The wage transition in developed countries and its implications for China

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Abstract The expression "wage transition" refers to the fact that over the past two or three decades in all developed economies wage increases have leveled off. There has been a widening divergence and decoupling between wages on the one hand and GDP per capita on the other hand. Yet, in China wages and GDP per capita climbed in sync (at least up to now).

In the first part of the paper we present comparative statistical evidence which measures the extent of the wage transition effect.

In a second part we consider the reasons of this phenomenon, in particular we explain how the transfers of labor from low productivity sectors (such as agriculture) to high productivity sectors (such as manufacturing) are the driver of productivity growth, particularly through their synergetic effects. Although rural flight represents only one of these effects, it is certainly the most visible because of the geographical relocation that it implies; it is also the most well-defined statistically. Moreover, it will be seen that it is a good indicator of the overall productivity and attractivity of the non-agricultural sector.

Because this model accounts fairly well for the observed evolution in industrialized countries, we use it to predict the rate of Chinese economic growth in the coming decades. Our forecast for the average annual growth of real wages ranges from 4% to 6% depending on how well China will control the development of its healthcare industry.

Provisional. Version of 29 April 2016. Comments are welcome.

Key-words: productivity, demographic transition, economic growth, wage, earnings, agriculture, industry, primary sector, secondary sector, tertiary sector.

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Introduction

Post-industrial societies

Nowadays (i.e. in early 2016) the dominant conception is that the post-industrial stage reached by most developed countries and in which at least 75% of employment is in the service sector is a superior stage. It seems to realize the dream of clean, energy efficient and highly productive economies. Clean and energy efficient they may be, but are post-industrial societies also highly productive? This is one of the questions that we try to answer in the present paper.

Perhaps it may be helpful to explain what lead us to question the mainstream conception. Doubts were raised step-wise by a number of observations among which one can highlight the following.

- In the past two or three decades, following in the footsteps of New York and other American cities, home-delivery of pizzas started in many west European cities. This marked a sharp break with the period following World War II. In this period labor had been considered as a rare and costly resource which had to be economized as much as possible. Home-delivery of pizzas was a low productivity business which could be profitable only if served by poorly paid employees. It was the harbinger of the creation of a whole range of jobs similarly characterized by poor pay and low productivity. As emphasized by economists such as Jean Fourastié, the fact that the price of hair cuts or opera tickets remained unchanged in the course of time strongly suggests that the tertiary sector holds little promises for productivity improvement. At the end of the paper we will propose a broader explanation which relies on the fact that most service goods have little or no synergetic potential.
- The second shock was the observation that in the United States the average hourly wage had peaked around 1975 and stagnated ever since[1] . True, the Gross Domestic Product (GDP) per capita had continued to increase but this was due to concomitant changes, for instance the fact that an increasing number of house wives took a full time job or the fact that an increasing share of income comes from non-salary earnings.
- The third element which triggered our questioning came from the observation of service-centered economies. Switzerland and Singapore embody fairly well the dream of an efficient, environment-friendly post industrial economy[2]. In addition both countries similarly benefited from massive capital inflows and foreign direct investments. Yet, in spite of such favorable conditions they show the same syndrome

[1] As a matter of fact there was a sudden change in the trend of many other economic (e.g. income inequality) and social indicators (e.g. proportion of inmate population). These changes are documented more fully in Roehner (2009, chapters 9-11).

[2] Although very different in terms of territory and area, the two countries are in the same class in terms of population (8 and 5,4 million respectively) and GDP per capita (US$ 84,000 and 55,000); the data are for 2013.

of levelling off wages as do other developed countries. For Switzerland this can be seen in Fig. 3 and for Singapore it can be observed that whereas wages have been multiplied by 5.5 in the 4 decades from 1965 to 2005, they have stagnated over the last decade from 2005 to 2015 (Shanmugaratnam 2015). In orther words, even under the best circumstances the post-industrial, service-based economy is not up to its promises.

Parallel with the demographic transition

Before describing the wage transition it may be useful to present a transition of same kind, namely the well-known "demographic transition". The two transitions are of same kind in the sense that they occur over a similar time span and in almost all countries. In spite of the fact that the causes of the demographic transition are not yet well understood, this paradigm gives us a predictive perspective which, although rough, is quite useful nevertheless.

There are many factors which may affect women fertility, that is to say the average number of children that a woman will have during her life-time. Just as illustrations on can mention the following: the mean age at marriage, the infant mortality rate, the attitude of the prevailing religion with respect to birth control, the laws ruling inheritance, the place of residence (whether rural or urban[3]), whether or not the family needs a second salary, the extent to which girls have access to education. Many other factors could be added to this list. As a matter of fact the list is boundless in the sense that for each "primary" factor one can cite many "secondary" factors. For instance, the mean age at marriage can be seen as a primary factor but it is affected by countless social and economic circumstances.

One may think that by focusing on a single country the question will become more clearly defined and hence easier to solve. This is an illusion, however. As an illustration, consider the case of France. Between 1850 and 1940, the average fertility rate of French women and the resulting rate of natural increase of the French population were much lower than in other Western European countries[4]. The explanation most commonly accepted by historians relies on the observation that according to French inheritance laws all children were entitled to an equal part of their father's landholding. Thus, it is said, to avoid splitting their land, farmers did not wish several children. However, can such an explanation be sufficient when one realizes that in 1906 only 43% of the labor force was working in agriculture and that only one half of this percentage, that is to say some 20% of the labor force, were landowners

[3]The role of this factor is demonstrated in a fairly dramatic way by the fact that the cities of Hong Kong, Macao and Singapore have fertility rates as low as 1.17, 0.93 and 0.80 respectively (the data are for 2014).

[4]Detailed comparative data can be found in Flora et al. (1987) but a broad view can be obtained just by comparing the number of immigrants to the United States or to Latin America. There is a strong contrast between the massive flows of Germans and Italians and the very small numbers of French immigrants

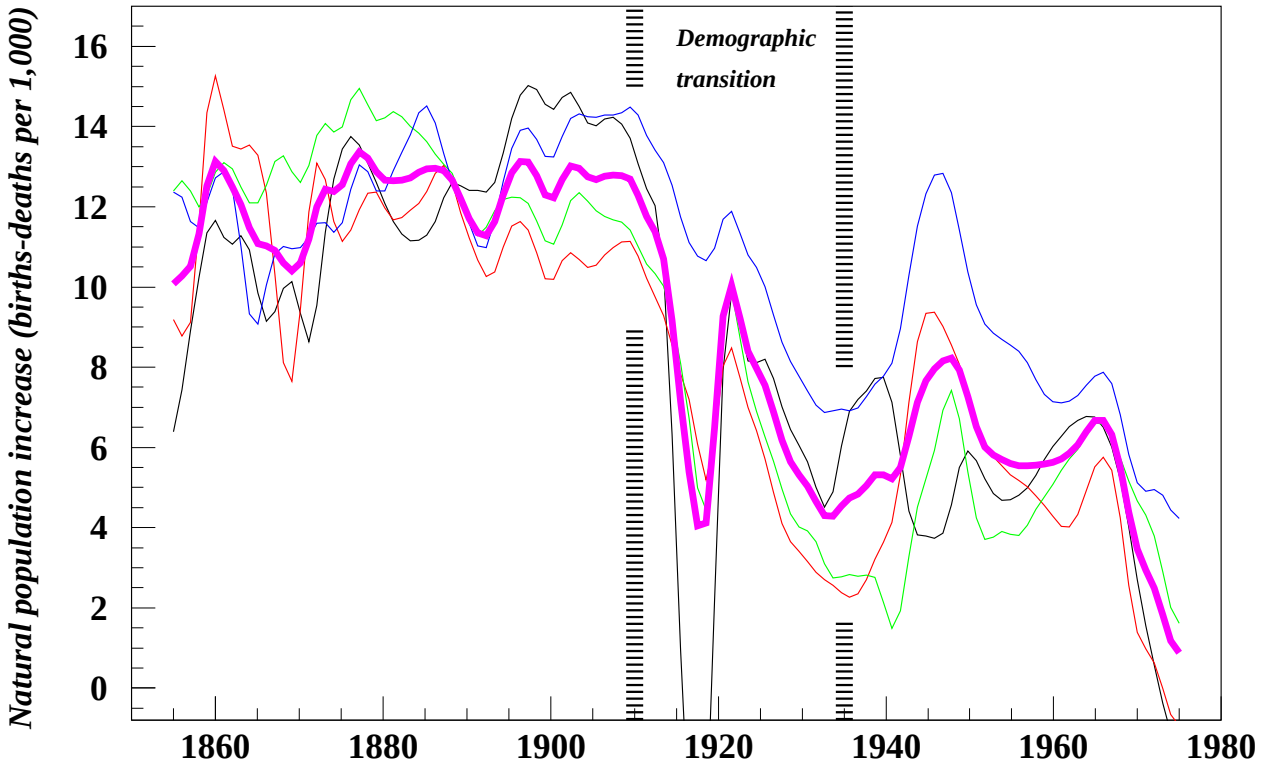

Fig. 1 Demographic transition in western Europe. The thin lines are centered moving averages (over intervals of 5 years) of the differences between birth and death rates for 4 countries: Germany (black), Denmark (blue), England and Wales (green). Sweden (red). The thick line is the average of the 4 cases. The demographic transition consisted in an almost simultaneous fall of death rates (mostly due to a decrease in infant mortality) and birth rates; however, because the second effect was predominant the net effect was a decrease in the rate of natural increase. The graph shows that this transition was marked by several ups and downs. In addition, for some countries (e.g. the Netherlands or France) this rule did not apply at all. *Source: Flora et al. (1987, vol. 2, chapter 6)*

(Flora et al. 1987, p. 500)?

On the contrary, if, instead of focusing on a single case, the scope of the analysis is broadened to a whole range of similar countries, then a fairly well defined pattern emerges which is called the *demographic transition*.
It consists in the fact that between 1900 and 1940, in almost all west European countries the annual rate of natural increase (per 10,000 population) fell from about 120 to less than 50[5].

We do not know exactly what causes triggered the fall in births per women and the correlative fall in natural increase. Was it better education, urbanization, higher income, or some other factors? Yet, despite possible exceptions, the observation of the

[5]For instance, in Germany the fall was from 141 to 54, in Britain from 116 to 30, in Sweden from 111 to 25, in Switzerland from 100 to 46 (Bunle 1954, p. 16). There were exceptions however, the most conspicuous of which were Italy and the Netherlands. In both cases, the rate of natural increase remained around 100. France should not be considered as an exception because with its initial increase rate of only 11 per 1,000, no transition could happen.

West European demographic transition gave us a predictive rule. This rule displayed its full usefulness when between 1950 and 2000 a similar demographic transition unfolded in many developing countries, e.g. Brazil, India, Indonesia, Mexico, South Korea, Turkey, Vietnam. This transition was even of greater magnitude than the first in the sense that within 50 years fertility rates fell from a high level of about 5 to a level of 2 which is the long-term replacement rate. As in the first transition, in this second transition there were also a few countries which did not follow the rule (e.g. the Philippines or Nigeria). However, it can hardly be denied that the demographic transition pattern gives us a better understanding and allows us to predict future trends.

The wage transition rule

In the present paper, we wish to describe what can be called a *wage transition*. It may be summarized by the following statement:

> *Wage transition rule.* *In developed economies, after an initial phase during which real wages increased exponentially (with a doubling-time of about 30 years), a second phase set in around 1980 during which average wages leveled off or even fell slightly. Most often this second phase set in after the share of agriculture in the labor force had fallen under 10%.*

Before stating this rule we discussed briefly the demographic transition because the two transitions share several important aspects.

- Although (as will be shown below) the wage transition is confirmed by a large amount of statistical evidence, there are a few exceptions (i.e. the UK).
- The demographic transition could not be attributed to a single factor but was rather correlated with a whole bundle of variables; similarly the wage transition comes along with a whole range of changes.
- Despite these limitations, the wage transition rule provides a framework that gives a better understanding and allows testable predictions.

As an example of a better understanding one can mention the case of the United States. When this example is considered alone it might appear surprising that wages increased sharply until 1975 and slumped thereafter up to present day. The observation becomes less puzzling when seen in the light of the wage transition rule because then it just appears as an early instance of a transition that took place in most countries. This tells us that instead of trying to explain it by purely American causes (e.g. the Vietnam War or the decline of the stock market) we should rather consider factors that are common to most industrialized countries.

Growth of the Chinese economy

As an example of a testable prediction, one can mention the issue of the growth of the

Chinese economy, a question much debated currently (November 2015). The wage transition rule and the observation that the share of Chinese agricultural employment will not fall under 10% until at least 2025 suggest the following prediction.

> After increasing exponentially (with a doubling time of 8.4 years) from 1990 to 2015, the average wage in China should follow the same trend for at least another decade that is to say until 2025.

During the past three decades the increase of the average wage paralleled the growth of the Gross Domestic Product (GDP). From 1990 to 2015 the GDP per capita (at current prices) grew from 1,866 RMB to 49,300 RMB. With an increase of the GDP deflator from 12 to 42 this gives a multiplication by 7.5 for the real GDP per capita. The average annual growth rate was 8.2% which corresponds to a doubling time of 8.4 years. In a country as large as China, domestic consumption plays a crucial and increasing role which means that a rising average wage is both the effect and engine of economic growth.

The following qualifications may apply as second order effects.

- If productivity progress slows down because of a rapid development of the healthcare sector (there is a longer discussion of this point below) then one would expect a somewhat slower growth, say around 6%.
- In addition, in the coming decades it is likely that, as in western countries, the share of non-salary earnings will increase. As a result, salaries may grow slower than the GDP/capita. This would lead to an annual growth forecast for salaries in the range $4\% - 5\%$.

Actually, in the previous prediction the key-point is not the exact value of the rate but rather the statement that such a long-term trend will not be derailed by one or two short-lived recessions[6]. Nevertheless, it may not hold if there is an upheaval similar to what happened in the Soviet Union in the years following 1991.

Connected issues

Before starting the discussion of the wage transition, it may be helpful to keep in mind the following observation. In economics all phenomena are inter-connected. Therefore, it would be easy to list many effects which may possibly play a role in the

[6] Just for the purpose of comparison, it can be of interest to consider the case of Mexico. Between 1980 and 2013 it experienced 3 major crises.

- In December 1982 the country was bailed out after defaulting on its sovereign debt. It was not until 1994 that the GDP/capita resumed its pre-crisis level.
- Then, in early 1995 a second bail out ($50 billion) was necessary to prevent a new default.
- Finally, the worldwide crisis of 2008 led to a 5% fall of GDP.

As nowadays for Greece, there were a succession of debt restructuring plans: e.g. the Baker, Brady and Clinton plans. Because of these recurrent crises, the GDP/capita expressed in US dollars increased by only 31% in the 33 years from 1980 to 2013. Expressed in constant dollars the growth would be about zero. Thus, it can be said that the "North American Free Trade Agreement" (NAFTA) which started in 1994 has had but a dismal effect on the economic growth of Mexico.

levelling off of wages. For instance, the financialisation of the economy contributes to the divergence between GDP/capita and wages; growing inequality contributes to the divergence between high and low earnings; through expansion of the supply side, immigration contributes to eroding wages; the gradual disappearance of unions may have the same effect.

Although all these effects may play a role, thanks to our comparative perspective, we know that they do not play the main role. Indeed, the great advantage of this approach is that it allows us to filter out secondary factors. In Japan there is little immigration, in Sweden unions are still important forces, in Germany, financialisation of the economy is much less developed than in the US. Nevertheless, in all these countries the wage transition effect can be observed. In short, even if the previous effects exist, they are only second-order effects in the sense given to this expression in physics.

The wage transition in the United States

Observation

There are two good reasons for starting this investigation with the case of the United States. The first is that, as already said, it was the first country where this transition occurred. Secondly, it is probably the country where the wage transition was the sharpest. This can be seen clearly by comparing Fig. 2 and Fig. 3.

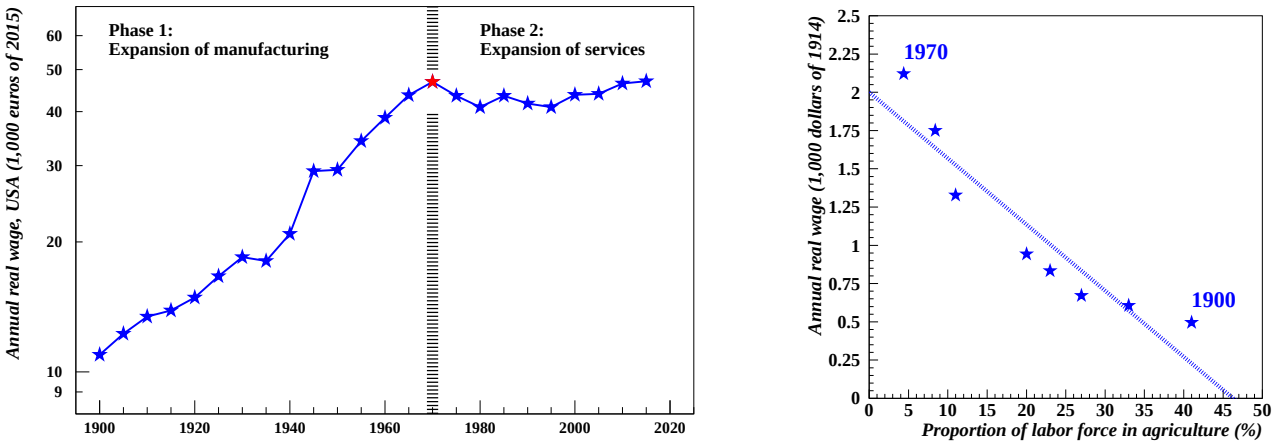

Fig. 2 Wage transition in the United States. In phase 1 the mean wage, w, increased exponentially at an average rate of 2.0% per year whereas in phase 2 it stagnated. Simultaneously the proportion of the labor force employed in agriculture, f_a fell from 41% in 1900 to 4.4% in 1970. There is a high correlation, namely 0.987, between the two changes. The relationship between the logarithms of the two variables is: $\log w = -a \log f_a + b, \quad a = 0.67 \pm 0.09, \; b = 1.87 \pm 0.06$. However, because several other economic factors changed as well during this time period, this close connection does not necessarily mean that the wage effect resulted from the shift in the labor force. *Sources: Historical Statistics of the United States 1975, Liesner 1989.*

Whereas in the US the transition from exponential increase to stagnation occurred abruptly, elsewhere there was a smooth transition involving a progressive reduction of the growth rate.

Possible "explanations"

If we limit our attention to the US case, many possible "explanations" may come to mind. For instance, one can mention the following.

- The decades after 1945 were marked by a progressive erosion of the fighting capability and bargaining power of American unions. This trend already started with the Taft-Hartley Act of 1947 but it really gained momentum only in the 1970s. One of its clearest manifestations was the dramatic fall in the frequency of strikes. More details can be found in Roehner (2009). For instance, in the private sector the unionization rate dropped from about 30% in the 1950s to 8% in 2007.
- The suddenness of the transition may be "explained" by a series of external shocks. (i) the confidence crisis which affected the dollar in the late 1960s and which eventually led to President Nixon's action in 1971 ending its convertibility to gold. (ii) the slump of stock prices at the New York Stock Exchange, (iii) the oil shock, (iv) the aftershocks of the Vietnam War débâcle.

In order to narrow down the set of possible "explanations" we must consider a broader range of cases. This is what is done in the next section. The fact that the same wage transition can be observed in many countries will ipso facto eliminate any specifically American explanation.

The wage transition in comparative perspective

Average wage increases

In February 2015, in his budget speech the Deputy Prime Minister (and also Finance Minister) of Singapore, Tharman Shanmugaratnam, warned that wage stagnation had set in for most developed economies in the United States, Europe and Japan (Shanmugaratnam 2015). As seen in the previous section regarding the United States, and as will be seen in the present section for the European countries and Japan, wage stagnation is in fact a phenomenon which started over two decades ago. However, as already mentioned, in Singapore the phenomenon started only around 2005. In other words, like the demographic transition, the wage transition did not occur simultaneously in all places but occurred gradually with country-dependent time lags. This is illustrated in Fig. 3.

The case of Britain

It can be observed that Britain stands apart both in Fig. 3 and in Fig. 6. One may

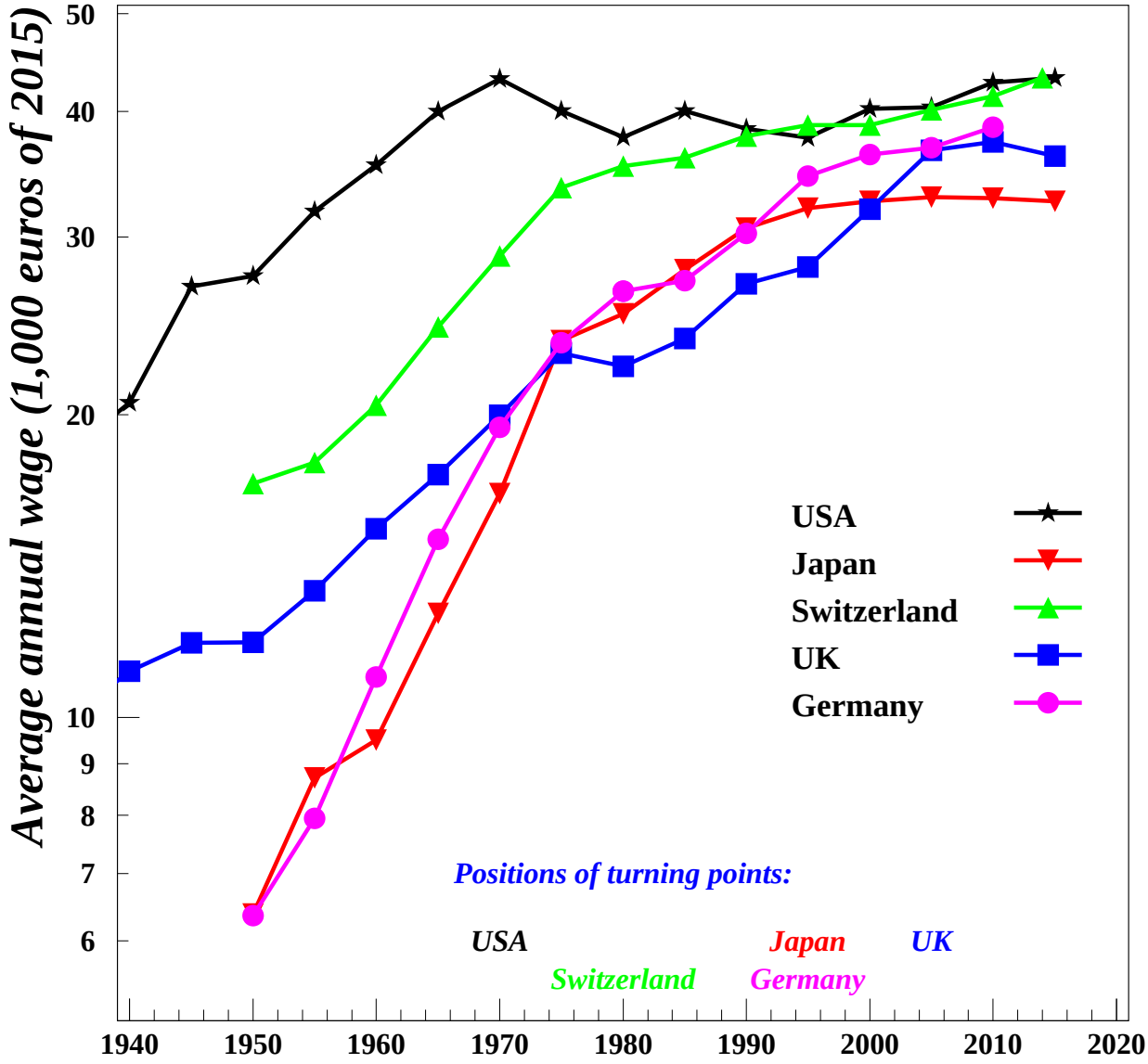

Fig. 3 Wage transition in several countries. In phase 1 the average wage increased exponentially whereas in phase 2 it stagnated or increased more slowly. The names of the countries at the bottom of the graph indicate the years when the transition occurred. To the 5 countries shown one could add Singapore whose transition occurred in 2005 as discussed in the text. *Sources: USA: see Fig.1; Japan: Historical Statistics of Japan, average monthly contractual earnings; Switzerland: The website of the "Federal Office of Statistics" gives an annual series of real wages starting in 1939; UK: Until 1985: Liesner 1989, 1990-2015: Office of National Statistics, average weekly earnings of manual workers; Germany: Until 1985: Liesner 1989, 1990-2015: Federal Statistical Office, gross hourly earnings for manual production workers.*

wonder why.

In 1846, that is to say very early compared with other European countries, through the repeal of the Corn Laws which imposed heavy duties on grain imports, Britain decided that grain supplies could be obtained in a much cheaper way through over-

seas imports particularly from the British Empire (e.g. from Canada or India[7]). This step was foreshadowed by recurrent land "Enclosure Acts" (e.g. those of 1801 and 1845) which transformed into private property the "common lands" that hitherto had allowed farming by landless farmers.

Through these steps people were compelled to move from the countryside to cities. In other European countries a substantial rural flight started only much later.

Interpretation

Table 1 shows that with respect to productivity the only clear and long-term distinction is the one between agriculture and manufacturing. The tertiary service sector is a mixed bag involving activities of very different productivity levels. As a consequence the composition of this sector will be different from one country to another and in each country it will change in the course of time. For instance, the software industry which nowadays is an important component in the United States was non-nonexistent some 30 years ago and is still under-represented in European countries. Another example is the health care industry; according to table 1, in 2012 this sector represented 12% of the total employment and 7.1% of the total GDP[8]; some 30 years ago the weight of this sector was much smaller and nowadays it is still much lower in many other developed countries.

It is this changing shape of the tertiary sector which makes it difficult to set up a model which would have a permanent validity. There is a similar difficulty with the demographic transition in the sense that the transition described by Fig. 1 was in fact followed by a second one in the early 21th century that brought down the fertility rates of many developed countries well below the replacement rate of 2.1. Although the two transitions may share some characteristics their mechanisms may not be identical.
The global productivity of the tertiary sector is a weighted average[9] which in the case of the sectors listed in Table 1 (i.e. all 13 sectors except agriculture, manufacturing and mining) is equal to $\$122,000$ per employee, a figure which is mid-way between the productivities of agriculture and manufacturing.

In the next section we examine the implications for economic growth.

Implications for economic growth

For China in 2013 the weights and productivity of the agricultural sector on the one side and of all non-agricultural sectors on the other side are given in Table 2.

[7] To the point that India exported grains to Britain even in years when there were famines in some parts of the country.

[8] Another indicator is the weight of health care expenditures; according to World Bank data in 2012 it represented 17% of the US GDP.

[9] In fact in the present case the weighted average is identical to the GDP per employee: $\sum(G_i/p_i)(p_i/P) = (1/P)\sum G_i$.

Table 1 GDP per employee in various economic sectors (USA, 2012)

	Sector	Contribution to GDP [billion $]	Employment [million]	GDP per employee [thousand $]
1	Educational services	183	3.34	54.8
2	Retail trade	932	14.9	62.5
3	Health care, social assistance	1,153	16.9	68.2
4	Art, entertainment	157	2.09	75.1
5	Agriculture, forestry, fishing	186	2.11	88.1
6	Government (federal and local)	2,197	21.9	100
7	Transportation, warehousing	467	4.41	106
8	Professional services	1,912	17.9	106
	All tertiary sectors	11,929	97.6	122
	All sectors	14,509	112	129
	All non-agricultural sectors	14,323	110	130
9	Manufacturing	1,983	11.9	166
10	Wholesale trade	962	5.67	169
11	Information	737	2.74	269
12	Financial activities	3,229	7.78	415
13	Mining	411	0.80	514

Notes: The GDP per employee given in the last column can be seen as a measure of employee productivity. Despite the modernization of US agricultural production there is still a 1:2 productivity gap between agriculture and manufacturing. This table suggests that what is usually called the service sector is in fact a very heterogeneous category in which productivity covers a scale from 1 to 10. The ratio between the productivities in agriculture and non-agriculture sectors is equal to $130/88 = 1.47$. The present table is not an exhaustive list of all sectors but it represents 90% of the total GDP.
Sources: GDP: Bureau of Economic Analysis (interactive table); Employment: Bureau of Labor Statistics ("Table 2.1 Employment by major industry sector").

With respect to rural flight, in the United States the major transformation took place between 1900 and 1950. In this time span the percentage of the labor force engaged in agriculture fell from 41% to 11%, that is to say at an annual rate of 0.6%. Based on the data of Table 1 and 2, Fig. 4 summarizes the respective situations of the United States and China. In the United States between 2000 and 2010 the percentage of the labor force employed in agriculture fell from 2.5% to 1.5%, that is to say at an annual rate of 0.1%.

In China during the same time interval, this percentage fell from 50% to 36%, that is to say at an annual rate of 1.4%. Whereas nowadays in the United States this transfer of jobs from the agricultural sector to the non-agricultural sector represents a very marginal source of productivity progress, in the first half of the 20th century it was a major source of productivity growth. However, the present transfer rate in China is twice as fast as it was at that time in the US. It was between 1940 and 1950 that the US transfer rate reached its maximum with an annual rate of 0.9%, still lower than

Table 2 Contribution of different sectors to the Chinese GDP, 1990-2013

Sector	Share of GDP g_i [% of GDP]	Share of employment e_i [% of employment]	GDP per employee $(g_i/e_i)g$	Productivity multiplier $k = (g_i/e_i)/(g_1/e_1)$
1990				
Agriculture	$g_1 = 25$	$e_1 = 60$	$g_1/e_1 = 0.42g$	1
Industry and tertiary sector	$g_2 = 75$	$e_2 = 40$	$g_2/e_2 = 1.87g$	4.3
2013				
Agriculture	$g_1 = 10$	$e_1 = 34$	$g_1/e_1 = 0.29g$	1
Industry and tertiary sector	$g_2 = 90$	$e_2 = 66$	$g_2/e_2 = 1.36g$	4.5

Notes: g denotes the GDP per employee for the whole economy. Between 1990 and 2013 the percentage of the total labor force engaged in the agricultural sector fell from 60% to 34%. In 2013 the productivity gap between agriculture and the rest of the economy was 4.5; this was three times the ratio of 1.47 found in Table 1 for the United States. Needless to say, even in agriculture there was a marked productivity increase due to the rapid growth of g.
Sources: GDP data: Bajpai (2014); employment data: World Bank, (Interactive table entitled "Employment in agriculture (% of total employment)").

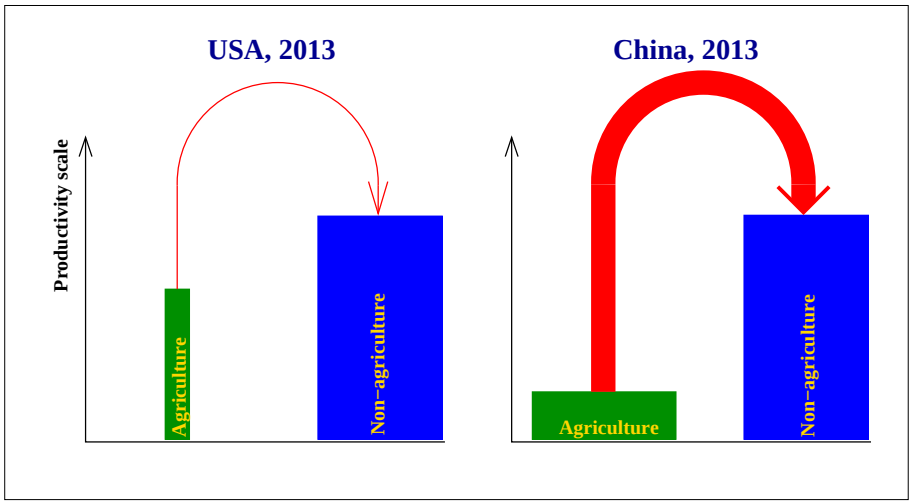

Fig. 4 Transfer of rural population to the non-agricultural sector. In China the transfer rate was over 10 times faster than in the United States.The figure respects the order of magnitude of the productivity gap within each country and also the magnitude of the respective rates of transfer. The scales of the two vertical productivity axes are not the same; this allowed us to draw two identical rectangles to represent the non-agricultural sectors. *Sources: Tables 1 and 2.*

seen in China in the past decades.

Model describing the transfer effect

In order to test to what extent the mechanism described in Fig. 4 can explain long-term wage increases we need to set up a model along these lines.

Definition of key-variables

In order to make it as simple as possible, we will introduce only two sectors: agriculture (sector 1) on the one hand and the rest of the economy (sector 2) on the other hand. At first sight this may seem a rough approximation; for instance, mining and health care will be together in sector 2; however, mining is a fairly small sector (it is 21 times smaller than health care). The purpose of our two-sector model is to provide a broad picture and to explain (and predict) long-term trends.

We introduce the following notations:
E: total employment, $E_i,\ i = 1, 2$: employment in sectors 1,2 respectively. $e_i = E_i/E$.
G: total (real) GDP, $G_i,\ i = 1, 2$: GDP of sectors 1,2 respectively, $g_i = G_i/G$.
We denote by $p = G/E$ the GDP per employee of the whole economy. $p_i = G_i/E_i = (g_i/e_i)(G/E) = (g_i/e_i)p$ denotes the GDP per employee in each sector, that is to say their productivity.

Now we introduce a variable that we call the *productivity multiplier* that will characterize how much the productivity of sector 2 is higher than the one of sector 1.

$$\text{Productivity multiplier:} \quad k = \frac{p_2}{p_1} = \frac{g_2/e_2}{g_1/e_1} = \frac{(1-g_1)/(1-e_1)}{g_1/e_1}$$

The interesting point is that k can be computed as soon as one knows the two numbers g_1, e_1.

Order of magnitude and changes of key-variables

In order to give some substance to these definitions, let us give some numerical values for the United States and China. The data for p are expressed in dollars of 1982 and renminbi of 2013 respectively.

- USA:

$1900:\ p = \$9,593,\ e_1 = 41\%,\ g_1 = 23\%,\ g_1/e_1 = 0.56,\ k = 2.32$

$1950:\ p = \$20,424,\ e_1 = 11\%,\ g_1 = 6.9\%,\ g_1/e_1 = 0.62,\ k = 1.66$

$1980:\ p = \$32,095,\ e_1 = 3.4\%,\ g_1 = 3.0\%,\ g_1/e_1 = 0.88,\ k = 1.14$

- China:

$1983:\ p = \text{RMB } 5,114,\ e_1 = 67\%,\ g_1 = 33\%,\ g_1/e_1 = 0.49,\ k = 4.12$

$2000:\ p = \text{RMB } 24,184,\ e_1 = 50\%,\ g_1 = 50\%,\ g_1/e_1 = 0.30,\ k = 5.67$

$2013:\ p = \text{RMB } 73,513,\ e_1 = 31\%,\ g_1 = 10\%,\ g_1/e_1 = 0.32,\ k = 4.04$

A noteworthy point is the stability of g_1/e_1; it changes much less than e_1 and g_1 separately and also much less than p. How should this be interpreted? The fact that $g_1/e_1 = p_1/p$ is quasi-constant in spite of the fact that p doubles, triples or

quadruples means that agricultural productivity increases approximately at the same pace as global productivity. Moreover, it can be observed that k changes fairly slowly which for a structural variable is of course a welcome characteristic.

Other data will be found in Table 3. In addition, intermediate values of the GDP per employee for 1995, 2000, 2005 and 2010 are as follows (expressed in 2015 RMB):
$p_1 : 7,434,\ 7,547,\ 10,150,\ 20,030$
$p_2 : 27,323,\ 42,189,\ 60,273,\ 75,394$
During these 25 years the GDP per employee has been increasing exponentially both in the agricultural sector and in the rest of the economy. The coefficients of correlation $(t, \log p_i)$ are 0.97 and 0.99 respectively. The exponents are given in the notes of Table 3.

Table 3: China: GDP per employee in agriculture and rest of economy, 1990-2015

			1990	2015	Ratio 2015/1990
	Whole economy				
1	GDP (billion of current RMB)		1,866	67,000	36.00
2	GDP deflator		12	42	3.50
3	GDP (billion of 2015 RMB)	G	6,531	67,000	10.30
4	Labor force (billion)	E	0.64	0.81	1.26
5	GDP per employee (2015 RMB)	p	10,204	82,716	8.10
	Agriculture				
6	GDP (billion of 2015 RMB)	G_1	1,763	6,030	3.42
7	Labor force (billion)	E_1	0.33	0.25	0.75
8	GDP per employee (2015 RMB)	p_1	5,342	24,210	4.51
	Rest of economy				
9	GDP (billion of 2015 RMB)	G_2	4,768	60,970	12.79
10	Labor force (billion)	E_2	0.31	0.56	1.81
11	GDP per employee (2015 RMB)	p_2	15,380	108,875	7.07

Notes: It can be observed that the rates of change of the labor force are an order of magnitude smaller than the rates of change of the GDP. When intermediate values are introduced one finds that both p_1 and p_2 increase as exponentials with exponents $\alpha_1 = 0.062 \pm 0.016$ (doubling time of 11.1 years) and $\alpha_2 = 0.075 \pm 0.011$ (doubling time of 9.2 years). As a result, in the long-term the productivity gap increases as $p_2 - p_1 \sim \exp(\alpha_2 t)$
Sources: World Bank, Trading Economics, http://www.investopedia.com.

The exponential increase of p_1 and p_2 has two interesting implications.

- As is well known, in a limited world an exponential growth cannot last for ever which means that a saturation effect will set in sooner or later. The data shown in Fig. 6 suggest that it should not occur before 2025.
- Over past decades the productivity gap between the agriculture sector and the rest of the economy has increased exponentially:

$$\text{gap} = p_2 - p_1 = p_2(1 - p_1/p_2) = p_2\left[1 - (A_1/A_2)\exp(-dt)\right]\ d = \alpha_2 - \alpha_1 = 0.013$$

For large t the gap becomes equal to p_2 itself. Thus, any labor transfer from sector 1 to sector 2 will trigger a productivity jump whose magnitude increases exponentially in the course of time. This effect may compensate for diminishing transfers as e_1 becomes smaller. In other words, the productivity effect of rural flight will remain significant even when e_1 will fall under 10% as may happen around 2030 according to Fig. 6.

Describing the GDP change due to a transfer of labor force

Now, in order to describe the mechanism of Fig. 4 we must assume that e_1 decreases by a quantity Δe_1. In fact, in what follows it will be more convenient to follow the variable e_2 because its variations $\Delta e_2 = -\Delta e_1$ are positive in the course of time.
The change in G resulting from a transfer of population from sector 1 to sector 2 will be:

$$G = G_1 + G_2 = p_1 e_1 E + p_2 e_2 E \rightarrow \Delta G = (p_1 \Delta e_1 + p_2 \Delta e_2)\, E = (p_2 - p_1) E \Delta e_2 \tag{1}$$

In the above expression of ΔG the productivities p_1, p_2 have been kept constant because we wish to focus on the effect of a labor force transfer[10]. By introducing the factor k, expression (1) becomes:

$$\Delta G = (k-1) p_1 E \Delta e_2 = (k-1) \left(\frac{g_1}{e_1}\right) G \Delta e_2 \rightarrow \left(\frac{1}{\Delta e_2}\right) \frac{\Delta G}{G} = (k-1) \left(\frac{g_1}{e_1}\right) \tag{2}$$

We can take advantage of our previous observation regarding the stability of g_1/e_1 to simplify expression (2) into:

$$\left(\frac{1}{\Delta e_2}\right) \frac{\Delta G}{G} = (k-1) < \frac{g_1}{e_1} > \tag{3}$$

where $< g_1/e_1 >$ represents the average value of g_1/e_1 over a period of several decades. For the United states, one would have $< g_1/e_1 >= 0.69$ whereas for China: $< g_1/e_1 >= 0.35$.

In the left-hand side the numerator and denominator can be multiplied by 100 which allows to express both Δe_2 and $\Delta G/G$ in percent. Thus the left-hand side represents the percentage variation of $\Delta G/G$ for a 1% variation of e_2.

Note that equation (3) applies to any transfer of labor force. In particular, it can also describe the *decline* in GDP that results from the transfer of labor force from manufacturing to healthcare, a key-feature in industrialized countries over the past three decades[11]. This point may be developed in a subsequent paper.

[10] The huge changes which occur in the course of time for p_1 and p_2 are a different question which will be discussed later.

[11] In this case sector 1 would be the whole economy except healthcare and sector 2 would designate the healthcare sector.

Labor force transfers as an engine of economic growth

Rural flight seen in the broader view of all labor force transfers

In the present paper we focus on the effect of rural flight on economic growth for two main reasons.

- This labor force transfer has a clear statistical definition because of the fact that agriculture is a well defined economic sector. In contrast, a sector such as healthcare has a fairly fuzzy statistical definition. For instance, do nursing homes belong to healthcare or to the hospitality industry?
- Historically rural flight has been of great importance in all developed countries and nowadays it is still a major factor in countries such as China and India.

However, this focus should not hide the fact that rural flight is only one case (albeit the most significant) of a broad variety of labor force transfers which take place continuously. For instance in developed countries two sectors have had a rapid growth over the past 50 years: (i) the healthcare and (ii) the information technology sector. According to Table 1, around 2012 in the United States healthcare employed about 15% of the total work force whereas the share of the IT industry was of the order of one or two percent. What impact on global productivity has had the development of these sectors? Table 1 shows that healthcare's and IT's productivities were one half and twice the national average respectively.

A case in point: healthcare versus infrastructure development

Across nations there are great disparities in the extension of the healthcare sector. For countries with an aging populations (as is the case of all developed countries) it is of course natural to have an expanding healthcare sector but it must be recognized that its actual extent is determined by a political decision. Thus, in the United Kingdom which has a nationalized medical system the weight of healthcare in the economy is only one half of what it is in the US[12].

The fact that through its own poor productivity level, the healthcare sector drags down overall productivity is not its only liability. Because most of its patients are elderly persons beyond retirement age, health care has little synergy with other activities.

Completely different is the case of infrastructure expenses. Many other sectors will benefit from better transportation infrastructure. Clearly, healthcare based development and infrastructure oriented development constitute two different models. As one knows, the infrastructure model is promoted by the Chinese government not only domestically but also for the rest of the Asian continent. Regarding healthcare,

[12] In spite of that, around 2009 life expectancy in the UK was 2.5 years longer than in the US.

at this point it is too early to say which system China will choose. Will it be the US or the UK model[13] ? Clearly this choice will affect the productivity of the whole Chinese economy. Too much resources and investments sunk in healthcare will be a drag on the economy. At the beginning of the paper we said that one would expect a 8% growth trend until 2025 but an over extended healthcare industry may well slow down this expectation to 6% or 5%.

What fraction of growth does rural flight explain?

In this section we compare the changes in GDP per employee actually observed to those predicted by the rural flight effect in three different ways.

Correlation of relative variations

Firstly, we wish to see if there is a connection between the ups and downs in e_2 on the one hand and the wage changes on the other hand. Obviously, cases (such as China) in which there were little ups and downs will not be appropriate for this test. In contrast, the test can be done in good conditions for the case of the US because its wage changes display several ups and downs.

The comparison between observed wage changes and those predicted by the transfer model shows a significant correlation (Fig. 5). Although one would like to perform additional tests, it is not easy to find appropriate cases. For instance, the income of countries such as France, Germany or Japan which have experienced wars on their territory will be affected by exogenous shocks which have nothing to do with the transfer effect.

Percentage of growth directly due to rural flight in 1990 and 2015

The correlation test performed in the previous subsection was largely independent of the magnitude of the respective changes. Now we wish to determine what proportion of the increase in GDP per employee can be accounted for by the rural flight effect. For this test one needs a case in which the change rate is as large as possible. China is well suited for this purpose. Before making a formal calculation we will compute the expected changes at the two ends of the time interval 1990-2015. For this purpose we will use the data given above (Table 3 and additional data).

As already explained the rural flight effect is only one of a number of transfer effects which contribute to GDP growth. One of the clearest manifestations of the effects of these transfers are the productivity increases *within* the two sectors. This effect cannot be explained by rural flight. Indeed, rural flight can only explain the global growth of G due to the interaction between agriculture and the rest of the economy.

[13] One can be sure that this kind of decision will be subject to lobbying efforts from many sides.

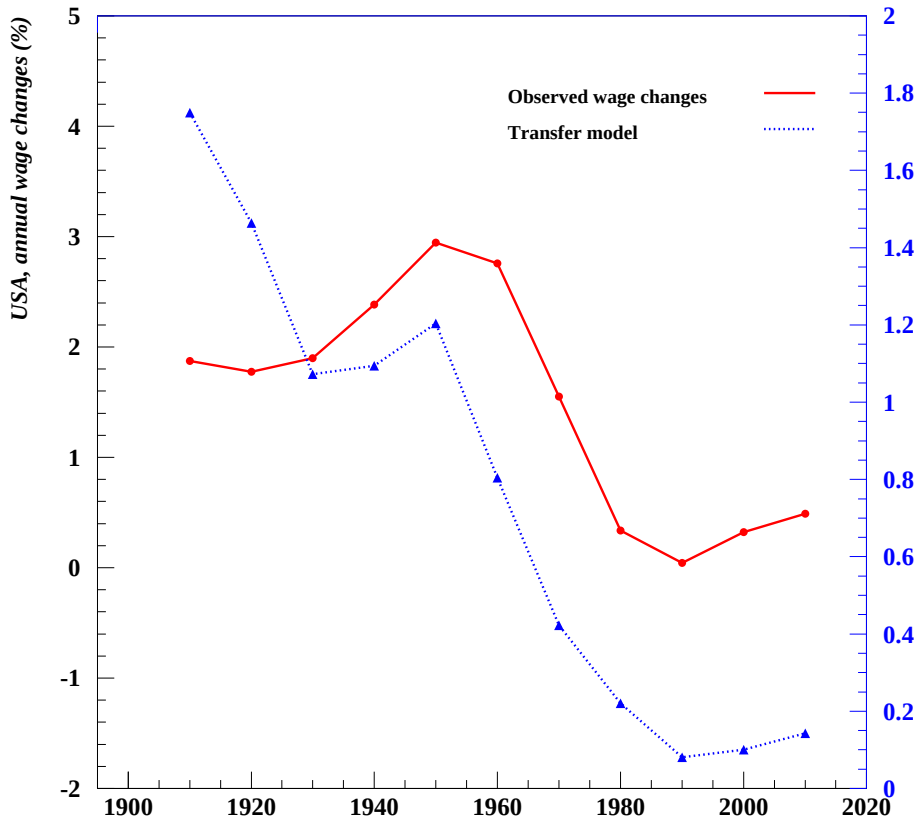

Fig. 5 Observed US wage changes versus changes resulting from the transfer effect. The correlation between the two series is 0.64 (95% confidence interval is 0.08 to 0.90). It can be observed that real wages did not fall during the Great Depression. This is due to the fact that the price consumer index fell faster than nominal wages. *Sources: Same sources as for Fig. 3.*

The productivity increases within the two sectors are due to interactions between their various sub-sectors.

- Tractors, trucks instead of horse driven carriages, engines, pumps, motorcycles, mobile phones and many other items that are produced in sector 2 progressively came into use in the country side, thereby lifting p_1. These changes would happen independently of any transfer of labor force.
- At the same time, in sector 2 outdated textile factories were equipped with modern spinning and weaving machines manufactured in other factories of sector 2, newspaper printing machines were replaced by computerized systems, supermarkets replaced small stores. As above, these changes would happen independently of any transfer of labor force. Because sector 2 is more diversified than sector 1 it experiences more synergy and that is probably why the endogenous growth of sector 2 is faster than the endogenous growth of sector 1.

According to the comments following Table 3, we expect a greater effect of rural flight in 2015 than in 1990. Let us see if this is confirmed by observation.

Over the whole period 1990-2015 the labor force in sector 1 decreased by 170 millions which gives an average change of 34 millions over every 5-year interval.

1990-1995 Over this time interval, one gets (everywhere RMB means "RMB of 2015")

- The average of p_1 is $\overline{p_1} = (5,231 + 7,434)/2 = 6,332$ RMB
- The average of p_2 is $\overline{p_2} = (15,380 + 27,323)/2 = 21,351$ RMB

Thus, rural flight from 1 to 2 will increase G by: $\Delta G' = 34 \times 10^6 (\overline{p_2} - \overline{p_1}) = 511 \times 10^9$ RMB.

The actual increase in G was $\Delta G = G(1995) - G(1990) = 5,627 \times 10^9$ RMB. Thus, the variation due to rural flight represents: $511/5627 = 9.1\%$.

2010-2015 A similar computation leads to: $\Delta G' = 2,383 \times 10^9$ RMB, and $\Delta G = G(2015) - G(2010) = 5,627 \times 10^9$ RMB. In this case the variation due to rural flight represents: 11.4%.

As expected we see that in 2015 the change due to rural flight is a larger proportion of the total increase than in 1990. We also see that the largest part of GDP growth must be attributed to endogenous increases of G_1 and G_2 which in turn are due to transfers occurring *within* these sectors.

General formulation

In this subsection the previous computation is presented in a broader and more formal way.

Let us denote by p the GDP adjusted for inflation and per employee. From 1985 to 2014, p has increased regularly at an average annual rate of 9.2%; for the whole interval this rate resulted in a multiplication by 10.3

The productivity multiplier $k = p_2/p_1$ fluctuated between 4 and 6. In order to get an upper bound of the growth accounted for by rural flight, we will give k its maximum value of 6. As a first step, consider the two extreme situations: $e_1 = 1$ and $e_1 = 0$. Moving from the first to the second would result in a multiplication of G by 6. In other words, in this thought experiment the transfer effect explains only $6/10.3 = 58\%$ of the growth.

In order to get a more realistic estimate we write the values of G in 1985 and 2014 in the following way (G' denotes the values of G predicted by rural flight):

$$G'(i) = p_1(i)E_1 + 6p_1(i)E_2 = [e_1(i) + 6e_2(i)]\, p_1(i)E$$

With $e_1(1) = 67\%$ and $e_1(2) = 31\%$ one gets: $G'(2)/G'(1) = 1.67\,(p_1(2)/p_1(1))$. In the rural flight model the productivity p_1 is supposed fixed, that is $p_1(1) = p_1(2)$. Under this assumption the transfer of labor accounts for only $1.67/11 = 15\%$ of the actual productivity growth.

Equation (3) would lead to a similar conclusion. For average annual changes it gives:
$\Delta G'/G' = (k-1) < g_1/e_1 > \Delta e_2 = 5 \times 0.4 \times 1.2 = 2.4\%$
whereas the actual annual GDP growth is $\Delta G/G = 9.2\%$.

Implications

The fact that rural flight accounts for only a fraction of the total growth has two important implications.

- A recession may temporarily stop employment shifts from sector 1 to sector 2. If this transfer would account for a high percentage (say some 80% or more) of economic growth, then its discontinuation would freeze further growth altogether and transform the recession into a depression. However, if employment transfer actually is only a secondary factor the synergy engine will continue to work and will pull the economy out of the recession[14].

This is indeed what was observed in developed countries in the decades following World War II. There were only mild recessions. In other words, unless there is a political upheaval no major interruption of growth should be expected in China for at least 15 years, that is to say until it has become a service economy too.

- As seen earlier, in developed countries the growth of wages stopped or slowed down in the 1980s. This was due to the shift of their economies toward a service sector economy which is dominated by low productivity sectors of which healthcare is an important component. The fact that rural flight almost came to an end in the 1980s was due to two circumstances: (i) The labor force of sector 1 was already largely depleted. (ii) Because productivity growth in sector 2 was slowed down, this sector lost its attractivity in terms of higher salaries. Indeed, the growth of sector 2 was largely due to the introduction of so-called “odd jobs”, “second class jobs” or “deskilled casual work”.

Conclusion

Chinese economic growth over 2015-2035 in comparative perspective

Several interesting features are highlighted in Fig. 6.

- The transfer of labor force from agriculture to the industrial and service sectors has progressed unabated in all developed countries. Economic crises or even the two world wars may have slightly slowed down the evolution (as in the case of Austria for instance) but they did not have any lasting impact.
- We have already suggested that South Korea may be a good predictor of the future of the Chinese economy. The development of South Korea followed the pat-

[14] Needless to say, economic growth can be thwarted for many other reasons, e.g. deflation, capital flight, disruption of the banking sector and so on.

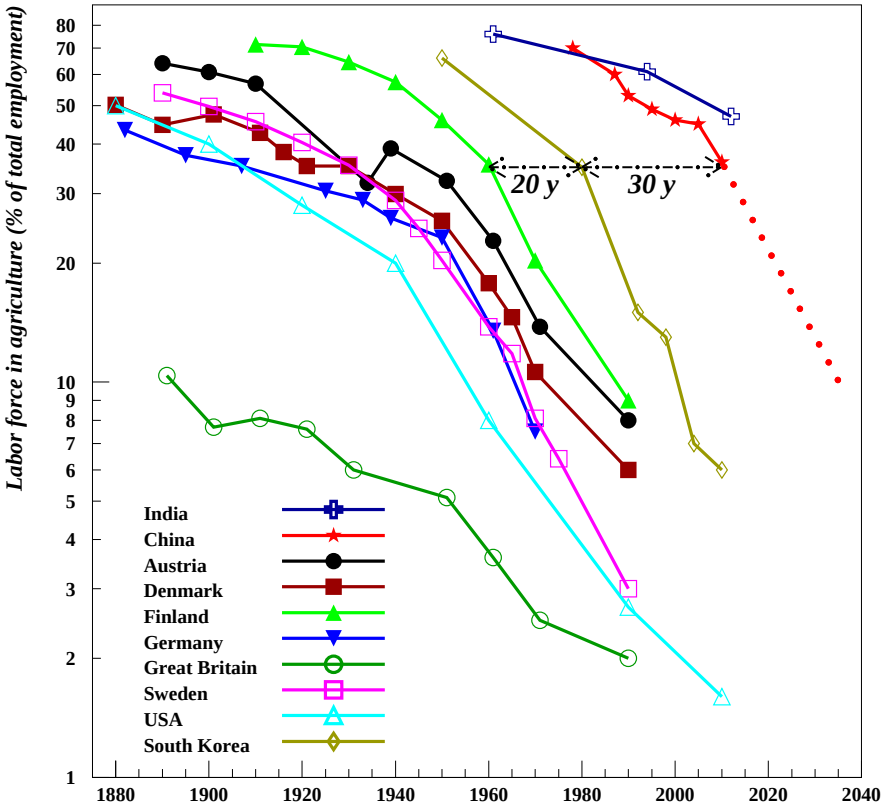

Fig. 6 Labor force in agriculture. Apart from the UK which stands apart, all developed countries experienced more or less the same evolution. The fact that the curves for Sweden and Germany are almost the same shows that wars had almost no impact. The curve for China was extrapolated based on the rates seen in other countries and particularly in South Korea. Regarding the special case of Britain see the explanation given above in relation with Fig. 3. *Sources: Until 1970: Flora et al, (1987) and Historical Statistics of the United States (1975). After 1970: Trading Economics website and Saint Louis Federal Reserve.*

tern set by developed countries. We see that in terms of proportion of the labor force working in the agricultural sector Finland was about 20 years ahead of South Korea which itself was 30 years ahead of China[15]. If one uses the rate of South Korea to extrapolate the curve for China one arrives to the conclusion that in 2035 the percentage of the labor force in agriculture will be about 10%.

- Among developed countries the UK is a case apart. Its agricultural sector fell to a level of 10% some 60 years before the United States. In this sense, Britain was the first post-industrial economy; this may explain the fact (observed in Fig. 3) that its rate of wage increase was substantially lower than in other countries.

What was the evolution of agricultural employment in the USSR and later on in the Russian Federation? By collecting data from various sources (Gaidar 2012, Wädekin 1982, Lerman et al. 2003, Trading Economics website) we got the following picture:

[15]In this respect one should not forget that, as in Taiwan, the Japanese occupation had resulted in a substantial industrialization not only in the north of Korea but also in the south; more evidence can be found in Roehner (2015).

Table 4 Russia: Employment in agriculture in percentage of total labor force

1930	1960	1978	1985	1990	2000	2010	2014
87%	39%	21%	15%	14%	15%	9%	7%

The table shows that the interruption of the fall of the share of agricultural employment coincided with the crisis of 1988-2000. So, once again, we see that this variable is a good indicator of long-term economic growth. We see also that the time interval 1930-1960 saw a massive reduction in agricultural employment and we know that it was accompanied by rapid economic development.

Rural flight seen as a good indicator of productivity growth

In the first part of the paper it was shown that a wage transition occurred in most developed countries in the 1980s. After decades of rapid growth, wages started to slump. Rural flight appeared as a good candidate for explaining not only this wage transition but also the rapid growth observed in China in past decades. Incidentally, one should not think that there was no or little growth before 1983. According to Chinese GDP statistics, the real average annual GDP growth rate was 9.8% from 1952 to 1982 and 9.9% from 1983 to 2014. Even though national accounting methods may have been different before 1983, the idea of a stagnant economy before 1983 seems inappropriate. Actually, the most conspicuous difference between the two periods is that in the first one growth was much more irregular than in the second. The coefficients of variation of the annual growth rates were 194% and 27% respectively.

In order to test the idea of a connection between rural flight and economic growth we set up a model which allowed us to predict the change of income resulting from rural flight. It was seen that this model is in good qualitative agreement with observation. As expected, rural flight accounts for only a fraction of total growth but it is also a good indicator of the dynamism of sector 2. If tomorrow the Chinese economic growth starts to create a lot of "second class jobs" (for instance by an over-extension of the healthcare sector) then, those young people who presently still remain in Chinese villages (see Appendix C) will certainly think about it twice before moving to cities. This, in turn, will make economic growth more sluggish. So, the main issue is whether in the coming decades China will be able to avoid the "odd job trap".

Wage progression and labor inflow

It may seem surprising that in this paper we did not consider the question of immigration. As for any other good, the cost of labor is affected by supply and demand changes. Supply is controlled by labor force expansion either endogenously

or exogenously (i.e. through immigration) whereas demand is conditioned by GDP growth. This question would deserve a separate study but here we will limit ourselves to a few observations.

- Due to the sheer size of the Chinese population foreign immigration will have little incidence in China. The only country whose population could match the population of China is India. However, whereas there are important Indian communities in the UK and US, immigrants to China would have to learn Chinese, quite a formidable challenge for them.
- The case of Japan suggests that at the level of a whole country (as opposed to a specific sector) labor inflow through immigration is rather a second-order effect. Indeed, despite a much lower immigration rate Japanese wages leveled off in the same way as in European countries (see Fig. 3).
- In contrast, at sectorial level, immigration may play a role. In this respect, as a case study, it would be interesting to investigate the impact on labor cost of the inflow of Filipino nurses into the US[16].

Acknowledgments We wish to express our gratitude to Ms. Corina Neuerer of the "Statistisches Bundesamt" (German Federal Statistical Office) and to Ms. Alyson Williams of the British "Office of National Statistics" for helping us to locate and retrieve some of the statistical series used in this paper.

Appendix A. Metrics for measuring income

Income can be measured by various indicators and as the findings reported in this paper are, at least to some extent, indicator-dependent it is important to keep in mind the differences between them. They are summarized in the table below.
For a better understanding of the difference between GDP/capita and wages it is useful to remember that the GDP has basically 3 components: (i) compensation of employees, (ii) operating surplus (i.e. mainly profits) and (iii) consumption of fixed capital (i.e. depreciation of equipment). Altogether these components usually account for 90% of the GDP; the first component is of the order of 50% and in most countries it has been decreasing over past decades.

As an illustration of the difference between median and average income, one can mention that in Singapore in 2014 the average monthly household income was $9,176$ Singapore dollars, whereas the median was only 6,500, i.e. some 30% less. In addition, it should be noted that most income statistics published by the Singapore statistics office include the "employer CPF contribution". The acronym CPF means

[16] Their immigration is facilitated by the fact that their curriculum integrates the requirements and specifications of the US healthcare industry which includes practising the English language.

Table A1 Different metrics for measuring personal income

	Indicator	*Comment*
1	GDP/capita	*Apart from income in the form of salary, the GDP also involves capital gains, such as dividends or profits. In recent decades this part of national income has been growing. Today in the US non-salary income represents around 50%*
2	GDP/employee	*Corrects the fact that GDP/capita increases when housewives take up a full time job.*
3	Average earnings	*In contrast with the median, the average is highly sensitive to top earnings*
4	Median earnings	
5	Average wage of workers in manufacturing	*The terms "worker" or "manual worker" usually mean non-managerial employee; compared to services, manufacturing provides better protection to workers particularly because of remaining unionization.*
6	Average wage of all workers	*Includes (non-managerial) service employees.*

Notes: Broadly speaking these different incomes decrease from top to bottom. Average earning is similar to the macroeconomic variable called "personal income" (i.e. basically GDP minus capital depreciation minus corporate profit divided by employment). At the bottom of the table an additional distinction may be appropriate between hourly, weekly and monthly wages especially in case of large changes in weekly hours worked.

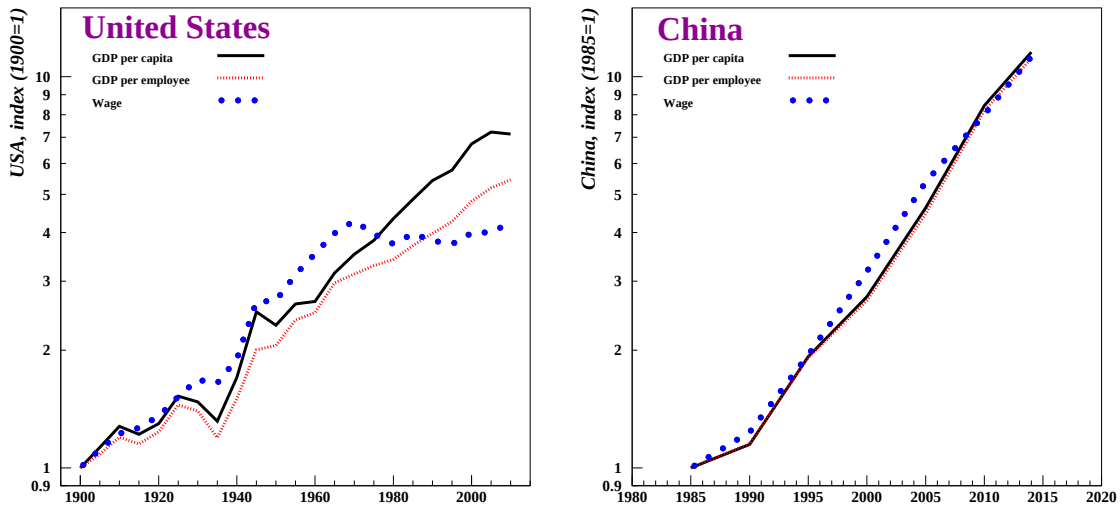

Fig. A1 Comparison of different metrics measuring income for the United States and China. All incomes are expressed in national currency and adjusted for inflation. The two countries are not at the same stage in terms of overseas investment and financialization of the economy; therefore, the fact that so far in China there has been no divergence between GDP/capita and wage level does not mean that it will be the same in the future. *Sources: USA: Historical Statistics of the United States (p.224), Saint Louis Federal Reserve website, Liesner (p.98-99), TradingEconomics website; China: http://www.chinability.com/GDP.htm, TradingEconomics website.*

"Central Provident Fund" and it designates a social security fund destined to cover the retirement, healthcare, and housing needs of the employees. Currently, it represents about 11% of the wages. A similar system exists in many countries. It can be

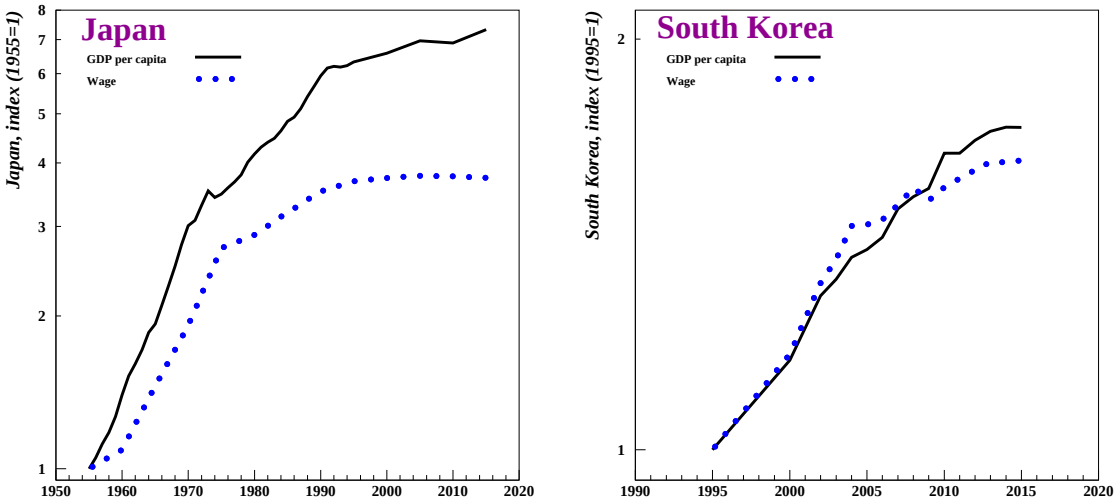

Fig. A2 Comparison of different metrics measuring income for Japan and South Korea. All incomes are expressed in national currency and adjusted for inflation. The curves of GDP per employed person were omitted because labor force as a percentage of population showed no definite trend. Thus, in South Korea it fluctuated randomly between 58% and 60%. The big gap observed in Japan between GDP per capita and wage came as a surprise. *Sources: Japan: Historical Statistics of Japan (website), Trading Economics website (GDP at constant prices in billion of yen); South Korea: Korean Statistical Information Service (KOSIS), statinfo.biz. It would be useful to find wage data series starting before 1995.*

noted that as health care expenses are much higher for elderly employees it means that they benefit more from CPF transfers than younger employees.

Appendix B. Data sources

As for any comparative research, one of the main challenges of this work was to find statistical data pertaining to different countries but recorded in such a way as to allow meaningful comparisons. Fortunately the Internet provides access to the websites of the statistical offices of many countries and of international organizations such as the Work Bank or the OECD. However, data comparability often remains a tricky issue.

Basically, for our study we needed data for the following variables.

- Average wages.
- Price consumer index (CPI) in order to deflate the nominal wage data into a series of real wages.
- Distribution of employment by industry.

Comparisons are hampered by several difficulties.

(1) Depending upon the country, the average wage may be defined in different ways: hourly wages (US), weekly wages (England and Germany), annual wages (China). In order to convert hourly wages into annual wages one must know the average weekly working hours.

(2) Much more problematic is the question of who are the recipients of the corresponding wages. The problem can be illustrated by the case of Germany for which one has fairly detailed information. The "Federal Statistical Office" publishes four quarterly series of wages. (i) The first gives weekly nominal hourly wages paid to manual workers in manufacturing. (ii) The second gives real wages paid to the same workers. (iii) The third gives real hourly wages paid to all employees. (iv) The fourth gives real monthly wages paid to all employees. Between 1991 and 2011, the first increased by 74%, the second by 22%, the third by 11%, and the fourth by 1% (International Labour Organization 2014, p. 47). Even, within the same series there can be changes in the course of time. Thus, the first series cited above referred to manual workers between 1980 and 2006 but to skilled workers after 2007.

Such observations lead to the conclusion that one should not expect an accuracy better than $\pm 10\%$ and that one should adopt a statistical methodology in line with this level of uncertainty. For the investigation of broad long-term trends as conducted in this paper the poor comparability of the data is not a major obstacle.

Appendix C. Workforce reserve in rural China

Defining the question

The mechanism on which this paper is based consists in transfer of population from rural to urban areas. It was observed that in industrialized countries productivity was boosted through this transfer and that this effect was significant as long as the rural population represented a sizable proportion of total population, basically over 5%. This argument assumes implicitly that the rural population comprises persons who can take up a job in the manufacturing or service sector once they have moved to cities. There are two situations in which such an assumption does not hold.

(a) The first case is when the rural population comprises only elderly persons beyond retirement age (Fig. C1b). This situation would occur when all middle-aged persons have moved to cities together with their children. In this case there would be no productivity reserve whatsoever in spite of a rural population which may be well over the 5% threshold.

(b) The second case is when the rural population comprises only grand parents and their grand children (Fig. C1a). This situation would occur when all middle-aged persons have moved to cities but have left their children behind them in their villages[17]. In this case, there is no short-term productivity reserve but over a period of one decade the young segment of the rural population will contribute to productivity

[17] In societies in which house wives are not supposed to take up a job, one could assume that they remained in their villages with their children. In this case there would be no productivity reserve despite a substantial rural population.

progress.

In former rural flights (described in Fig. 6 for industrialized countries) the situations (a) and (b) occurred only marginally and, as a result, productivity progress was not substantially slowed down. Why should the picture be different in China?

One obvious reason can be mentioned which is the pace of the rural flight in China. The very same evolution that took one century and a half in western countries is taking place in China in less than 50 years. So, in order to make sure that the rural flight mechanism will have the effect that we expect we must consider more closely the changes in the composition of the rural population. We will do that in two steps: first we give a fairly qualitative picture, then in a second step we show two graphs which illustrate age-specific composition changes.

Qualitative picture

This subsection is based on a paper in Chinese by Zong and Xiang (2013). As this paper provides many interesting tables and graphs one may wonder why we use it here to give a *qualitative* picture. It is because the paper is not based on census data but rather on a survey of their neighbors carried out by Chinese graduate students when returning to their home place during their term break[18]. As a result, the data are based on fairly small samples of one or two thousands. However, they provide a much more detailed view than could be obtained from census data. The following points are of particular interest.

- Instead of a simplistic binary picture the paper considers several cases: persons who moved away and are no longer registered in the village (A); persons who are still registered but are present in the village during less than 3 months per year (B_1); this category would correspond to students or young people who return to their village a few times every year. Three similar categories (B_2, B_3, B_4) correspond to persons who stay in the village more than 3 months but less than 6 months, more than 6 months but less than 10 months, and more than 10 months. Around 2010 the percentage distribution was as follows:

$$A:\ 29\%, \quad B_1:\ 18\%, \quad B_2:\ 3.2\%, \quad B_3:\ 2.7\%, \quad B_4:\ 47\%$$

Not surprisingly, the age group which had the smallest proportion of $B_3 + B_4$ was $20 - 24$; however, even in this age group the $B_3 + B_4$ represented about 30% of the whole $B_1, \ldots B_4$ group.

- If one considers children under 15, about 50% lived with their two parents, 22% lived only with their mother, and 25% lived with their grandparents[19].

[18] At the geographical level it is limited to 5 provinces of central China, namely: Anhui, Henan, Hunan, Jiangsu and Sichuan. All results given below are averages over these provinces.

[19] A negligible proportion of 1.7% lived only with their father.

Quantitative picture

The age distributions shown in Fig. C1a,b are based on the censuses of 1982, 2000 and 2010. They confirm the picture suggested by the previous subsection in the sense that the demographic situation in rural areas is still fairly remote from the idealized cases represented by the dotted curves.

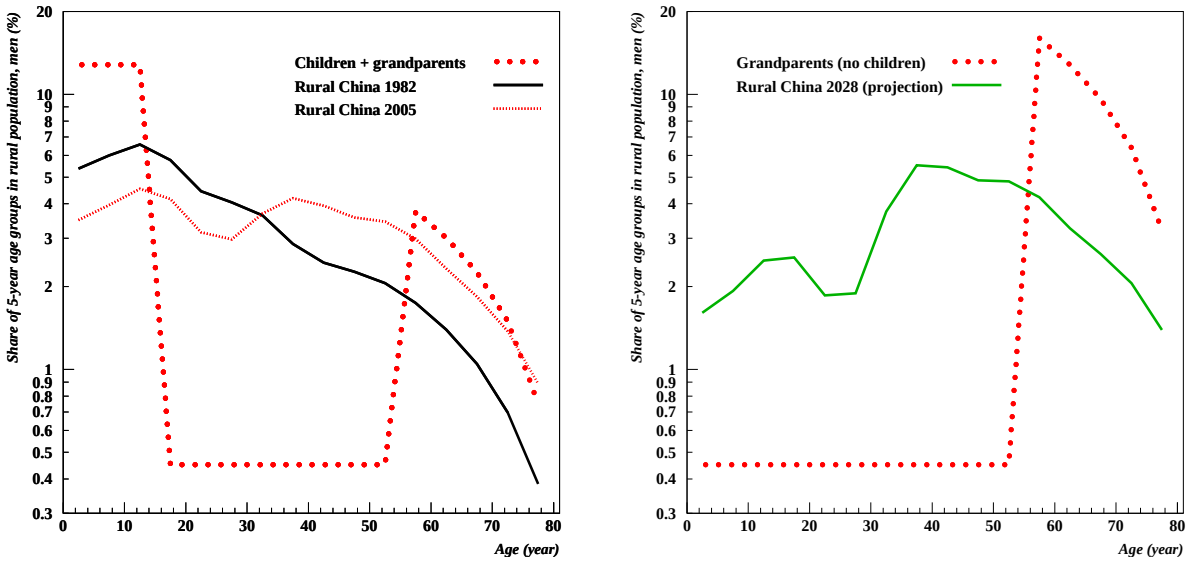

Fig. C1a,b Age distribution in rural China. The graphs compare two idealized situations (dotted curves) with the actual age distributions. The expression "grandparents" designates persons over the age of 55 that is to say persons who can no longer be counted in the manpower reserve susceptible of moving to cities. The curve for 2028 is a linear projection based on the data of 1982 and 2005. It can be seen that although closer to the "grandparents only" picture, it is still fairly remote from it. Note that because of the y log scale the flat parts of the dotted curves that should be at zero percent had to be set to a low but non-zero percentage. *Sources: Kasperkevic (2012), Zhong (2013), Yiliminuer (2015).*

Can we make comparisons with other countries? In the United States around 1930 the rural population represented 44% of the whole population. In the rural population the share of the group under 15 was 35%. For China around 2010 the corresponding figures were 55% and 13%. The first number confirms what we already emphasized namely that rural flight is only at its beginning in China. Comparing the shares of the age-groups under 15 makes little sense because it simply shows that in the US the birth rate and immigration rate were much higher than presently in China.

In conclusion, we can say that there is still a substantial manpower reserve in rural areas that will become available for moving to cities as soon as higher agricultural productivity will make that possible.

Appendix D. From personal to social productivity

At the end of the paper it was observed that progress in productivity comes mainly

from what we called a synergetic effect. In the present section we try to explain this effect in more detail, at least in a qualitative way.

Productivity at individual level

The simplest measure of the productivity of labor is through the ratio of GDP to the total number of hours worked. According to this definition it is fairly clear that the transfer of an agricultural worker to a modern factory will result in his productivity being substantially improved. This was true in the 19th century, when Irish tenants came to work in Birmingham, Liverpool, or Manchester. This same mechanism operates when a Chinese worker moves from his (or her) village to a modern factory in Guangzhou or Shanghai, but in this case the effect is much stronger for indeed the productivity of a 21st century textile factory will be way higher than the productivity of a textile factory of the 19th century.

As demonstrated by Adam Smith's needle factory example, higher productivity can be obtained by decomposing the production process into simple steps that can then be standardized and mechanized. At the other end of the spectrum are tasks which so far have not been subjected to the same process. A classical example given by the French economist Jean Fourastié is the "production" of an haircut. Fourastié observes that the time required for an haircut, namely about 20 minutes, did hardly change over the past two centuries. It is important to observe that the reason of this stagnation is more social than technical. It would certainly be possible to build a machine able to perform a haircut in a few minutes. However, such machines would perhaps not be well accepted by customers, nor would they be welcomed by haircutters. Similarly it would be fairly easy to set up online visits to the doctor, but it can be expected that such a move will not be welcomed by the medical profession because doctors in developed countries would have to compete with doctors from developing countries.

We mentioned the previous examples in order to emphasize that the improvement of productivity is not only a technical challenge but that it has also an important social dimension. This leads us directly to the notion of social productivity.

Social productivity

If we consider productivity not only at the level of a company or an industry but at the level of the whole society the picture changes completely. For the sake of the present discussion we assume that a capital C (say one million euros) is spent in different ways. Let us examine the possible effects on the productivity of the whole country.

- Type -1: Frozen capital, negative effect. In this first operation the capital C is kept at home by its owner and not spent in any way. Thus, C is simply withdrawn

from the money in circulation. This reduction of the money supply will have the usual deflationary effect. From an economic perspective this operation is the most negative way of using (or rather not using) the capital. The same negative effect would be achieved if the capital is sent abroad without any return.

- Type 0: Capital re-injected into the economy but with no positive benefit. The classical example of such an operation is the broken window fallacy introduced by the French economist Frédéric Bastiat in 1850. Bastiat considers a shopkeeper whose careless son happened to break a pane of glass and he describes bystanders who say "Everybody must live, isn't it? What would become of the glaziers if panes of glass were never broken?". Bastiat comments that by paying the glazier the shopkeeper puts the money in circulation, but at the same time he emphasize that had the window not be broken, then this expense could have been affected to an usage of greater social usefulness for the *society as a whole*. This brings us to the case of an expense which has a positive effect on the society.
- Type 1: Capital outlay which has a positive effect on social productivity. Suppose that the owner of a firm spends the capital C on buying several new trucks which will allow easier delivery of the goods produced by the firm. Not only will the capital be re-injected into the economy but throughout the trucks' life-time, it will allow smoother and faster delivery. In short, the production and usage of the trucks will improve the productivity of the firm and of society as a whole. The same observation applies to other investments which will help doing things faster and better. As an illustration at household level, one can mention the fact that the production and usage of washing machines will save much time compared to hand washing. In contrast, using bigger plasma TV screens will have little effect on social productivity; actually it may have a negative effect in the sense that children will spend more time watching TV at the expense of their school work. The same observation may apply to other innovations of present time, e.g. video games or mobile phones.

In a general way, it is certainly true that most devices produced by industry will at the same time enhance the productivity of the society. This is of course true for capital goods such as machine tools or tractors but also for many products bought by the public, e.g. clocks, computers, cars and so on. In these cases, there is a kind of synergy through which the technical and scientific capabilities of a population increase. On the contrary, most services provided by the tertiary sector are of type 0. It is true that many of them (e.g. healthcare) cannot be avoided and that others such as cultural services are enjoyable, but this does not remedy their weak (or sometimes negative) contribution to global productivity.

An additional word is in order regarding the computer and telecommunication industry. Whereas the production of computers and other telecommunication devices is

naturally included in the manufacturing sector it is not always clear how the software industry is categorized. On account of the fact that software applications are sold along with computers, digital machine tools or mobile phones, it would be logical to include the software industry into the manufacturing sector. The synergy which links together software applications is another reason for including the software industry into the secondary sector rather than into the service sector.

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