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The Higher Educational Transformation of China and its Global Implications

Yao Li, University of Western Ontario
John Whalley, University of Western Ontario
Shunming Zhang, Victoria University of Wellington
Xiliang Zhao, Xiamen University

The Emergence of China and India in the Global Economy Conference
Centre for Economic Performance (CEP)
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NBER WORKING PAPER SERIES

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Working Paper 13849
http://www.nber.org/papers/w13849

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2008

This paper has been written with support from The Centre for International Governance Innovation (CIGI, Waterloo). We are grateful to Weimin Zhou, Kun Peng, and Li Wang for comments. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 13849
March 2008
JEL No. I2,I23

ABSTRACT

This paper documents the major transformation of higher education that has been underway in China since 1999 and evaluates its potential global impacts. 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 (2001-2005) and 11th (2006-2010) five-year plans, this transformation focuses on major new resource commitments to tertiary education and also embodies significant changes in organizational form. This focus on tertiary education differentiates the Chinese case from other countries who earlier at similar stages of development instead stressed primary and secondary education. The number of undergraduate and graduate students in China has been grown at approximately 30% per year since 1999, and the number of graduates at all levels of higher education in China has approximately quadrupled in the last 6 years. The size of entering classes of new students and total student enrollments have risen even faster, and have approximately quintupled. 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 with no tenure and annual publication quotas often used. All of these changes have already had large impacts on China's higher educational system and are beginning to be felt by the wider global educational structure. We suggest that even more major impacts will follow in the years to come and there are implications for global trade both directly in ideas, and in idea derived products. These changes, for now, seem relatively poorly documented in literature.

Yao Li
Department of Economics
Social Science Centre
University of Western Ontario
London, Ontario, Canada, N6A 5C2
yli267@uwo.ca

John Whalley
Department of Economics
Social Science Centre
University of Western Ontario
London, Ontario N6A 5C2 CANADA
and NBER
jwhalley@uwo.ca

Shunming Zhang
School of Economics and Finance
Victoria University of Wellington
P.O. Box 600 Wellington, NZ
shunming.zhang@vuw.ac.nz

Xiliang Zhao
Department of Economics
Xiamen University
zhaoxiliang@tsinghua.org.cn

1 Introduction

This paper documents the major transformation of higher educational that has been underway in China since 1999 and evaluates its potential global impacts. 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 (2001-2005) and 11th (2006-2010) five-year plans, this transformation focuses on major new resource commitments to tertiary education and also embodies significant changes in organizational form. The number of undergraduate and graduate students in China has been growing at approximately 30% per year since 1999, and the number of graduates at all levels of higher education in China has approximately quadrupled in the last 6 years. The size of entering classes of new students and total student enrollments have risen even faster, and have approximately quintupled. 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, with no tenure and annual publication quotas often used. All of these changes have already had large impacts on China's higher educational system and are beginning to be felt by the wider global educational structure. Skilled labor supply in China now equals around 40% of that in all OECD countries. The growth rate of student numbers is much higher than in the OECD. We suggest that even more major impacts will follow for these changes in the years to come and there are implications for global trade both directly in ideas, and in idea derived products. These changes, for now, seem relatively poorly documented in literature.

The changes we document in what follows also reflect a wider strategy in China of attempting to upgrade both the quality and skill content of production through large increases in higher educational resource inputs, along with a series of other changes in economic policy in China. This strategy primarily reflects strategic decisions made at high policy levels in China, and is seemingly not driven by the demand side of labor markets defining potential requirements of labor of different types. One result so far has been a sharp increase in the number of individuals with high educational attainment in various areas independently of the

size of respective job markets, and this has created significant short term problems of absorption and unemployment for labor associated with these activities. These education policies have also been a factor in China's increasing inequality. The educational transformation underway in China seemingly differs from that in other low wage economies at either similar or earlier stages of development, in focusing heavily on tertiary education rather than on primary or secondary (unlike, say, India).

We suggest that the potential implications for the global educational system are major. We discuss the relative size of changes in China's labor force by category relative to the world supply of labor by type or profession; the possible impacts on academic performance outside China via potential international paper submissions and publications, and also how the global supply and trade in ideas and idea related products maybe affected. The paper also speculates on the effectiveness of these policies. In our final section we also briefly discuss the potential global implications of these changes in terms of the ways in which perceptions of the education growth link may change. 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 the focus has been primary and secondary education, not tertiary. In China's case, these latest 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 China succeeds, other countries may follow with higher educational competition between countries as a possible outcome.

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

transformation underway in China and Section 6 concludes.

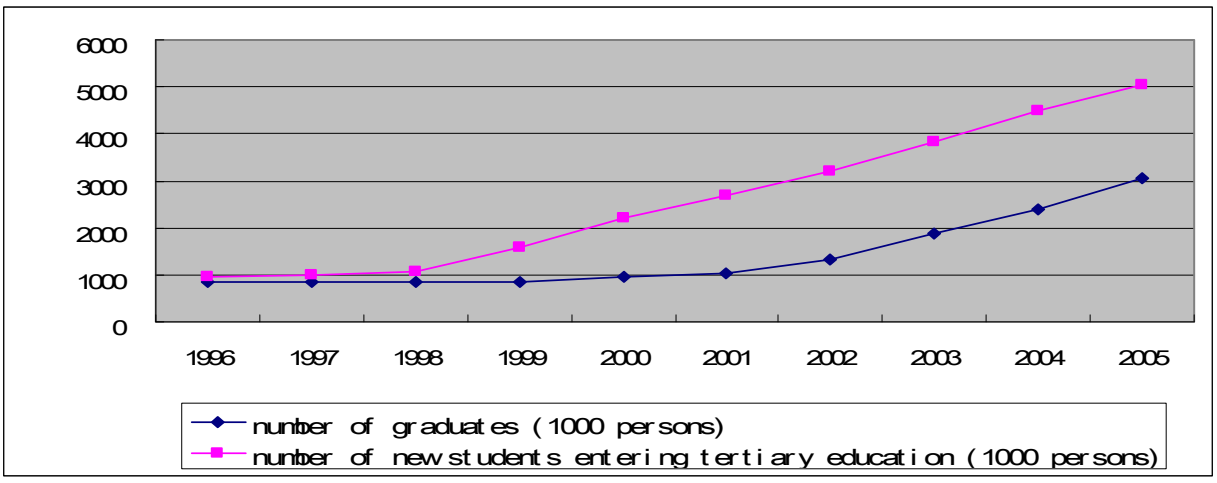
2 The Dimensions of the Higher Educational Transformation in China

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.

2.1 Large increases in the number of students

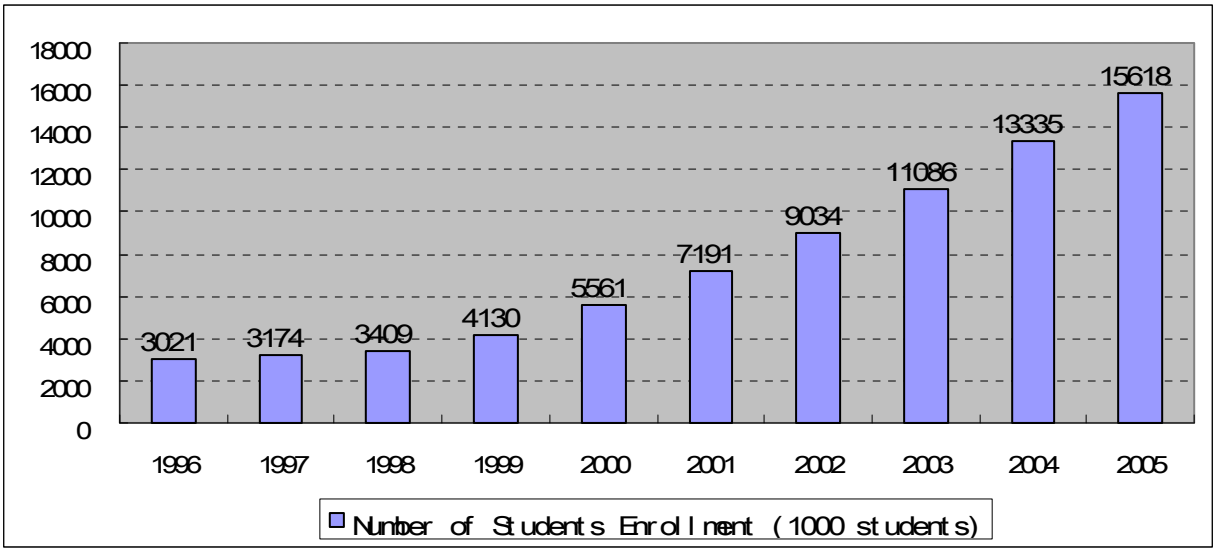
The number of graduate students and undergraduate students in China has approximately quadrupled in the last 6 years (see Figure 1). Before 1999 the number of students both graduating and enrolling was stable. In 1998, the total number of graduates from tertiary education was 830,000; in 2005, it was 3,068,000, an increase by a factor of 3.7. The number of enrollments (both for new students and total students) has risen even faster, and has approximately quintupled between 1998 and 2005 (see Figure 2). The new student enrollment is 4.7 times larger in 2005 than in 1998. The total enrollment is 4.6 times larger in 2005 than in 1998.

Figure 1: The number of graduates from and entering students into tertiary education in China



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

Figure 2: Enrollment in tertiary education in China



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

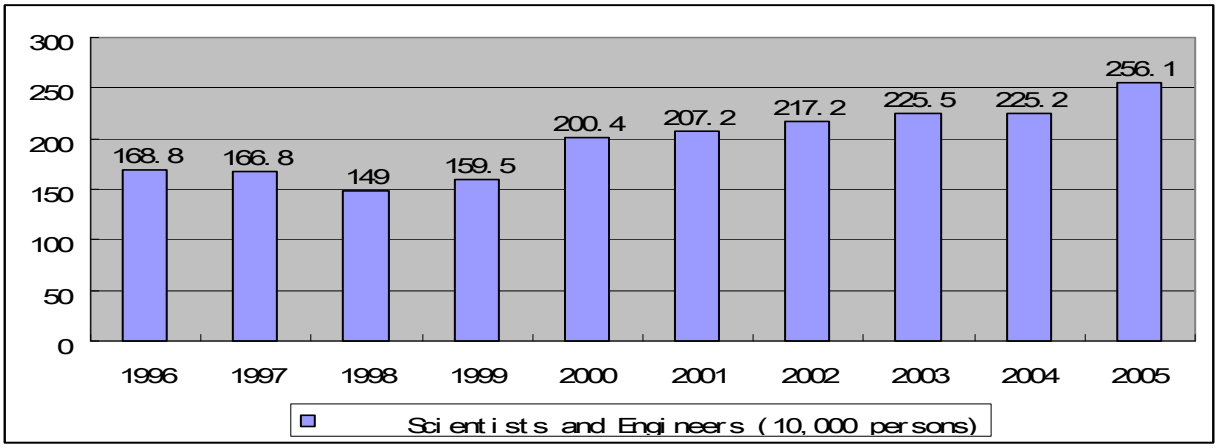
2.2 More Ph.D. engineers and scientists in China by 2010 than in the US

In engineering and sciences these changes have been especially pronounced (see Figure 3). It is widely recognized that there will be substantially more Ph.D. engineers and scientists in China in 2010 than in the US, since on a flow basis China produces three times the number of engineers compared to the US. Among 24-year-olds in 2001 who had a Bachelor of Science or Bachelor of Arts degree, only 5% in the U.S. were engineers, compared to 39% in China and 19% or more in South Korea, Taiwan, and Japan (see Table 1). The U.S. also compares poorly to European countries bachelor's degrees awarded in the fields of engineering and science.[1] R.E. Smalley, a Nobel Prize-winning scientist from Rice University recently concluded that by 2010 90% of all Ph.D. physical scientists and engineers in the world will be Asian living in Asia.[2] And among Asian Ph.D. engineers and scientists, most will be produced by China. National Science Foundation data shows that U.S. is now also producing fewer engineers than from other parts of the world, and particularly from Asia (see Figure 4).[3]

[1] See Herbold (2006).
[2] As for 2.
[3] See National Science Foundation (2006) as well as National Science Foundation (2007).

Figure 3: The number of China's scientists and engineers

(Unit: 10,000 persons)



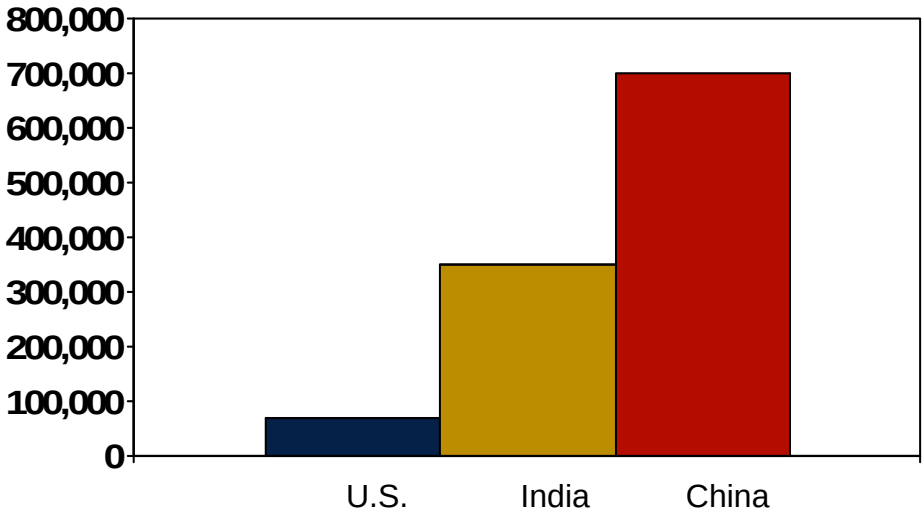
Source: National Bureau of Statistics of China (2001, 2006).

Table 1: BS/BA degrees among 24-year olds in 2001 by country

	BS/BA (000)	BS Engineering	% Engineering
USA	1,253.1	59.5	4.75%
China	567.9	219.6	38.67%
South Korea	209.7	56.5	26.94%
Taiwan	117.4	26.6	22.66%
Japan	542.3	104.5	19.27%

Source: Herbold (2006).

Figure 4: Engineering graduates in the U.S., India and China (2005)



Source: Fortune Magazine (2005).

2.3 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 5 in 2003 for the whole of China. In the mid 1990s, conditional upon being in the urban sector (including counties and town) the probability of high school graduates obtaining admission to university was around 0.3. That probability in 2005 is almost 0.5.[4] Admission rates are higher than these since not all high school graduates register for high education entrance exams, and entrance exams are organized through all over China. The data we report in Table 2 shows that admission rates for both urban and rural registrants have increased sharply. The proportion of urban students in total admissions is decreasing, while the proportion of rural students in total admissions is

[4] 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.

increasing (see Figure 5). Admission rates for the population in rural areas has risen much faster than admission rates for the urban population (see Table 3).

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.

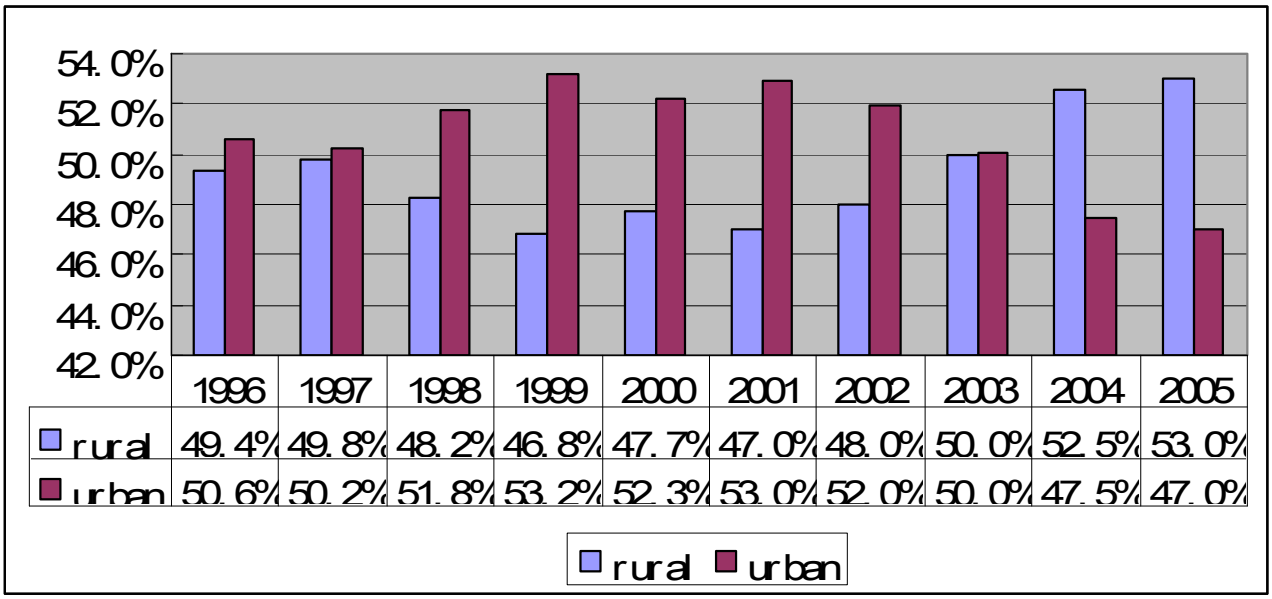
Table 2: China's higher education entrance exam registrants and admissions

(Unit: 10,000 persons)

year	# of admissions (urban)	# of admissions (rural)	# of registrants for entrance exam (urban)	# of registrants for entrance exam (rural)	Admission rate (urban)	Admission rate (rural)
1996	52.03	50.75	111.75	152.48	46.56%	33.28%
1997	53.15	52.66	123.64	157.05	42.99%	33.53%
1998	59.82	55.77	142.22	173.79	42.06%	32.09%
1999	84.47	74.40	157.02	180.30	53.80%	41.26%
2000	116.00	106.00	193.00	196.00	60.10%	54.08%
2001	150.55	133.76	230.59	227.40	65.29%	58.82%
2002	181.90	168.14	263.41	267.35	69.06%	62.89%
2003	214.40	213.99	295.73	324.56	72.50%	65.93%
2004	246.64	273.04	334.60	396.87	73.71%	68.80%
2005	269.27	303.81	393.85	482.96	68.37%	62.91%

Source: Gou (2006).

Figure 5: The proportion of urban and rural students in new student admissions by Chinese universities



Source: as for Table 2.

Table 3: 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	37304	85085	0.14%	0.06%
1997	53.15	52.66	39449	84177	0.13%	0.06%
1998	59.82	55.77	41608	83153	0.14%	0.07%
1999	84.47	74.40	43748	82038	0.19%	0.09%
2000	116.00	106.00	45906	80837	0.25%	0.13%
2001	150.55	133.76	48064	79563	0.31%	0.17%
2002	181.90	168.14	50212	78241	0.36%	0.21%
2003	214.40	213.99	52376	76851	0.41%	0.28%
2004	246.64	273.04	54283	75705	0.45%	0.36%
2005	269.27	303.81	56212	74544	0.48%	0.41%

Source: Admissions data from Table 2; Population data from National Bureau of Statistics of China (2006).

2.4 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 ten 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 both 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 significant increase in infrastructure to handle this increase in student numbers lags. Increases in undergraduates of 30% a year have common in many universities are as a result of this policy.

In many of China’s major cities there has also been consolidation of universities, with, say, 4 or 5 small universities in the city 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 January 12, 1990 and May 15, 2006 and 60% of these occurred between 1999 and 2006.[5] Many of the consolidations involved elite universities. But this also partly reflects a Chinese government reorientation of higher education in the mid 1990s. under the “211 Higher Education Development Project”[6] put forward at the time. 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.

[5] China’s Ministry of Education (2006a).
[6] Announced in 1993, Project 211 is to identify for the 21st century 100 institutions and a number of disciplines of 'world standard' by preferential treatment. See Lang, D. W. and Q. Zha (2004).

2.5 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 by participating institutions. Funding is now longer simply a matter of increasing the numbers of students enrolled and universities and institutions of high education in China are now subject to extraordinary pressures to upgrade themselves in terms of objective rankings. High priority is placed on international rankings taken as publications in international journals, citations, and international cooperation. These are used as demonstration of elevation of attainment for 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 ranking and what is generated by publication citations counts equally for Chinese scholars in 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 which goes substantially beyond the once in a lifetime tenure system outside China. 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 fulfillment. 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 individual faculty members and students are striking. For instance, China’s share of Asian science and engineering articles was increased from 14.54% in 1998 to 22.43% in 2003, with an annual growth rate of 9%.

The primary stress on education attainment is on traditional academic disciplines, especially sciences, but social sciences and business also enter. Arts has been given relatively low priority.

Conventional vocational training as practiced in OECD countries in professions 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 professions -- doctors, nurses, lawyers, dentists and others.

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

2.6 Data on China's educational transformation

While the educational transformation underway since 1999 in China seems major and radical, surprisingly enough, available data on a system-wide basis is 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. Educational 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.[7] 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

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

educational institution can be attained by their children.[8] 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.[9] The proportion of tuition and other education fees to per capita net income for rural households has increased from 16.6% in 1996 to 33.2% in 2003.[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 6 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 Center (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.

2.6.1 Countrywide data by subject area of study and institution type

Table 4 shows numbers of students in regular HEIs (higher education institutions, including universities, colleges, short-term colleges and vocational institutions). In Table 5 we report data on postgraduate student entry, enrollment and graduation by area of study. Tables 6 and 7 present data by type of educational institution in China as well as enrollment size.

[8] See Hu (2005).
[9] See Chinese Academy of Social Sciences (2005).
[10] See Peng and Chen (2007).
[11] See [49] Xinhua News Agency (2007).

Table 4: Numbers of students in regular HEIs by field of study in China (2005)

(unit: persons)

	Entrants			Total Enrollments			Graduates		
	Total	Normal Courses	Short-cycle Courses	Total	Normal Courses	Short-cycle Courses	Total	Normal Courses	Short-cycle Courses
Total	**5044581**	**2363647**	**2680934**	**15617767**	**8488188**	**7129579**	**3067956**	**1465786**	**1602170**
Philosophy	1797	1797	0	6323	6323	0	1275	1275	0
Economics	264219	145512	118707	857757	518989	338768	162977	80710	82267
Law	199521	108779	90742	697174	414309	282865	163529	76140	87389
Education	315638	86080	229558	1022708	307402	715306	280134	50342	229792
Literature and foreign language	760475	435484	324991	2318665	1455454	863211	415206	226903	188303
History	13379	13379	0	49390	49390	0	10694	10694	0
Science	270147	268061	2086	967908	959757	8151	164867	163076	1791
Engineering	1809426	739668	1069758	5477207	2699776	2777431	1090986	517225	573761
Agriculture	97188	45674	51514	308107	174783	133324	69531	35419	34112
Medicine	338563	147726	190837	1132165	627249	504916	202577	96011	106566
Management	974228	371487	602741	2780363	1274756	1505607	506180	207991	298189

Source: China's Ministry of Education (2006b).

Table 5: Numbers of postgraduate students by field of study in China (2005)

(unit: persons)

	Entrants			Total Enrollments			Graduates		
	Total	Doctor's Degree	Master's Degree	Total	Doctor's Degree	Master's Degree	Total	Doctor's Degree	Master's Degree
Total	**364831**	**54794**	**310037**	**978610**	**191317**	**787293**	**189728**	**27677**	**162051**
Philosophy	4414	731	3683	11632	2395	9237	2249	436	1813
Economics	18612	2662	15950	49752	9695	40057	10930	1617	9313
Law	24770	2305	22465	65272	7520	57752	14103	1191	12912
Education	12357	1005	11352	29855	3029	26826	5101	455	4646
Literature	28962	2334	26628	73000	7543	65457	13314	1216	12098
History	5249	946	4303	13790	3180	10610	2657	547	2110
Science	45193	10214	34979	120510	33059	87451	22028	5458	16570
Engineering	131345	20983	110362	369738	79714	290024	72941	9427	63514
Agriculture	13864	2253	11611	36061	7386	28675	6038	1093	4945
Medicine	38340	6738	31602	100343	20236	80107	19405	4291	15114
Military	219	34	185	546	122	424	114	22	92
Management	41506	4589	36917	108111	17438	90673	20848	1924	18924

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

Tables 6 and 7 present summary statistics for Chinese universities and colleges (not including short-term colleges[12]) by type and enrolment size. This includes specialized universities including universities of business, international trade, tax affairs, accounting, auditing and other specialties. Each of these categories is in the data we present.

[12] Short-term colleges refer to those colleges which only offer 2 or 3 year programmes.

Table 6: Numbers of Chinese universities and colleges by type and enrollment size (2004)

type	number of universities	Number of students enrolled			
		More than 10,000	8,000-10,000	5,000-7,999	Less than 5,000
Total	**682**	**411**	**89**	**115**	**67**
Comprehensive Universities	124	97	13	11	3
Science and technology	185	148	20	14	3
Agriculture	33	28	1	3	1
Forestry	6	4	2	0	0
Medical and pharmacy	76	12	18	35	11
Normal (teacher's training)	125	79	21	24	1
Language and Literacy	14	3	1	5	5
Economics and finance	47	31	7	8	1
Law and politics science	17	3	1	3	10
Physical education	14	0	1	5	8
Arts	29	1	0	4	24
Minority (Ethnic nationalities)	12	5	4	3	0

Source: Dai (2005).[13]

[13] The statistics come from China Ministry of Education.

Table 7: Numbers of regular Chinese higher educational institutions by type (2005)

Type	Total	Universities & Colleges	Short-term Colleges	Tertiary Vocational-technical Colleges
Total	**1792**	**701**	**1091**	**921**
Of which: Non-state/private colleges	**250**	**27**	**223**	**217**
Comprehensive University	380	146	234	228
Natural Science and Technology	648	188	460	430
Agriculture	74	32	42	40
Forestry	18	6	12	11
Medicine and Pharmacy	115	76	39	7
Normal (teacher's training)	182	117	65	5
Language and Literacy	34	14	20	18
Economics and finance	169	50	119	100
Law and politics science	64	17	47	30
Physical education	26	14	12	11
Arts	66	29	37	37
Minority (Ethnic nationalities)	16	12	4	4

Source: China's Ministry of Education (2006c).

Table 8: Numbers of Chinese regular higher educational institutions (1997-2005)

Type	Total	Universities & Colleges	Short-term Colleges	Tertiary Vocational-technical Colleges
1997	1020	603	337	80
1998	1022	590	331	101
1999	1071	597	313	161
2000	1041	599	258	184
2001	1225	597	242	386
2002	-	-	-	-
2003	1552	644	197	711
2004	1731	684	1047	872
2005	1792	701	1091	921

Source: China's Ministry of Education (2006c).

Table 8 reports the changes in numbers of Chinese higher educational institutions between 1997 and 2005. The rapid increase in total numbers mostly reflects expansion of numbers in short-term colleges and vocational colleges. 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.

2.6.2 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 discuss each.

Government funding for China's leading universities is largely programme based. In 1998

under a special "985" Project,[14] 10 of China's leading universities were given three-year grants in excess of 30 billion RMB (current price) for quality improvements (Wang, 2002). 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 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 (see Table 9). According to 2003 data,[16] those Project 985 universities in this phase of support accounted for only 1% of the total higher education enrollments, but their key labs accounted for almost a half of the whole annual research funds, 20% of post-graduate student enrolment and 30% 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 program aimed at developing 100 quality universities for China for the 21st 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 improved 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. Table 9 provides this data with funding in the year of 2004 categorized by their sizes. 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

[14] 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% of its annual revenue in 3 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.

[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).

[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).

2004. The universities in Level 2 primarily appeared in only the second phase of the 985 Project. Among all 32 universities (more than 500 million RMB) in Level 1 and 2, 29 universities obtained support from the 985 Project.[18]

In addition to government funding, higher education institutions 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. Profits from these activities to the universities along with fees collected from participating students. Information on funding from these sources is set out in Table 10. The scope and size of the educational transformation which these resource commitments imply is clear from these data. In 2004, all university-owned companies and entities in China make total revenue of 96.93 billion RMB, in which they refund universities 1.75 billion RMB.[19] In 1998, the total revenue was 31.2 billion RMB, and payment to universities was 1.5 billion RMB.[20] The refund to universities is growing slowly, much less than the growth of income and profit (see Table 11). However, the funding which is flowing into these educational activities is increased by approximately 15%.

[18] Liu, Zhimin. "Study of the Status of Agriculture and Forestry Colleges and Universities in China in Light of Popular National College and University Ratings". Mimeo. Available online: http://jiaoyu.ustc.edu.cn/qkln/2007/2/2007xdh2-10.doc
[19] See China's Ministry of Education (2005).
[20] See Liu (2001).

Table 9: Education funding for elite universities in China (2004)

(Unit: 100 million RMB)

Funding size (per university)	Number of universities	Total Funding for universities in the same level	Name of Top Elite Universities	Funding of Top Elite Universities
Level 1: Top Elite Universities --More than 1000 million RMB	11	174.34	Tsinghua University	35.91
			Peking University	24.08
			Zhejiang University	18.74
			Shanghai Jiao Tong University	14.61
			Harbin Institute of Technology	14.43
			Fudan University	13.12
			Huazhong University of Science & Technology	11.51
			Xi'an JiaoTong University	10.53
			Wuhan University	10.48
			Jilin University	10.47
			Nanjing University	10.46
Level 2: 500-1000 million RMB	21	146.02	-	-
Level 3: 300-500 million RMB	38	143.31	-	-
Level 4: 200-300 million RMB	53	126.75	-	-

Source: China's Ministry of Education (2006d).

Table 10: Income earned by university-owned companies and entities (2005)

(Unit: billion RMB)

rank	Name of University	Revenue of University-owned Companies and Entities
1	Peking University	26.76
2	Tsinghua University	19.83
3	Zhejiang University	5.73
4	Northeastern University	3.53
5	China University of Petroleum (Eastern China)	3.01
6	Wuhan University	2.28
7	Fudan University	2.27
8	Tongji University	2.24
9	Harbin Institute of Technology	2.02
10	Xi'an JiaoTong University	1.81
11	Shanghai Jiao Tong University	1.57
12	Huazhong University of Science & Technology	1.23
13	Zhongshan University	1.06

Source: China's Ministry of Education.

Table 11: Details of university-owned companies and entities

(Unit: billion RMB)

Year	Number of companies	Revenue	Profit	Refund to universities
1998	5928	312.33	25.34	1.50
1999	5444	379.03	30.53	1.60
2000	5451	484.55	45.64	1.69
2001	5039	602.98	48.17	1.83
2002	5047	720.08	45.93	1.72
2003	4839	826.67	42.98	1.8
2004	4563	969.3	49.93	1.74

Sources: China's Ministry of Education (1998-2005).

Before the higher educational transformation began in 1999, the Chinese government was the main funding source for higher education institutions in China. But from 2001 on, private funding (tuition and fee payment) covers more than 50% of total education expenditures.[21] An even larger resource commitment is the time commitment of participates in the educational process. The educational activity 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 to 15 years of prior activity in education and extraordinary time commitments from the age of 4 to the age of 18 to 20. Some survey data reports, for stance, 40% junior middle school students work for more than 12 hours per day, 7 days a week and 58.3% students work for 6 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 part of mechanism generating a highly educated, well motivated and hard working labor force in China. Casual observation indicates that Chinese people work extraordinary lengths of time and with high 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

[21] National Bureau of Statistics of China (2005).
[22] See http://gs.studentboss.com/xiaoyuan/newsjj.php?id=4511

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 the China's economy through various forms of quality upgrading.

Many of the details of the elements of the strategy are in the 11th 5-Year Plan, but were also set out in the earlier 9th and 10th 5-year plans which provided detailed policies aimed to maintain China's growth process.[23] The 11th 5-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: (1) harmonization in the development of urban and rural areas (greater priority to the development of rural areas and solving problems concerning farmers), (2) harmonization in regional development (greater assistance to less developed areas), (3) harmonization between economic and social development (expansion of employment opportunities and enhancement of social security and public services, such as medical care and education), (4) harmonization between economic development and the human and natural environment (greater emphasis on resource preservation and the protection of the natural environment), and (5) harmonization between domestic development and integration into the global economy (acceleration of domestic market growth while internationally opening-up).

[23] See Fan (2006).
[24] See Ma (2006).

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 medial care systems, insurance schemes for unemployment and labor 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 government expenditures to enhance public goods and services, with a spending emphasis on infrastructure development and education, in order to modernize rural areas. Education, especially higher education, plays an important role in the 11th 5-Year Plan.

In the 11th 5-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 5-Year Plan are as follows. The gross enrollment rate of higher education is to reach 25% of each entering age cohort by 2010 and the total enrollment 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

[25] The State Council of China (2007).

accordance with the demand for quality-oriented higher education.

To promote balanced and sustainable development of higher education area in China, the 11th 5-Year Plan sets out concrete measures to improve the quality of tertiary education.[26] 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. Programs of quality improvement are to be implemented, and a quality evaluation system designed to fulfill 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 emphasized with a focus on a group of academic leaders with international excellence. There is stress placed 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 emphasized. 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 authorized to receive certificates of graduation and degrees and their chance of finding good jobs is small. In the 11th 5-Year Plan, the government commits itself to a "Sunshine Program" to ensure the recruitment process by universities is open, fair and justifiable. The government also acknowledges the importance of

[26] The Press Conference of the State Council Information Office (2006).

creating employment for university graduates and encourages them to take jobs at grass-root level.

These plans are complex in both specificity and form. Some of the details are set out in the Whalley and Zhou (2007) who discuss the 11th 5-Year Plan more broadly. The educational component of the 11th 5-Year Plan is clear in providing for large injections of funds into China's tertiary educational system. Education is a major focus over the 5 year period of the plan, with the proportion of education expenditures to GDP increasing to 4% in 2010, from 3.4% in 2002. 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. David Zweig (2006) points out that "a reverse brain drain is underway in mainland China. The number of returnees hit 30,000 in 2005, up from 7,000 in 1999." Data from Chinese Ministry of Education shows 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.[27] 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.

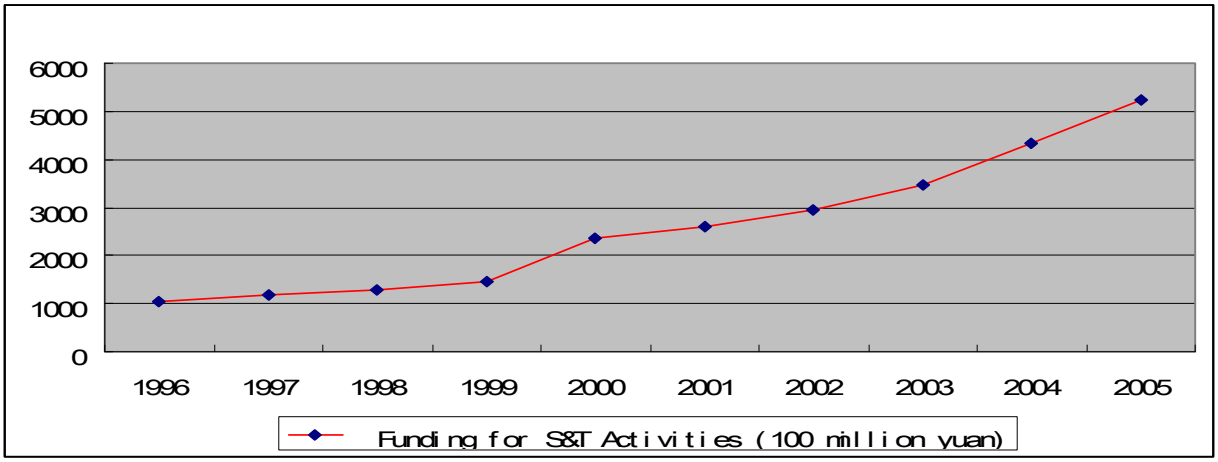
Some educational funds are focused on providing resource packages to encourage researchers abroad to return to Chinese universities, often in conjunction with enterprises. Stress is placed on combining enterprise related research development activity with similar activities undertaken in research institutions. 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

[27] China's Ministry of Education (2004, 2005).

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% of gross domestic product in 2010 and 2.5% 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 6 reports the funding for science and technology activities in China, which is increasing and 1999 is a key point in the growth trend.

Figure 6: China's funding size for Science and Technology (S&T) activities

(Unit: 100 million RMB)



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

All these elements of China's educational transformation are part of a process which feeds this transformation into the overall growth strategy. This strategy in turn proceeds on the assumption that China's export growth rate of 30% 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 labor intensive manufactured products such as clothing, since it is believed China will run out of international markets in their products. A central element of a long term growth strategy is increasing 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 emphasizing, however, that the transformation in higher education in China is only part for 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 we discuss above. The potential benefits to China are in 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 soul 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.

4.1 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 an earlier work by Carneiro et al. (2001), which emphasizes comparative advantage in the labor 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 4-year college experience a 43% increase in lifetime earnings (nearly 11% annually) in 2000, compared with just 36% (nearly 9% 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)[28] is very high, 43% on average and 11% annually for young people in the urban areas in China. These estimates are all higher than the conventional OLS (ordinary least squares) estimates (29%, annual returns of 7.25%) 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 twenty 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.[29] 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 4.4). 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% and 5.7% respectively in 2001 and 5.0% and 6.7% respectively in 2005. It implies that hourly earnings of migrant workers increased by 4.6% for every additional years of schooling, and hourly earnings of urban local workers increased by 5.7% 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.

Other studies, however, suggest that rates of return to education in China will continue to

[28] Average Treatment Effect (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. $ATE=E[Y_{1i} - Y_{0i}]$.

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

increase. Zhang and Zhao (2002), Li (2003), and Yang (2004) show that there is evidence that in the past 15 years, rates of returns on schooling in China have increased. 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 year of college. The average treatment effect of college education was 11.85% in 1995 and 23.2% 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.

4.2 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 Spence (1973) and Arrow (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 overeducate 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 Ministry of Personnel shows that in 2006 number of total graduates from higher education institutions hit 4 million but the total demand for college graduates in China was only 1.66 million. It implies that nearly 60% of college graduates faced unemployment following graduation.[30] Under this view, the radical changes which have taken place since 1999 can be seen in part as a mechanism from absorbing undergraduate unemployment and delaying the eventual labor market adjustments associated with a large pool of younger workers entering the labor force with an additional 4 years of university under graduate 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,

[30] See http://news.qq.com/a/20060716/001002.htm

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 for the top portion of recent educational cohorts.

The evaluation of China's educational transformation policies therefore if in terms of its growth and efficiency contribution to the economy thus rests heavily on ones 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 of 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 viewed as a screening mechanism may raise social rates of return beyond those generated empirically.

4.3 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 (Li and Zhao, 2006; 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,[31] almost the highest country in Asia and approaching Latin American levels. The income disparity between the households in eastern and western and coastal/noncoastal 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 China Urban Labor Survey (CULS) to

[31] Economist.com: "Asia's rich and poor", Aug 9th, 2007, from *The Economist* print edition. Available online: http://www.economist.com/world/asia/displaystory.cfm?story_id=9616888

calculate the urban Gini coefficient as 0.3969 in 2005 and 0.3476 in 2001. In other words, the Gini coefficient numbers are smaller among 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 in inequality.

A further statistic is that 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 underway 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 Fleisher and Wang (2004b) and Heckman (2004), though there was a sharp acceleration in schooling expenditures in the previous decade in China, the proportion of the population attending college remained small. 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% in 1993 and grew to only 3.5% in 2000 according to 1993 and 2000 population census (National Bureau of Statistics of China, 1994 and 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 labor supply.

4.4 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 is impacts both on total factor productivity and the rate of growth of labor productivity adjusted to account for changes in educational quality in human capital.

Recent extensive literature on growth accounting in China (Li, et al. (2005)) 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 in the 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[32] underpins many of these policies set out in the 11th 5-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 U.S. 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 US to come to the conclusion that approximately 85% 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 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 US. Factor accumulation was a more major determinant of China's growth. Using this work, the 11th 5-Year Plan sets targets that the proportion of growth to be accounted for by total factor productivity growth should rise to 60% 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

[32] See Li, Hou, Liu, and He (2005).

calculation for China which suggests most of Chinese total factor productivity growth over the last twenty years is accounted for by growth in foreign invested enterprises and specifically by foreign direct investment into the Chinese economy. Under this view the role of educational transformation in China's growth would be significant diminished in terms of its potential impact on growth performance.

Other work in growth accounting area involving Shai (2004) and Berges and Shai (2007) uses a dual approach rather than the original Solow direct approach as modified by Denison and also comes to the conclusion that factor accumulation in the Chinese case has been less central for growth than previously been thought. Thus growth accounting literature suggests that higher educational transformation in China in terms of its impact on growth has been influenced by international environment in which China has been operating with the role of foreign direct investment potentially and the significance of factor accumulation as against technical progress in terms of generation of growth an important issue.

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 global educational structure and the global economy itself.

5.1 Changes in outputs of educated labor in China as a percentage of world supply

The first is the impacts these changes imply for global labor markets, and trade in products incorporating skilled rather than the less skilled labor that has largely characterized China's export growth thus far. In Table 12 we present data which indicates 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 changes in educational outputs. The data in Table 12 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 has increased significantly due to the post 1999 educational transformation policies. In all areas, numbers of graduates in China are growing much faster than in the OECD countries.

Table 13 reports data for Science and Engineering (S&E) Indicators 2006 published by the US National Science Foundation. 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 an underestimate. 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 15.77%.

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 1990's, there has been outsourcing of manufacturing of the U.S electronics and other industries. Initially outsourcing was to recontract 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.[33] The educational transformation process in China will seemingly underscore this trend.

[33] See Donahoe (2003).

Table 12: Graduates by regions 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	734798	628041	736417	266256	1072255	492492	101687
China	466801	186251	685443	117900	293989	123563	53906
total	1201599	814292	1421860	384156	1366244	616055	155593
China (%)	***39%***	***23%***	***48%***	***31%***	***22%***	***20%***	***35%***
1998 (unit: persons)							
OECD	596104	474693	654489	137904	665830	354287	115628
China	197817	100202	329255	32034	-	66256	30656
total	793921	574895	983744	169938	665830	420543	146284
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.

Table 13: Field of first university degrees and ratio of first university degrees and S&E degrees to 24-year-old population, by selected region and country/economy (2002 or most recent year)

Region/location	Field of first university degree			Ratio of degree entrant or holder to 24-year-old population [a]		
	All fields	All S&E fields	Non-S&E	first university	NS&E	social/behavioral sciences
All regions[b]	9057193	3384260	5672933	11.4	3	1.2
Asia[b]	3224593	1496795	1727798	6.7	2.2	0.9
China (2003)	***929598***	***533582***	***396016***	***5***	***2.6***	***0.3***
India (1990)	750000	176036	573964	4.2	1	NA
Japan (2004)	548897	351299	197598	32	7.8	12.7
South Korea	239793	113097	126696	30.8	12.5	2
Middle East[b]	445488	149600	295888	7.8	1.8	0.8
Sub-Saharan Africa[b]	174471	42291	132180	4.2	0.7	0.3
Europe[b]	2682448	930192	1752256	29.1	7.7	2.4
America[b]	2371031	717533	1653498	19.7	3.6	2.3
North/Central America	1827226	589999	1237227	26.6	5	3.6
Canada (2001)	128950	59915	69035	30	7.1	6.8

United States	1305730	415611	890119	33.9	5.7	5.1
South America	543805	127534	416271	10.5	1.9	0.6
Oceania[b]	159162	47849	111313	49.9	11.8	3.2
China (%)	***10.26%***	***15.77%***	***6.98%***	**-**	**-**	**-**

Note: NS&E = natural sciences and engineering.

[a] Number of degrees per 100 24-year-olds.

[b] Includes only locations for which relatively recent data are available.

Source: Science and Engineering Indicators 2006.

5.2 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 on Science, Technology and Innovation",[34] 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. In 2004, China is ranked fourth, and represents 6% of the world's scientific output (see Figure 7). The shares of both the EU and the US 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 internationalization 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),[35] China's rank is not as high as its share of the world's scientific outputs. Evaluated by the most frequently cited papers, China is ranked seventh, lower than South Korea, but still higher than

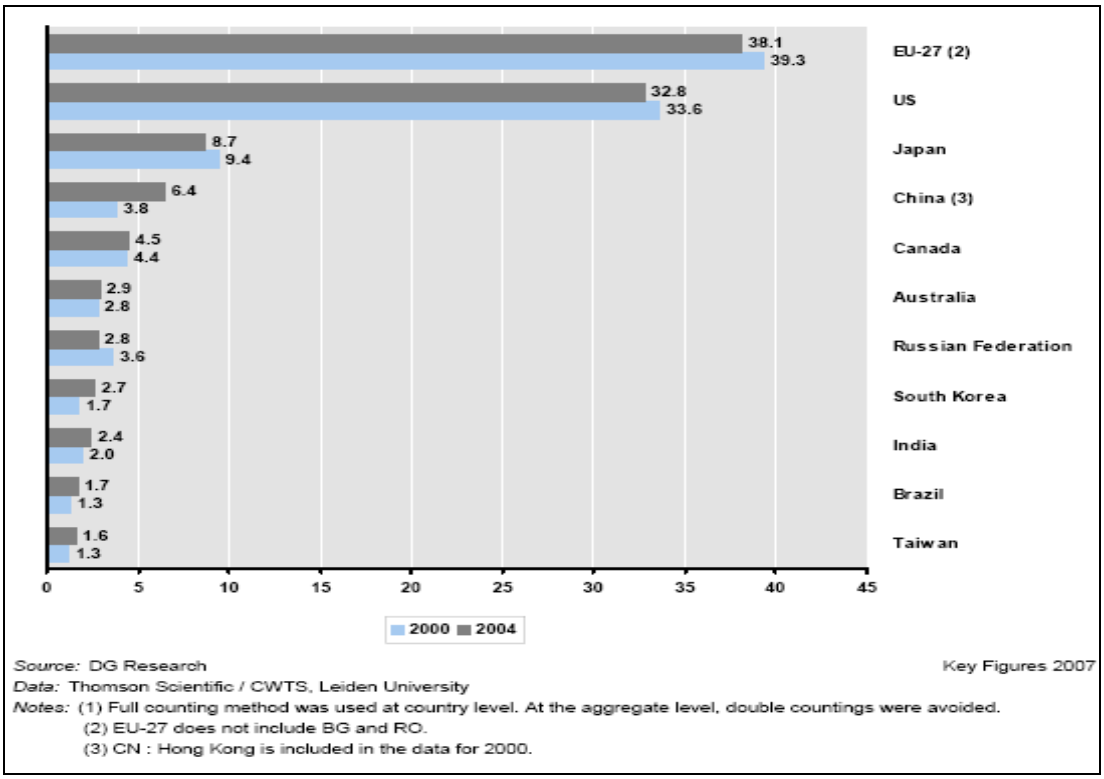
[34] See "Key Figures 2007 on Science, Technology and Innovation—toward a European Knowledge Area", June 11, 2007, by European Union.

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

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.

Figure 7: World shares of scientific publications (%) [(1)], 2000 and 2004



Source: From “Key Figures 2007 on Science, Technology and Innovation: towards a European Knowledge Area”, June 2007, Figure I.4.1, page 37.

The contribution to this growing stress which may be attributable to the educational transformation underway 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 global educational structure.

5.3 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 China's higher education system, the tenure system for professors in universities and colleges has been 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 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 3 year contracts and these contracts differ sharply by individual circumstance. 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 3 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 given payment 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.

5.4 Impacts on the global supply and trade in ideas

There are also implications of the educational changes in China for global trade in and 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 foreign direct investment into China. But along with the educational transformation in China, there is now a major focus on patenting, both in China itself and international patenting. The latter is to be both by Chinese residents and Chinese institutions, including Chinese universities and academies of science.

There is clear evidence for this 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)[36] patents rose ninefold between 1995 and 2003 (see Table 14). China has recently joined the top ten countries filing international patents according to WIPO, with filings for 2005 having increased by 47 per cent compared to 2004. And while China still has relatively modest numbers of patents in absolute terms compared with the U.S., EU and Japan, its patent applications are growing rapidly.

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 form both in products themselves and methods of production are seen as an output. In turn, these patent related activities and the increasing number of educational attainees, is seen as a mechanism for also attracting increased foreign direct investment to further fuel Chinese growth.

[36] 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.

Table 14: Triadic patents by priority year and residence of inventor

	1990	1995	2000	2003
US	11062	11999	17440	19701
EU-27 (1)	9903	11328	16057	16108
Japan	9904	9904	13086	13557
South Korea	67	325	644	839
China	12	19	90	184
Taiwan	10	23	77	108
India	12	12	58	87
Singapore	4	24	79	84
Russian Federation	21	51	66	59
Hong Kong	11	20	33	40
South Africa	14	24	37	36
Brazil	11	13	27	35

Note: (1) EU-27 doesn't include BG.

Source: "Key Figures 2007 on Science, Technology and Innovation: towards a European Knowledge Area", June 2007, Table I.7.1, page 47.

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 China's growth process. China may be the

first case of a lower income country using major tertiary (rather than primary or secondary) transformation in educational delivery as a development strategy and on a scale in which is reflective of China's growth rate and population size. This educational transformation starts 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 global educational structure. These all 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 in China's integration into the international economy. There is, in our view, a need for further research in the area.

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