Productivity, Economic Growth and Middle Income Traps: Implications for China

Yanrui Wu (吴延瑞）

Business School

University of Western Australia

yanrui.wu@uwa.edu.au

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Abstract: This paper investigates the role of productivity in economic growth. Through the examination of cross-country historical statistics as well as China's regional data, it sheds light on the debate about whether the Chinese economy can avoid the middle income trap. It should be one of the first papers proposing an analytical framework to address this controversial issue. The findings should have important implications for economic policies guiding China's development in the coming decades.

Key words: Productivity, middle income trap, economic growth and Chinese economy

1. Introduction

The middle income trap (MIT) concept refers to countries which reached middle income status and then failed to grow into the high income stage due to a sharp growth slowdown or prolonged stagnation. Since its first appearance in a World Bank report published in 2007, the MIT concept has been controversial and hence triggered a lively debate in the academic circle as well as the policy-making arena.[1] This debate has particularly been extended to the discussion of economic development policies in China as the country has just joined the rank of the middle-income economies (MIEs) in recent years. According to the latest statistics, China's GDP per capita in 2012 exceeded US$6,000 which qualifies the country as an upper middle income nation following the World Bank classification.[2] Whether China can continue to enjoy high economic growth and therefore avoid the so-called MIT to become a high income nation has important implications for this country, as well as the rest of the world, as China is now the world's second largest economy. This paper contributes to the current debate by empirically examining the roles of innovation and catch-up in economic growth across nations and China's regional economies. It draws policy implications for China's future economic growth by exploring the historical performance of world nations at different stages of development.

To achieve the above-stated objectives, this paper proposes an analytical framework which decomposes total factor productivity (TFP) growth into innovation and catch-up components. It compares the performance of MIT-affected countries with that of MIT-avoided economies. It then applies the same approach to China's regional data. The cross-country analysis

[1] The World Bank report is titled "An East Asian Renaissance: Ideas for Economic Growth" (Gill et al. 2007).
[2] According to the National Statistics Bureau (2013), China's total GDP and population in 2012 were 51932 billion *renminbi* (RMB) and 1.354 billion, respectively. These numbers effectively imply that China's GDP per capita in 2012 was US$6088 (US$1=6.3RMB).

involves data of 109 economies. The proposed parametric method allows for statistical tests of various scenarios. This paper is probably one of the first papers to adopt an econometric approach to explore whether China can avoid a MIT and hence join the club of rich nations in the coming decades. The rest of the paper begins with a discussion of the MIT concept in Section 2. This is followed by description of the analytical model in Section 3. The empirical examination of cross country data is presented in Section 4. A case study of Chinese regional economies is reported in Section 5. Section 6 concludes the paper.

2. Conceptual Issues

Prior to the empirical analysis, two concepts have to be discussed. The first one is the concept of "middle income" which is used to group the world nations into different categories. The second one is the MIT concept which is used to identify whether a middle income nation is trapped or not. In the existing literature, various criteria have been adopted to define the "middle income" concept. The popular ones are summarised in Table 1. These definitions vary according to the sources of data involved. In general there are three sources of resources with public access, namely, the World Bank, the Penn World Tables (PWT) and the database compiled by Angus Maddison. Due to the use of different base periods and prices, these databases are often not directly compatible. Neither are the relevant "middle income" groupings compatible directly. For example, the World Bank (2013) classifies the countries according to per capita income in current US dollars while GDP statistics reported in Maddison (2010) is measured in terms of the 1990 international dollars or purchasing power parity (ppp). Both the World Bank (2013) and Felipe et al. (2012) distinguish the lower and upper middle income groups. Their classification methods are similar but their data are drawn from different sources (Table 1). Woo (2012) and Robertson and Ye (2013) compared the world economies relative to the US income level. Their studies are also based on different databases, namely the Maddison data for Woo and PWT statistics for Robertson and Ye. According to the latest version of PWT statistics, GDP per capita is measured in 2005 constant international dollars (Heston et al. 2012). In addition, Eichengreen et al. (2012, 2013) presented an alternative perspective using the PWT data. They showed that a country's economic growth slows down when its per capita income reaches ppp$10,000-11,000 or ppp$15,000-16,000.[3] These figures could be treated as the upper bound of per capita income in a middle income economy (MIE).

Table 1 Classification of the MIEs

Sources	Lower MIE	Upper MIE	Remarks
World Bank	$1,026-4,035	$4,036-12,475	US$/current prices
Felipe et al.	$2,000-7,250	$7,251-11,750	ppp$/1990 prices
Woo	GDP per capita = 20-55% of US's		ppp$/1990 prices
Robertson and Ye	GDP per capita = 8-36% of US's		ppp$/2005 prices
Aiyar et al.	$2,000 to $15,000		ppp$/2005 prices

Notes and Sources: Data are compiled by the author from Felipe et al. (2012), Aiyar et al. (2013), Robertson and Ye (2013), Woo (2012) and the World Bank (2013).

Even if the concept of "middle income" is clearly defined, it is still difficult to decide which countries are actually trapped at the middle income level. Woo (2012) introduced the concept of the catch-up index (CUI) which is measured as the ratio of a country's per capita income over the US's. According to Woo, a country is trapped in the middle income group if its CUI remains at the level of 20-55% during the period from 1960 till 2006 (47 years). Following his definition, he identified several MITs in Latin America (Argentina, Brazil, Chile, Mexico and Venezuela) and East Asia (Malaysia and Thailand). Felipe et al. (2012) identified the threshold number of years of 28 in the lower middle income group and 14 in the upper

[3] It is noted that several papers focused on the identification of growth episodes or spells for the world nations (Hausmann et al. 2006, Berg et al. 2012 and Aiyar et al. 2013).

middle income level. A country exceeding these threshold numbers of years would be classified as a MIT (a total of 42 years). According to Felipe et al., among their sample of 38 lower MIEs and 14 upper MIEs in 2010, 35 are identified as the MITs (30 lower MIEs and 5 upper MIEs). Robertson and Ye (2013) presented a test for the existence of a MIT using the PWT data. Their middle income countries in 2010 had per capita income equivalent to 8-36% of US GDP per capita. They found a small number of MITs among 46 middle income countries following their definition.

This research extends the literature by linking the MIT concept with the role of productivity in economic growth among various groups of countries. Thus it explores the MIT concept by presenting a productivity perspective. Eichengreen et al. (2012) briefly touched upon this point. They argue that the bulk of the economic slowdown among the MIEs is due to the fall in the rate of productivity growth. Their findings are based on the assumption of *ad hoc* weights for capital and labour shares. The present study proposes an econometric model to estimate the contribution of productivity to economic growth. Through the analysis of cross-country data, it draws implications for China through the use of Chinese regional data and hence contributes to the current debate on the economic policies of China.

3. Analytical Framework

To examine the role of productivity in economic growth, a parametric method is employed here. This method enables the decomposition of productivity growth into technological progress and efficiency change. The former reflects the progress in innovation while the latter captures the status of catch up. This technique belongs to the same family of models such as Cornwell et al. (1990), Battese and Coelli (1995) and Wu (1995).[4] Symbolically,

$$Y_{it} = f(X_{it}, t)e^{u_{it}+v_{it}} \tag{1}$$

where (and hereafter) the subscripts i and t stand for the i^{th} economy (or region) at the t^{th} period. It is assumed that several inputs (X_{it}) are employed to produce an output (Y_{it}). $f(\,.\,)$ is an assumed function form to represent the structure of technology in production. The term u_{it} is nonpositive and associated with technical inefficiency in the production process. v_{it} is the white noise term which has the usual properties. u_{it} and v_{it} are assumed to be independent of each other.

Given the specification in equation (1), the corresponding level of technical efficiency (TE_{it}) is defined as the ratio of the observed output (Y_{it}) over the maximum feasible output or the frontier output (y_{it}). That is,

$$TE_{it} = \frac{Y_{it}}{y_{it}} = e^{u_{it}} \tag{2}$$

Manipulating equations (1) and (2) gives the growth accounting

$$\dot{Y}_{it} = f_t + f_x\dot{X}_{it} + \dot{TE}_{it} \tag{3}$$

where (and hereafter) the superscript dot indicates the growth rates of relevant variables. f_t and f_x are partial derivatives of $f(\,.\,)$ with respect to t and X. f_t can also be called the rate of technological progress ($\dot{TP}_{it}$). The middle term on the right hand side of equation (3) measures the contribution of production inputs to economic growth. If total factor productivity (TFP) growth is defined as the residual of economic growth unexplained by the changes in production inputs, then the following decomposition is derived

$$\dot{TFP}_{it} = \dot{TP}_{it} + \dot{TE}_{it} \tag{4}$$

[4] For a review of the literature, see Coelli et al. (2005) and Greene (2008).

Equation (4) implies that TFP growth is the sum of the rates of technological progress and technical efficiency change.

The estimation of equations (1) to (4) involves a two-step procedure. In the first step, a traditional production function specification is adopted. It is assumed that labour (L) and capital (K) are employed to produce an output (Y) in the production process.[5] Symbolically,

$$Y_{it} = e^{\alpha_0 t} K_{it}^{\beta_1} L_{it}^{\beta_2} e^{\alpha_i + \varepsilon_{it}} \tag{5}$$

α and β are parameters to be estimated. ε_{it} represents the random forces (v_{it}) and factors (u_{it}) affecting efficiency in the production process. In the logarithmic form incorporating some cross-terms, equation (5) can be expressed as

$$lnY_{it} = \alpha_i + \beta_1 lnK_{it} + \beta_2 lnL_{it} + (\alpha_0 + \beta_3 lnK_{it} + \beta_4 \ln L_{it})t + \beta_5 lnK_{it} lnL_{it} + \varepsilon_{it} \tag{6}$$

Equation (6) is estimated using both the fixed effect and random effect formats which are tested against each other. After the estimation of equation (6), the first derivative of the fitted model with respect to time (t) gives an estimate of the rate of technological progress as follows

$$\dot{T}P_{it} = \left(\hat{\alpha}_0 + \hat{\beta}_3 lnK_{it} + \hat{\beta}_4 \ln L_{it}\right) \tag{7}$$

where (and hereafter) the superscript hat represents the estimated value of a relevant parameter or variable.

In the second step, the following regression is considered

$$\hat{\varepsilon}_{it} = \delta_{0i} + \delta_{1i}\mathrm{t} + \delta_{2i}\ln\left(\frac{K_{it}}{L_{it}}\right) + \delta_{3i} t \ln\left(\frac{K_{it}}{L_{it}}\right) + \epsilon_{it} \tag{8}$$

[5] The data for capital, labour and output are estimated using GDP per worker, GDP per capita and total population reported in PWT (see Heston et al. 2012 for more details).

where $\hat{\varepsilon}_{it}$ is the residual from the estimation of equation (6) and ϵ_{it} represents the white noise. Equation (8) can be estimated using time series data for each i or panel data for a variable-coefficient model. Technical efficiency and its change can then be estimated as

$$TE_{it} = \exp(\hat{\hat{\varepsilon}}_{it} - \varepsilon) \tag{9}$$

where $\hat{\hat{\varepsilon}}_{it}$ is the fitted value of the dependent variable in equation (8) and ε is the maximum value of $\hat{\hat{\varepsilon}}_{it}$ for all i and t, and

$$\dot{TE}_{it} = \hat{\delta}_{1i} + \hat{\delta}_{3i}\ln(\frac{K_{it}}{L_{it}}) \tag{10}$$

Thus TFP growth can be expressed as

$$T\dot{F}P_{it} = \left(\hat{\alpha}_0 + \hat{\beta}_3 lnK_{it} + \hat{\beta}_4 \ln L_{it}\right) + (\hat{\delta}_{1i} + \hat{\delta}_{3i}\ln\frac{K_{it}}{L_{it}}) \tag{11}$$

In the empirical analysis, the procedures described above are applied to both cross country data and China's regional statistics.

4. Cross-country Analysis

For cross country analysis, the latest PWT statistics are employed. After the initial data cleaning, a total of 109 countries are included in the final sample with data covering the period from 1961 to 2010. The data cleaning process excludes countries with missing data. Using the value of GDP per capita in 1961, the countries are grouped into three categories; low, middle and high income groups. The middle income group has 61 countries with per capita GDP between ppp$1,000 and ppp$10,000 in 1961. Examples include Brazil, the Philippines, South Africa and Thailand. In terms of individual member's income level relative to the US GDP per capita, it ranges from 6.2% to 42.4%. The remaining countries belong to either the low income (below ppp$1,000 per capita) or the high income (above ppp$10,000 per capita) group. A main consideration for the grouping of the countries is to ensure that in each subgroup there are enough countries (sample observations) for econometric analysis. The details of the grouping are given in Appendix A.

For the 61 MIEs in 1961, 37 countries remained in the same group and 24 countries joined the high income group (or graduated) in 2010 (Table 2). If the criterion of the existence of a MIT is that a country remains in the middle income group for at least 50 years (hereafter it is called the "time horizon"), these 37 countries can be classified as being trapped at the middle income level (and hence they are called the MITs). This number is close to the one reported by Felipe et al. (2012) who identified 35 MITs among 52 middle income countries. However, the number of MITs depends upon the criterion or the time horizon adopted as it is showed in Table 2. For example, if the time horizon is 20 years, then 47 countries out of 61 MIEs were trapped in 1981. These variations offer the opportunity for the consideration of different scenarios in the empirical exercises. Table 2 also shows that during the decades three countries (Gabon, Iran and Mexico) graduated from the MIE group and then returned to the group. In the case of Iran, this country retreated to the MIE group in 1981 and has since been trapped at the middle income level.

Table 2 Changes in the number of MIEs

Year	Remained	Graduated	Returned
1961	61		
1971	51	10	
1981	47	5	1 (Iran)
1991	45	3	1 (Mexico)
2001	44	1	
2010	37	8	1 (Gabon)

Source: Author's own calculation.

The empirical estimation begins with the assumption of a 30 year time horizon covering the years 1961 to 1990. Thus, it is defined that, among 61 MIEs, 45 countries were MITs and 16 countries graduated to join the high income group in 1991. The first set of regression results are presented in Table 3. The Hausman tests imply that the preferred model is the fixed model in the five groups with the exception of the low income group. For the sake of consistency, productivity growth decomposition is hence based on the fixed effect models.

A summary of the results is presented in Table 4. It is clearly shown that productivity has played an important role in economic growth in high income countries while its role is trivial or even negative in low income economies. The role of productivity in economic growth in the middle income countries stands truly in the "middle" of the three income groups. In particular, Table 4 shows that the contribution of productivity to economic growth in the MIT or "trapped" group is negative. In addition, it is noticed that all income groups with the exception of the low income group have made significant technological progress. However, the high income economies have on average improved their efficiency modestly while efficiency has deteriorated in the middle income groups. For the MITs, efficiency deterioration has overwhelmed technological progress over time. As a result, the net contribution of productivity to economic growth is negative.

As it is mentioned earlier, the exercises similar to Table 4 are extended to consider several scenarios, namely, time horizons covering 40 years (1961-2000) and 50 years (1961-2010), respectively. The results are reported in Appendix B. Similar conclusions can be drawn. On the one hand, it is found that productivity has played an important role in economic growth in high income economies and MIEs. One the other hand, it is observed that high income

Table 3 Estimation results using data of 1961-1990

	High-income			Low-income			Middle-income			Graduated			MIT		
Var	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
t	0.0140	0.0081	*	-0.0149	0.0031	***	0.0190	0.0036	***	0.0318	0.0077	***	0.0311	0.0044	***
lnL	-0.3719	0.0936	***	0.8376	0.0931	***	-0.0596	0.0576		1.1656	0.1009	***	-0.1863	0.0683	***
lnK	0.3295	0.0346	***	0.2209	0.0245	***	0.1476	0.0274	***	0.5317	0.0607	***	0.0854	0.0329	***
t*lnL	-0.0039	0.0013	***	-0.0073	0.0009	***	-0.0093	0.0007	***	0.0130	0.0020	***	-0.0089	0.0010	***
t*lnK	0.0012	0.0014		0.0087	0.0006	***	0.0035	0.0004	***	-0.0073	0.0014	***	0.0018	0.0005	***
lnK*lnL	0.0473	0.0098	***	0.0006	0.0085		0.0660	0.0078	***	-0.0573	0.0140	***	0.0777	0.0103	***
constant	4.2040	0.2582	***	0.2004	0.2905		3.2715	0.1618	***	0.0246	0.3204		3.6334	0.1862	***
R-square	0.91			0.96			0.93			0.96			0.89		
Hausman	131.37	***		2.86			140.27	***		39.64	***		132.41	***	
N	480			960			1830			480			1350		

Source: Author's own estimates.
Notes: * and *** indicate significance at the level of 10% and 1% respectively. The significance of the Hausman test implies the rejection of the relevant random effect model. For consistency, all estimation results in this table are based on the fixed effect models.

Table 4 TFP contributions to economic growth (1961-1990)

Groups	No. of countries	Rates of growth (%)				TFP/Y (%)
		TP	TE	TFP	Y	
High-income	16	1.07	0.09	1.16	3.33	34.83
Low-income	32	-0.18	0.00	-0.18	4.28	-4.21
Middle-income	61	1.16	-0.60	0.56	4.64	12.07
Graduated	16	1.94	-1.52	0.42	5.73	7.33
Trapped	45	1.34	-1.41	-0.07	4.25	-1.65

Source: Author's own calculation.
Notes: TP, TE, TFP and Y are short for technological progress, technical efficiency, total factor productivity and GDP, respectively. TFP/Y indicates the contribution of TFP growth to economic growth.

countries and graduated MIEs have shown a more balanced pattern in productivity growth, namely, both technological progress and efficiency change have made positive contributions to productivity growth and hence economic growth. The findings also imply that, as the time horizon is extended from 30 years to 50 years, the MITs and graduated MIEs are less distinguishable in terms of productivity performance. This is not surprising; if a MIE takes 50 years to graduate or pass the threshold income of ppp$10,000, its growth performance is probably not impressive at all. Typical examples include Argentina, Chile and Mexico which all passed the threshold income of ppp$10,000 in 2010 while their average annual growth rates during 1961-2010 are 1.44%, 2.47% and 1.78% respectively. These rates are well below the growth rate of 4.31% in Malaysia which is often cited as an unsuccessful example in East Asia, not to mention 5.21% in Singapore and 5.69% in Korea during the same period.[6]

Furthermore, to take the dynamic issues into consideration, the base year is allowed to change over time so that low income economies can join the middle income group or MIEs may be downgraded to low income members. In Table 5, five base years are considered. The number of MIEs in each year is listed in the "Middle" column in the table. Some movement between

[6] These growth rates are calculated by the author using the PWT statistics.

the income groups is observed. However, over the five decades, the number of MIEs in the world remains stable according to the criterion defined here (per capita GDP between ppp$1,000 and ppp$10,000). There were 58 MIEs out of a total of 109 countries in 1971. Within four decades, this number became 55 though there are countries moving in and out of the MIE group.

Table 5 Middle income countries in selected years

Year	Low	Middle	High (examples)
1971	7 out	58	10 graduated (Japan)
1981	5 out 2 in	57	5 graduated (Hong Kong/Singapore) 1 retreated (Iran)
1991	2 out 1 in	56	3 graduated (Taiwan/Korea) 1 retreated (Mexico)
2001	2 out 1 in	56	1 graduated (Mexico)
2010	5 out	55	7 graduated (Argentina/Malaysia) 1 retreated (Gabon)

Source: Author's own account.
Notes: "Low", "Middle" and "High" represent the low, middle and high income groups, respectively. In the "Low" column, "out" means the number of countries moving out of the low income group to join the MIE group and "in" the number of MIEs retreating to the low income group.

To check the robustness of the results reported in Table 4, three more scenarios are considered; a 30 year time horizon starting in 1971 and 1981 respectively and a 40 year time horizon starting in 1971. To compare with the results in Table 4, two cases corresponding to the 30 year time horizon (1971-2000 and 1981-2010) are reported in Table 6. The results of the third case (1981-2010) are presented in Appendix B. In general the findings are consistent with those in Table 4. It is shown that productivity growth plays an important role in sustaining economic growth among the high income economies while poor productivity performance is consistently recorded in low income countries. The findings in Table 6 confirm again that the MIEs stand in the middle in terms of their productivity performance.

While both graduated MIEs and MITs showed positive growth in TFP, the former tends to benefit from both technological progress and efficiency change. It is also shown in Table 6 that the MITs on average grow at a slower rate than the graduated MIEs. In summary, cross-country analysis shows that both high income countries and MIEs have benefited positively from productivity growth. The low income group is yet to gain from productivity growth. In general, there is evidence of a more balanced performance between technological progress and efficiency change in the graduated MIEs than that in the MITs.

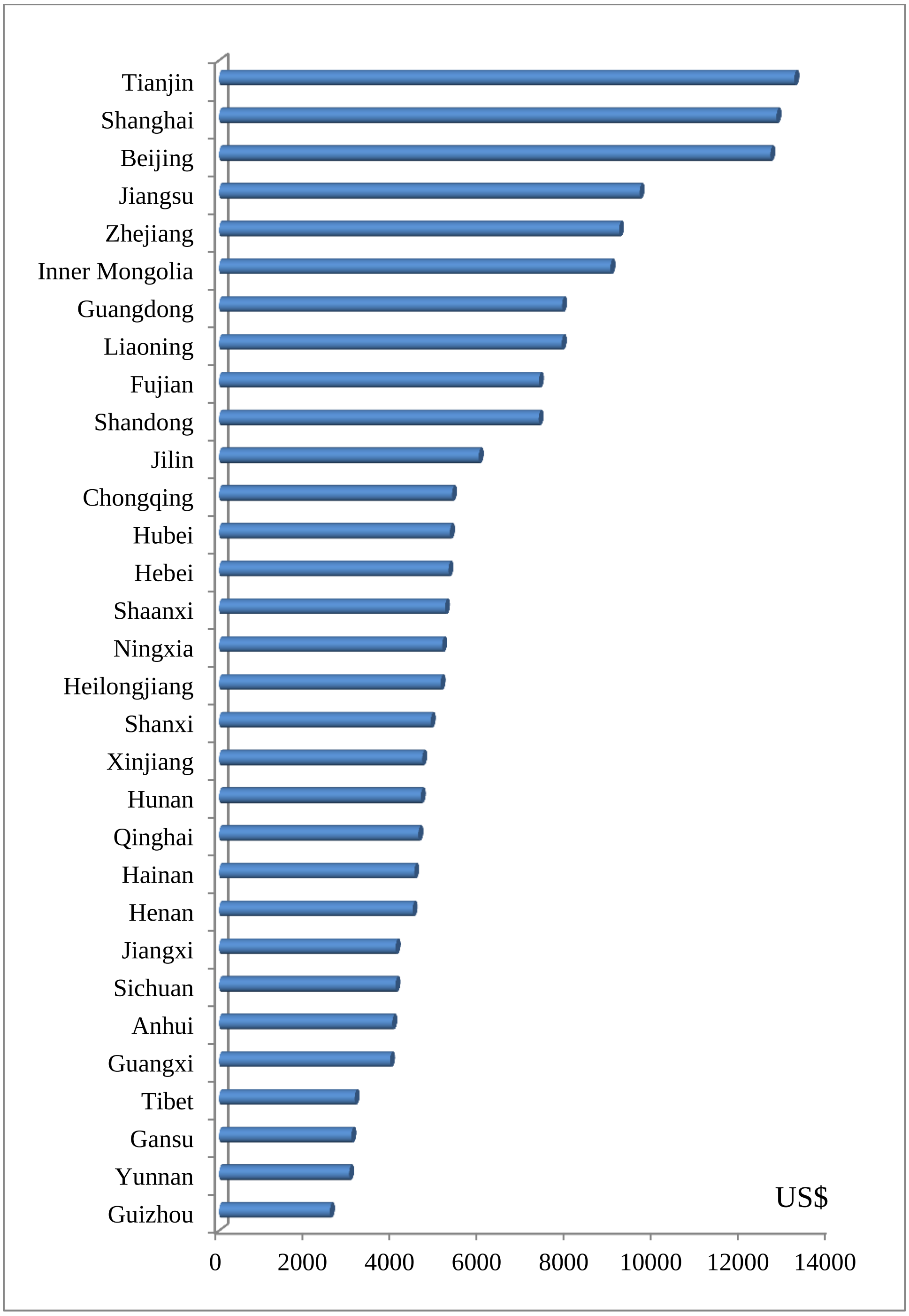
Table 6 TFP estimates for the periods of 1971-2000 and 1981-2010

Groups	No. of countries	Rates of growth (%) TP	TE	TFP	Y	TFP/Y (%)
1971-2000						
High-income	26	1.56	-0.04	1.52	2.90	52.41
Low-income	25	-1.31	0.26	-1.05	3.40	-30.88
Middle-income	58	0.53	0.05	0.58	3.95	14.68
Graduated	8	0.03	0.84	0.87	5.92	14.70
Trapped	50	0.57	-0.10	0.47	3.64	12.91
1981-2010						
High-income	30	0.59	0.66	1.25	2.67	46.82
Low-income	22	-2.19	0.70	-1.49	3.76	-39.63
Middle-income	57	1.65	0.10	1.75	3.67	47.68
Graduated	11	1.46	0.45	1.91	4.61	41.43
Trapped	46	1.68	0.00	1.68	3.45	48.70

Source: Author's own estimates.
Notes: TP, TE, TFP and Y are short for technological progress, technical efficiency, total factor productivity and GDP, respectively. TFP/Y indicates the contribution of TFP growth to economic growth. Relevant regression results are presented in Appendix C.

5. Can China Avoid the Middle Income Trap?

To explore whether China can avoid being trapped at the middle income level, the analytical framework introduced in Section 3 is applied to the country's regional data. There is considerable income disparity between China's thirty-one administrative regions with gross regional product (GRP) ranging from about US$2,541 per capita in Guizhou to US$13,193 in Tianjin in 2011 (Figure 1). For this reason, separate regressions are run for the coastal high income group (10 regions) and the interior low income regions (21 regions). The former recorded a mean income of US$9,309 per capita in 2011 which is twice as much as the average income per capita (US$4,582) in the interior regions in the same year.



Source: Author's own calculation using data from the National Statistics Bureau (2012).

Figure 1 GRP per capita in 2011

The empirical analysis covers the past two decades, from 1991 to 2010. According to the PWT statistics (China version 1), China's GDP per capita reached ppp$1,000 in 1986. Economic growth was briefly interrupted during 1989-1990. In 1990 there was also a major revision of the employment statistics in the country leading to a 17% increase in total employment in that year. For these reasons, 1991 is chosen as the starting year. During the two decades from 1991 to 2010, China enjoyed robust economic growth which lifted tens of millions of Chinese out of poverty and helped the country gain the status of an upper middle income economy.

To implement the estimation procedure described in Section 3, both capital stock and GRP values are expressed in 2005 constant prices. Capital stock data is estimated by using region-specific rates of depreciation which are drawn from Wu (2008). The estimation results are summarized in Table 7. In general, productivity is found to play an important role in China's economic growth in the past two decades. TFP contribution to China' economic growth during 1991-2010 is on average 44.85%. This is compatible with the estimate of about 41.24% during 1993-2004 cited by the World Bank (2012) and slightly higher than the share in high income economies examined in Section 4.[7] Zhuang et al. (2012) also reported an average TFP growth rate of 6.3% in China during the period of 1990-2009. The coastal regions have however performed much better than the interior regions. In particular both technological progress and efficiency change have made positive contributions to productivity growth in the coastal regions though technological progress is the dominant factor. This is consistent with the pattern observed among the high income countries.

[7] The World Bank estimates are drawn from Bosworth and Collins (2007). It is noticed that Wu (2013) presented TFP estimates using both official and his own revised data.

To investigate the interior areas further, eleven regions with the lowest per capita income in 2011 (the "Bottom" row in Table 7) are separated from the rest of the group (the "Rest" row in Table 7). The "bottom" group, with an average income per capita of US$3,740 in 2011, is more like the lower middle income economies while the "rest" group with an average income per capita of US$5,508 in the same year is more like the upper middle income countries as defined by the World Bank (2013). It is found that the "Rest" group seems to follow the growth pattern of the coastal regions and has benefited from both technological progress and efficiency change. However, the "bottom" group on average performed very differently, and showed an unbalanced productivity growth pattern with a high TP rate and a negative TE rate. In comparison with the world's MIEs, productivity still plays a significant role in the growth of the economies in the "bottom" group. This could be a relief for those who are overwhelmed with the view that the Chinese economy may be trapped at the middle income level.

Table 7 Decomposition of productivity growth in China, 1991-2010

Groups	No of regions	Rates of growth (%)				TFP/Y (%)
		TP	TE	TFP	Y	
China	31	5.89	-0.53	5.36	11.95	44.85
Coastal	10	7.68	0.43	8.11	12.92	62.77
Interior	21	5.81	-0.88	4.93	11.48	42.94
Bottom	11	6.14	-2.30	3.84	11.42	33.63
Rest	10	5.14	0.24	5.38	11.55	46.58

Source: Author's own estimation.
Notes: TP, TE, TFP and Y are short for technological progress, technical efficiency, total factor productivity and GDP, respectively. TFP/Y indicates the contribution of TFP growth to economic growth. Relevant regression results are presented in Appendix C.

The above productivity prospective implies that China is likely to maintain high growth and hence join the high income world in the coming decade. This view is shared by other scholars like Woo (2012) and Malkin and Spiegel (2012). However, sustainable growth is by no means guaranteed. For example, Woo (2012) argued that China needs further reforms in order to avoid a MIT. Zhuang et al. (2012) highlighted six challenges which may lead to a MIT-type growth slowdown in China. Others offered more general policy options for a middle income country to avoid being trapped at that stage (Kharas and Kohli 2011, Agenor and Canuto 2012). These discussions have important policy implications for China. Historical data show that it takes at least ten years to double the level of China's current income per capita (above ppp$7,000). Examples include Japan, Korea, Hong Kong and Taiwan (see Table 8). Other countries, including Belgium, Portugal, Puerto Rico and Ireland, have taken more than two decades. Some countries have yet to reach that target, including Malaysia, Turkey, Mexico and Argentina. Thus while the productivity story in this study provides a positive outlook for the Chinese economy, Chinese policy makers should not take it for granted that the country is MIT-free in the coming decades.

6. Conclusions

This paper contributes to the current debate on whether the Chinese economy can avoid a MIT. Empirical analysis of cross-country historical data shows that productivity has played an important role in sustaining economic growth in high income nations. In addition, high income economies also tend to follow a more balanced growth path by exploiting the benefits of both technological progress (innovation) and efficiency change (catch-up). It is also found that productivity has made no or even negative contributions to economic growth in low income economies and hence is a key factor responsible for those economies being trapped in poverty.

Table 8 Years of income growth from ppp$7,000 to ppp$15,000

Economies	Year with income over ppp$7,000	years to reach ppp$15,000
Japan	1963	9
Singapore	1970	10
Korea, Republic of	1985	10
Hong Kong	1971	12
Spain	1961	13
Greece	1963	13
Taiwan	1979	13
Austria	1954	16
Italy	1956	17
Israel	1961	17
Cyprus	1977	18
France	1950	19
Finland	1954	19
Portugal	1969	21
Puerto Rico	1964	23
Ireland	1959	28
Trinidad &Tobago	1958	42
Gabon	1966	not yet reached
Argentina	1969	not yet reached
Mexico	1972	not yet reached
Costa Rica	1973	not yet reached
Malaysia	1993	not yet reached
Turkey	1993	not yet reached
Chile	1994	not yet reached
Dominican Republic	1999	not yet reached
Panama	2004	not yet reached

Source: Author's own calculation using PWT statistics.

Among the middle income countries, those which have excelled to join the high income group have also benefited more from productivity growth than the MITs. Once again productivity performance is vital for sustainable economic growth. An examination of China's regional economic data during the past two decades shows that productivity has made significant contributions to economic growth within the regions. China's coastal economies resemble the performance pattern of the world's high income group and have benefited greatly from both technological progress and efficiency change. This may underlie the rapid increase in per capita income in the coastal regions which on average is approaching US$10,000. In China's interior regions, productivity and economic growth are also impressive. However, the main driving force is technological progress with very little efficiency change. This is particularly evident amongst the "bottom" income group in China. Thus the Chinese economy may be well positioned to avoid a MIT but a more balanced growth pattern is needed, in particular among the less developed regions. In addition, it is warned that there are challenges ahead for the successful transition of the Chinese economy from the upper middle income stage to the high income status. These challenges call for specific economic policies in the coming years.

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Appendix A: A list of the low, middle and high income countries

High (16)

Australia
Austria
Barbados
Belgium
Canada
Denmark
France
Iceland
Luxembourg
Netherlands
New Zealand
Norway
Sweden
Switzerland
United Kingdom
United States

Costa Rica
Cote d`Ivoire
Cyprus
Dominican Republic
Ecuador
El Salvador
Fiji
Finland
Gabon
Gambia, The
Ghana
Greece
Guatemala
Haiti
Honduras
Hong Kong
Iran
Ireland

Namibia
Nicaragua
Nigeria
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Portugal
Puerto Rico
Romania
Senegal
Singapore
South Africa
Spain
Syria
Taiwan
Thailand

Botswana
Burkina Faso
Burundi
Cape Verde
Central African Republic
Chad
China
Comoros
Congo, Dem. Rep.
Egypt
Ethiopia
Guinea
Guinea-Bissau
India
Indonesia
Lesotho
Malawi
Mali

	Israel	Trinidad &Tobago	Mauritania
Middle (61)	Italy	Tunisia	Mozambique
	Jamaica	Turkey	Nepal
Algeria	Japan	Uruguay	Niger
Argentina	Jordan	Venezuela	Pakistan
Bolivia	Kenya	Zambia	Rwanda
Brazil	Korea, Republic of		Sierra Leone
Cameroon	Malaysia	**Low (32)**	Sri Lanka
Chile	Mauritius		Tanzania
Colombia	Mexico	Bangladesh	Togo
Congo, Republic of	Morocco	Benin	Uganda
			Zimbabwe

Appendix B: Alternative estimation results

Groups	No. of countries	Rates of growth (%) TP	TE	TFP	Y	TFP/Y (%)
1961-2000						
High-income	16	0.84	0	0.84	3.19	26.33
Low-income	32	-0.48	0.16	-0.32	3.97	-8.06
Middle-income	61	0.99	0.2	1.19	4.39	27.11
Graduated	17	0.58	0.84	1.42	5.28	26.89
Trapped	44	1.17	-0.08	1.09	4.04	26.98
1961-2010						
High-income	16	0.79	0.13	0.92	2.87	32.06
Low-income	32	-0.05	0.64	0.59	4.24	13.92
Middle-income	61	1.03	0.11	1.14	4.21	27.08
Graduated	24	0.78	0.39	1.17	4.70	24.89
Trapped	37	1.49	-0.06	1.43	3.90	36.67
1971-2010						
High-income	26	1.35	-0.04	1.31	2.64	49.62
Low-income	25	-0.84	0.58	-0.26	4	-6.50
Middle-income	58	0.85	0.15	1.00	3.91	25.58
Graduated	12	1.57	0.52	2.09	5.04	41.47
Trapped	46	0.81	0.08	0.89	3.62	24.59

Source: Author's own estimates.
Notes: TP, TE, TFP and Y are short for technological progress, technical efficiency, total factor productivity and GDP, respectively. TFP/Y indicates the contribution of TFP growth to economic growth. Relevant regression results are reported in Appendix C.

Appendix C Alternative regression results

	High-income			Low-income			Middle-income			Graduated			MIT		
Var	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
								1961-2000							
t	-0.0188	0.0062	***	-0.0167	0.0025	***	0.0146	0.0026	***	-0.0117	0.0049	**	0.0273	0.0033	***
lnL	0.0127	0.0938		0.7431	0.0679	***	0.0471	0.0432		0.9337	0.0790	***	-0.0686	0.0501	
lnK	0.3800	0.0371	***	0.2076	0.0216	***	0.2027	0.0226	***	0.7683	0.0450	***	0.1014	0.0282	***
t*lnL	-0.0064	0.0011	***	-0.0086	0.0006	***	-0.0074	0.0005	***	0.0022	0.0014		-0.0068	0.0006	***
t*lnK	0.0060	0.0010	***	0.0091	0.0005	***	0.0030	0.0003	***	0.0013	0.0009		0.0011	0.0004	***
lnK*lnL	0.0173	0.0099	*	0.0177	0.0070	**	0.0529	0.0061	***	-0.0669	0.0107	***	0.0704	0.0083	***
constant	3.4435	0.2740	***	0.3310	0.2160		2.8926	0.1271	***	-0.5268	0.2658	**	3.3063	0.1423	***
R-square	0.97			0.96			0.94			0.98			0.91		
Hausman	103.80	***		4.52			171.32	***		7.33			232.66	***	
N	640			1280			2440			680			1760		
								1961-2010							
t	-0.0137	0.0042	***	-0.0128	0.0020	***	0.0103	0.0020	***	0.0060	0.0027	***	0.0172	0.0028	***
lnL	0.4333	0.0803	***	0.5817	0.0509	***	0.1316	0.0356	***	0.3061	0.0463	***	0.0537	0.0467	
lnK	0.4714	0.0360	***	0.2095	0.0185	***	0.2467	0.0185	***	0.3539	0.0271	***	0.1762	0.0250	***
t*lnL	-0.0017	0.0008	**	-0.0080	0.0005	***	-0.0055	0.0003	***	-0.0064	0.0006	***	-0.0032	0.0004	***
t*lnK	0.0033	0.0007	***	0.0085	0.0003	***	0.0028	0.0002	***	0.0032	0.0004	***	0.0014	0.0004	***
lnK*lnL	-0.0192	0.0090	**	0.0198	0.0057	***	0.0383	0.0049	***	0.0294	0.0064	***	0.0322	0.0072	***
constant	2.4188	0.2461	***	0.7885	0.1673	***	2.6600	0.1055	***	1.9486	0.1456	***	3.1146	0.1354	***
R-square	0.98			0.97			0.95			0.98			0.98		
Hausman	74.43	***		3.41			271.21	***		19.05	***		10214.68	***	
N	800			1600			3050			1200			1850		

Var	High-income Coeff	SE		Low-income Coeff	SE		Middle-income Coeff	SE		Graduated Coeff	SE		MIT Coeff	SE	
							1971-2000								
t	-0.0590	0.0090	***	-0.0165	0.0049	***	-0.0004	0.0031		-0.0021	0.0090		0.0014	0.0034	
lnL	1.2911	0.1399	***	0.7665	0.0982	***	0.2303	0.0566	***	0.7082	0.1367	***	0.2293	0.0622	***
lnK	0.4489	0.0660	***	0.1551	0.0487	***	0.5161	0.0311	***	0.7373	0.0804	***	0.5035	0.0341	***
t*lnL	-0.0034	0.0017	*	-0.0076	0.0013	***	-0.0038	0.0006	***	-0.0036	0.0023		-0.0023	0.0006	***
t*lnK	0.0103	0.0016	***	0.0068	0.0008	***	0.0029	0.0004	***	0.0019	0.0017		0.0019	0.0005	***
lnK*lnL	-0.1159	0.0157	***	0.0483	0.0123	***	0.0031	0.0086		-0.0267	0.0185		-0.0011	0.0099	
constant	2.6636	0.4660	***	-0.3020	0.3778		1.3463	0.1714	***	-0.6131	0.4970		1.4388	0.1814	***
R-square	0.76			0.96			0.96			0.99			0.96		
Hausman	151.48	***		17.85	***		55.03	***		0.74			51.63	***	
N	780			750			1740			240			1500		
							1971-2010								
t	-0.0263	0.0053	***	-0.0108	0.0038	***	-0.0044	0.0022	**	0.0332	0.0063	***	-0.0051	0.0024	**
lnL	1.1720	0.1007	***	0.6576	0.0734	***	0.3118	0.0436	***	-0.2290	0.1098	**	0.3340	0.0493	***
lnK	0.4988	0.0546	***	0.1644	0.0411	***	0.5333	0.0223	***	0.1414	0.0686	**	0.5393	0.0240	***
t*lnL	0.0005	0.0012		-0.0095	0.0010	***	-0.0021	0.0004	***	-0.0130	0.0012	***	-0.0005	0.0004	
t*lnK	0.0044	0.0010	***	0.0080	0.0006	***	0.0031	0.0003	***	0.0035	0.0006	***	0.0024	0.0003	***
lnK*lnL	-0.0949	0.0122	***	0.0492	0.0099	***	-0.0144	0.0061	**	0.0902	0.0155	***	-0.0221	0.0070	***
constant	2.0227	0.3532	***	0.0309	0.2929		1.3231	0.1278	***	3.6695	0.4223	***	1.2566	0.1340	***
R-square	0.89			0.97			0.96			0.95			0.96		
Hausman	119.25	***		16.96	***		127.86	***		40.32	***		91.76	***	
N	1300			1250			2900			600			2300		

Var	Coeff	High-income SE		Coeff	Low-income SE		Coeff	Middle-income SE		Coeff	Graduated SE		MIT Coeff	SE	
								1981-2010							
t	0.0120	0.0060	**	-0.0163	0.0043	***	0.0077	0.0028	**	0.0229	0.0070	***	0.0056	0.0031	*
lnL	0.6233	0.1083	***	0.8151	0.0790	***	0.1100	0.0539	***	-0.0407	0.1173		0.1747	0.0603	***
lnK	0.7322	0.0502	***	0.2744	0.0468	***	0.4661	0.0279	***	0.1965	0.0854	**	0.4807	0.0302	***
t*lnL	0.0019	0.0014		-0.0092	0.0010	***	-0.0001	0.0004		-0.0060	0.0013	***	0.0015	0.0005	***
t*lnK	-0.0015	0.0012		0.0062	0.0010	***	0.0013	0.0004	***	0.0018	0.0011	*	0.0008	0.0004	**
lnK*lnL	-0.0350	0.0129	***	0.0810	0.0130	***	-0.0013	0.0071		0.0648	0.0174	***	-0.0142	0.0080	*
constant	0.1337	0.3300		-1.6624	0.3004	***	2.1736	0.1853	***	3.2729	0.4639	***	2.0786	0.2027	***
R-square	0.98			0.96			0.96			0.98			0.96		
Hausman	8.44			82.84	***		190.84	***		10.07			133.99	***	
N	900			660			1710			330			1380		

Var	Coeff	China SE		Coeff	Coastal SE		Coeff	Interior SE		Coeff	Bottom SE		Rest Coeff	SE	
t	0.0787	0.0123	***	0.1624	0.0544	***	0.0745	0.0134	***	0.0897	0.0144	***	-0.2417	0.0614	***
lnL	-0.2257	0.1027	**	-0.7381	0.5077		-0.2386	0.1162	**	-0.4333	0.1480	***	2.8143	0.5914	***
lnK	0.0824	0.0812		-0.4381	0.4404		0.1890	0.0875	**	0.1385	0.0895		2.8859	0.5280	***
t*lnL	-0.0087	0.0016	***	-0.0135	0.0072	*	-0.0068	0.0018	***	-0.0066	0.0020	***	0.0360	0.0088	***
t*lnK	0.0048	0.0005	***	0.0017	0.0011		0.0037	0.0007	***	0.0023	0.0009	**	0.0037	0.0011	***
lnK*lnL	0.0397	0.0124	***	0.0968	0.0589		0.0266	0.0142	*	0.0338	0.0161	**	-0.3403	0.0734	***
constant	5.4950	0.6686	***	10.5640	3.7905	***	5.2628	0.7081	***	6.4811	0.8177	***	-16.878	4.2401	***
R-square	0.78			0.84			0.65			0.41			0.94		
Hausman	242.36	***		28.84	***		163.82	***		166.48	***		9.08		
N	620			200			420			220			200		

Source: Author's own estimates.

Notes: *, ** and *** indicate significance at the level of 10%, 5% and 1% respectively. The significance of the Hausman test implies the rejection of the relevant random effect model. For consistency, all estimation results in this table are based on the fixed effect models.

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