1995 and 2012 the total number of published journal articles in Thomson-ISI Web of Knowledge increased by 47 per cent but the number of articles with authors from at least two different countries increased by 168 per cent. Between 1995 and 2012 the number of countries publishing at least one thousand journal articles per annum, a proxy measure for the existence of a national research capacity, rose from 37 to 51 (NSF, 2014). Table 1 sets out the nations publishing a thousand papers in 2011. Nations that entered this group of science nations after 1995 include Croatia, Serbia, Slovenia, Chile, Malaysia, Thailand, Iran and Tunisia. The output of published science grew faster in Iran than any other country, increasing at 25.2 per annum between 1995 and 2011 (NSF, 2014). The growing emphasis on research has become joined to widely distributed national policies designed to achieve 'world-class universities' (WCUs): higher education institutions (HEIs) that are listed in the world top 100, 200 or 500 in the research rankings, or to elevate the existing ranked universities. In 2013 the President of Russia announced there should be five Russian universities in the global top 100 by 2020. Government funding was allocated to develop 15 selected universities towards this goal (Vorotnikov, 2013). There are significant WCU programmes in, among other countries, Germany, France, China, Japan, South Korea and Vietnam (Salmi, 2009).

Science is no longer the province of the English-speaking world, Western Europe, Russia and Japan. It has become part of the business of middle income and emerging states. It seems that nations need an indigenous science infrastructure just as they need clean water, stable governance, and a globally viable financial sector. Most innovations in technology and product development, with the possible exception of innovations in the United States, are now sourced wholly or partly from outside the country, as opposed to being nationally sourced. (This follows directly from the pattern of publication of scientific knowledge – no country apart from the US publishes more than a small proportion of the highly cited science papers, and little basic science is now produced that remains outside the world literature. (NSF, 2014)) Nations therefore need to be effective participants in the one-world science system and be fully in touch with current work; and to do this they must themselves be contributors and partners in the science system. In turn, to be producers of research they must have an indigenous research capacity and train at least some of their research personnel. The alternative is a position of continuing scientific and technological dependence.

The point cannot be emphasised too strongly. The effectiveness of national and university science – whether old or new – now depends on its capacity to operate globally. National and university science everywhere is positioned on the edge of the global science system, and feeds off it. Everyone is borrowing freely from everyone else in accessing the common store of knowledge. Countries partly disengaged from the global science system, like North Korea, are increasingly penalised. It is inevitable that they will fall behind. Because countries like North Korea do not work openly and collaborate freely, they do not have full access to knowledge and cutting edge expertise from elsewhere. Because they do not contribute freely into the global system, their scientists lack profile and fail to build international relationships, based on continuous exchange and collaboration, which allow them to anticipate new knowledge as it emerges. They do not draw strategic talent from other countries. Many of their best people want to leave to work at the cutting edge elsewhere. In this setting, open systems of science and people mobility prosper, like the American system. States with strong central authority in China, Korea and Singapore now realise this and have created broad highways between their science systems and the systems of other countries. Managed internationalisation is a vital tool of strategy in East Asia (Wang, Wang and Liu, 2011: Postiglione, 2011; Yonezawa, Kitamura, Meerman and Kuroda, 2104).

The importance of states

All over the world the objective of state policy is to facilitate autonomous product innovations in capitalist industries. Nevertheless, in research and science, the state never finally vacates the field. Because research is largely a public good subject to market failure (Stiglitz, 1999) it depends on prolonged state investment. (This also makes research infrastructure irreducibly expensive, which means that the poorest nations, those with per capita incomes of about USD $8000 or less, cannot finance their own science systems, as is obvious from cross-country comparisons of research output: see NSF, 2014). Therefore science policy, and the organisational forms of research and research-based universities, are closely implicated in the nation's political culture, meaning that they are shaped by the tradition and evolution of the state.

In emerging systems the capability and focus of the state are crucial to building infrastructure, funding research personnel and organising the government institutes and universities where research takes place. In general, where the state is fragmented, weak, corrupt or lacks coherent policies, the potential of universities is limited. Significant research programmes – those that require expensive equipment, materials and trained personnel – cannot begin. Once indigenous science is established, the imperatives change. It becomes increasingly important to nurture the independent capacity of research professors, institute directors and university executive leaders to make operational decisions. For example, governments are not in a strong position to decide on the direction of scientific creativity in academic disciplines – only specialist researchers can do that (Kerr, 2001) – and are therefore unable to decide effectively on the desired national and international research partnerships. The state also needs to encourage direct relations between, on the one hand, research organisations, and on the other hand, cities and localities, professions and employers, in order to enable research to have maximum take-up and use. However, the dependence of researchers on the state never evaporates. Government remains crucial to funding, especially in relation to basic science, but often even in the subsidisation of commercially relevant research for industry (OECD, 2013). Also, governments often intervene in research content decisions, perhaps more than they should. Most governments influence the directions of research by establishing broad priorities among disciplines, and they often pick favourites in relation to research topics, even when for the most part the detailed grant allocations are handled by scientific peers (OECD, 2008).

Political cultures and state traditions vary across the world. Core notions of state-science relations, 'autonomy' and 'academic freedom' are practised in varying ways. All researchers want to operate free of interference, yet all are also nested in organisational and social contexts that sustain customary practices – whether through top-down regulation, or voluntary initiative (and self-censorship) – and shape human agency itself. Scientific freedom and creativity are not wholly universal qualities. There are irreducible historical-cultural elements.[1] In East Asia and Singapore, and also in Russia in a different way, the state retains closer supervision (even of leading research universities) than occurs in India, in the German, Francophone and Nordic countries (notwithstanding the large Nordic states) and in the English-speaking world. These differences do not in themselves determine success or failure in science policy. Clearly there is more than one way to sustain a high performing research system. The US/UK model – the template of global rankings and World Bank development programmes – the Nordic model, and the East Asian or 'Post-Confucian' model (Marginson, 2013) are all associated with successful science systems, in specific circumstances. By the same token, it would be misleading to argue that the East Asian (Sinic) state is both necessary and sufficient to achieving advanced science universities, in Asia or anywhere else. Nevertheless it is clear that this kind of state is effective in the accelerated development of science, under the right economic and cultural conditions.

Sinic states and Sinic learning

As noted, the East Asian countries and science systems lie within the historical boundaries of Sinic (Chinese) civilization. Arguably Vietnam, which was occupied by China for more than a thousand years, shares this geo-cultural region. The non-adjacent island state of Singapore in Southeast Asia has primarily Sinic political, economic and educational cultures. Although there are differences in language and political systems, and current tensions within the Sinic group, all sustain the comprehensive form of state that developed 2,200 years ago in Qin and Han China (Holcombe, 2011). East Asian countries do not exhibit the state/society and

[1] The same insight about the irreducible importance of states, and differences between state political cultures, also underpins the comparative studies by Green (2013) and Carnoy et al. (2013), the latter in relation to the BRICS countries.

state/market tensions typical of the English-speaking world, with its limited liberal states. Nor was East Asia closely affected by the egalitarian upheavals of the French revolution and nineteenth century social democracy. Whether in single party or multi-party polities, national states in East Asia exhibit strong continuity in policy and personnel and a characteristically long-term view (Jacques, 2012). Government posts enjoy high social status, attracting many of the best graduates. The Sinic state is not a welfare state – the Sinic family has a larger role than in Europe and North America – but it exercises overall responsibility for social order and prosperity. Although the Sinic state does not administer society in detail, it is supreme viz a viz economies and cities, and intervenes at will (Gernet, 1996). As noted, the present East Asian state intervenes in universities and science.

The Sinic societies also share a common heritage of Confucian learning practices in the family. From infancy, self-cultivation through education is part of the mutual responsibilities of parent and child, even in poor families. It is believed that success in education derives primarily from effort, not talent. There is a broader and deeper commitment to learning than in other societies, and the role of education in determining social destinations is near-universal (Zhao and Biesta, 2011). In East Asia secondary education is highly competitive, culminating in end of school examinations that determine who enters the high prestige universities that are the fast track to stellar careers. Confucian self-formation in the home, a teaching profession in good standing, extra classes after school, and private tutoring, all contribute to exceptional levels of learning at school (Bray, 2007; Chua, 2012; Gernet, 1996). East Asia and Singapore dominate the OECD's comparison of student learning achievement at age 15, the Program for International Student Achievement (PISA). In mathematics in the 2012 PISA results the leading seven systems were all post-Confucian. They did almost as well in PISA science and reading. Even Vietnam, with a per capita income of only 10 per cent of the US in 2013, does better than both the US and Russia in all three PISA disciplines (OECD, 2014).

Table 2: East Asia, Singapore, Russia and selected others in the OECD'S Programme of International Student Assessment (PISA), 15-year olds, Mathematics, 2012

School system	Position in PISA table for learning achievement of 15-year olds in mathematics (n= 65)	Mean score in PISA mathematics	Proportion of all students in the top PISA group (Levels 5-6)	Proportion of all students in the bottom PISA group (Level 1)
			%	%
OECD average	--	494	12.6	23.1
Shanghai, China	1	613	55.4	3.8
Singapore	2	573	40.0	8.3
Hong Kong China SAR	3	561	33.7	8.5
Taiwan	4	560	37.2	12.8
South Korea	5	554	30.9	9.1
Macao China SAR	6	538	24.3	10.8
Japan	7	536	23.7	11.1
Switzerland	9	531	21.4	12.4
Germany	16	514	17.5	17.7
Vietnam	17	511	13.3	14.2
United Kingdom	26	494	11.8	21.8
Russia	34	482	7.8	24.0
United States	36	481	8.8	25.8

Source: OECD, 2014

As Table 2 shows, not only are the average PISA scores very high, the size of the highest achieving group is large, and there are few students in the lowest achieving group. In Singapore, 40 per cent of students are in levels 5-6 in PISA, compared to 8.8 per cent in the US. Only 8.3 per cent of Singaporean students are in the bottom group in PISA, compared to 24 per cent in Russia (OECD, 2014). Although post-Confucian societies are not egalitarian, student learning is distributed on an egalitarian basis without a trade-off between equity and excellence. It is a strong foundation on which to build a national science system. Not only is there a large pool of potential candidates for research and other science-specific roles, many people working in business, government and the professions tend to be comfortable with science and technology.

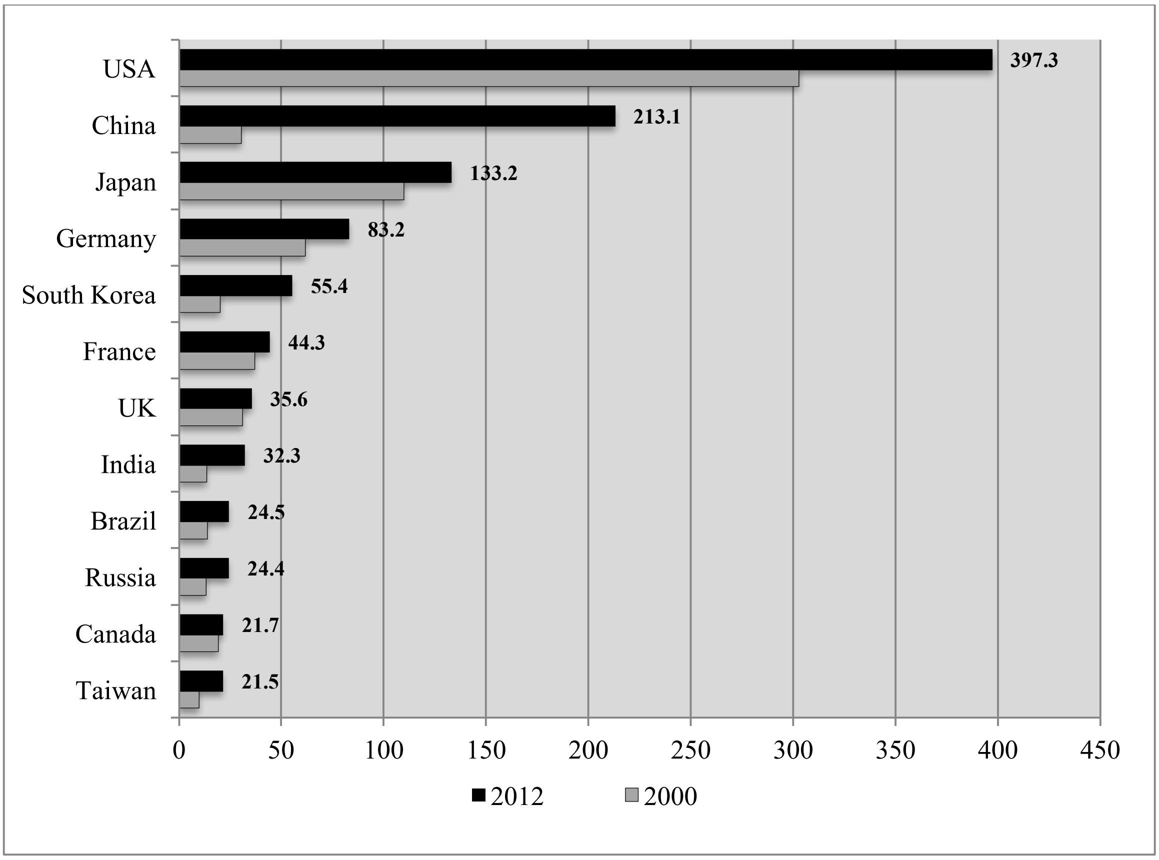
In addition to these elements from tradition, the Han comprehensive state and the Confucian education family, all Sinic countries have undergone an accelerated modernisation stimulated by imperial intervention and later by global competition. Economic prosperity has been both cause and effect of this. The central state strategic focus on 'catch up to the West', in education and elsewhere, is feasible because of sustained high economic growth. One feature of the Sinic state is its capacity to mobilise the population on the basis of deep common commitment. While East Asian states play an essential role in developing science education (Freeman, Marginson and Tytler, 2014) in leading universities and the research system, they do so in tandem with strong drivers in the household (Marginson, 2013). Intense family investment in tuition beyond the formal classroom combines with society-wide pride in 'rising China', 'rising Korea', etc. The term 'post-Confucian' captures the way that inner tradition is hybridised with modernisation, which takes the form of external pressures that are absorbed into personal and national identity.

Research-based science in East Asia

In the last two decades, all countries in East Asia have increased their R&D at a rapid rate, except Japan and Vietnam. In Hong Kong SAR, the GDP share allocation to research is modest, but GDP per head is high and so even at a low GDP rate the research universities are well funded. In 2011, South Korea invested 4.03 per cent of GDP in R&D, higher than any nation in the world in 2012. China's R&D investment rose by more than 18 per cent a year from 2000-2012. By 2012 it was 1.98 per cent of GDP, well above the UK. Total R&D funding in China was $213.1 billion (constant 2005 US dollars), which was already 54 per cent of the level in the US (see Figure 1).

China's spending on R&D is on track to pass the US in the next decade. Research is closely tailored to centrally-determined disciplinary priorities and joined to strategies for building capacity and continually improving outputs. Singapore and China especially, and to a lesser extent other systems, pursue internationalisation strategies designed to force early and rapid improvement, such as benchmarking with leading American universities and incentives to publish in English in leading journals. Taiwan, Korea and China have pursued successful policies designed to attract their overseas trained nationals at post-doctoral and mid career stages back home. Singapore, Hong Kong and, in selected areas, China, offer internationally competitive salaries.

Figure 1: Expenditure on R&D in 2000 and 2012 (constant 2005 USD, billions) or nearest year, 12 countries with highest spending in 2012



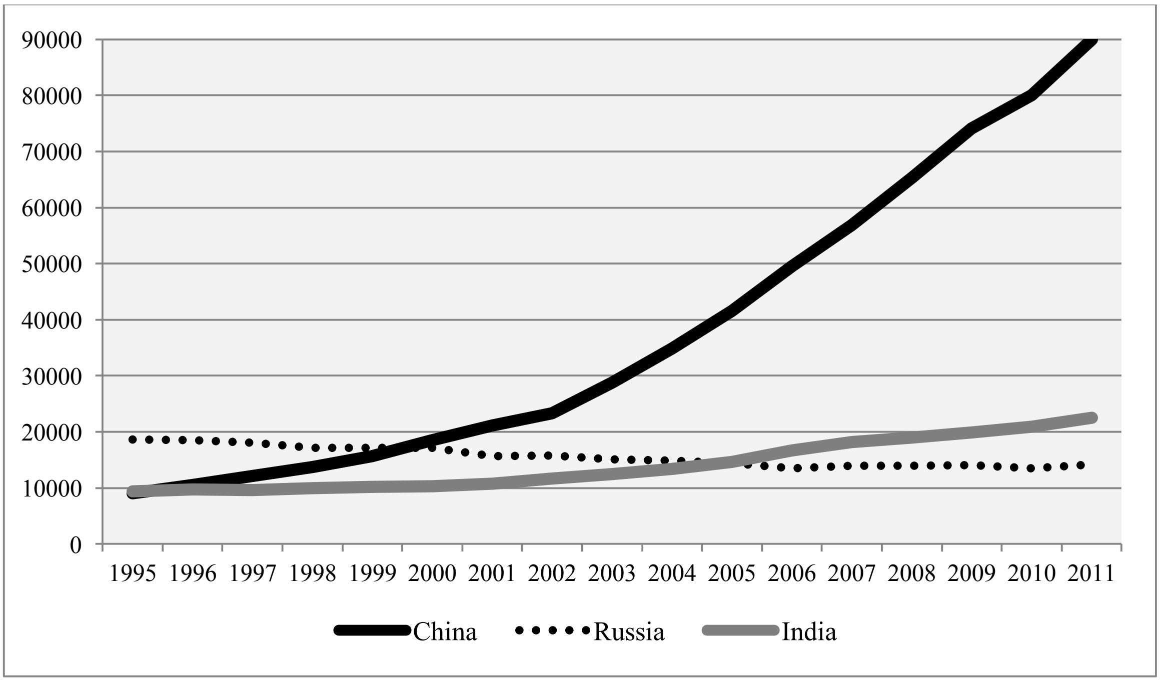
Data for 2011 not 2012: Japan, South Korea, India, Brazil, Turkey, Switzerland.
Data for 2010 not 2012: Australia, Taiwan (expenditure only).
Data for 2001 not 2000: Sweden, Denmark.
Source: UNESCO, 2012; CIA Factbook, 2014; Taiwan Today, 2014

Published science is increasing almost as quickly as funding. Between 2001 and 2011, the number of journal articles authored or co-authored by Chinese scholars rose by 15.6 per cent a year (see Figure 2, which compares the growth of science in China to the slower but significant increase in India, and decline in Russia). Over the same time period, published papers grew 8.8 per cent a year in Korea, 6.4 per cent in Singapore and 6.5 per cent in Taiwan.

It is often argued that East Asian science has yet to prove itself because quality is lower than the US and Western Europe, as measured by citation rates. Average citation rates are much lower than in the leading English-language countries, Germany and the smaller Northwest European systems: Switzerland, Sweden, Denmark, Finland and the Netherlands. But relative quality is changing. Average citations are high in Singapore – the National University of Singapore has a research profile similar to a strong UK university – and fairly strong in Hong Kong SAR, where, as in Singapore, most people use English as a primary language. Citations in China, Korea and Taiwan are improving rapidly. Take chemistry: in the year 2000, China published 3.7 per cent of all papers in chemistry in the Thomson-Reuters Web of Science collection, based on all Thomson-accredited English-language journals. In 2012, that proportion had reached 16.9 per cent, and China's total quantity of chemistry papers exceeded that of the US.

More strikingly, in 2000 China authored just 0.6 per cent of chemistry papers ranked in the global top one per cent on citation rate in the Web of Science. Only 12 years later, in 2012, China published 16.3 per cent of the leading one per cent of papers, half as many as the US – an astonishing rate of improvement. There were similar patterns in engineering, physics and computing – where China publishes more top one per cent papers than the US – and mathematics (NSF, 2014). China, Taiwan, Korea, Japan, and to some degree Singapore, have concentrated research development in the physical sciences and related applied fields like engineering, computing and materials. In Korea and Japan this supports advanced manufacturing. China also emphasises research that supports accelerated modernisation: energy, urbanisation, construction, transport and communications. As this stage medicine and life sciences are much weaker.

Figure 2: Annual output of published science papers in Russia, China and India, 1995-2011



Source: NSF, 2014

All East Asian systems except Vietnam have been successful in creating world-class universities. (Arguably, at this stage Vietnam is too poor to do so, and it lacks a coherent state policy and uncorrupt ministry: see the analysis of higher education in Vietnam in Ly, et al., 2014). Between 2005 and 2013 the number of Chinese universities in the Academic Ranking of World Universities top 500 rose from eight to 28. Taiwan's top 500 universities grew from five to nine (ARWU, 2014). The ARWU understates the position of Asian universities, because 30 per cent of the ranking position is determined by Nobel Prizes and there have been few Nobel prizewinners in Asia. The Leiden University ranking, which provides several single indicators of research quantity, and quality as measured by citation rates, is useful. One Leiden indicator lists universities by the number of science papers in the top 10 per cent of the research field by citation rate. There were 28 Asian universities in the world top 200 on the basis of 2009-2012 research papers. Table 3 shows that the highest placed Asian HEIs are the University of Tokyo (1,389 top 10 per cent papers, 29th in the world), National University of Singapore (30th), and Tsinghua in China (49th) (Leiden University, 2014). These are not remarkable figures. However, current research rankings reflect R&D investments up to about 2005. When the last decade of investment is realised in the rankings there will be many East Asian universities in the top 200, and pushing up in the top 50.

Table 3: Asian universities in the world top 200 on the basis of the number of high citation (top 10% in field) papers produced in 2009-2012

world rank	University	Papers 2009-12	world rank	University	Papers 2009-12
29	Tokyo U JAPAN	1389	120	Tohoku U JAPAN	606
30	NU Singapore SINGAPORE	1361	123	Nanjing U CHINA	595
49	Tsinghua U CHINA	1025	130	Sun Yat-sen U CHINA	563
53	Zhejiang U CHINA	1018	135	Chinese U HK HK SAR	548
55	Nanyang UT SINGAPORE	986	145	Sichuan U CHINA	529
57	U Kyoto JAPAN	982	152	Harbin IT CHINA	522
67	Peking U CHINA	906	157	Yonsei U KOREA	517
70	Seoul National U KOREA	901	169	Korea Advan. I S&T KOREA	493
72	Shanghai JT U CHINA	887	180	Jilin U CHINA	466
87	Fudan U CHINA	784	182	Huazhong U S&T CHINA	463
95	U Osaka JAPAN	724	183	Shandong U CHINA	457
100	N Taiwan U TAIWAN	695	185	Nankai U CHINA	456
103	U Hong Kong HK SAR	669	199	Dalian UT CHINA	428
117	U S&T China CHINA	621	200	Nagoya U JAPAN	427

Source: Leiden University, 2014

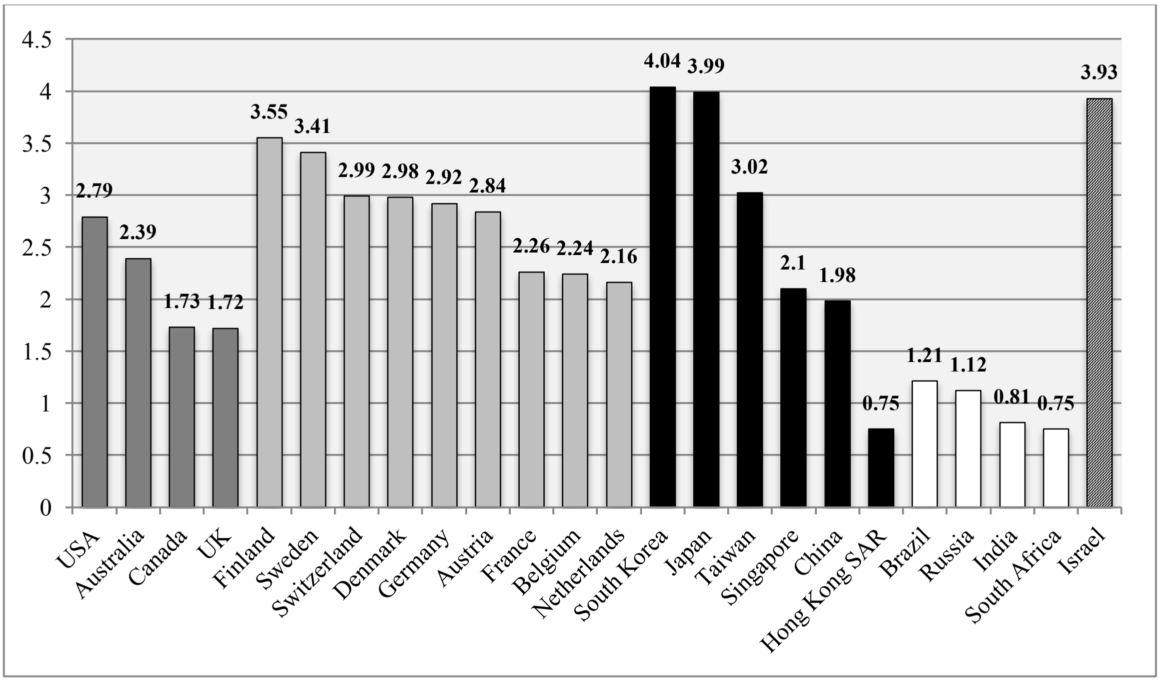
Aside from the Confucian educational ethic in the home and high student learning achievement in the teenage years, and high rates of economic growth, what other factors have conditioned the phenomenally rapid growth of East Asian science? The short answer is effective Sinic states, and effective programmes for accelerated internationalisation, carried out under the auspices of those states. In East Asia, government is politicised like it is everywhere, but on the whole it is more meritocratic and performance-driven, and mostly less corrupt, than the state in the post-socialist countries (Marginson, 2010-13). The East Asian states give high priority to science, focus substantial investment in it, and set performance targets that are authentic, not just words on paper. They monitor the achievement of those targets, then they raise the targets further to drive progress. The result is real and rapid improvement (Marginson, 2011a). Internationalisation has been a key driver of improvements. Encouraged by the state, universities set incentives for English language publication, bring back the diaspora from the US and attract new foreign talent, support collaboration with foreign scholar-researchers, and engage in systematic benchmarking with strong foreign universities (Wang, et al., 2011). A benchmarking approach to international comparison is a more focused, contextually appropriate, detailed and transformative strategy than a rankings approach (Altbach & Salmi, 2011). East Asian governments see better rankings for their universities as the outcome of policy and of better performance, not as a principal policy instrument or driver (Liu & Cheng, 2005). To focus on ranking outcomes as the objective of policy is to focus on reputation, and the appearance of global strength – rather than focusing on real education, real science and the *substance* of global strength.

Research-based science in Russia

Russia's current investment in R&D as a percentage of GDP is lower on the international scale than was Soviet R&D, and it is likely that it is lower in absolute terms (constant prices) than the peak R&D spending in the Soviet years. Figure 1 shows that Russia was 10th in total R&D in 2012. Although funding doubled between 2000 and 2012, it was from a low base. Russia's 2012 level of investment was only 6.1 per cent that of the US, 11.4 per cent that of China, and less than half the level of South Korea which has only one third of Russia's population (UNESCO, 2014).

Figure 3 provides data on the proportion of GDP allocated to R&D in 2012 (or nearest year). It clusters national systems on a regional basis. Russia's total investment in R&D of 1.12 per cent of GDP in 2012 was the lowest of the top 10 R&D countries except for India. Russia's investment in research was higher than South Africa but below Brazil and well below China. However, it is probably more appropriate to compare Russia not to the BRICS, which are only now developing high capacity systems, but to the English-speaking and Western European nations that, like Russia, have a longer history of developed research. In Figures 1 and 3 the standout countries are the US, the dominant world power in R&D, the smaller knowledge-intensive European countries in Scandinavia and Switzerland that have high rates of GDP investment, and the rising science powers in East Asia and Singapore.

Figure 3. Investment in R&D as a proportion of GDP, 2012 or nearest year, selected leading countries (%)



Data for 2011: South Korea, Japan, Brazil, India, Switzerland.
Data for 2010: Australia, Hong Kopng SAR, South Africa, Taiwan
Source: UNESCO, 2014

Russia's international position in globally published science is weaker than its comparative R&D investment. Russia was 10th in investment in 2012 but 15th in the number of science papers produced in 2011. Russia's output of published science in 2011 was 6.6 per cent that of the US, and 15.8 per cent that of China. As indicated in Figure 2, the output of published science papers fell from 15,658 in 2001 to 14,151 in 2011, an average annual decline of one per cent. Along with Japan (1.7 per cent per year) and Sweden (0.6 per cent per year) Russia was one of only three countries in the top 20 research producers where output declined. The average annual growth in output on a worldwide basis was 2.8 per cent (NSF, 2014). The decline of output in Russia can be attributed to the continued erosion and ageing of the Soviet research system, the slow emergence of comprehensive research universities, and the slow rate at which the whole system has internationalised. Published science in Russia is weaker than funded research in part because much research in Russia takes place in the academies and other institutes outside the universities, and in specialist universities that service local manufacturing, energy, extraction and defence sectors (Scimago, 2014). Many of the papers produced by specialist institutes and universities are in Russian not English, do not show up in the global science data, and do not lead to worldwide exchange of knowledge. There is nothing wrong with doing useful research, of course. Ideally, however, researchers are fluent and active in both the national and global languages, and both research conversations, rather than only one. The problem here is not just a lack of English language versions of the research findings: the weakness in the global engagement of Russian science means localised work simply never gets close to the common global pool of knowledge, which contains the overwhelming bulk of new scientific ideas. As noted, between 1995 and 2012 the world's total number of journal articles with international co-authors rose by 168 per cent, much faster than the number of journal articles as a whole. In China, South Korea and Singapore, joint publishing multiplied by 8-12 times, depending on country. In Russia the number of jointly published articles rose only 35 per cent in that 17 year period (NSF, 2014), meaning that there has been little opening up since Soviet times. Further, in its failure to grow collaborations sharply in the global era, Russia's science system has been radically out of step with most of the rest of the world, and radically out of step with all leading research countries outside Russia, whatever their political regime or foreign policy.

The Soviet strategy was 'science and technology in one country'. Contacts between Russian and foreign researchers were not encouraged (Smolentseva, 2014). Useful research from abroad was translated into Russian, and fed into the bounded national science system. Little research flowed out, to avoid giving away strategic secrets and to keep researchers in Russia (Marginson, 2010-2013). The closed-door legacy of this period continues to retard global awareness and engagement. The imperative of globalisation is that the barriers come down and it becomes necessary to move freely between local/national/global dimensions, while maintaining a clear national identity and strategy (Marginson, 2011b). The Russian science system does not foster these attributes sufficiently, instead fostering too many people who find a way to turn their backs on the global realm. Russian science and technology are less internationalised than those of all the other nations ahead of Russia in the comparative tables. It seems that the focus on local research problems is often seen to be in opposition to, rather than in conjunction with, global research work (Marginson, 2010-2013). In short, there is a highly fragmented connection between the global science system and the national science system. Arguably, in many fields, a better term for the state of affairs is 'disconnect'.

Individual research organisations in Russia

Given these problems, how well do individual Russian research universities, the academy of sciences and the non-university research institutes, perform in comparative terms? One way to answer this question is by looking at science publication and citation data in detail. The most useful data sets are from Leiden University, based on Thomson-Reuters Web of Knowledge, and Simago, based on the Scopus data set from Elsevier. The Leiden University ranking provides separate measures for each university of total science papers in global journals, citations per paper, and the proportion of all published papers in the top 10 per cent of their field of research, on the basis of citation rate. Leiden looks at just the top 750 universities in the world by paper volume. The *only* Russian university in the list is Lomonsov Moscow State University (LMSU), which occupies position 305 in the world in the league table based on paper volume – LMSU published 2,888 papers in the 2009-2012 period under analysis by Leiden, compared to 29,693 at Harvard University, 9,149 at MIT, and 14,399 at the University of Tokyo – the top university from a non English-speaking country. Just 4.8 per cent of LMSU's papers were in the top 10 per cent of their field on the basis of citation rate. It was 697th out of the 750 universities on this citation rate, and published just 138 high citation papers: 74 in natural sciences; 29 in life sciences; 15 in mathematics, computer science and engineering; 11 in earth and environmental sciences; six in medical sciences; and none in either cognitive sciences or behavioural sciences (Leiden University, 2014).

Table 4. Number of science papers and high citation papers in selected leading universities in eight countries, science outputs for 2009-2012

University and system	Number of journal papers 2009-2012	Average field normalized citation rate (mean = 1.00)	High citation papers (top 10% of field) 2009-2012	High citation papers as a proportion of all papers %
U California Berkeley USA	11,384	1.90	2560	22.5
Massachusetts IT USA	9149	2.05	2304	25.2
U Cambridge UK	11,778	1.55	2163	18.4
U College London UK	11,434	1.55	1833	16.0
Ludwig-Maximillians U Munich GERMANY	7081	1.20	928	13.1
Technical U Munchen GERMANY	5733	1.29	811	14.2
Tsinghua U CHINA	9713	1.03	1025	10.6
Peking U CHINA	9534	0.96	906	9.5
Indian IT Kharagpur INDIA	4108	0.78	190	6.4
U Delhi INDIA	3333	0.72	111	7.5
Lomonosov Moscow State U RUSSIA	2888	0.61	138	4.8
U Sao Paulo BRAZIL	12,319	0.67	634	4.6
U Capetown SOUTH AFRICA	2333	1.06	257	11.0

Source: Leiden University, 2014

Table 4 compares LMSU's research output in the global science system with selected individual leading universities outside Russia in more detail. It compares LMSU's overall research output with a group of leading universities in the US, UK, Germany, China, Brazil, India and South Africa: universities with a comparable role to LMSU. These individual universities are not necessarily the top one or two in their systems by paper volume or citation rate but have been chosen because they parallel LMSU as national universities, or capital city universities, or science and technology leaders. In the other BRICS countries there are more universities in the Leiden ranking than Russia's one. There are 16 in India, though with relatively low citation rates, 13 in Brazil, five in South Africa, and no less than 83 in China, which has the world's second biggest research system.

Table 4 shows that at present, in terms of global science, Lomonosov Moscow State is simply not in the same league as the top universities in the English-speaking world and Germany, and has been left well behind by the two Beijing universities in China and the large University of Sao Paulo in Brazil. Sao Paulo has a lower proportion of high citation papers than LMSU (4.6 per cent compared to 4.8 per cent) but a better average citation rate. In aggregate terms it pumps out many more papers and many more high citation papers. Like LMSU, Sao Paulo has the disadvantage of being a major national leader operating in a global research setting, but it is clear from these data that Sao Paulo's academic staff are more actively bilingual – they publish more than four times as many papers in English as staff from LMSU. Also, the University of Capetown in South Africa is much stronger than LMSU in citation quality (Leiden University, 2014).

Leiden also provides breakdowns of the above data on the basis of broad discipline groups, enabling universities' strong research areas to be identified. At LMSU there is no strong area. The high citation proportion is greater in earth and environmental sciences (7.9 per cent, with an average citation rate of 0.77) than other areas. There are no high citation papers in the English language literature in cognitive and social sciences. Despite Russia's historical strengths in mathematics and engineering there were only 15 high citation papers in those disciplines over the four years, and 4.7 per cent of all papers received high citations. The average citation rate was 0.63 (Leiden University, 2014).

These data underline the distance that even the nation's top research university must travel in order to match the research capacity and performance of the leading universities in Europe, the English-speaking systems and East Asia. This should not be surprising. It has taken 15 years for China to build a strong research system on the basis of exceptional and continually increasing levels of investment, and China does not yet have top 100 universities except on the basis of volume of papers. It has taken 25 years of exceptional investment and focused policy for the National University of Singapore – which at this stage is significantly stronger in research than any mainland Chinese university – to achieve the standard of a leading Northwestern European university in citation rates and high citation papers.

The Scopus data collection Scimago, unlike the Leiden ranking, allows the output of non-university research organisations to be explored. There are more papers in the Scimago collection than in the Leiden collection because there is greater inclusion of formats other than research articles. In addition, the Scimago collection includes 2,744 university and non-university research organisations ranked in order of volume of papers, many more than the 500 in ARWU and the 750 in Leiden, and this allows other Russian universities and research institutes to be investigated. Table 5 shows that China strongly outperforms both the Russian academy and the Russian universities. For a non English-speaking country China's Academy of Science, which in volume terms is the second largest research organisation in the world, has a good academic impact factor (normalised across academic fields) of 1.01. Tsinghua is at 0.96. The Russian academy is the third largest research organisation in the world but the impact average for the papers published in English is only 0.54, and below LMSU at a low 0.63 (Scimago, 2014).

Table 5. Output of science papers from national academy and leading universities, 2007-2011, China and Russia compared

World rank on volume	Research organisation	Total volume of papers 2007-2011	Normalised impact (average = 1.00, Harvard U = 2.40)
2	Chinese Academy of Sciences CHINA	157,814	1.01
11	Tsinghua U CHINA	48,396	0.96
19	Zhejiang U CHINA	42,606	0.87
24	Shanghi Jiao Tong U CHINA	39,399	0.81
3	Russian Academy of Sciences RUSSIA	97,105	0.54
115	Lomonosov Moscow State U RUSSIA	20,151	0.63
624	Russian Academy of Medical Sciences RUSSIA	5694	0.63
660	St Petersburg State U RUSSIA	5404	0.61

Source: Scimago, 2014

Scimago also measures academic research impact, with its field-normalised impact indicator (NI). This provides a useful comparative measure of citation-related quality of papers on an averaging basis across research organisations. In the Scimago collection the current top eight research universities in terms of paper volume includes LMSU, St Petersburg State, Novosibirsk, the Federal Universities of Ural, Southern and Kazan, the Moscow Engineering Physics Institute, and the Moscow Institute of Physics and Technology. Those below MSU and St Petersburg State are currently ranked between 1,207 and 1,698, which in volume terms is not close to the world top 100. This table confirms that having five universities in the top 100 is a long way from present practice. The list of high impact Russian research organisations is different, except the Moscow Engineering Physics Institute appears on both lists. None of the high impact organisations are comprehensive universities. They are all working in Physics and its applications – including nuclear, energy, space and engineering. The Institute for High Energy Physics is in the world's top 80 organisations in relation to academic impact as measured by the NI indicator (Scimago, 2014). Six of the leading 12 organisations on impact are part of the Academy of Sciences, indicating that, notwithstanding its poor overall impact, it retains pockets of research excellence.

Conclusions

In summary, the system attributes that are associated with the spectacular success of China and other East Asian countries, in building science capacity and outputs, are absent or largely absent in Russia. First, like most countries, Russia lacks the Confucian learning tradition at home; and in-school learning achievement is average in terms of international comparisons. Traditionally Russians see their nation as strong in mathematics and physics. This does not show in the PISA results. However, it is apparent in pockets of research excellence, as the Scimago data reveal. The quality of physics-related research can be understood as part of the legacy of state-managed Soviet science.

Second, Russia has not benefitted from economic growth on the scale of China, which in China has augmented household incomes, which in turn are fed into part of the cost of tuition. This has released the state to fund infrastructure, research, WCUs and scholarships for high achieving students. Yet Russia has experienced economic growth, albeit on a more modest scale than China, and arguably could have expanded R&D funding more than it has.

Third, and most importantly, Russia lacks an East Asian-style state. The characteristic East Asian state takes a comprehensive responsibility for social order and prosperity. The quality of the bureaucracy is high and the merit principle is generally accepted. There is corruption, but arguably on a lower scale than in the Soviet and post-Soviet states. In science in China, a larger problem than corruption is (a) arbitrary government interference in decisions that should be made by scientists and based on the logic of development of knowledge, rather than political factors, and (b) cases of repression of and pressure on critical public intellectuals. The last used to also be a problem in one-party Singapore, and arguably the potential is still there. Over-centralisation and top-downism are inherent tendencies of the Sinic state but it is possible to avoid the worst excesses. The Sinic state also has a long-term approach and is both critical and realistic. It creates an authentic policy setting – targets and performance measures are real and compliance must be substantial, rather than ritualistic (or faked). And the Sinic state has an inbuilt focus on catching up to the West and benchmarks everything instinctively in terms of leading countries. Thus it readily fosters internationalisation strategies in science and these have been crucial.

Finally, as discussed, Russian science has low levels of international engagement by comparison with parallel national science systems across the world – in the English-speaking world, both of Western and Eastern Europe, East and Southeast Asia, Brazil and India. Russia is partly decoupled from and ineffective within the global research system. English-language skills are not developing rapidly as they are in East Asia, and the comparative publication, citation and research collaboration data indicate a serious problem.

Russia cannot replicate the Sinic family. It cannot become a Sinic state. However, it can return to being a nation-building state of the Russian kind in universities and research, and it can internationalise its research system if it chooses to do so. Countries with a broad range of political cultures and institutional configurations have internationalised univiersities and science. Nevertheless, universities, research institutes and the academy of sciences are unlikely to take internationalisation far without strong policy buy-in by the state. The ultimate key to a renovated research system in Russia is reform of government. In science policy, the post-Soviet state inherited from the breakup of the Soviet Union has been lethargic, parsimonious, and at worst, indifferent to the running down of research. Until the culture of government changes, Russia will not be able to return to the front table in science.

References

Academic Ranking of World Universities (ARWU), 2014. *Academic Ranking of World Universities*. http://www.shanghairanking.com/index.html

Altbach, P. and Salmi, J., eds., 2011. *The road to academic excellence: The making of world-class research universities*. Washington: World Bank.

Bayly, C., 2004. *The birth of the modern world 1780-1914: Global connections and comparisons*. Oxford: Blackwell.

Bray, M. 2007. *The shadow education system.* 2nd Edition. UNESCO. http://unesdoc.unesco.org/images/0011/001184/118486e.pdf

Central Intelligence Agency (CIA), 2014. *World Factbook: Taiwan*. https://www.cia.gov/library/publications/the-world-factbook/geos/tw.html

Cerny, P., 1997. Paradoxes of the Competition State: The dynamics of political globalization" *Government and Opposition*, 32 (2), pp. 251–274.

Chua, A. 2012. *Battle hymn of the tiger mother*. London: Bloomsbury.

Freeman, B., Marginson, S. and Tytler,R., eds. (2014). *The age of STEM: Educational policy and practice across the world in Science, Technology, Engineering and Mathematics*. New York: Routledge.

Gernet, J., 1996. *A history of Chinese civilization*. 2nd ed. Cambridge: Cambridge University Press.

Green, A., 2013. *Education and state formation. Europe, East Asia and the USA.* 2nd Edition. Houndmills: Palgrave Macmilla.n

Hayhoe, R., Li, J., Lin, J., and Zha Q., eds., 2011. *Portraits of 21st century Chinese universities: In the move to mass higher education*. Hong Kong: Springer/Comparative Education Research Centre, the University of Hong Kong.

Holcombe, C., 2011. *A History of East Asia: From the origins of civilization to the twenty-first century*. Cambridge: Cambridge University Press.

Jacques, M. 2102. *When China rules the world: The end of the Western world and the birth of a new global order.* 2nd edition. London: Penguin.

Kerr, C., 2001. *The uses of the university*. 5th edition. Cambridge, MA: Harvard University Press.

Leiden University, 2014. *The Leiden ranking 2014.* Centre for Science and Technology Studies, CWTS. http://www.leidenranking.com/ranking/2014

Liu, N. and Cheng, Y. (2005). The Academic ranking of world universities. *Higher Education in Europe*, 30 (2), pp. 127-136.

Marginson, S. 2011a. Higher Education in East Asia and Singapore: Rise of the Confucian model. *Higher Education,* 61 (5), pp. 587-611.

Marginson, S. 2011b. Imagining the global. In R. King, S. Marginson & R. Naidoo (eds.), *Handbook of Higher Education and Globalization*, pp. 10-39. Cheltenham: Edward Elgar.

Marginson, S., 2013. Emerging higher education in the Post-Confucian heritage zone. In D. Araya and P. Marber (Eds.), *Higher education in the global age*, pp. 89-112. New York: Routledge.

Marginson, S. 2010-13. Unpublished programme of research interviews in universities and government, conducted in China (2010-12), Vietnam (2010), South Korea (2011-12), Hong Kong SAR (2011), Taiwan (2011), Russia (2013).

Marginson, S., 2014. University rankings and social science. *European Journal of Education*, 49 (1), pp. 45-59.

National Science Foundation (NSF), 2014. *Science and engineering indicators 2014*. http://www.nsf.gov/statistics/seind14/

Organization for Economic Cooperation and Development (OECD), 2008. *Tertiary education for the knowledge society. Volume 2.* Paris: OECD.

Organization for Economic Cooperation and Development (OECD), 2013. *Science and technology indicators.* Paris: OECD.

Organization for Economic Cooperation and Development (OECD), 2014. *PISA 2012 Results in Focus. What 15 year olds know and what they can do with what they know.* Paris: OECD.

Peters, M., Marginson, S. and Murphy, P., 2009. *Creativity and the global knowledge eonomy*. New York: Peter Lang.

Postiglione, G., 2011. The rise of research universities: The Hong Kong University of Science and Technology. In P. Altbach & J. Salmi, eds., *The road to academic excellence: The making of world-class research universities,* pp. 63-100. Washington: The World Bank.

Salmi, J., 2009. *The challenge of establishing World-class Universities*. World Bank Publications. Washington: World Bank.

Scimago (2014) *Scimago Institutions Rankings*. http://www.scimagoir.com

Smolentseva, A., 2014. Globalization and the research mission of universities in Russia. In S. Schwartzman, P. Pillay and R. Pinheiro, eds. *Higher education in the BRICS cuntries: Investigating the pact between higher education and society*. Springer. [Details To Be Advised]

Taiwan Today, 2014. Taiwan's R&D spending tops 3 per cent of GDP. http://www.taiwantoday.tw/ct.asp?xItem=219742&ctNode=445

United Nations Educational, Scientific and Cultural Organization (UNESCO), 2014). *Educational Statistics*. UNESCO Institute for Statistics. http://www.uis.unesco.org/Pages/default.aspx

Vorotnikov, E., 2013. State kicks off plans for world-class universities. *University World News*, 258, 9 February.

Wang, Q., Wang, Q. and Liu, N., 2011. Building world-class universities in China: Shanghai Jiao Tong University. In P. Altbach and J. Salmi, eds., *The road to academic excellence: The making of world-class research universities*, pp. 33-62. Washington DC: The World Bank.

Yonezawa, A., Kitamura, Y., Meerman, A. and Kuroda, K., 2014. *Emerging international dimensions of East Asian higher education*. Dordrecht: Springer.

Zhao, K. and Biesta, G., 2011. Lifelong learning between 'East' and 'West': Confucianism and the reflexive project of the self. *Interchange*, 42 (1), pp.1-20.

Centre for Global Higher Education
UCL Institute of Education
London WC1H 0AL

www.researchcghe.org
@ResearchCGHE

E·S·R·C
ECONOMIC
& SOCIAL
RESEARCH
COUNCIL

HIGHER EDUCATION hefce
FUNDING COUNCIL FOR ENGLAND