The World Economy

The World Economy (2011)
doi: 10.1111/j.1467-9701.2011.01344.x

The Higher Educational Transformation of China and Its Global Implications

Yao Amber Li[1], *John Whalley*[2], *Shunming Zhang*[3] *and Xiliang Zhao*[4]

[1]*Hong Kong University of Science and Technology, Kowloon, Hong Kong, China,* [2]*University of Western Ontario, London, Ontario, Canada,* [3]*China Financial Policy, Research Centre, Renmin University, Beijing, and* [4]*School of Economics, Xiamen University, Xiamen, Fujian, China*

1. INTRODUCTION

THIS paper documents the major transformation of higher education that has been under way in China since 1999 and evaluates its potential global impacts. This transformation has involved major new resource commitments to tertiary education and significant changes in organisational form, reflecting China's commitment to continued high growth through quality upgrading and the production of ideas and intellectual property as set out in both the 10th (2001–05) and the 11th (2006–10) Five-Year Plans. The number of undergraduate and graduate students in China has been growing at approximately 30 per cent per year since 1999, and the number of graduates at all levels of higher education in China has approximately quadrupled in the last six years. Entering class sizes and total student enrolments have risen even faster, approximately quintupling. Prior to 1999, increases in these areas were much smaller. Much of the increased spending is focused on elite universities, and new academic contracts differ sharply from earlier ones, which lacked tenure and often used annual publication quotas.

These changes have already had large impacts on China's higher educational system and are beginning to be felt by the global educational structure. Skilled labour supply in China now equals around 40 per cent of that in all

This paper has been written with support from The Centre for International Governance Innovation (CIGI, Waterloo). We thank Emanuel Ornelas, Peter Schott, John van Reenen, Stephen Redding and participants of the Emergence of China and India in the Global Economy Conference (London, UK, 2008), as well as Kun Peng, Li Wang and Weimin Zhou for valuable comments.

OECD countries, and the growth rate of student numbers is much higher than in the OECD. We suggest that in the coming years, these shifts may have major implications for global trade both directly in ideas, and in idea-driven products. These changes, for now, seem relatively poorly documented in literature.

The changes we discuss also reflect a wider strategy of attempting to upgrade the quality and skill content of Chinese production through large increases in higher educational resource inputs and other changes in economic policy in China. This strategy, adopted by high-level policymakers in China, is seemingly not driven by analysis of the demand side of labour markets. The sharp increase in the number of individuals with higher educational attainment has created significant short-term problems of absorption and unemployment for such labourers in various areas. These education policies have also been a factor in China's increasing inequality. China's transformative strategy differs from that of most low-wage developing economies, such as India, which focus on primary or secondary rather than tertiary education.

The transformation has potentially major implications for the global educational system, as China's changes will have global impacts on relative supplies of skilled labour, academic publications, and trade in ideas and idea-related products. The strategy may also change our perception of the link between education and growth. The paper also speculates on the effectiveness of these policies. China seems to be alone among lower-income economies in having focused its educational transformation in recent years on the tertiary educational sector, but at the same time China is clearly undergoing radical change in many different areas of economic activity and the educational system is only one of these. Previous efforts in other countries to use educational transformation as a mechanism either to maintain high growth or to initiate episodes of high growth have generally been regarded as unsuccessful, but those efforts focused on primary and secondary education. China's efforts seem to be motivated by a desire to maintain high growth by using educational transformation as the primary mechanism for skill upgrading and raising total factor productivity. If it succeeds, other countries may follow, leading to higher education competition.

The rest of the paper is organised as follows. Section 2 sets out broad dimensions of the educational transformation under way in China, drawing on the latest countrywide data. Section 3 analyses the policy objectives behind these educational policies and how they relate to the broader development strategy now being used to maintain high growth in China's economy through various types of quality upgrading. Section 4 assesses the effectiveness of educational transformation policies. Section 5 assesses the wider global implications of the transformation under way in China and Section 6 concludes.

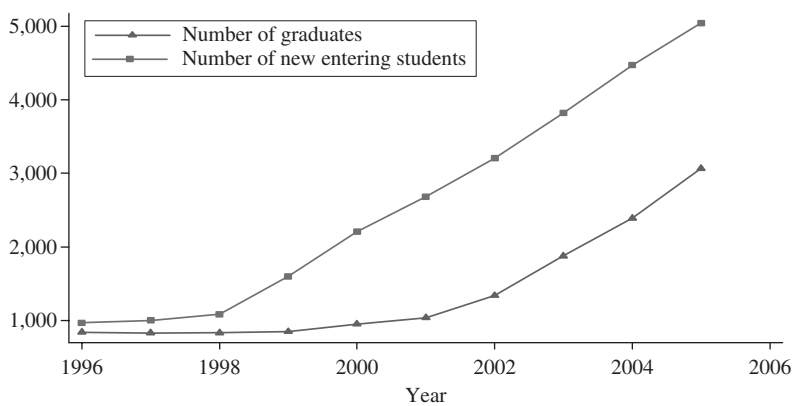
2. THE DIMENSIONS OF THE HIGHER EDUCATIONAL TRANSFORMATION IN CHINA

The changes which have taken place in China's higher educational system since 1999 are relatively poorly documented in available literature, but the changes are large and seemingly have major implications for economic activity both within China and globally since China is a large economy with a population of 1.3 billion. Below we set out some dimensions of the changes involved.

a. Large Increases in the Number of Students

The number of graduate students and undergraduate students in China has approximately quadrupled in the last six years (see Figure 1). Before 1999, the number of students both graduating and enrolling was stable. In 1998, the total number of graduates from tertiary education was 830,000; in 2005, it was 3,068,000, an increase by a factor of 3.7. The number of enrolments (both for new students and for total students) has risen even faster and has approximately quintupled between 1998 and 2005 (see Figure 2). The new student enrolment is 4.7 times larger in 2005 than in 1998. The total enrolment is 4.6 times larger in 2005 than in 1998. The proportion of college (and higher) degree holders grew at the rate of approximately 7.5 per cent per year between 2000 and 2005.[1]

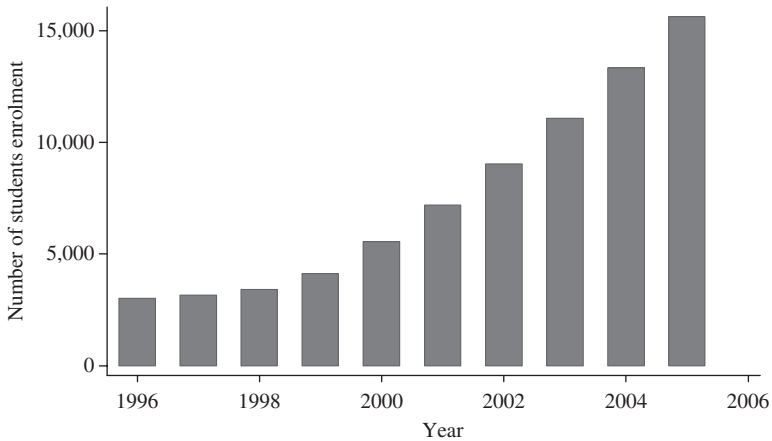
FIGURE 1
The Number of Graduates from and Entering Students into Tertiary Education in China
(Unit: 1,000 persons)



Source: National Bureau of Statistics of China (2006).

[1] In 2000, the number of college (and higher) degree holders per million in China was 36,110. This number went up to 51,781 in 2005. Data source: National Bureau of Statistics of China.

FIGURE 2
Enrolment in Tertiary Education in China
(Unit: 1,000 persons)



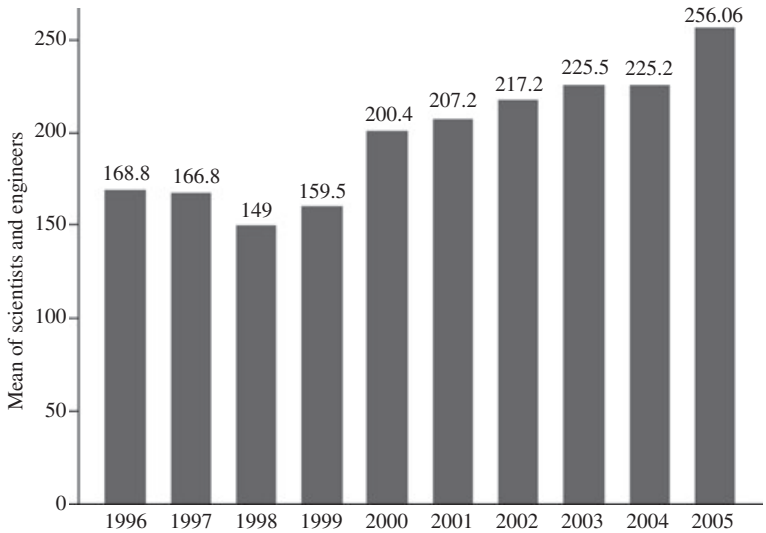
Source: National Bureau of Statistics of China (2006).

b. More PhD Engineers and Scientists in China by 2010 than in the United States

In engineering and sciences these changes have been especially pronounced (see Figure 3). It is widely recognised that there will be substantially more PhD engineers and scientists in China in 2010 than in the United States, since on a flow basis China produces three times the number of engineers compared to the United States. Among 24-year-olds in 2001 who had a Bachelor of Science or Bachelor of Arts degree, only 5 per cent in the United States were engineers, compared to 39 per cent in China and 19 per cent or more in South Korea, Taiwan and Japan.[2] The United States also compares poorly to European countries' bachelor's degrees awarded in the fields of engineering and science.[3] Recent data by National Science Foundation (NSF) also shows that United States is now producing fewer engineers than from other parts of the world, and particularly from Asia.[4] R. E. Smalley, a Nobel Prize-winning scientist, concluded that by 2010 90 per cent of all PhD physical scientists and engineers in the world will be Asian living in Asia.[5] Among Asian PhD engineers and scientists, most will be produced by China.

[2] See Herbold (2006).
[3] See Herbold (2006).
[4] See NSF (2006) as well as NSF (2007).
[5] See Herbold (2006).

FIGURE 3
The Number of China's Scientists and Engineers
(Unit: 10,000 persons)



Notes:
The indicator 'scientists and engineers' refers to the number of personnel engaged in S&T activities who have BS/BA (equivalent or above) degrees. This is different from the total number of graduates in science and engineering.

Source: National Bureau of Statistics of China (2001, 2006).

c. Sharply Changed Access to Higher Education for Urban and Rural Households

A further feature of China's higher educational transformation is considerably improved access to higher education for rural households. As a result, the gap in access between rural and urban areas is gradually diminishing. Data from 'Science and Engineering Indicators 2006' shows that number of university degrees per 100 24-year-olds is five in 2003 for the whole of China. In the mid-1990s, conditional upon being in the urban sector (including counties and towns) the probability of high school graduates obtaining admission to university was around 0.3. That probability in 2005 is almost 0.5.[6] Admission rates are higher than these since not all high school graduates register for high education entrance exams, and entrance exams are organised throughout China. The admission rates for both urban and rural registrants have increased from 42 per cent and 32 per cent in 1998 to 68 per cent and 63 per cent in 2005,

[6] We conclude this from data on numbers of high school graduates from 'Educational Statistical Yearbook of China' and data on numbers of admissions to universities from Ministry of Education. The probabilities in 1996 and 2005 are 0.30 and 0.45, respectively.

TABLE 1
China's Higher Education Admission Rates for Urban and Rural Population
(Unit: 10,000 persons)

Year	*Admissions (Urban)*	*Admissions (Rural)*	*Population (Urban)*	*Population (Rural)*	*Admissions Rate to Population (Urban) (%)*	*Admissions Rate to Population (Rural) (%)*
1996	52.03	50.75	37,304	85,085	0.14	0.06
1997	53.15	52.66	39,449	84,177	0.13	0.06
1998	59.82	55.77	41,608	83,153	0.14	0.07
1999	84.47	74.40	43,748	82,038	0.19	0.09
2000	116.00	106.00	45,906	80,837	0.25	0.13
2001	150.55	133.76	48,064	79,563	0.31	0.17
2002	181.90	168.14	50,212	78,241	0.36	0.21
2003	214.40	213.99	52,376	76,851	0.41	0.28
2004	246.64	273.04	54,283	75,705	0.45	0.36
2005	269.27	303.81	56,212	74,544	0.48	0.41

Source: Admissions data from Gou (2006); Population data from National Bureau of Statistics of China (2006).

respectively. The proportion of urban students in total admissions decreased from 52 per cent in 1998 to 47 per cent in 2005, while the proportion of rural students in total admissions increased from 48 per cent in 1998 to 53 per cent in 2005. Admission rates for the population in rural areas have risen much faster than admission rates for the urban population (see Table 1).

Entry into tertiary education in China for now is still largely restricted to urban residents, but with increasing attention being paid now to social harmony as a broad policy direction in China, educational attainment data are likely to show ever more rural participation in the years ahead. Current data show evidence of this trend.

d. The Promotion of Elite Universities and Consolidation of Other Universities

A further feature of recent Chinese higher educational policy has been both to promote so-called 'elite' universities and also to consolidate other universities and reduce their numbers. Elite universities are the top 10 universities in China, which receive the largest education funds from central and local governments. They have priority in selecting students through national entrance exams and have the best faculty and research resources in China. The focus of policy is to elevate a small number of Chinese universities to world class status and to strengthen them and make them bigger. All universities in China have in recent years been subject to directives from central ministries to substantially increase their numbers of undergraduate students, even if a significant increase

in infrastructure to handle this increase in student numbers lags. Increases in undergraduates of 30 per cent a year common in many universities are a result of this policy.

In many of China's major cities, there has also been consolidation of universities, where, say, four or five small universities in the city are consolidated into a large single entity as a way of improving their ranking. This in part reflects incentives pursued by local governments so as to secure more central funding. Data from the Chinese Ministry of Education show that 431 consolidations occurred between 12 January 1990 and 15 May 2006 and 60 per cent of these occurred between 1999 and 2006.[7] Many of the consolidations involved elite universities. But this also partly reflects a re-orientation of higher education by the Chinese government in the mid-1990s under the '211 Higher Education Development Project'.[8] This advocated priority development of about 100 higher educational institutions so that they could rank among the top universities in the world. For example, Beijing Medical University was incorporated into Peking University and was formally renamed Faculty of Health Science, Peking University, in 2000. Eventually, the Central Arts and Design College was incorporated into Tsinghua University and was renamed Faculty of Arts and Design, Tsinghua University, in 1999.

e. A Change from Quantity- to Quality-orientation in Education

These higher educational changes have also been accompanied by a change in focus from quantity flow through in education in the pre-1999 period, to an elevated emphasis on quality post-1999. Educational attainment in China is now subject to firm quantity indicators which are designed to drive continued improvement of educational quality in participating institutions. Funding is no longer simply a matter of increasing the numbers of students enrolled; universities and institutions of higher education in China are now subject to extraordinary pressures to upgrade themselves in terms of objective rankings. High priority is placed on international rankings based on publications in international journals, citations and international cooperation. These are used as demonstration of elevation of attainment at each educational institution and funding is directly linked to these indicators. Some of this focus on improved educational attainment in China seems to be spontaneous and itself accelerated by the policy process that exerts the pressure. It is now accepted as important for universities and related institutions to achieve publication in journals of good

[7] China's Ministry of Education (2006), 'Consolidation of Universities since 1990 in China'. Available at: http://www.moe.edu.cn/edoas/website18/level3.jsp?tablename=621&infoid=19558 (accessed on 5 March 2011).

[8] Announced in 1993, Project 211 is to identify for the twenty-first century 100 institutions and a number of disciplines of 'world standard' by preferential treatment. See Lang and Zha (2004).

ranking, and what is generated by publication citations counts equally for Chinese scholars in their appointment, maintenance of position and promotion. Indicators of educational attainments in terms of international rankings across countries, publications of papers and citations feed directly into annual performance indicators for Chinese faculty in an ongoing process. It is not uncommon for an annual target of three international publications to be set for faculty members, with termination of employment to occur on non-fulfilment of this. Universities themselves may also be given targets for improvements in international rankings and activities. The resulting changes in quality of educational performance both by educational institutions overall and by individual faculty members and students are striking. For instance, China's share of Asian science and engineering articles increased from 14.54 per cent in 1998 to 22.43 per cent in 2003, with an annual growth rate of 9 per cent.

The primary stress on education attainment is on traditional academic disciplines, especially the hard sciences. The social sciences and business however also attract much attention. The arts have been given relatively low priority. Conventional vocational training as practised in the OECD countries in trades such as plumbers, electricians, travel agents and hairdressers has been given low priority, but more recently vocational training has been paid more attention than before. So far, there is limited professional certification for trades in China and the focus on vocational training has been on professionals such as doctors, nurses, lawyers, dentists and others.

Later in the paper we outline what some of the dimensions of the quality of change are and stress that both quality and quantity of educational changes are occurring together. It is also important to stress that the increase in student numbers in both undergraduate and graduate programmes of over 30 per cent per year is much higher than the underlying growth rate of China's economy, and these changes are also taking place in a period of demographic transition to one child per family.

f. Data on China's Educational Transformation

While the educational transformation under way since 1999 in China seems major and radical, available data on a system-wide basis are surprisingly sparse. We have assembled data on numbers of students both entering and graduating by area of study and educational institution. These areas of attainments include sciences (physics, chemistry, engineering, computer science and related fields), social sciences (including economics, political science, psychology and other disciplines), business and business-related studies, and also professions, including doctors, nurses and lawyers.

In many of these areas, particularly in business, there are now large private costs involved with educational participation for households in China. Educa-

tional attainment is given high priority in the social structure, and the gains in terms of upward social mobility and income benefits associated with educational attainment are perceived to be large. Entry into education seemingly generates social inequalities, which is a source of current concern in China given the rapid increases in income and wealth inequality in recent years.[9] There are some data, for instance, that suggest that it is not uncommon for a substantial proportion of urban and rural households to devote considerable incomes to tutoring expenditures, so that entrance into an educational institution can be attained by their children. A survey conducted by Chinese Academy of Social Sciences (hereafter CASS) shows that education expenditures for children ranks No. 1 in consumption categories for Chinese households and overwhelms pension and house expenditures.[10] These costs are additional to the time costs of parents.

It is also not uncommon for students to study subject material from the age of six at which point that may on average devote 8.6 hours a day at school, with some spending 12 hours a day in the classroom, according to a survey conducted by the Chinese Youth and Children Research Centre (CYCRC).[11] The survey also claimed that the majority of children spend longer hours at school than their parents spend at work. All of these features thus feed into an educational process which is now central to both China's economy and social structure.

(i) Countrywide data by subject area of study and institution type

We have collected data from China's Ministry of Education and National Bureau of Statistics of China on numbers of students in regular higher education institutions (HEIs, including universities, colleges, short-term colleges and vocational institutions) as well as numbers of postgraduate students by field of study. Ranked by the proportion of student numbers in total enrolments in 2005, the top fields in China's HEIs are science and engineering (41.3 per cent), economics and management (23.3 per cent), literature and foreign language (14.8 per cent), medicine (7.2 per cent), education (6.5 per cent) and law (4.5 per cent); the most popular fields for Doctor's and Master's programmes are science and engineering (50.1 per cent), economics and management (16.1 per cent), medicine (10.3 per cent), literature and foreign language (7.5 per cent), law (6.7 per cent) and education (3.1 per cent). Data on entrants and graduates show that management is the most rapidly expanding field in tertiary education in China.

[9] See Zhang (2006) as well as Li (2005).

[10] See CASS (2005), 'China's Education Blue Paper'. http://gb.cri.cn/14714/2007/01/15/1745@1399576.htm (accessed on 12 August 2008).

[11] Source: People's Daily Online (2007), 'China's Children Too Busy for Playtime', 13 May 2007. Available at: http://english.peopledaily.com.cn/200705/13/eng20070513_374164.html (accessed on 14 October 2008).

We also obtained summary statistics for Chinese universities and colleges, short-term colleges[12] and tertiary vocational-technical colleges by type of educational business, international trade, tax affairs, accounting, auditing and other specialities. In 2005, there are 1,792 HEIs in total, in which 39.1 per cent are universities and colleges, and 60.9 per cent are short-term colleges. Among those short-term colleges, 84 per cent are vocational colleges. While non-state/private colleges are only 3.9 per cent of total universities and colleges, they account for 23.6 per cent of total vocational colleges. The top types of HEIs (in terms of numbers of HEIs) are natural science and technology (36.2 per cent), comprehensive university (21.2 per cent), teacher's training (10.2 per cent) and economics and finance (9.4 per cent). The rapid increase in total numbers of Chinese higher educational institutions between 1997 and 2005 mostly reflects expansion of numbers in short-term colleges (an increase by a factor of 3.3) and vocational colleges (an increase by a factor of 9.1). Numbers of universities and colleges also rise, but not by too much. At university and college level, growth depends more on the enlarged size of each institution rather than the increased number of total institutions. At short-term college and vocational college level, growth relies more on expansion in the number of institutions.

(ii) Funding sources for China's higher educational institutions

We next discuss funding sources for China's higher educational institutions. There are three separate sources – government funds, commercial income from university-owned companies and entities, tuition and other educational charges such as fees paid by students and parents – and we will discuss each.

Government funding for China's leading universities is largely programme based. In 1998, under a special '985' Project,[13] 10 of China's leading universities were given three-year grants in excess of 30 billion RMB (current price) for quality improvements.[14] Included in the first round of 985 Project grants were Peking, Tsinghua, Fudan, Zhejiang and Nanjing Universities.[15] Peking and Tsinghua Universities, the top two ranked institutions, each

[12] Short-term colleges refer to those colleges which only offer two- or three-year programmes.

[13] Project 985 was officially approved in May 1998 during the centennial anniversary of Peking University, when the Ministry of Education appealed to the top leadership for reserving China's 1 per cent of its annual revenue in three consecutive years, from 1999 to 2001, for the purpose of building world class universities in China. The objective of the large extra investment is to promote the around 10 universities into world well-known universities.

[14] Wang, H. (2002), 'High Profile Universities in China Compete for ¥30 Billion Governmental Appropriation, and to be "World Class" in 10 Years)', 21CN BUSINESS HERALD, 27 May 2002: 1 and 3.

[15] Both Peking University and Tsinghua University were granted $225 million each over five years, while Nanjing University and Shanghai Jiaotong University received $150 million each. See World Education News & Reviews (2006).

received 1.8 billion RMB. Afterwards, the Ministry of Education cooperated with provincial or municipal governments and other departments to also develop Shanghai Jiaotong University, Xi'an Jiaotong University, Science and Technology University of China and Harbin Industry University. According to 2003 data,[16] those Project 985 universities in this phase of support accounted for only 1 per cent of the total higher education enrolments, but their key laboratories accounted for almost a half of the whole annual research funds, 20 per cent of postgraduate student enrolment and 30 per cent of doctoral candidates. Project 985 funds provided these universities with considerable support. These grants were awarded in addition to financial support provided by a further 211 Project under a separate programme aimed at developing 100 quality universities for China for the twenty-first century. In 2004, the second phase of the 985 Project was launched and the number of universities covered was enlarged to 30.[17]

China's 11th Five-Year Plan provides detailed information on the amount of resources devoted to improve educational attainment within the Chinese higher educational system. Much of this information is unfortunately not consolidated in a consistent way across institutions. Generally, the financing arrangements involved are institution specific, and no more information is given by the institutions themselves.

We have been able to collect some information for a small number of HEIs and top elite institutions in China and use this to generate data on the amount of government funding flowing into these institutions. The top 11 universities (those universities included in the 985 Project at the first phase) received more than 17.43 billion RMB from government funds in 2004. Among all 32 universities who received more than 500 million RMB, 29 universities obtained support from the 985 Project.[18]

In addition to government funding, HEIs in China also generate significant support by engaging in commercial activities. These include companies and other entities owned by the institutions and which the institutions operate. In 2004, all university-owned companies and entities in China had total revenue of 96.93 billion RMB, in which they refunded universities 1.75 billion RMB.[19] In 1998, the total revenue was 31.2 billion RMB, and payment to universities

[16] See Zhou Mansheng, Deputy Director-General of National Center for Education Development Research, 'Developing the Chinese High-level Universities, Enhancing the Competitiveness'.
[17] See World Education News & Reviews (2006).
[18] Liu (2007), Mimeo. Available at: http://jiaoyu.ustc.edu.cn/qkln/2007/2/2007xdh2-10.doc (accessed on 12 August 2008).
[19] See China's Ministry of Education (2005), 'Statistics Report on China's University-owned Companies and Entities (1998–2005)'. Available at: http://www.edu.cn/20010101/19698.shtml; http://www.cutech.edu.cn/cn/kjcy/xbcytj/2005/08/1179971252173016.htm (accessed on 12 August 2008).

was 1.5 billion RMB.[20] The refund to universities is growing slowly, much less than the growth of income and profit. However, the funding flowing into these educational activities has increased by approximately 15 per cent.

Before the higher educational transformation began in 1999, the Chinese government was the main funding source for HEIs in China. But from 2001 on, private funding (tuition and fee payment) covers more than 50 per cent of total education expenditures.[21] An even larger resource commitment is the time commitment of participants in the educational process. The educational activity undertaken by students participating in higher education implies a large investment in human capital for China. This is reflected not only in the time spent in education once admitted to the institution, but also in the time spent in obtaining entry into the educational institutions. This can involve 10–15 years of prior activity in education and extraordinary time commitments from the age of four to the age of 18–20. Some survey data report, for instance, 40 per cent junior middle school students work more than 12 hours per day, seven days a week, and 58.3 per cent students work six days a week, to prepare for the entrance exam to high school.[22] One can realistically claim that the educational process in China is a central mechanism generating a highly educated, well-motivated and hard-working labour force in China. Casual observation indicates that Chinese people work extraordinary lengths of time and put in great effort, and in the process generate enormous energy and drive which is central to China's extraordinary growth process. China's educational transformation can thus be seen in this way as a central element underpinning the sustainability of current China's high-growth performance.

3. EDUCATIONAL TRANSFORMATION AS PART OF CHINA'S WIDER DEVELOPMENT STRATEGY

We next turn to the broad policy objectives underlying the educational transformation in China. Current thinking in the Chinese government treats the educational transformation of China as part of China's broader development strategy. This educational transformation strategy is part of a wider strategy in place for a number of years designed to maintain growth in China's economy through various forms of quality upgrading.

[20] Source: China Education and Research Network (2001), 'Statistics Analytical Report on University-owned Companies and Entities in China (1998)'. Available at: http://www.edu.cn/20010821/189449.shtml (accessed on 12 August 2008).
[21] National Bureau of Statistics of China (2005), 'How Much is China's Educational Expenditures?'. Available at: http://news.xinhuanet.com/report/2005-06/16/content_3093744.htm (accessed on 12 August 2008).
[22] See http://gs.studentboss.com/xiaoyuan/newsjj.php?id=4511 (accessed on 12 August 2008).

Many of the details of the elements of the strategy are in the 11th Five-Year Plan, but were also set out in the earlier 9th and 10th Five-Year Plans which provided detailed policies aimed to maintain China's growth process.[23] The 11th Five-Year Plan laid down action guidelines for a five-year period aimed at achieving an 'all-round well-off society' by 2020. Currently, the construction of a 'harmonious society' based on a 'scientific outlook of development' is the focus of the Chinese government.[24]

This so-called scientific outlook for Chinese development seeks human-oriented, balanced and all-dimensional sustainable development. It consists of five initiatives: (i) harmonisation in the development of urban and rural areas (greater priority given to the development of rural areas and solving problems concerning farmers), (ii) harmonisation in regional development (greater assistance to less developed areas), (iii) harmonisation between economic and social development (expansion of employment opportunities and enhancement of social security and public services, such as medical care and education), (iv) harmonisation between economic development and the human and natural environment (greater emphasis on resource preservation and the protection of the natural environment), and (v) harmonisation between domestic development and integration into the global economy (acceleration of domestic market growth while internationally opening-up).

The 11th Five-Year Plan aims to shift China's economic and social policies away from the priority of 'getting rich first' by equally stressing 'common prosperity and highlighting the need to create a 'harmonious society'. The policy of getting rich first was based on ideas proposed by Deng Xiaoping, the reform architect of China in the 1980s who argued that the whole country would eventually become rich by allowing some people and regions to prosper first. This idea ran contrary to the principle of absolute equality adhered to by Mao Zedong and was aimed to stimulate people's desire to work and get rich. This has served as the driving force behind China's rapid economic growth beginning in the 1980s, but has also resulted in widening disparities between the rich and the poor. In order to deliver the fruits of economic development more broadly to the whole country, the latest proposals call for the establishment of a social safety net – social security and medical care systems, insurance schemes for unemployment and labour accidents, and other elements – in addition to creating jobs, narrowing regional disparities and resolving the so-called 'three agriculture-related problems', namely, agriculture, peasants and rural villages. In particular, the plan calls for increasing

[23] See Fan (2006).

[24] Source: China National Development and Reform Commission (2006), 'The 11th Five-Year Plan: Targets, Paths and Policy Orientation'. March 2006. http://en.ndrc.gov.cn/newsrelease/t20060323_63813.htm (accessed on 12 August 2008).

government expenditures to enhance public goods and services, with a spending emphasis on infrastructure development and education, in order to modernise rural areas. Education, especially higher education, plays an important role in the 11th Five-Year Plan.

In the 11th Five-Year Plan, a strategy of rejuvenating the country through science and education and strengthening the country through improving human resources is a central element. Education is given priority status, with quality-oriented education a main theme, and especially improving the quality of higher education. The Chinese government seeks to promote an all-round, coordinated and sustainable development of educational institutions.

The main tasks for the higher educational development strategy in the 11th Five-Year Plan are as follows. The gross enrolment rate of higher education is to reach 25 per cent of each entering age cohort by 2010 and the total enrolment of higher education is to hit 30 million.[25] In the meantime, vocational training, further education and adult education of various forms will receive more emphasis with the establishment of a learning society. There is also stress on improving the abilities of teachers to implement quality-oriented education. Reforming and improving the examination and evaluation component of the system is seen as a key and in accordance with the demand for quality-oriented higher education.

To promote balanced and sustainable development of the higher education area in China, the 11th Five-Year Plan sets out concrete measures to improve the quality of tertiary education. The '211 Projects' and '985 Project' are to be continued, with an emphasis on technology innovation, cultivating talents with creativity, and improving the capacity for self-innovation, so that top universities in China become an important force in an increasingly innovative nation. Programmes of quality improvement are to be implemented, and a quality evaluation system designed to fulfil the objective of quality-upgrading orientation change. Also, the Chinese government seeks to deepen reforms of technology innovation to generate an educational system which integrates learning, research and production activity together. The government encourages universities and research institutions to place priority on original and integrative innovation, to improve ability in applied research and transform technology in industrial and commercial production.

To improve the quality of teachers, a strategy of 'developing the institution through human resources' in higher education is emphasised with a focus on a group of academic leaders with international excellence. There is stress placed

[25] The State Council of China (2007), 'The 11th Five-Year Plan Outline for National Education Development'. Available at: http://news.xinhuanet.com/edu/2007-05/24/content_6143354.htm; http://news.xinhuanet.com/politics/2007-06/11/content_6226661.htm (accessed on 12 August 2008).

on producing a group of middle-aged and young leading academics who can undertake national key tasks and participate in international competition.

'Fair Play' in education is also emphasised. There is an objective that public education be promoted in ways that are open, fair and equal access to higher education should prevail in China. The government is to improve facilitation mechanisms for poorer students in HEIs, with student loans as a major factor so that no student will be denied access to higher education because of financial difficulties.

While these objectives are commendable, there have been difficulties in implementation. Chinese banks have been reluctant to lend money to poor students and often ask them to return the loan before they graduate. If poor students cannot return funds before they graduate, they are not authorised to receive certificates of graduation and degrees and their chance of finding good jobs is small. In the 11th Five-Year Plan, the government commits itself to a 'Sunshine Programme' to ensure the recruitment process by universities is open, fair and justifiable. The government also acknowledges the importance of creating employment for university graduates and encourages them to take jobs at the grass-root level.

These plans are complex in both specificity and form. Some of the details are set out in Whalley and Zhou (2007) who discuss the 11th Five-Year Plan more broadly. The educational component of the 11th Five-Year Plan is clear in providing for large injections of funds into China's tertiary educational system. Education is a major focus over the five-year period of the plan, with the proportion of public education expenditures to GDP aimed to increase to 4 per cent in 2010, from 3.4 per cent in 2002. This target is for public education at all levels, not specifically higher education. However, among the tertiary education expenditures, much of the additional spending is focused on the elite universities, a group of around 20 universities in China, which are thought to have the best students and the capability to grow and mature into major global educational institutions which are comparable to those in the OECD. The research component of university activities is also seen as a central element in generating new ideas and eventually process and production methods which will improve profitability. Educational improvement in both research and student generation is thus seen as a central element of a continued high Chinese growth process.

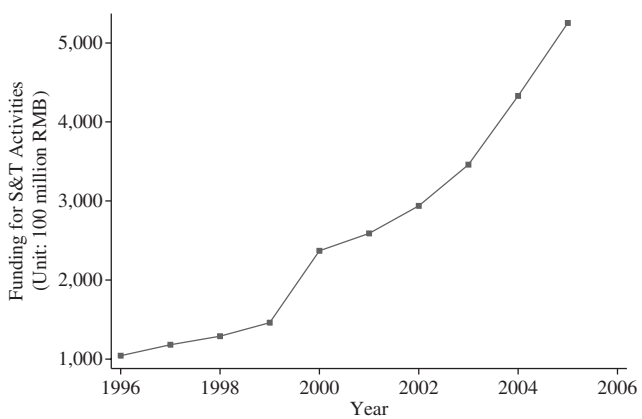
Along with a focus on elite universities, there is also a focus on improving the talent pool in China by raising the quality of available talent and particularly for higher levels of the talent pool. There is some evidence of reversal 'brain drain' to China consistent with this policy. Zweig (2006) points out that 'a reverse brain drain is under way in mainland China. The number of returnees hit 30,000 in 2005, up from 7,000 in 1999'. Data from the Chinese Ministry of Education show that in 2005, the total number of returnees is 35,000;

in 2004, the number is 25,000; in 2003, the number is around 20,100.[26] The number of returnees is thus continuously increasing. Also, the production of a high-level talent pool within China has accelerated after the educational transformation policies were put in place.

Some educational funds are focused on providing resource packages to encourage researchers abroad to return to Chinese universities, often in conjunction with enterprises. Stress is placed on combining enterprise-related research development activity with similar activities undertaken in research institutions. The objective is to achieve an improvement in the international stature of education institutions in China, with links and contacts with education institutions abroad to be encouraged. Funding is provided for Chinese graduate students to spend time abroad to interact with members of the international research community. China's State Council claims that China will boost R&D investment to 2 per cent of gross domestic product in 2010 and 2.5 per cent by 2020, and these activities are part of this effort. Total R&D spending in China in 2005 – not including foreign investment – reached $29.4 billion, rising steadily from $11.13 billion in 2000. Figure 4 reports the funding for science and technology activities in China, which is increasing and 1999 is a key point in the growth trend.

All these elements of China's educational transformation are part of a process which feeds this transformation into the overall growth strategy. This

FIGURE 4
China's Funding Size for Science and Technology (S&T) Activities
(Unit: 100 million RMB)



Source: National Bureau of Statistics of China (2001, 2006).

[26] China's Ministry of Education (2004, 2005), 'Statistics on China's Talents Studying Abroad (2003, 2004)'. Available at: http://www.edu.cn/tong_ji_366/20060323/t20060323_87921.shtml; http://www.gxzs.com.cn/2006/info.asp?classid=7&ArticleID=227 (accessed on 12 August 2008).

strategy in turn proceeds on the assumption that China's export growth rate of 30 per cent per year (which implies a rough doubling of China's international trade on average every two or one half years) will continue. In the process, China will focus less on simple labour-intensive manufactured products such as clothing, since it is believed China will run out of international markets for their products. A central element of a long-term growth strategy is increasing the quality of existing products and establishing new product lines. These will cover all products from textiles and clothing to chemicals, and to sophisticated electronics, including computer technology design and eventually management of higher quality service-related activities, including accounting, consulting and related activities such as sophisticated banking. These are all seen as part of the growth process and educational transformation is a route to this goal.

It is worth emphasising, however, that the transformation in higher education in China is only part of a wide overall growth strategy, and there is equal focus on other elements, as improved research development tax credits which have already been targeted towards specific industries and zones in the country. There is also a focus on large mega projects involving technology, infrastructure and other areas. Many of these are set out in Whalley and Zhou (2007). Maintaining progress on all these fronts is central to China's policy with education and the generation of ideas and talent as key to the effort.

4. EVALUATING THE IMPACTS OF CHINA'S EDUCATIONAL TRANSFORMATION POLICIES

We next discuss the effectiveness of the education policies in China discussed above. The potential benefits to China are in a large part reflected in estimates of the rate of return to education in China. But we also note the central issue of the extent to which the educational process in China serves as a screening device, and if so whether more efficient screening is available. We also suggest that in part entry to tertiary education in China is motivated by incentives to relocate abroad in high-wage countries using education as the visa-obtaining mechanism. To the extent this is true the sole return to China from expanded education is smaller than the private return. We finally discuss the impacts of China's educational transformation on total factor productivity and implicitly on growth performance.

a. Estimates of Rates of Return on Education in China

A central issue in evaluating the effectiveness of educational transformation policies in China is assessing the rates of return on educational investment in China. In this area, there are sharply differing results from available studies.

One recent study by Heckman and Li (2004) estimates the return on higher education in China allowing for heterogeneous returns and for self-selection into schooling using micro data from China in 2000 since in Chinese urban areas, heterogeneity in returns is substantial. They draw on earlier work by Carneiro et al. (2001), which emphasises comparative advantage in the labour market for schooling. Their estimate is that for a randomly selected young person from an urban area (in six provinces: Beijing, Guangdong, Zhejiang, Sichuan, Liaoning and Shaanxi) those attending a four-year college experience a 43 per cent increase in lifetime earnings (nearly 11 per cent annually) in 2000, compared with just 36 per cent (nearly 9 per cent annually) for those who do not attend. Their estimate is that on average the return to four-year college attendance in the sense of average treatment effect (ATE)[27] is very high, 43 per cent on average and 11 per cent annually for young people in the urban areas in China. These estimates are all higher than the conventional ordinary least squares (OLS) estimates (29 per cent, annual returns of 7.25 per cent) of a Mincer model applied by them to the same data, which in turn are higher than the OLS estimates reported for earlier time periods. Heckman and Li (2004) suggest that these estimates imply that, after more than 20 years of economic reform with market orientation, the average return to education in China measured by OLS or ATE has increased substantially when compared with figures for early period.[28] Skills are now being rewarded more adequately than they have been in the past in China.

The Heckman and Li (2004) estimates of the rate of return on years of schooling in China suggest that the social return to China's educational transformation policies is high and helps in maintaining high growth (see Section 4*d*). However, other recent studies by Chinese scholars have cast doubt on the size of the Heckman return estimates. These studies suggest that the rate of return may be much more modest. For instance, Wang (2007) estimates the rates of return to years of schooling for migrant workers and urban local workers, and her estimates are 4.6 per cent and 5.7 per cent, respectively, in 2001 and 5.0 per cent and 6.7 per cent, respectively, in 2005. It implies that hourly earnings of migrant workers increased by 4.6 per cent for every additional years of schooling, and hourly earnings of urban local workers increased by 5.7 per cent for every additional years of schooling, holding all other factors fixed. Wang's estimates are, however, general return to schooling, not specific to college education.

[27] ATE: The term 'treatment effect' refers to the causal effect of a binary (0–1) variable on an outcome variable of scientific or policy interest. Let Y_{1i} denote the potential earnings of individual i if he were to receive training and let Y_{0i} denote the potential earnings of individual i if not. Let $E[\cdot]$ denote the mathematical expectation operator, i.e. the population average of a random variable. $ATE = E[Y_{1i} - Y_{0i}]$.

[28] Chow (2001) presents estimates of OLS-generated rates of return in the 1980s and early 1990s.

Other studies, however, suggest that rates of return to education in China will continue to increase. For example, Fleisher et al. (2004) estimate that the OLS return to college education increased sharply between 1995 and 2002. In the year of 2000, it remained approximately 7.1 per cent per year of college. The ATE of college education was 11.85 per cent in 1995 and 23.2 per cent in 2002 in terms of the percentage return per year of college.

Most of these estimate the return to education in general more so than tertiary education and focus on the return to years of schooling in the combined system. The incremental returns associated with tertiary education conditional on attainment of primary and secondary education have only recently received attention. It is the size of these which is critical to an assessment of the success of China's educational transformation.

b. Education as a Filter/Screening

A critical issue in evaluating the effectiveness of China's educational transformation policies is whether one views education in China as screening as distinct from human capital formation. A particularly important element in the Chinese case is that tertiary education, through entrance to foreign professional programmes, is in part a visa obtaining mechanism for entry to high-wage economies and as such the private return to education in China may be influenced by this element in the educational process. Generally, the return on the international cohort provided to employers through education that arrives to employers is not reflected in available studies of the rate of return to schooling and as such estimates of the private rate of return understate the real rate of return.

The main contributors to this discussion reflect the work of Arrow (1973) and Spence (1973) who argued that higher education conveys information to employers about differing abilities of individuals and acts as a screening device, and hence, educational processes may be viewed as providing a filter. Arrow suggested that the filter mechanism is useful to employers with imperfect information on individual (potential) productivities and college educations act as a double filter, once in selection (entering) and once again in grading. Arrow also suggested that mere admission to college may perform the screening function. Spence (1973) had earlier put forward similar ideas arguing that education was primarily served to select individuals, without really influencing their productivity in future professional life. Under this view a person's productive efficiency is as an intrinsic quality, which may depend on a wide range of factors, but over which education exerts little influence. According to Spence, if productive efficiency is not observable by potential employers, then success as a student serves to signal the presence of productive characteristics. Spence (1973) argued that under this view of the world that if education serves solely

to signal productive capacities to employers, workers have a tendency to over-educate themselves. The direct value added to society from education may thus be relatively small.

Thus, if the educational process in China serves mainly as a mechanism for employers to distinguish between high and low attainment individuals, the return to education to employers lies in allowing them to sort individuals by ability, attitude and other characteristics using educational attainment. If this is the case, one can argue that the screening mechanism is best served by undergraduate education and graduate education adds relatively little benefit as a filter. If this is the case, then the component of China's educational transformation focused on research and graduate training may be inefficient social investment.

One can go further and argue that the significant increases in graduate education in China do little to enhance filtering and only delay employment. One could even suggest that current high unemployment rates experienced by undergraduates in China generate political pressure for more graduate education as a way of absorbing (postponing) undergraduate unemployment. Data from the Ministry of Personnel show that in 2006 the number of total graduates from HEIs hit 4 million but the total demand for college graduates in China was only 1.66 million. It implies that nearly 60 per cent of college graduates faced unemployment following graduation.[29] Under this view, the radical changes which have taken place since 1999 can be seen in part as a mechanism for absorbing undergraduate unemployment and delaying the eventual labour market adjustments associated with a large pool of younger workers entering the labour force with an additional four years of university undergraduate education.

Finally, a key issue for China that needs to be injected into this discussion is that educational screening in the Chinese case can also be for entry to foreign graduate schools and, eventually, residence abroad in high-wage countries. These returns are private returns to departees, but not social returns to China as a nation. They are not reflected in current empirical studies and may dominate other components of the rates of return on tertiary education among the top portion of recent educational cohorts.

The evaluation of China's educational transformation policies therefore in terms of its growth and efficiency contribution to the economy rests heavily on one's view of the educational process. Rates of return to education reflect different interpretations as to the nature of the education process. If education is viewed as screening more so than direct generation associated with human capital, then marginal benefits to employers need to be factored in as well as observed higher returns to workers through higher wages. As such education

[29] See http://news.qq.com/a/20060716/001002.htm (accessed on 5 March 2011).

viewed as a screening mechanism may raise social rates of return beyond those generated empirically.

c. Impacts of Education on Inequality

A further element in an evaluation of China's educational transformation policies is the impact of educational transformation on inequality. Fleisher et al. (2004) claim that changes in rates of return to schooling have paralleled rising income inequality, suggesting a link between inequality and schooling. According to Yang (1999), by the late 1990s China had surpassed most other countries for which data are available in rising income inequality, and by 2000 China had one of the most unequal income distributions in the world (Yang, 2002).

China's unequal society has been the focus of recent studies (Yue et al., 2006). According to the data released by Asia Development Bank, China's Gini coefficient rose from 0.41 in 1993 to 0.47 in 2004,[30] almost the highest among countries in Asia and approaching Latin American levels. The income disparity between households in eastern and western and coastal/non-coastal areas has also increased. The Gini coefficients for urban and rural areas separately are 0.34 (Yin et al., 2006) and 0.38 (National Bureau Statistics, 2006). Other studies show similar numbers. For instance, Wang (2007) uses the China Urban Labour Survey (CULS) to calculate the urban Gini coefficient as 0.3969 in 2005 and 0.3476 in 2001. In other words, the Gini coefficient numbers are smaller within urban and rural areas, but if urban and rural areas are taken as a whole, the Gini coefficient rises to 0.47. This suggests that income disparity between towns and villages is a key element of inequality.

A further statistic is that the ratio of urban to rural incomes in China has risen from 1.8 in the mid-1980s up to around 3.3 or 3.4 today (Li and Luo, 2007). This change seems closely related to the major educational transformation under way in China since this transformation focuses on tertiary education rather primary or secondary. Also, the objective of maintaining growth through higher tertiary educational expenditures seems likely to intensify inequality issues in China. In turn, one can argue that increasingly educational attainment is now focused on rural rather than urban households, and the process of educational transformation may be a factor which will also progressively combat relatively inequality in China.

According to Heckman and Li (2004) and Fleisher and Wang (2005), though there was a sharp acceleration in schooling expenditures in the previous decade in China, the proportion of the population attending college remained small.

[30] Economist.com: 'Asia's Rich and Poor', 9 August 2007, from *The Economist* print edition. Available at: http://www.economist.com/world/asia/displaystory.cfm?story_id=9616888 (accessed on 12 August 2008).

Fleisher et al. (2004) argued that the proportion of the population aged 20 and higher with a college degree in China was less than 3.2 per cent in 1993 and grew to only 3.5 per cent in 2000 according to 1993 and 2000 population census (National Bureau of Statistics of China, 1994, 2002). The more critical number, however, is the fraction of the entering age cohort who receives higher education and this is much higher and increasing. And even though the proportion of the total population with higher education is small, the magnitude of the population with higher education is large globally and the total number of higher education graduates in China ranks first in the world labour supply.

d. Impacts on Growth

The evaluation of impacts of educational changes in China on growth performance is another central element in an overall evaluation of the impacts of China's educational transformation. The issue impacts both on total factor productivity and the growth rate of labour productivity adjusted to account for changes in educational quality in human capital.

Recent extensive literature on growth accounting in China has tried to understand the determinants of high-growth performance in China and how growth performance could change in the years ahead as well as the role of various elements of changes in policy, and the changed international environment on the Chinese economy. Much of the literature applies simple growth accounting of traditional Solow (1957) and Denison (1967) to the Chinese economy and attempts to try to understand the primary determinants of growth. In recent years, work in this area by Shantong Li underpins many of these policies set out in the 11th Five-Year Plan in China which focuses on quality upgrading and specifically on educational transformation as a central element of growth.

The original Solow paper on the United States used the time series back to the 1870s and used time derivatives of an aggregate production function to produce the famous Solow growth accounting equation that overall growth rates can be decomposed into a rate of growth of Hicks-neutral technical change and a weighted sum of rates of growth of factor inputs where weights are given by factor shares. Solow used long time-series data for the United States to come to the conclusion that approximately 85 per cent of the US growth was due to technical change and not to the accumulation of factor inputs. If this view is also accepted for the Chinese case, how educational transformation will relate to overall total factor productivity growth becomes a key in evaluating the impacts of China's educational policies. Subsequent work, however, challenged the Solow–Denison view of the world. Christensen and Jorgenson (1969) noted that changes in the quality of factor inputs would also play a major role in growth performance as educational input is one of those elements able to dramatically reduce the Solow residual by taking into account quality change in factor inputs.

The work by Shantong Li on China comes to the conclusion that total factor productivity growth in China was a less central driver of growth as in the original Solow work on the United States. Factor accumulation was a more major determinant of China's growth. Using this work, the 11th Five-Year Plan sets targets that the proportion of growth to be accounted for by total factor productivity growth should rise to 60 per cent and educational transformation is seen as a key element of this. However, other more recent work focused on the role of foreign direct investment (FDI) in China's growth accounting decomposes the Chinese economy into FDI and non-FDI economy and challenges this view. Whalley and Xin (2006) provide a growth accounting calculation for China which suggests most of Chinese total factor productivity growth over the last 20 years is accounted for by growth in foreign invested enterprises and specifically by FDI into the Chinese economy. Under this view, the role of educational transformation in China's growth would be significantly diminished in terms of its potential impact on growth performance.

Other work in the growth accounting area also comes to the conclusion that factor accumulation in the Chinese case has been less central for growth than has previously been thought. Thus, the growth accounting literature suggests that higher educational transformation in China in terms of its impact on growth has been influenced by the international environment in which China has been operating with the role of FDI potentially, and the significance of factor accumulation, as against technical progress in terms of generation of growth.

5. POTENTIAL GLOBAL IMPLICATIONS OF CHINA'S EDUCATIONAL TRANSFORMATION

In this section, we discuss the potential global implications of China's educational transformation. China is now a large entity in the global economy and the changes in China's education policies since 1999 also have important implications both for the global educational structure and the global economy itself.

a. Changes in Outputs of Educated Labour in China as a Percentage of World Supply

The first is the impacts these changes imply for global labour markets, and trade in products incorporating skilled rather than the less skilled labour that has largely characterised China's export growth thus far. In Table 2, we present data that indicate in broad terms the total supply of graduates by field of study both from OECD countries and China. The total global supply of graduates has been changing from the late 1990s through until 2003 (the latest complete data for OECD countries), and this enables calculations to be made of the global

TABLE 2
Graduates by Region and Field of Study from China and the OECD

	Education	*Science*	*Engineering, Manufacturing and Construction*	*Law*	*Business and Administration*	*Health*	*Agriculture*
2003 (unit: persons)							
OECD	734,798	628,041	736,417	266,256	1,072,255	492,492	101,687
China	466,801	186,251	685,443	117,900	293,989	123,563	53,906
Total	1,201,599	814,292	1,421,860	384,156	1,366,244	616,055	155,593
China (%)	39	23	48	31	22	20	35
1998 (unit: persons)							
OECD	596,104	474,693	654,489	137,904	665,830	354,287	115,628
China	197,817	100,202	329,255	32,034	–	66,256	30,656
Total	793,921	574,895	983,744	169,938	665,830	420,543	146,284
China (%)	25	17	33	19	–	16	21
Growth rate (1998–2003)							
OECD (%)	23	32	13	93	61	39	−12
China (%)	136	86	108	268	–	86	76

Source: OECD data from the UNESCO/OECD/EUROSTAT (UOE) database; China data from *China Statistical Yearbook*.

changes in educational outputs. The data in Table 2 clearly show that outputs in China are now a significant percentage of world supplies by area and profession. Moreover, the percentage changes reflecting China's production of graduates have increased significantly due to the post-1999 education transformation policies. In all areas, the number of graduates in China is growing much faster than in the OECD countries.

Data from the US NSF also show the significant proportion China accounted for in the worldwide higher-educated labour force.[31] In 2002, more than 9 million students worldwide earned a first university degree, and students earned more than 3 million of these in S&E fields. These worldwide totals only include countries for which recent data are available (primarily countries in Asia, Europe and North America) and are under-estimated. Asian universities account for almost 1.5 million of the world's S&E degrees in 2002, and China provides a significant proportion of these at 15.8 per cent. China's proportion in all fields of first university degree is 10.3 per cent.

Nowadays, many educated Chinese workers and those with educational skills remain in China constrained by immigration restrictions in the OECD. To the extent that economic activity in the OECD is relatively mobile and can move to China through outsourcing, then the impact of China's educational transformation activities becomes more important for global location of productivities. Since the 1990s, there has been outsourcing of manufacturing by the US electronics and other industries. Initially, outsourcing was to re-contract manufacturing suppliers and was mostly offshore and largely to China. Whalley (2007) discusses recent literature on outsourcing, accessing what seems to be happening in China as China proceeds with her historic transformation of high growth and integration into the world economy. Much of the world's commercial electronics are made in China, and outsourcing in this area in China is growing rapidly.[32] The educational transformation process in China will seemingly underscore this trend.

b. Global Implications of Incentive Mechanisms Used for Academic Performance in China

The educational transformation now taking place in China also has major implications for both global academia and educational delivery in the global higher education market. The prime emphasis which is now placed on international publications in China has already resulted in large increases in paper submissions to international journals, and paper submissions are likely to grow further in the next few years. According to a recent study 'Key Figures 2007',

[31] See Science and Engineering Indicators 2006.
[32] See Donahoe and Pecht (2003).

China is now one of the largest producers of scientific output as measured by its share in the world total of peer-reviewed scientific articles.[33] In 2004, China ranked fourth and represented 6.4 per cent of the world's scientific output. The shares of both the EU and the United States have been declining in recent years, because of the rise of China and India. Chinese annual scientific output almost doubled between 1997 and 2004, mirroring the rapid expansion and internationalisation of the Chinese Science and Technology (S&T) system as well as the changes stemming from China's educational transformation. Looking at the quality of scientific output based on bibliometric evidence ('quality' being primarily measured by the citation impact scores of scientific publications), China's rank is not as high as its share of the world's scientific outputs.[34] Evaluated by the most frequently cited papers, China is ranked seventh, lower than South Korea, but still higher than other large developing economies, such as India and Brazil.

There are many comments now being voiced in professional circles in the OECD and elsewhere as to the stress already evident in the global process created by the rapidly growing volume of submissions to professional journals. Rejection rates are increasing sharply, and the quality of referring is even being called into question due to the volumes of submissions. There is also a tendency for relatively low-status educational journals to grow in number. Papers on record are only a small fraction of those appearing in lower ranking international journals.

The contribution to this growing stress which may be attributable to the educational transformation under way in China is debatable but likely significant. And it seems likely to grow and be a potential source of instability in the global educational system going forward generating further changes in the global educational structure.

c. Global Implications of Contractual Arrangements in Chinese Universities

The contractual arrangements in universities in China are a further element of China's educational transformation and portend future global change. They are sharply different from those in the OECD. Before the 1999 educational transformation in China, teaching in institutions of higher learning effectively involved a lifelong employment contract, which any college or university could not override. But along with the changes in numbers of students in

[33] See European Commission (2007), Office for Official Publications of the European Communities.

[34] This reflects data extracted from the Science Citation Index (SCI) and related Citation Indices on CD-ROM, produced by Thomson Scientific (formerly the Institute for Scientific Information) and covering some 7,000 international journals in all domains of scholarship, with good coverage, especially in basic science.

China's higher education system, the tenure system for professors in universities and colleges has changed significantly. The first changes were made by Peking University in reforming its deep-rooted academic tenure system, and this was followed by other Chinese elite universities. These reforms were implemented in February 2004. Taking Peking University as an example, the reforms are that only professors enjoy lifelong employment, and the university does not offer tenured positions to associate professors, lecturers and assistant professors. Associate professors in the arts and sciences and lecturers in all subjects are offered employment contracts up to 12 years. If associate professors and lecturers fail in their promotions after appraisal and examination of their academic attainments within the contracted period, they are dismissed.

Contractual arrangements elsewhere in China's universities differ even more from Western academic practice. It is now common for researchers and scholars in many Chinese universities to receive only three-year contracts and these contracts differ sharply according to individual circumstances. And individuals receiving contracts are often given quotas in terms of the number of the publications in designated journals which should be attained within a limited period of time. It is not uncommon for these quotas to specify three papers per year in international journals, although what is accepted as an international journal varies sharply from institute to institute. It is also the case that individuals receiving such contracts may be remunerated directly related to publication performance. Again, global incentives for paper submissions and papers publication are intensified by these developments.

Since this new structure sharply differs from that in the OECD countries, it will likely produce pressures in the wider international community outside China for changes elsewhere because of the competitive pressures which will be created. Institutions in the OECD and elsewhere will likely have to react and eventually adapt.

d. Impacts on the Global Supply and Trade in Ideas

There are also implications of the educational changes in China for global trade in ideas, and the production of ideas and products based on new ideas. Chinese integration into the global economy has, for now, been primarily in terms of trade in goods and services and flows of FDI into China. But along with the educational transformation in China, there is now a major focus on patenting, both in the Chinese market itself and in international markets. The latter is both by Chinese residents and Chinese institutions, including Chinese universities and academies of science.

There is clear evidence for an increasing tendency of China's patent activity from multiple databases. These include the European (EPO) and US Patent

offices (USPTO) database, China's own database and the World Intellectual Property Organization (WIPO) database. For instance, China has seen rapid growth in patent applications. The most important (triadic)[35] patents rose nine-fold between 1995 and 2003.[36] China has recently joined the top 10 countries filing international patents (mainly high-income or upper-middle-income economies[37]) according to WIPO, with filings for 2005 having increased by 47 per cent compared to 2004. China and India are the only two lower-middle-income countries in this top 10 list. While China still has relatively modest numbers of patents in absolute terms compared with the United States, EU and Japan, its patent applications are growing rapidly. Between 1995 and 2003, China's yearly average growth rate of triadic patents was 33 per cent, the fastest in the world. Other fast-growing patenting economies during this period include India (28 per cent), Taiwan (21 per cent), Singapore (17 per cent), South Korea (13 per cent) and Brazil (13 per cent).

Recently, economists have started to study international knowledge flows, or what one may call trade in ideas. Patents and citations data provide a proxy measure for trade in ideas. Inventions as a part of the international trade in ideas are a further focus of the educational transformation in China. New inventions and new ideas which are eventually to take commercially applicable forms both as products themselves and as methods of production are seen as an output. In turn, these patent-related activities and the increasing number of educational attainees are also seen as a mechanism for attracting increased FDI to further fuel Chinese growth.

6. CONCLUDING REMARKS

This paper discusses the changes taking place in China's educational system since 1999 and particularly in tertiary education which we label as China's Higher Educational Transformation. We attempt to document these changes and assess their implications. We evaluate what these changes may mean both for the global economy and for China's growth process. China may be the first case of a lower-income country using major transformations in tertiary (rather than primary or secondary) educational delivery as a development strategy and

[35] The European Patent Office, the US Patent and Trademark Office and the Japanese Patent Office. Because it is expensive to apply for patents in several offices, such patents generally relate to inventions which promise a high economic return.

[36] Source: European Commission (2007), Office for Official Publications of the European Communities (Table I.7.1, p. 53).

[37] Here, we use the definitions of income groups based on *World Bank List of Economies (July 2008)*. Available at: http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS (accessed on 12 September 2008).

on a scale which is reflective of China's growth rate and population size. This education transformation started in the late 1990s and may still only be in its relatively early stages. Potential major impacts follow for China, the global economy, and for the global educational structure. All of these reflect the increasing global importance of China's educational system and the competitive impacts on global educational delivery. The implications are relatively little discussed in available literature, but will increasingly form a central element of China's integration into the international economy. There is, in our view, a need for further research in the area.

REFERENCES

Arrow, K. J. (1973), 'Higher Education as a Filter', *Journal of Public Economics*, **2**, 3, 193–216.

Carneiro, P., J. J. Heckman and E. Vytlacil (2001), 'Estimating the Return to Education When It Varies Among Individuals'. Available at: http://www.econ.upenn.edu/cgi-bin/mecon/bin/serve.cgi/Epirical120520020 (accessed on 12 August 2008).

China's Ministry of Education (2006), *China Educational Statistics Yearbook* (Beijing: People's Education Press).

Chow, G. (2001), *China's Economic Transformation* (Malden, MA: Blackwell).

Christensen, L. R. and D. W. Jorgenson (1969), 'The Measurement of U.S. Real Capital Input, 1929–1967', *Review of Income and Wealth*, **15**, 4, 293–320.

Denison, E. F. (1967), *Why Growth Rates Differ* (Washington, DC: Brookings Institution).

Donahoe, D. N. and M. Pecht (2003), 'Are U.S. Jobs Moving to China?', *IEEE Transactions on Components and Packaging Technologies*, **26**, 3, 682–86.

European Commission (2007), 'Key Figures 2007: Towards a European Research Area – Science, Technology and Innovation', European Communities. Available at: http://ec.europa.eu/invest-in-research/pdf/download_en/keyfigures_071030_web.pdf (accessed on 10 October 2008).

Fan, C. C. (2006), 'China's Eleventh Five-Year Plan (2006–2010): From "Getting Rich First" to "Common Prosperity", *Eurasian Geography and Economics*, **47**, 6, 708–23.

Fleisher, B. M. and X. Wang (2005), 'Returns to Schooling in China under Planning and Reform', *Journal of Comparative Economics*, **33**, 2, 265–77.

Fleisher, B. M., H. Li, S. Li and X. Wang (2004), 'Sorting, Selection, and Transformation of the Return to College Education in China', IZA Discussion Paper 1446.

Gou, R. (2006), 'Explore on China's High Education Equality from Admission to Urban and Rural Students', *Research on Education Development*, **2006**, 5A, 29–31.

Heckman, J. J. and X. Li (2004), 'Selection Bias, Comparative Advantage and Heterogeneous Returns to Education: Evidence from China in 2000', *Pacific Economic Review*, **9**, 3, 155–71.

Herbold, R. J. (2006), 'K-12 Establishment is Putting America's Industrial Leadership at Risk', *USA Today (Society for the Advancement of Education)*, March. Available at: http://findarticles.com/p/articles/mi_m1272/is_2730_134/ai_n16108107 (accessed on 12 August 2008).

Lang, D. W. and Q. Zha (2004), 'Comparing Universities: A Case Study between Canada and China', *Higher Education Policy*, **17**, 4, 339–54 Available at: http://www.palgrave-journals.com/hep/journal/v17/n4/full/8300061a.html (accessed on 12 August 2008).

Li, S. (2005), 'Features of China's Income Inequality', Lecture presented at the 56th China Reform International Forum, Beijing, China, December 2005.

Li, S. and C. Luo (2007), 'Recalculating China's Urban and Rural Income Inequality', *Journal of Peking University*, **2**, 111–20.
Liu, Z. (2007), 'Study of the Status of Agriculture and Forestry Colleges and Universities in China in Light of Popular National College and University Ratings', *Education and Modernization*, **2**, 55–61.
National Bureau of Statistics of China (2001, 2006), *China Statistical Yearbook* (Beijing: China Statistics Press).
National Science Foundation (2006), *Science and Engineering Indicators 2006*, Chapter 2 (Arlington, VA: National Science Foundation).
National Science Foundation (2007), 'Asia's Rising Science and Technology Strength: Comparative Indicators for Asia, the European Union, and the United States' (Arlington, VA: NSF 07-319).
Solow, R. M. (1957), 'Technical Change and the Aggregate Production Function', *Review of Economics and Statistics*, **39**, 3, 312–20.
Spence, M. (1973), 'Job Market Signaling', *Quarterly Journal of Economics*, **87**, 355–74.
Wang, M. (2007), 'Overall Earnings Inequalities in Urban China and Earnings Differentials between Migrant Workers and Urban Local Workers', Paper presented at the IDRC/CIGI Young China Scholars Poverty Research Network, Second Annual Meeting, Beijing, China, May 2007.
Whalley, J. (2007), 'China and Outsourcing', Paper presented at Industry Canada Conference on Outsourcing, held at Rotman School, University of Toronto, October 2006 and forthcoming.
Whalley, J. and X. Xin (2006), 'China's FDI and Non-FDI Economies and the Sustainability of Future High Chinese Growth', NBER Working Paper 12249, National Bureau of Economic Research, Inc.
Whalley, J. and W. Zhou (2007), 'Technology Upgrading and China's Growth Strategy to 2020', Centre for International Governance Innovation (CIGI) Working Paper No. 21, March 2007, Waterloo, Ontario.
World Education News & Reviews (2006), 'WENR, August 2006: China', **19**, 4. Available at: http://www.wes.org/eWENR/06aug/china.htm (accessed on 12 August 2008).
Yang, D. T. (1999), 'Urban-biased Policies and Rising Income Inequality in China', *American Economics Review*, **89**, 2, 306–10.
Yang, D. T. (2002), 'What has Caused Regional Inequality in China?', *China Economic Review*, **13**, 4, 331–34.
Yin, H., S. Li and Q. Deng (2006), 'Income Mobility in Urban China', *Economics Research*, **10**, 30–43.
Yue, X., T. Sicular, S. Li and B. Gustafsson (2006), 'Explaining Incomes and Inequality in China', in B. Gustafsson, S. Li and T. Sicular (eds.), *Inequality and Public Policy in China* (Cambridge: Cambridge University Press), 88–117.
Zhang, H. (2006), 'Urban–Rural Inequality in Education Opportunity and the Increasing Income Gap: Evidence from Provincial Pooled Cross-sectional Data', *Journal of Shanxi Finance and Economics University*, **28**, 2, 31–38.
Zweig, D. (2006), 'Is China a Magnet for Global Talent?', *Horizons, Special Issue on Canada–China*, **9**, 2, 70–72.