HAS THE CAPITAL ACCUMULATION IN THE ASIAN MIRACLE ECONOMIES BEEN FUELLED BY GROWTH? [1]

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Abstract. The Asian growth miracle is often attributed to factor accumulation under the implicit assumption that savings, broadly defined, have been high and increasing due to exogenous forces. Using data for India, Indonesia, Korea, Singapore and Taiwan over the period 1870-2011 this paper examines the causal relationship between growth and saving. The response of growth to savings is first estimated using instruments to generate exogenous variation in savings rates. The residual variation in growth that is *not* driven by savings is then used as an instrument to estimate the effect of growth on savings. The estimates show that the spectacular saving rates in the Asian Miracle Economies have been fuelled by growth, and not the other way around.

JEL classification: E21, E4
Key words: saving, growth, Asian miracle economies, factor accumulation, schooling

1. Introduction

Following the neoclassical revival in the 1990s, capital accumulation has been regarded by some economists as the key driver behind the spectacular productivity growth performance in the Asian Miracle Economies (AME), whereas technological progress has played only a subsidiary role – the so-called Krugman-Young hypothesis (Hsieh and Klenow, 2010; Lee and Hong, 2012; van der Eng, 2010). These findings, which are based on growth accounting exercises, suggest that the miraculous productivity growth (henceforth growth) experienced in the East Asian economies is predominantly driven by transitional dynamics in the neoclassical growth framework. Lu (2012) has extended the growth accounting framework for the East Asian economies and shows that factor accumulation was the driving

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force behind the early growth experience, while TFP growth became the prime mover of growth during the later stages of the economic expansion.[2]

However, several economists have questioned whether factor accumulation can be considered to be an independent force of growth and argue that the high and the increasing savings rates in East Asian economies have, to some extent been an outcome of growth. Modigliani (1986) has stressed that the positive relationship between savings and growth is the most central and important prediction of his life-cycle model. Furthermore, Carroll, Overland, and Weil (2000) show that, under plausible assumptions, savings are positively related to growth under habit persistence, and Deaton (1999) suggests that East Asia's contemporaneously high savings rates have been partly driven up by these countries' high growth rates. Finally, the seminal papers of Lewis (1954) and Kaldor (1957) show that growth drives saving rates up because it increases the share of income of the capitalists who are the savers.

This paper asks whether the factor accumulation in the AMEs can be seen as a consequence of increasing savings rates or whether the savings spurts have been caused by high growth rates, where savings in this exposition are broadly defined as gross financial saving (henceforth saving) following national account systems as well as investment in education (henceforth schooling). Mankiw, Romer, and Weil (1992), among others, argue that education is a critical part of saving and show that the Solow model is consistent with the data when education is included as a part of saving.

The identification strategy, suggested by Blanchard and Perotti (2002) and developed further by Brückner (2013), is used to ensure the parameter estimates are not biased due to endogeneity. In the first step, the response of growth to financial saving is estimated using young age dependency rates, the gender ratio at the ages 10-24, and life expectancy at the age of ten as instruments for gross saving to generate exogenous variation in savings rates. In the second step, after the causal response of real per capita GDP growth to gross saving is quantified by the instrumental variables estimates, the residual variation in growth that is *not* driven by saving is used as an instrument for growth. The advantage of this identification strategy over alternative strategies is that instruments are only required for one of the endogenous variables. In our case we choose to instrument saving since it is difficult to find good instruments for income. Endogenous growth models predict that, in steady state, growth

[2] Several papers have been critical to the capital accumulation hypothesis and argue that too much of the growth has been attributed to capital accumulation in growth accounting exercises, particularly the AMEs (see, for example,Aghion and Howitt, 2007; Ang and Madsen, 2011; Easterly and Levine, 2001; Hsieh and Klenow, 2010; King and Rebelo, 1993; Klenow, 2001; Klenow and Rodriguez-Clare, 1997; Robertson, 2002)

is driven by investment, R&D and human capital – variables that are all highly endogenous, and theory offers little guidance about exogenous factors that drive these variables in the time-domain.

The tests are carried out using data for private saving, public saving, educational attainment and several other variables are compiled for India, Indonesia, Korea, Singapore, and Taiwan over the period 1870-2011. The historical data on savings rates have been constructed from several different national and international sources as detailed in the data appendix. Recent reconstructions of historical national accounts for Korea (Kim, 2012), Singapore (Sugimoto, 2011), Taiwan (Mizoguchi and Umemura 1988) , India (Sivasubramonian, 2000), and Indonesia (van der Eng, 2010) have enabled us to construct data back to 1870 for the AMEs. The shortcoming of using long historical data is that the quality of the data deteriorates as we go back in time; an issue we address by considering different estimation periods.

Despite this shortcoming there are several benefits from using long historical data. First, the parameter estimates are much less subject to finite sample bias than cross-country studies that typically span 20 or 30 years. It is well-known that IV estimates are biased in the same direction as OLS estimates in small samples; particularly if the instruments are weak (Murray, 2006). Furthermore, Davidson and MacKinnon (2006) show that instrument variable parameter estimates can be severely biased in small samples. Second, tests of over-identifying restrictions suffer from size distortions in small samples by failing to reject the null hypothesis too often (Murray, 2006). Third, several cycles in the long savings and income data can be identified in the period 1870-2011, therefore, giving lots of identifying variation in the data.

The AMEs considered here have high growth rates after WWII in common. For India and Indonesia the high growth rates have, particularly, been concentrated in the metropolitan areas. Except for India these economies have further in common that a large fraction of the population is of Chinese ethnicity. Confucian culture has often valued thrift and it has always been taken for granted that parents in these cultures save up for their children's education and house purchases (Liang, 2010). In the context of the present paper it is crucial that the increasing growth enabled the parents to enhance their savings to fulfill their desires to provide for their children's future. In Taiwan "in the 1970s and 1980s, as saving increased along with the higher standard of living, this customary practice imperceptibly evolved into 'buying a house for one's eldest son,' then 'buying a house for each of one's sons,' and ‘buying a house for each of one's children” (Liang, 2010, p. 211). In other words there has been a great urge to enhance savings as the economic opportunities developed.

Although the factor accumulation versus TFP growth controversy has been on-going for two decades, very little work has been done to address the key question of whether the factor accumulation was driven by growth in the first place and the extent to which growth has been caused by saving in the AMEs. In the most extreme cases in which saving is caused entirely by growth, or if saving does not affect growth, the factor accumulation hypothesis loses ground and factor accumulation cannot be seen as an independent force of growth.

The empirical work on saving and growth has been predominantly limited to gross financial saving using a world sample typically spanning two or three decades and endogeneity has not been dealt with adequately (for example, see, Aghion, Comin, and Howitt, 2006; Baumol, Blackman, and Wolfe, 1991; Bosworth, 1993; Carroll and Weil, 1994; Deaton and Paxson, 1994; Edwards, 1995; Loayza, Schmidt-Hebbel, and Servén, 2000; Modigliani and Cao, 2004; Radelet, Sachs, and Lee, 2001). Radelet, Lee, and Sachs (1997) is one of the few studies that has investigated the determinants of savings in Asia. Although some of the aforementioned papers have addressed endogeneity, the exclusion restriction is highly unlikely to hold; particularly because mostly lagged independent variables have been used as instruments. Finally, very little work, if any, has investigated whether growth influences education.

The rest of the paper is organized as follows. Section 2 briefly discusses the theory of saving and growth, section 3 presents the empirical estimates, section 4 provides robustness checks, Section 5 investigates the relationship between investment and growth, and Section 6 concludes the paper.

2. Factor accumulation, saving and growth

Theories of savings give contradictory predictions about the financial saving effect of growth. The theories of Lewis (1954), Kaldor (1957), Modigliani (1970) and Carroll *et al*. (2000), Chen, İmrohoroğlu, and İmrohoroğlu (2006) and Wen (2009) predict that growth affects saving positively, while the permanent income hypothesis (PIH) predicts that growth impinges negatively on saving. For saving in education the model of Bils and Klenow (2000) predicts that growth causes schooling, while several growth models predict that education causes growth (for well-known models, see Lucas, 1988; Mankiw *et al*., 1992; Romer, 1990).

2.1 Financial saving

For the PIH the relation between growth and saving can be seen most easily by considering the 'rainy day equation' by Campbell (1988) in which saving is the discounted value of the expected reduction in earnings:

$$S_t = -\sum_1^{\infty} E_t \frac{\Delta Y_{t+k}}{(1+r)^k}, \quad (1)$$

where S is saving, Y_{t+k} is real income (sum of real earnings and real asset income) in year $t+k$, E is the expectation operator, and r is a fixed real interest rate. The model shows that the relationship between saving and growth is negative if positive growth is expected, and zero if income growth is unanticipated. When income is expected to grow, current income is, on average, below the permanent income; thus establishing a negative relationship between saving and growth.

A problem associated with the PIH is the assumption of an exogenous real interest rate. In a production economy the real rates of return to capital are determined by the marginal products of capital, which in turn will respond to changes in productivity growth; the fundamental source of changes in permanent income. A permanent increase in TFP raises the rate of return to capital, so investment demand will increase, resulting in a higher equilibrium saving rate through a higher real interest rate. Consequently, in contrast to the prediction of the PIH, Chen *et al*. (2006) show, in a general-equilibrium growth model, that household saving may increase rather than decrease in response to a higher permanent income. This mechanism will only be active during the transitional period since capital deepening will drive returns down to their initial level in the steady state.

The life-cycle model predicts a positive relationship between growth and savings (Modigliani, 1986). In periods of positive productivity growth each successive cohort will earn a life-time income higher than the previous cohort and, thus, consume correspondingly higher, because it is assumed that the life-time income is expected to remain constant over the life-cycle for each age cohort. In other words, with positive income growth, the savings of the working population will exceed that of the retirees' dissaving and the aggregate savings will, consequently, be higher than the savings of a stagnant economy. For this mechanism to work one needs to assume that growth expectations are zero; an assumption that is hard to maintain (Carroll *et al.*, 2000); at least to the extent that growth is predictable.

In the model of Carroll *et al*. (2000) a growth spurt will endogenously enhance saving as the utility of consumers depends on past as well as contemporaneous consumption. Based on a non-stochastic perfect foresight *AK* model, Carroll *et al*. (2000) show that the derivative of the gross saving rate with respect to the growth rate of output will be positive in *steady state* if and only if the following condition is satisfied:

$$\sigma < 1 + \frac{\theta}{\delta(1-\gamma)}, \tag{2}$$

where σ is the coefficient of relative risk aversion, δ is the depreciation rate of fixed capital stock, θ is the time-preference, and γ is an index of the importance of habits, $0 \leq \gamma \leq 1$, where $\gamma = 0$ if only the absolute level of consumption matters for utility (CRRA preferences) and $\gamma = 1$ if it is only the consumption relative to habits that is important for utility. From Eq. (2) it can be seen that the inequality is much less likely to be satisfied in the neoclassical model ($\gamma= 0$) than in habit persistence models. Carroll *et al*. (2000) argue that the inequality is likely to be satisfied.

Kaldor (1957) suggests a two-way relationship between growth and saving. The economy is composed of workers (non-savers) and capitalists (savers) and the only way the economy can grow is through capital accumulation, which in turn is driven by capitalists' saving; thus establishing a link from saving to growth. Conversely, growth drives profits and, thus, capitalists' savings. Kaldor's model is quite similar to the model of Lewis (1954). In the model of Lewis (1954) the modern sector develops by utilizing labor from the traditional non-capitalist backward subsistence sector. At an early stage of development, the unlimited supply of labor from the subsistence economy means that the capitalist sector can expand for some time without any need to raise wages. This results in higher returns to capital, which are reinvested in capital accumulation; thus establishing a positive relationship between growth and savings and self-sustained development.

2.2 Saving in education

Since households ultimately have to make a portfolio decision about their saving, including investment in schooling, it follows that growth will impinge on schooling through the same channels as financial saving. Furthermore, Bils and Klenow (2000) show that growth is influential for expected returns to schooling and that growth increases the optimal years of schooling. They derive the following equation for the optimal years of education, E^*:

$$E^* = T - \frac{1}{r-g} ln \left[\frac{\phi}{\phi-\mu(r-g)}\right], \tag{3}$$

where r is a constant interest rate, ϕ is the returns to schooling following the Mincerian approach, μ (μ >0) is the ratio of schooling tuition fees and the opportunity cost of student time, g is productivity growth and T is the number of years that the individual is expected to stay in the labor force. Using some algebra it can be shown that $\frac{\partial E^*}{\partial(r-g)} < 0$, i.e., the number of years of schooling that optimizes life income is positively related to the expected growth rate but is negatively related to the real interest rate. The quantitative effects of growth on schooling are potentially large. With a real interest rate of, say, 3 percent and returns to schooling of 7 percent, Eq. (3) implies that an increase in the expected perpetual growth rate from 1 to 4 percent increases the optimal length of schooling by 3.5 years.

Another reason for expecting a positive relationship between growth and schooling is that growth-induced savings increase investment in education along with investment in other assets. If the real return to education is approximately 7 percent, it compares well with other investments and, unlike financial asset investment, there is no risk of losing the investment through confiscation, inflation or the inability of borrowers to honor their debts. Furthermore, since educated individuals are less affected by unemployment in downturns than their less educated counterparts (Mincer, 1991), it follows that the returns to schooling are countercyclical. Thus, a *negative* risk premium to schooling returns is incurred, noting that risk in the consumption CAPM depends on the covariance between consumption growth and growth in the returns to education. Finally, since Chinese parents have often been dedicated to educating their children (Liang, 2010) it is conceivable that their educational level has been below their desired level because they, at least until recently, are credit constrained. An increase in income will, therefore, increase schooling affordability.

2. Empirical estimates

The following three models are regressed to examine the nexus between savings and growth:

$$s_{it}^{X} = a_0 + a_1 A_{it}^{Y} + a_2 A_{it}^{O} + a_3 r_{it} + a_4 g_{it} + \varepsilon_{1,it}, \quad (4)$$

$$GER_{it}^{J} = b_0 + b_1 e_{it}^{10} + b_2 r_{it} + b_3 g_{it} + \varepsilon_{2,it}, \quad (5)$$

$$g_{it} = c_0 + c_1 s_{it} + c_2 \left(\frac{Pat}{Pop}\right)_{it} + c_3 \Delta h_{it} + c_4 DTF_{i,t-1} + c_5 \left(\frac{Pat}{Pop} DTF\right)_{i,t-1} + \varepsilon_{3,t}, \quad (6)$$

where s^X is ($X = P$, T) private (P) and total (T) saving, measured as nominal gross financial saving divided by nominal GDP; A^Y is the young age dependency (ratio of the population in the 0-14 age group to the working population aged 15 to 64); A^O is the old age dependency (ratio of population in the 65+ age group to the working population aged 15 to 64); r is the real interest rate computed as the nominal interest rate minus the contemporary rate of consumer price inflation; g is the productivity growth rate; GER^J is gross enrolment rates at ($J = P, S, T$) primary (P), secondary (S) and tertiary (T) levels; h is educational attainment of the working age population; (*Pat/Pop*) is research intensity; *Pat* is the number of patent applications by residents; *Pop* is the size of the population; e^{10} is life expectancy at the age of ten; and *DTF* is the distance to frontier; $DTF = (\bar{y} - y)/y$, where y is productivity measured as per capita output in purchasing power parity units; and $\bar{y}$ is per capita output in purchasing power parity units at the frontier (Japan).

Country and time-dummies are included in all regressions. The regressions are undertaken in five-year non-overlapping intervals to allow for dynamic adjustment. Furthermore, five-year estimates appear to be less subject to measurement errors than one-year estimates (Johnson, Larson, Papageorgiou, and Subramanian, 2013) .

We have several comments on the models. Eq. (4) is a standard growth-augmented saving model in which saving is expected to be negatively related to young and old age dependency rates as well as real interest rates. The age dependency-induced saving is allowed to differ between young and old because the literature finds that the saving behavior differs substantially between these two groups. Radelet *et al*. (1997) found old age dependency ratio insignificant in their savings regressions for Asia, and Deaton (1999) argues that families are better insurance against the inability to work than relying on saving. Only recently has the demographic transition in the AMEs rendered it more difficult to rely on children for old age support and it may turn individuals into life-cyclers; however it will still take some time before this effect takes hold. Empirically, there is a great deal of evidence that old people save, or at least do not dissave, as required by the life-cycle model without bequest (Deaton, 1999).

The GER model, Eq. (5), is derived from the Bils and Klenow (2000) model in which schooling depends on growth, life expectancy and the real interest rate. Life expectancy at the age of ten is used as regressor instead of life expectancy at birth because it reflects better the expected returns to schooling at the time at which the would-be students or their parents make their schooling decision. Life expectancy at birth is a poor proxy for age life expectancy at the time at which the schooling decision is made because the increase in life expectancy at birth has, until recently, been dominated by a marked decrease in infant mortality.

Eq. (6) is growth as a function of the saving rate, research intensity, educational attainment, the DTF, and the interaction between the DTF and research intensity. The model encompasses the predictions of the education-extended Solow growth model, in which growth is a function of the savings rate and the change in education as a proxy for the rate of saving in the form of education, and recent endogenous growth models in which productivity advances are driven by technological progress, which is in turn driven by innovations (See, for derivation,Madsen, 2008).

The domestic innovative activity is assumed to influence productivity growth through research intensity following the Schumpeterian growth models of Aghion and Howitt (1998), Dinopoulos and Thompson (1998), Peretto (1998), Howitt (1999), Peretto and Smulders (2002), and Dinopoulos and Waldo (2005). These Schumpeterian models assume that the effectiveness of R&D dilutes due to the proliferation of products as the economy expands; thus, growth is driven by research intensity in the Schumpeterian models. Patents are divided by population to allow for product proliferation. In the steady state the number of product lines is proportional to the size of the population. To ensure sustained growth the number of patents has to increase over time to counteract the increasing range and complexity of products that lower the productivity effects of R&D activity.

DTF and its interaction with research intensity follow the prediction of the Schumpeterian growth models of Howitt (2000) and Aghion and Howitt (2006). In these models a country at the technology frontier makes incremental improvements to existing leading edge technology, while countries behind the technology frontier implement technologies that have been developed elsewhere. Furthermore, Howitt (2000) shows that increasing research intensity enhances the capacity to absorb the technology developed at the frontier. Investment in R&D is required for a country to understand the technologies that are developed at the frontier. Japan is chosen as the frontier country because it has been the regional leader in the period 1870-2011. The strong trade links, geographic proximity and cultural links to Japan renders Japan a better technological leader for these countries than the traditional frontier countries such as the UK and the US. Furthermore, Taiwan and Korea were colonies of Japan in the periods 1895-1945 and 1910-1945, respectively.

Finally, there is no direct link between the schooling (GER) regression and educational attainment in the growth equation. Growth does not directly depend on GERs because the enrolled students are not in the labor force. Instead growth depends on the educational attainment of the working age population. As shown below, educational attainment is generated by combining past GERs, age dependent life expectancies, distribution of population on ages, and the time at which an age cohort exits the labor market at the age of 65.

2.1 Identification strategy

Identification is a major issue here since the causality may go in either direction. The identification strategy used here is to instrument savings in the productivity growth equation in the first step and then use growth net of savings-induced growth as an instrument for growth in the savings model, following Blanchard and Perotti (2002) and Brückner (2013) . This method can be shown more formally as follows.

To simplify the exposition consider the following bivariate relationship between growth and savings and where country and time sub-scripts are omitted:

$$s = \alpha g + u,$$
$$g = \beta s + e,$$

where *u* and *e* are stochastic error-terms. Clearly, the coefficients of *g* and *s* are biased because $cov(g,u) \neq 0$ and $cov(s,e) \neq 0$. To overcome the endogeneity problem, savings, *s*, is regressed on its instruments, *Z*:

$$s = \gamma Z + w,$$

where *w* is a stochastic error term and $cov(Z,w) = 0$. Using the predicted value of savings, $\hat{s}$, yields $g*$, which is the growth rate purged of the influence of savings:

$$g^* = g - \widehat{\beta}\hat{s}.$$

Since g* is purged of the endogenous component it yields consistent estimates in OLS regressions.

To see that this method eliminates the simultaneity bias, consider first the probably limit of the OLS estimator:

$$Plim\ \alpha^{OLS} = \alpha + \frac{\beta}{1-\alpha\beta}\frac{var(u)}{var(g)} + \frac{1}{1-\alpha\beta}\frac{cov(u,e)}{var(g)}, \quad (7)$$

where the second term on the right-hand-side is the simultaneity bias and the third term is the omitted variable bias.

The probably limit of the IV estimator is:

$$Plim\, \alpha^{IV} = \alpha + \frac{1}{1-\alpha\beta}\frac{cov(u,e)}{cov(e,g)}. \tag{8}$$

Comparing Eqs. (7) and (8) indicates that the IV strategy used here eliminates the simultaneity bias.

Although, the two-step identification strategy overcomes the simultaneity bias, the efficiency of this method rests on the ability to find instruments that can explain a large fraction of the variance in saving. We may be able to find instruments that are statistically significant determinants of growth; however, if they only explain a fraction of the variance in saving we get that $g*$ and g are highly correlated and unless this high correlation reflects that growth is little affected by saving, the two-step identification procedure may not represent advances over previous identification strategies.

3.1.1 Instruments

As mentioned above, life expectancy at the age of ten, the gender ratio and young age dependency are used as instruments for saving. Instruments are not used for educational attainment since educational attainment is determined by the decision to enroll in education up to 58 years earlier. Old age dependency rate is excluded from the instrument set because of the reasons given above and because it was insignificant in initial regressions.

Life expectancy at the age of ten, e^{10}, is likely to be a good instrument for saving following from the predictions of the life-cycle hypothesis that people save more the longer they expect to live after retirement. Bloom, Canning, and Graham (2003) add health and longevity to a standard model of life-cycle saving and show that a rise in life expectancy increases the optimal length of life spent working, but not by enough to offset the increased need for retirement income. Therefore, savings rates rise at every age as longevity rises in order to meet the increased need for assets to finance consumption during retirement. In the regressions we have chosen life expectancy at the age of ten as opposed to the life expectancy at birth because the latter is highly influenced by infant mortality, as discussed above, and because infant mortality may be affected negatively by contemporary growth. Life expectancy at the age of ten, however, is not affected by contemporaneous growth but is determined by inflammation and oxygenation throughout life (Finch, 2010).

The gender ratio, (M/F), measured as the ratio of males and females aged between 10 and 24, is used as an instrument for saving because it is potentially important for the savings behavior and, at the same time, is likely to be exogenous. The significant historical variations in the M/F rate ensure large identifying variations in the data. Data are used for the 10-24 year age group because it includes the age at which the males start competing in the marriage market. The gender ratio has, traditionally, been highly skewed in favor of boys in South Asia, Southeast and East Asia in the period considered in this paper and the strong male-bias has been achieved through infanticide, abortions, and negligence of baby girls when they are sick.

Male-bias sex ratios are likely to reduce saving for four reasons. First, the AMEs, at least until recently, have relied on their boys for old age support, which implies that a high male gender-ratio will reduce precautionary saving. Furthermore, groom prices such as dowries in which the bride's parents pay a sum to the groom's parents for the gift exchange, has been widely practiced in India. An increasing male-biased sex-ratio will, consequently, lower saving. Second, a male-biased sex ratio increases men's competition for mates. In order to improve their attractiveness men will advertise their financial resources through conspicuous spending of items such as upmarket cars, expensive houses, and fancy clothes (Griskevicius *et al*., 2012). The thesis that consumption is used to show status was already put forward in the late 19th century by Veblen (1899) who argued that each social class tries to emulate the consumption behavior of the class above it, to such an extent that even the poorest people are pressured to engage in conspicuous consumption. Thus, to gain a competitive edge in the marriage market, males will acquire new consumption goods to distinguish themselves from other males.

Third, evolutionary biology in animal behavior finds that an abundance of rivals will lead men to value immediate rewards because there is a trade-off between acquiring immediate resources and waiting in hopes of acquiring more or better quality resources in the future (Griskevicius, Delton, Robertson, and Tybur, 2011). Evolutionary perspective highlights an important drawback of delaying rewards: If a man forgoes picking the fruit immediately, there is no guarantee that any fruit will be left in the future or that he will be around to collect them even if there are remaining fruit. Furthermore, increased competition for limited resources, such as when there is an abundance of rivals, decreases the likelihood that any fruit will remain accessible in the future.[3] Fourth, examining the financial behavior of males and females in the US Griskevicius *et al*. (2012) find that male-biased sex ratios are significantly associated with having more credit cards and higher debt.

[3] The potential effects of unbalanced sex ratios are likely to be more prominent in males than females. Male-biased sex ratios are likely to increase intrasexual competition of males because they are at an increased risk of failing to attract a mate when there is a scarcity of females (Kvarnemo and Forsgren, 2000)

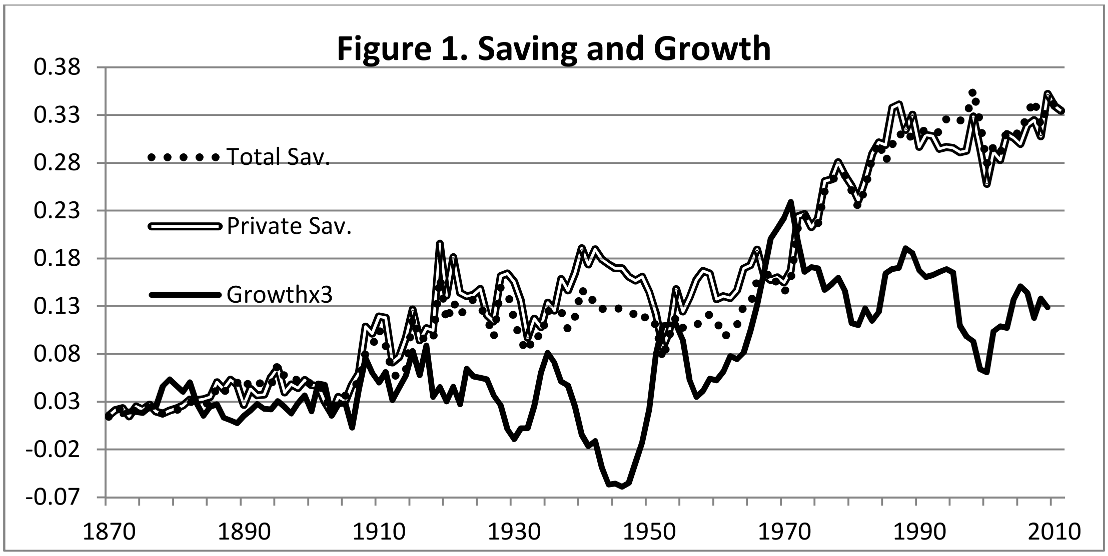
3.3 Data

Financial saving is measured as private, s^P as well as total saving, s^T. Private saving is measured as total saving minus public saving, where public saving is the surplus on the government's primary balance net of interest payments on government debt. Theory gives conflicting guidelines whether to use total or private saving in the individual's saving function. According to the Barro-Ricardo equivalence theorem total saving is the relevant saving variable in the saving function since government debt belongs to the individual consumer. If, on the other hand, consumers do not internalize government deficits, it follows that private saving is the essential variable in the saving function. In the basic IS-LM model, for example, there are no counterbalancing private savings effects from discretionary fiscal policies and, therefore, it is private saving that is the essential variable in this model.

The saving data are constructed using one of two methods for each individual country depending on data availability. The first method estimates total nominal savings as total nominal fixed investment plus the current account on the balance of payments. The second method computes total nominal savings as the nominal GDP minus nominal government and private consumption. Private savings are then total savings minus the surplus on the government budget including interests on government debt. Educational attainment is estimated by combining GER's and the age distribution of the population following the method suggested by Madsen (2010). Total educational attainment is computed as the sum of primary, secondary and tertiary educational attainment.

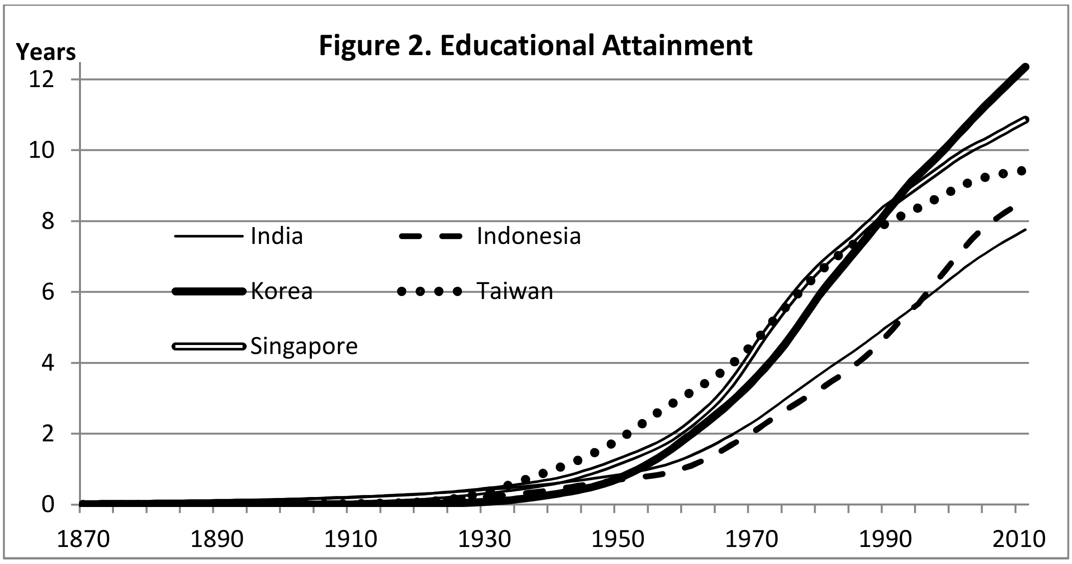
Growth is measured either as per capita income growth, g^P, or per labor hour income growth, g^H, where labor hours is annual hours worked multiplied by employment in full-time equivalents. The importance of basing growth on labor hours is that the exclusion restriction for savings only holds when labor productivity growth is used as regressor because the young age dependency rate is negatively related to per capita income, while labor productivity is unaffected. Furthermore, labor productivity is a more accurate measure of productivity than per capita output in growth models since annual hours worked and labor force participation rates have changed substantially over time for the countries considered here. The downside of using GDP per hour worked is that employment data are mostly based on census data prior to WWII and, therefore, had to be interpolated between the census periods (usually every ten year). This problem is alleviated by our five-year interval estimates.

Figure 1 traces private and total savings rates and growth rates (multiplied by three) for the AMEs over the period 1870-2011. Private and the total saving rates almost coincide prior to 1920 and after 1970; however, private saving was, on average, higher than total savings in the interim period, 1920-1970, indicating that governments were running government deficits. The private saving rate gradually increased up to WWII, increased markedly during WWII, increased significantly up to the Asian Crisis in 1998 and has since stabilized at around 30%. Growth rates fluctuated around one percent up to 1906, notched up to approximately 1.5% in period 1906-1926 before entering the downturns during the Great Depression and WWII. From 1965 up until today the growth rates have fluctuated around five percent.



Notes. The data are unweighted averages of the AMEs. The growth rates are 5-year centered moving averages of per capita income growth rates. The growth rates are in decimal points and are multiplied by three.

The figure indicates a positive relationship between growth and saving. Saving and growth were both at low levels up to around 1906, shift up to a higher level over the period 1906-1928 and rose to high levels in the post-WWII period. The period 1929-1950 is unusual and dominated by the Great Depression and WWII. Savings rates went up during the Great Depression as well as during and immediately after WWII, presumably because of goods rationing, forced saving and uncertainty.



Educational attainment is displayed in Figure 2. The labor force was incredibly uneducated before WWII. In 1900 the average educational attainment of the working population was 0.05 years; figures that are supported by literacy rates in 1900 - the earliest year at which literacy rates are available. Literacy rates of the adult population in 1900 were between 5 and 10 percent in the AME economies while they exceeded 90 percent in North-West and North Europe, the US, Australia, New Zealand and Canada (Barret, 1982). Educational attainment in 1940 was, on average, one year, which was even well below that of the OECD countries in 1870 (Madsen, 2014). Thus, in 1940 there was little indication that the AMEs would later be among the most successful and highly educated economies in the world. The increase in educational attainment in the post WWII period has been spectacular and the educational attainment of Korea and Singapore is almost on par with that of the mature OECD countries today. Remarkably, the timing of the take-off in educational attainment corresponds to the timing of the productivity take-off. In terms of educational attainment and productivity growth, Korea, Singapore, and Taiwan were the first countries to take off while India and Indonesia have lagged behind these countries.

4. Estimation Results

Simple regressions without control variables are first carried out in Sections 4.1 and 4.2, while, to deal with the effects of omitted variables, full growth regressions are presented in Sections 4.3 and 4.4.

4.1 Simple growth regressions

The first-round regressions, in which saving rates are regressed on their instruments, are presented in the lower panel in Table 1. The F-tests for excluded restrictions are between 15 and 12, suggesting that the instruments are sufficiently correlated with savings to serve as potentially good instruments. Furthermore, Sargan's p-values for overidentifying restrictions do not reject the null hypothesis of no correlation between the instruments and the residuals from the structural regressions in any case; thus giving further evidence in favor of the instruments. Finally, the coefficients of the instruments are of the right sign and significant, particularly, in the total savings regressions.

Table 1. Restricted growth Regressions (Eq. (6)).

	Per capita real GDP growth rate (g_{it}^{P})				**Per labor hour real GDP growth rate (g_{it}^{H})**			
	LS (1)	**IV (2)**	**LS (3)**	**IV (4)**	**LS (5)**	**IV (6)**	**LS (7)**	**IV (8)**
s_{it}^{Tot}	0.450*** (0.007)	0.016 (0.962)			0.188 (0.449)	-0.458 (0.378)		
s_{it}^{Priv}			0.338** (0.045)	-0.171 (0.740)			0.259 (0.302)	-0.661 (0.400)
Sargan test p value		0.132		0.156		0.821		0.812
First Stage Regression: Total Saving (s_{it}^{T})					**First Stage Regression: Private Saving (s_{it}^{P})**			
	(1b)				(2b)			
$(M/F)_{it}$	-0.189*** (0.000)				-0.155*** (0.003)			
e_{it}^{10}	0.005*** (0.014)				0.005** (0.047)			
A_{it}^{Y}	-0.352*** (0.000)				-0.168* (0.067)			
First Stage F-stat	15.247				11.746			

Notes. The results are based on 5-year interval data and the number of observations is 145. The numbers in parentheses are p-values. LS = least squares regression, IV = instrument variable regression. The Instrumental Variables (IVs) are male–female ratio in the age group 10-24, (M/F), life expectancy at age 10, e^{10}, and young age dependency ratio for both total and private savings. Asterisks denote significant difference from zero at * 10% significance, ** 5% significance, *** 1% significance. Country and year fixed effects are included in all regressions.

Considering the structural regressions in the upper panel in Table 1, the OLS regressions give mixed results. When growth is based on per capita income, the saving rate has a statistically significant effect on growth as predicted by the standard Solow growth model (columns (1) and (3)) and the coefficients of savings are close to the prediction of ½ in the Solow model when capital's share is set to 1/3 (Mankiw *et al.*, 1992). However, the coefficients of saving become insignificant when growth is based on GDP per hour worked (columns (5) and (7)); showing that the results, crucially, depend on the way productivity is measured and that per capita income may be a misleading measure of productivity. Turning to the IV regressions, the coefficients of savings are all statistically insignificant regardless of whether private or total saving is used as regressor and whether productivity is based on population or hours worked (columns (2), (4), (6), (8)).

These results are highly surprising given that capital accumulation is often stressed as the fundamental factor of growth and capital accumulation has been assumed to be driven by saving under the assumption that investment follows saving (the Feldstein-Horioka puzzle, Feldstein and Horioka, 1980). However, Jiranyakul and Brahmasrene (2009) fail to find evidence for the Feldstein-Horioka puzzle for Southeast Asia, suggesting that capital accumulation may not have been driven entirely by saving because part of the saving flows overseas. Furthermore, a large fraction of investment consists of unproductive investment in property and if a large and changing fraction of saving is channeled into real estate, the relationship between savings and growth may break down.

Characteristic for AMEs is that the current account balances have often been positive in periods of high growth; a result that is consistent with the empirical estimates of Gourinchas and Jeanne (2007) and, which is counter to the predictions of the standard neoclassical growth model (Gourinchas and Jeanne, 2007). In the context of this paper the finding that saving exceeds investment in high growth periods delinks a potentially positive relationship between saving and growth. Thus, the insignificance of saving in the growth regression may not be a puzzle after all. Since investment plays such a large role for growth in standard growth models, the growth-investment nexus is investigated further below to ensure that the results in Table 1 do not reflect measurement errors.

4.2 Simple saving regressions

The results of estimating the saving model are presented in Table 2. Growth is a statistically significant and positive determinant of saving in the least squares estimates when growth is based on per capita income but insignificant when growth is based on GDP per hour worked. However, growth is consistently highly significant and positive in the IV regressions regardless of how growth and saving are measured, underscoring the importance of using instruments in the regresions. The economic significance of the growth rates is also very high. Using the average coefficient of growth of 0.l5 (per capita income) and 0.10 (per hour worked GDP) from the IV regresions, a one percentage point increase in the growth rate is associated with an increase in the savings rate by 0.15 and 0.10; thus, indicating that the savings rates experienced by the AMEs today are, to a large extent, explained by the high growth rates.

Table 2. Restricted saving regressions (Eq. (4)).

	Dependent variable: Total Saving (s_{it}^{T})				**Dependent variable: Private Saving (s_{it}^{P})**			
	LS (1)	**IV (2)**	**LS (3)**	**IV (4)**	**LS (5)**	**IV (6)**	**LS (7)**	**IV (8)**
g_{it}^{P}	0.147*** (0.002)	0.143*** (0.002)			0.116** (0.024)	0.161*** (0.002)		
g_{it}^{H}			0.044 (0.168)	0.093*** (0.005)			0.048 (0.159)	0.129*** (0.001)
$(M/F)_{it}$	-0.206*** (0.000)	-0.206*** (0.000)	-0.195*** (0.000)	-0.201*** (0.000)	-0.168*** (0.001)	-0.173*** (0.001)	-0.161*** (0.002)	-0.171*** (0.001)
e_{it}^{10}	0.005*** (0.014)	0.005*** (0.014)	0.005*** (0.013)	0.005*** (0.015)	0.004** (0.051)	0.004** (0.056)	0.005** (0.046)	0.005** (0.052)
A_{it}^{Y}	-0.321*** (0.000)	-0.322*** (0.000)	-0.357*** (0.000)	-0.362*** (0.000)	-0.143 (0.114)	-0.133 (0.142)	-0.172* (0.059)	-0.180** (0.054)

Notes: see notes to Table 1.

Finally, the coefficients of the gender ratio, life expectancy at the age of 10 and young age dependency are all of the right sign and mostly significant; particularly the coefficients of the gender ratio, which are highly significant. As life expectancy at the age of 10 has increased and the young age dependency ratio has decreased since 1960 or earlier, these variables have contributed to increasing saving along with growth. The gender ratio has also mostly contributed to the increase in saving; however its path has differed somewhat across countries.

4.3 Unrestricted growth regressions

Control variables are included in the growth regressions in Table 3. The coefficients of saving are insignificant except for the OLS regressions for total saving and where growth is based on per capita GDP. The coefficients of human capital are consistently significant and of the right sign. The approximately 10 year increase in educational attainment for the average AME in the post-WWII period has resulted in a 253 percent increase in GDP per hour worked and 170 per cent increase in per capita income. Thus, improved education has been an important force behind the productively increase in the AMEs.

Table 3. Unrestricted growth regressions (Eq. (6)).

	Per Capita Real GDP Growth Rate (g_{it}^{p})					**Per Labor hour Real GDP Growth Rate (g_{it}^{h})**				
	LS (1)	**IV (2)**	**LS (3)**	**IV (4)**	**LS (5)**	**LS (6)**	**IV (7)**	**LS (8)**	**IV (9)**	**LS (10)**
s_{it}^{T}	0.389** (0.031)	-0.200 (0.613)				0.223 (0.426)	-0.291 (0.627)			
s_{it}^{P}			0.283* (0.092)	-0.348 (0.485)				0.284 (0.273)	-0.272 (0.713)	
$\left(\frac{invst}{gdp}\right)_{it}$					0.926*** (0.004)					-0.052 (0.919)
$\left(\frac{Pat}{Pop}\right)_{it}$	-0.063 (0.126)	-0.095** (0.023)	-0.072* (0.076)	-0.098** (0.019)	-0.078** (0.044)	-0.003 (0.951)	-0.032 (0.610)	-0.004 (0.946)	-0.027 (0.658)	-0.016 (0.792)
Δh_{it}	0.165** (0.021)	0.179*** (0.005)	0.176** (0.014)	0.172*** (0.008)	0.079 (0.295)	0.250** (0.025)	0.263*** (0.007)	0.257** (0.020)	0.254*** (0.008)	0.261** (0.034)

$DTF_{i,t-1}$	0.0006 (0.925)	-0.007 (0.332)	-0.003 (0.654)	-0.007 (0.278)	-0.001 (0.874)	0.012 (0.226)	0.005 (0.643)	0.011 (0.241)	0.008 (0.436)	0.009 (0.347)
$\left(\frac{Pat}{Pop}DTF\right)_{i,t-1}$	0.251*** (0.005)	0.238*** (0.003)	0.241*** (0.008)	0.244*** (0.003)	0.212** (0.017)	0.237* (0.089)	0.226* (0.062)	0.231* (0.096)	0.234* (0.053)	0.234* (0.096)
Sargan test *p* value		0.445		0.522			0.584		0.557	

Note. See notes to Table 1.

The coefficients of the interaction between research intensity and the *DTF* are significant and positive; however, individually the coefficients of the *DTF* and research intensity are not growth stimulating. Thus, innovations have been growth enhancing because they have enabled the AMEs to adapt and imitate the technology that has been developed at the frontier (Japan). The insignificance of the coefficients of *DTF* suggests that formal and informal R&D have to be undertaken in order to adapt the technology developed at the frontier – being backward is not a sufficient condition for growth.

4.4 Unrestricted savings regressions

The savings regressions in Table 4 extend the regressions in Table 2 with old age dependency, the real interest rate and urbanization as additional regressors. In line with other empirical literature, the real interest rate as well as the old age dependency ratio are insignificant except in one case. In terms of statistical significance, the inclusion of control variables has not changed the basic regression results in Table 2. Per capita income growth is a positive and significant determinant of saving in all regressions, while per hour worked income growth is only a significant determinant of saving in the IV regressions.

Table 4. Unrestricted saving regressions (Eq. (4)).

	Dependent variable: Total saving (s_{it}^T)				Dependent variable: Private saving (s_{it}^P)			
	LS (1)	IV (2)	LS (3)	IV (4)	LS (5)	IV (6)	LS (7)	IV (8)
g_{it}^P	0.162*** (0.001)	0.158*** (0.000)			0.133** (0.011)	0.180*** (0.000)		
g_{it}^H			0.0466 (0.152)	0.0960*** (0.001)			0.0528 (0.129)	0.134*** (0.000)
$(M/F)_{it}$	-0.190*** (0.000)	-0.189*** (0.000)	-0.184*** (0.000)	-0.188*** (0.000)	-0.151*** (0.004)	-0.154*** (0.000)	-0.147*** (0.005)	-0.155*** (0.001)
e_{it}^{10}	0.005** (0.013)	0.005*** (0.003)	0.005** (0.015)	0.006*** (0.004)	0.004** (0.040)	0.005** (0.016)	0.005** (0.039)	0.005** (0.016)
A_{it}^Y	-0.277*** (0.002)	-0.278*** (0.000)	-0.332*** (0.000)	-0.333*** (0.000)	-0.0973 (0.310)	-0.0814 (0.320)	-0.143 (0.137)	-0.145* (0.084)
A_{it}^O	0.909 (0.146)	0.897* (0.091)	0.529 (0.407)	0.634 (0.249)	1.000 (0.146)	1.139* (0.052)	0.718 (0.295)	0.889 (0.137)
r_{it}	0.008 (0.836)	0.008 (0.805)	0.010 (0.802)	0.007 (0.852)	-0.012 (0.778)	-0.014 (0.708)	-0.012 (0.794)	-0.018 (0.649)

Note. See notes to Table 1.

4.5 Schooling and growth

The GERs regressions (Eq. (5)) are presented in Table 5. Three sets of estimates are presented: Estimates with and without time-dummies over the period 1870-2011, and estimates including time-dummies in the post-WWII period (1950-2011). Separate regressions are carried out in the post-WWII period because school enrollment rates were negligible before WWII. Country fixed effect dummies are included in all regressions. As noted above, growth is not instrumented because there is no feedback effect from GERs to growth. Changes in educational attainment - the ultimate growth outcome of schooling - are determined by changes in historical GERs, age-dependent survival rates and relative sizes of GERs between age cohorts; factors that are quite independent of economic growth.

Table 5. GER regressions 1870-2011 (Eq. (5)).

	Total GER		**Primary GER**		**Secondary GER**		**Tertiary GER**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
g_{it}^{P}	0.445*** (0.004)	0.208 (0.257)	0.255** (0.017)	0.120 (0.262)	0.286*** (0.000)	0.169*** (0.005)	-0.097 (0.228)	-0.082 (0.407)
e_{it}^{10}	0.068*** (0.000)	0.019** (0.015)	0.035*** (0.000)	0.013*** (0.005)	0.021*** (0.000)	0.0003 (0.904)	0.012*** (0.000)	0.006 (0.170)
r_{it}	0.156 (0.250)	0.287* (0.074)	-0.084 (0.374)	0.080 (0.389)	0.115** (0.050)	0.090* (0.079)	0.126* (0.080)	0.116 (0.178)
Observations	145	145	145	145	145	145	145	145
R^2	0.906	0.940	0.848	0.931	0.849	0.945	0.483	0.652
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes. The numbers in parentheses are *p*-values. Asterisks denote significant difference from zero at * 10% significance, ** 5% significance, *** 1% significance.

In the regressions covering the period 1870-2011 the coefficients of growth are positive and highly significant for all levels of schooling as well as for GER^P and GER^S in the regressions in which the time-dummies are excluded. However, the coefficients of growth become insignificant when time-dummies are included in the regressions. This result reveals an important methodological dilemma: Including time fixed effects purges informative variation from the data; however excluding them may introduce a potential omitted variable bias. Since the time-fixed effects purge informative variation - the common element in the variation over time - it is questionable whether the time-dummies belong to the regression model. In any event, the insignificance of growth when time-dummies are included in the regressions is, to a large extent, driven by the pre-WWII data. In the post-WWII regressions in Table 6 growth is significant in the GER^P and GER^S regressions regardless of whether time-dummies are included (results without time-dummies are not shown).

Table 6. GER regressions 1950-2011 (Eq. (5)).

	Total GER		Primary GER		Secondary GER		Tertiary GER	
	(1)	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
g_{it}^{P}	0.658** (0.021)		0.426** (0.021)		0.369*** (0.001)		-0.138 (0.407)	
g_{it}^{h}		0.289* (0.086)		0.116 (0.292)		0.125* (0.073)		0.0480 (0.621)
e_{it}^{10}	0.0780*** (0.000)	0.0622*** (0.001)	0.0294** (0.015)	0.0185 (0.103)	0.0160** (0.028)	0.00671 (0.337)	0.0326*** (0.004)	0.0370*** (0.000)
r_{it}	0.697** (0.019)	0.377 (0.189)	0.329* (0.084)	0.145 (0.445)	0.162 (0.154)	-0.00509 (0.965)	0.205 (0.239)	0.238 (0.159)
A_{it}^{Y}	-1.350*** (0.003)	-1.432*** (0.003)	0.416 (0.137)	0.423 (0.164)	-0.429** (0.013)	-0.443** (0.022)	-1.337*** (0.000)	-1.412*** (0.000)
Observations	65	65	65	65	65	65	65	65
R^2	0.907	0.902	0.739	0.713	0.922	0.908	0.816	0.814
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes. The numbers in parentheses are *p*-values. Asterisks denote significant difference from zero at * 10% significance, ** 5% significance, *** 1% significance.

Overall it can be concluded that growth is highly influential for schooling after WWII but less so before WWII. A problem associated with the pre-WWII data is that GERs were minuscule and not very reliable because of the informality of the schooling systems and the lack of adequate reporting of school enrollment. Since school funding is dependent on number of pupils, schools would have incentives to over report the number of enrolled children; particularly back in time when it was difficult to monitor schools (Madsen, 2014).

5. The growth-saving nexus before and after WWII

WWII is a landmark in the AMEs growth history. Before that time people were uneducated, innovative activity was close to zero and growth rates were very low. This raises the question of whether the growth and saving dynamics as well as the growth-saving relationship were different before and after WWII. To examine these issues the estimation period is split into the periods 1870-1945 and 1945-2011.

Consider first the result of estimating Eq. (6) (growth regression) over the period 1870-1945 in Table 7. All the coefficients of educational attainment, research intensity, and the interaction between research intensity and DTF are insignificant. However, the coefficients of DTF are positive and significant in three of the four cases. Finally, the coefficients of saving are all insignificant.

Table 7. Unrestricted growth regressions, 1870-1945, 1945-2011 (Eq. (6)).

	1870-1945		**1945-2011**	
	Per Capita Real GDP Growth Rate (g_{it}^{p})	**Per Labor hour Real GDP Growth Rate**	**Per Capita Real GDP Growth Rate (g_{it}^{p})**	**Per Labor hour Real GDP Growth Rate**

			(g^h_{it})				(g^h_{it})	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
s^T_{it}	0.845 (0.152)		0.485 (0.522)		-0.403 (0.311)		-0.0899 (0.905)	
s^P_{it}		1.313 (0.117)		0.508 (0.613)		-0.115 (0.796)		0.287 (0.735)
$\left(\frac{Pat}{Pop}\right)_{it}$	-4.105 (0.117)	-4.957 (0.100)	-1.934 (0.565)	-1.836 (0.611)	-0.121*** (0.005)	-0.102** (0.015)	-0.0209 (0.796)	-0.000306 (0.997)
Δh_{it}	-0.226 (0.482)	-0.408 (0.290)	-0.121 (0.768)	-0.170 (0.714)	0.167** (0.013)	0.162** (0.018)	0.268** (0.036)	0.276** (0.033)
$DTF_{i,t-1}$	0.0812 (0.103)	0.118* (0.065)	0.183*** (0.004)	0.192** (0.012)	-0.0150 (0.138)	-0.00924 (0.306)	0.00856 (0.656)	0.0138 (0.423)
$\left(\frac{Pat}{Pop}DTF\right)_{i,t-1}$	2.788 (0.298)	0.740 (0.838)	0.296 (0.931)	-0.0607 (0.989)	0.196** (0.016)	0.196** (0.015)	0.105 (0.494)	0.103 (0.504)
Sargan test p value	0.306	0.512	0.0675	0.0656	0.00254	0.00143	0.178	0.184
	First Stage Regression: Total Saving (s^T_{it})		**First Stage Regression: Private Saving (s^P_{it})**		**First Stage Regression: Total Saving (s^T_{it})**		**First Stage Regression: Private Saving (s^P_{it})**	
	(1b)		(2b)		(3b)		(4b)	
$(M/F)_{it}$	-1.391*** (0.000)		-1.304*** (0.001)		-0.196*** (0.000)		-0.187*** (0.000)	
e^{10}_{it}	0.00808** (0.010)		0.00788** (0.029)		0.00426 (0.197)		0.000420 (0.902)	
A^Y_{it}	-0.811** (0.026)		-0.584 (0.159)		-0.392*** (0.000)		-0.255*** (0.006)	
First Stage F-stat	5.820		5.725		19.01		11.08	

Note. See notes to Table 1.

Turning to the post-WWII regressions, the coefficients of saving are insignificant regardless of whether total or private saving is used as regressor and whether growth is based on per capita income or output per hour worked. This result suggests that the high post-WWII growth rates have not been driven by saving, which, therefore, challenges the hypothesis that growth in the AMEs has been fuelled by high savings rates. Among the covariates, educational attainment is consistently positive and significant and the coefficients of the interaction between research intensity and DTF remain positive and significant in the per capita income growth regressions.

Table 8. Unrestricted savings regressions, 1870-1945, 1945-2011 (Eq. (4)).

	1870-1945				**1950-2011**			
	Dependent variable: Total Saving (s^T_{it})		**Dependent variable: Private Saving (s^P_{it})**		**Dependent variable: Total Saving (s^T_{it})**		**Dependent variable: Private Saving (s^P_{it})**	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
g^P_{it}	0.143*** (0.008)		0.162*** (0.010)		0.110** (0.020)		-0.018 (0.710)	
g^H_{it}		0.179*** (0.000)		0.209*** (0.000)		0.056** (0.024)		0.063** (0.013)

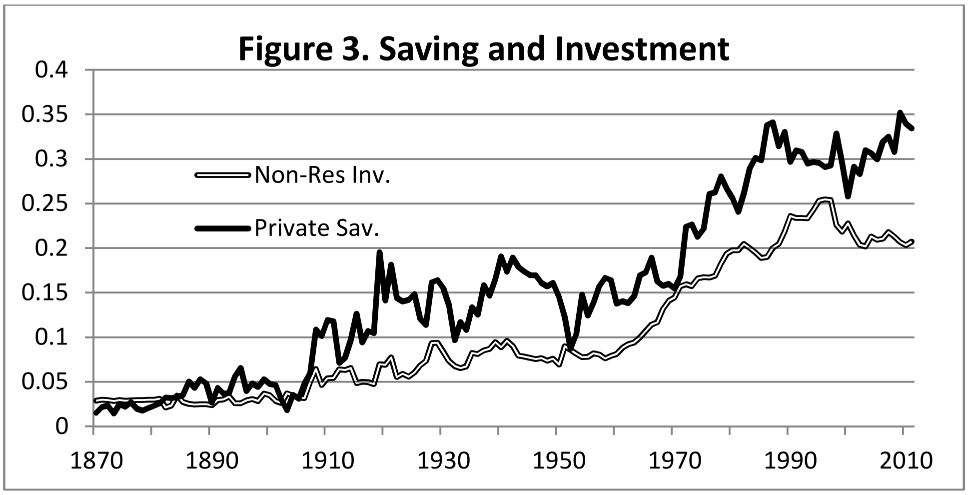
$(M/F)_{it}$	-1.420*** (0.000)	-1.421*** (0.000)	-1.299*** (0.000)	-1.297*** (0.000)	-0.201** (0.010)	-0.199*** (0.000)	-0.178*** (0.000)	-0.189*** (0.000)
e_{it}^{10}	0.007*** (0.004)	0.008*** (0.003)	0.008*** (0.005)	0.009*** (0.005)	0.005* (0.097)	0.004 (0.226)	-0.002 (0.497)	-0.001 (0.798)
A_{it}^{Y}	-0.763** (0.012)	-0.721** (0.020)	-0.406 (0.248)	-0.349 (0.343)	-0.329*** (0.000)	-0.340*** (0.000)	-0.158* (0.073)	-0.178** (0.045)
A_{it}^{O}	-2.791 (0.534)	-6.310 (0.162)	0.843 (0.870)	-3.182 (0.554)	0.798 (0.115)	0.723 (0.157)	0.953* (0.072)	0.996* (0.060)
r_{it}	-0.091** (0.022)	-0.079** (0.049)	-0.121*** (0.008)	-0.107** (0.024)	-0.031 (0.505)	-0.064 (0.159)	-0.054 (0.267)	-0.053 (0.259)

Note. See notes to Table 1.

The results of estimating the unrestricted savings models in the split periods are presented in Table 8. The coefficients of growth are significant in seven of the eight regressions regardless of estimation period or the measurement method of saving and growth rates. The significance of the finding that savings are positively affected by growth in the pre-WWII period is that it has not been the high growth rates in the postwar period that has triggered the high savings rates; the result appears to have general validity for the AMEs. Of the control variables, the gender ratio is consistently negative and significant in both estimations periods and the young age dependency ratio is negatively significant in six of the eight cases. The coefficients of life expectancy at ten are significantly positive in six of the eight cases. Finally, the coefficients of the real interest rates are negative and significant in the pre-1945 regressions, suggesting a higher income than substitution effect in savings during this period.

6. Investment and growth

The finding that saving is consistently an insignificant determinant of growth raises the question as to whether this insignificance reflects that saving is a bad proxy for investment or that investment has not contributed to growth in the AMEs. To investigate this issue the investment rate is used instead of savings in the growth regressions. Before turning to the regression results consider the investment rate (real investment divided by real GDP) and the private savings rate displayed in Figure 3. Non-residential investment is used instead of total investment because residential investment is a large fraction of investment and, yet, it does not impinge directly on growth.



Note. Unweighted average of the AMEs.

The figure shows that investment follows the same broad trend as private saving. Starting out with low investment in 1870, the investment ratio climbs to a higher plateau in 1906, which lasts to 1960 after which the ratio continuously increased up to the mid-1990s. However, there are several instances of discrepancies between saving and investment; particularly in the period 1906-1960 during which private saving fluctuated markedly while the investment rate was relatively stable. Furthermore, the investment ratio starts increasing in 1960, which is ten years before private saving starts ascending to a higher plateau. This profile suggests that investment in the AMEs has been fuelled by factors other than saving during the crucial take-off phase. Finally, private saving and investment rates have moved in reverse over the past 25 years. Thus, overall, private savings rates appear not to be adequate proxies for non-residential investment because of wedges created by changing government budget positions, changing current account balances and fluctuations in residential investment.

The non-residential investment ratio is substituted for the saving rate in the extended growth regression in Table 3 in columns 5 and 10. The coefficient of the investment rate is statistically and economically highly significant when the growth rate is based on per capita GDP; however, it becomes insignificant when per hours worked GDP is the dependent variable. The coefficient of the investment rate in the regression in column 5 is higher than the predictions of 0.5 in the Solow model when labor's income share is set to 2/3 of national income. This result has two implications. First, investment is a much more significant determinant of growth than the savings rate, indicating that saving is a noisy and inadequate proxy for non-residential investment. Second, the finding that the coefficient of the investment ratio strongly exceeds the predictions of the Solow model in the per capita income growth regression suggests that there are potentially large positive externalities to non-residential investment as advocated and found by Romer (1987) and De Long and Summers (1991).

7. Concluding Remarks

Several economists have long argued that accumulation of fixed and human capital have been the driving forces behind the AMEs high growth rates over the past half century and, therefore, that the human capital-extended Solow model is well-equipped to explain the Asian growth miracle. This prediction rests on the assumption that saving and schooling are independent of growth and that saving induces investment in fixed productive capital. Theories of saving, however, often predict that growth enhances saving and, therefore, that accumulation of fixed and human capital cannot be assumed to be exogenous and independent of productivity growth. Furthermore, the Confucian value system that has dominated the AMEs cultures for centuries, values education and thrifty lifestyles highly; however, living standards close to subsistence levels almost up to WWII offered households in the ACEs only a few saving opportunities. The increasing living standards after WWII gave the East Asians the opportunity to increase their financial saving and improve their children's education; thus rendering the assumption that saving and education are exogenous dubious.

Utilizing a two-way identification strategy and unique data covering the period 1870-2011 for the AMEs this paper has shown that 1) financial saving as well as education has been driven predominantly by productivity growth; 2) growth is independent of the level of saving; and 3) growth is positively related to the change in educational attainment. These results were robust to choice of instrument set, productivity measurement, the choice of growth model, measurement of saving, inclusion of covariates, and to choice of estimation period.

The finding of a one-way relationship from growth to financial saving is a major challenge to the hypothesis that capital accumulation, enabled by saving, has been the prime mover behind the Asian growth miracle and a major challenge for the early workhorse growth model of Harrod (1939) and Domar (1946) in which growth directly and nearly exclusively is linked to the savings rate. The markedly increasing saving rates starting after WWII were primarily set in motion by growth while fluctuations in saving have often been channeled overseas and to residential investment.

The results in the paper point towards a more complicated growth scenario in the AMEs than hypothesized by the factor accumulation hypothesis. Forces other than saving have set growth in motion and the high growth rates have resulted in spectacular savings rates, which in turn have financed investment. Bloom and Williamson (1998) showed that the demographic transition has been influential for the Asian growth miracle and Hsieh and Klenow (2010) have shown that the reallocation of unproductive firms to productive entities has boosted growth in China, an effect that could well have applied to the countries considered here. Ang and Madsen (2011) have shown that growth has been, predominantly, innovation driven.

Data Appendix

Total Saving-GDP ratio: Two methods are used depending on data availability: **Method 1** (**M1)**. S (Total Savings) = I (Investment) + CA (Current Account) (M1) where Gross Fixed Capital Formation (GFCF) and Capital Formation (CF) are said to be Investment. **Method 2** (**M2)**. S (Total Savings) = Y (Nominal GDP) – C (Consumption) – G (Government Purchases). Total Saving-GDP ratio = Total Savings/Nominal GDP.

Private Saving-GDP ratio: Total Saving-GDP ratio minus Government Saving-GDP ratio where the Government Savings equals Total Government Revenue – Total Government Expenditure. Government Saving-GDP ratio = Government Savings/Nominal GDP

India:

Total Saving-GDP Ratio (M1): 1976-2011 World Development Indicator (WDI) Database: Gross Fixed Capital Formation (GFCF) to Nominal GDP ratio and Current Account(CA) to Nominal GDP ratio, 1870-1951 Investment, Nominal GDP: : Roy, B., 1996, An Analysis of Long Term Growth of National Income and Capital Formation in India (1850-51 to 1950-51), Firma KLM Private Limited, Calcutta, India. 1951-1975 Investment, Nominal GDP: Mitchell, B. R., 2007. International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York. 1870-1951 Investment, Nominal GDP spliced with 1951-1975 Investment, Nominal GDP, 1870-1922 Current Account: Net Export 1870-1923 spliced with Current Account 1923 : Net Export 1870-1923 , Mitchell B.R. *op cit*., Current Account 1923-1975: Mitchell B.R. *op cit*.

Government Saving-GDP Ratio: Government Revenue 1870 - 1989 , Government Expenditure 1870-1989 : Mitchell B.R. *op cit*., Nominal GDP 1870 – 1951: Roy, B. *op cit*. spliced with Nominal GDP 1951 – 1989 : Mitchell B.R. *op cit*., Government Revenue to GDP ratio 1990-2011, Government Expenditure to GDP ratio 1990-2011 World Development Indicator (WDI) Database.

Indonesia:

Total Saving-GDP Ratio (M1 & M2) : 1991-2011 World Development Indicator (WDI) Database: Gross Fixed Capital Formation (GFCF) to Nominal GDP ratio and Current Account(CA) to Nominal GDP ratio, Total Saving Rate 1890-1990: Total Saving/Nominal GDP, Total Saving = Nominal GDP – Household Consumption – Government Expenditure, Nominal GDP, Household Consumption: Leeuwen, V. B. 2007, Human Capital and Economic growth in India, Indonesia and Japan: A Quantitative Analysis, 1890-2000, PhD Dissertation, Utrecht University. Government Expenditure: Mitchell B.R. *op. cit*. Total Saving-GDP Ratio 1870-1889: Total Saving-GDP Ratio of Japan 1870-1890 spliced with Indonesia Total Saving-GDP Ratio 1890.

Government Saving-GDP Ratio: Government Revenue 1890 - 1995, Government Expenditure 1890-1995: Mitchell B.R. *op cit*., Nominal GDP 1890 – 1995: Leeuwen, V. B. *op cit*. Government Revenue to GDP ratio 1995-2011, Government Expenditure to GDP ratio 1995-2011 World Development Indicator (WDI) Database. Government Saving-GDP Ratio 1870-1889: Government Saving-GDP Ratio of Japan 1870-1890 spliced with Indonesia Government Saving-GDP Ratio 1890.

Korea:

Total Saving-GDP Ratio (M1): 1976-2011 World Development Indicator (WDI) Database: Gross Fixed Capital Formation (GFCF) to Nominal GDP ratio and Current Account(CA) to Nominal GDP ratio, 1911-1938 and 1955-1976 Investment, Current Account, Nominal GDP: Mitchell B.R. *op cit*., current Account 1955-1976 converted to LCU applying exchange rates: International Financial Statistics Yearbook 1987, International Monetary Fund , Total Saving-GDP Ratio 1939-1954 interpolated, Total Saving-GDP Ratio 1870-1911: Total Saving-GDP Ratio of Japan 1870-1911 spliced with Korea Total Saving-GDP Ratio 1911.

Government Saving-GDP Ratio: 1911-1938 and 1953-1990: Government Revenue, Government Expenditure, Nominal GDP Mitchell B.R. *op cit*., Government Saving-GDP Ratio 1939-1952 Interpolated, Government Revenue to GDP ratio 1990-2011, Government Expenditure to GDP ratio 1990-2011 World Development Indicator (WDI) Database. Government Saving-GDP Ratio 1870-1910: Government Saving-GDP Ratio of Japan 1870-1911 spliced with Korea Government Saving-GDP Ratio 1911.

Singapore:

Total Saving-GDP Ratio (M1): 1994-2011 World Development Indicator (WDI) Database: Gross Fixed Capital Formation (GFCF) to Nominal GDP ratio and Current Account (CA) to Nominal GDP ratio, 1900-1993: Nominal GDP, Investment : Sugimoto, I. 2011, Economic Growth of Singapore in the Twentieth Century, Historical GDP Estimates and Empirical Investigations. Soka University Japan, World Scientific Publishing Co. Pte. Ltd. Singapore. Current Account: 1900 – 1962: Current Account = (Net Export + Cumulative Net Export* 0.04), Net Export 1900-1962: Sugimoto, I. *op cit*., Current Account 1962-1993 : Mitchell B.R. *op cit*., Current Account 1900 – 1962 spliced with Current Account 1962 – 1993. Total Saving-GDP Ratio 1870-1899: Total Saving-GDP Ratio of Japan 1870-1900 spliced with Singapore Total Saving-GDP Ratio 1900.

Government Saving-GDP Ratio: Government Surplus/Deficit 1900 - 1962, Nominal GDP 1900-1962: Sugimoto, I. *op cit*., 1963-1990: Government Revenue, Government Expenditure, Nominal GDP: Mitchell B.R. *op cit*., Government Revenue to GDP ratio 1991-2011, Government Expenditure to GDP ratio 1991-2011 World Development Indicator (WDI) Database, Government Saving-GDP Ratio 1870-1899: Government Saving-GDP Ratio of Japan 1870-1900 spliced with Singapore Government Saving-GDP Ratio 1900.

Taiwan:

Total Saving-GDP Ratio (M1): 1955-2011 Total Saving-GDP Ratio: Statistical Data Book Taiwan 2011, 1903-1938 and 1951-1954 Investment, Current Account, Nominal GDP: Mitchell B.R. *op cit*., Total Saving-GDP Ratio 1939-1950 Interpolated, Total Saving-GDP Ratio 1870-1902: Total Saving-GDP Ratio of Japan 1870-1903 spliced with Taiwan Total Saving-GDP Ratio 1903.

Government Saving-GDP Ratio: 1903-1938 and 1951-1954 Government Revenue, Government Expenditure. Nominal GDP: Mitchell B.R. *op cit*., Government Saving-GDP Ratio 1939-1950 Interpolated. Government Revenue, Government Expenditure, and Nominal GDP 1955-2011 Statistical Data Book Taiwan 2011. Government Saving-GDP Ratio 1870-1902: Government Saving-GDP Ratio of Japan 1870-1903 spliced with Taiwan Government Saving-GDP Ratio 1903.

Young Age Dependency Ratio: Ratio of population in the 0-14 age group to the working population aged 15 to 64.

Old Age Dependency Ratio: Ratio of population in the 65+ year age group to the working population aged 15 to 64.

The population distributions are classified according to the following age groups: 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80+. Principal data sources used were Mitchell, B. R., 2007. International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York and the United Nations (UN), 2012, World Population Prospects: The 2012 Revision, Database, http://esa.un.org/wpp/Excel-Data/population.htm, accessed on 15th of March 2013. All total population data are from Maddison, A. 2010, Historical Statistics of World Economy*:* 1-2008AD, Organization for Economic Cooperation and Development: Paris.

India
1870 was backdated using total population from Maddison, A. *op. cit*. and age distributions from 1881 as proxy. 1881, 1891, 1901, 1911, 1921, 1931, 1951, 1961, 1971, 1981, 1993 and 2001 population by age groups was obtained from Mitchell, B.R. *op. cit*. The 60-64, 65-69, 70-74, 75-79, 80+ age group data for 1881, 1891 and 1901 was obtained by decomposing Mitchell B.R. *op cit*.'s combined age groups data using 1911 age distributions. Similarly, the 70-74, 75-79, 80+ populations were obtained using 1961 age distributions as proxy. The intervening years within the census data were growth interpolated. 2002-2010 is from the UN database, while 2011 was obtained using 2010 age distributions and Maddison, A. *op. cit*.'s total population data which was growth extrapolated to 2011.

Indonesia: 1870-1949 was backdated using age distributions from India as proxy and total population from Maddison, A. *op. cit*. 1950-1960 data is from the UN database, and 1961 is from Mitchell, B.R. *op. cit*. The population within the 25-80+ age group was decomposed to the default distributions using 1971 proportions as proxy. 1971, 1980, 1993, 1995 and 2003 is from Mitchell, B.R. *op. cit*. All intervening years were growth interpolated. 2003-2010 was obtained from the UN database. 2011 was extrapolated using total population from Maddison, A. *op. cit*. and the 2010 age distributions.

Korea

1870-1929 was backdated using age distributions from India as proxy and total population from Maddison, A. *op. cit*. 1930, 1944, 1960, 1975, 1980 and 1994 census data was obtained from Mitchell, B.R. *op. cit.* The 1870-1929 backdated data was then spliced to the level census data using 1930 as base year. 1995-2010 is from the UN database. 2011 was obtained using 2010 age distributions and Maddison, A. *op. cit*.'s total population which was growth extrapolated to 2011. All intervening years were growth interpolated.

Singapore

1870-1949 was backdated using age distributions from India as proxy and total population from Maddison, A. *op. cit*. 1950-2010 is from the UN database. 2011 was obtained using 2010 age distributions and Maddison, A. *op. cit*.'s total population which was growth extrapolated to 2011.

Taiwan

1870-1904 was backdated using age distributions from India as proxy and total population from Maddison, A. *op. cit*. 1905, 1915, 1920, 1930, 1940, 1956, 1966, 1970 and 1980 census data was obtained from Mitchell B.R. *op. cit.* The backdated 1870-1904 data was then spliced to the level of census data using 1905 as base year. The 70-74, 75-79 age group data for 1905, 1915 and 1920 was obtained by decomposing Mitchell B.R. *op. cit*.'s age groups using the 1940 age distributions as proxy. The 70-74, 75-79 and 80+ data for 1970, as well as the 70-74, 75-79 populations for 1980 were also computed using age distributions from 1966 as proxy. 1981-2011 was obtained using age distributions from India as proxy and total population from Maddison, A. *op. cit*. This was subsequently spliced to the level of actual census data using 1980 as base year. All intervening years were growth interpolated.

Educational attainment and gross enrolment rates. See Madsen (2010) for estimation method.

Population distribution data sources are detailed above.

School Enrolment:

India

Primary
Combined primary and secondary enrolment from 1870-1876 was obtained from Mitchell, B. R., 2007. International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York and the decomposed using 1877 proportions. Separate primary and secondary enrolments data for 1877-1879 is also from Mitchell, B.R. *op. cit*. 1880-1996 is from Leeuwen, V. B. 2007, Human Capital and Economic growth in India, Indonesia and Japan: A Quantitative Analysis, 1890-2000, PhD Dissertation, Utrecht University; and 1997-2000 from Mitchell, B.R. *op. cit*., while 2001-2009 was growth extrapolated.

Secondary
Combined primary and secondary enrolment for 1870-1876 was obtained from Mitchell, B.R. *op. cit*. and then decomposed using 1877 proportions. Enrolments for 1877-1996 are from Leeuwen, V. B. *op. cit*., and 1997-2009 is growth extrapolated.

Tertiary
1870-1872 enrolment was backdated using the first 20-year average growth rate from 1873; 1873-1879 is from Mitchell, B.R. *op. cit*. and 1880-1999 is from Leeuwen, V. B. *op. cit*. 2000-2009 enrolment was growth extrapolated.

Indonesia

Primary
1870-1974 enrolment was backdated using the first 20-year average growth rate from 1875. 1875-1877 and 1879 is from Mitchell, B.R. *op. cit*. 1878 is growth interpolated. Enrolment figures for 1880-1999 are sourced from Leeuwen, V. B. *op. cit*., while 2000-2009 is from World Development Indicators. The World Bank, WDI (http://data.worldbank.org/indicator).

Secondary
1870-1875 enrolment was backdated using the first 20-year average growth rate from 1876. Data for 1876-1879 is from Mitchell, B.R. *op. cit*.; 1880-1941, 1946, 1949-1999 is from Leeuwen, V. B. *op. cit*.; and 2000-2009 WDI, *op. cit*. All intervening gaps are growth interpolated.

Tertiary
1870-1919 was backdated using the first 20-year average growth rate from 1920. 1920-1941, 1946, 1950-2000 is from Leeuwen, V. B. *op. cit*. while 2001-2009 figures are from the WDI, *op. cit*.

Korea

Primary
1870-1909 enrolment was backdated using the first 20-year average growth rate from 1910. 1910-1937, 1939 is from Mitchell, B.R. *op. cit*.; 1948-1966 from Banks, A.S. 1971, Cross Polity Time Series Data. The MIT Press: Cambridge, Massachusetts and London, England and 1967-2003 was obtained from Mitchell, B.R. *op. cit*. All intervening gaps were growth extrapolated. 2004-2009 was growth extrapolated.

Secondary
1870-1911 enrolment was backdated using the first 20-year average growth rate from 1912. 1912-1937, and 1939 is from Mitchell, B.R. *op. cit*.; 1948-1966 Banks, A.S. *op. cit*.; 1967-2003 is from Mitchell, B.R. *op. cit*. All intervening gaps are growth interpolated. 2004-2009 was growth extrapolated.

Tertiary
1812-1949 enrolment was backdated using the first 20-year average growth rate from 1950. 1950, Mitchell, B.R. *op. cit*.; 1951-1966 from Banks, A.S. *op. cit*.; 1967-2003 is from Mitchell, B.R. *op. cit*.; 2004-2009 was growth extrapolated.

Singapore

Primary
1870-1946 enrolment was backdated using the first 20-year average growth rate from 1947; 1947-1991, 1992-1993 is growth interpolated and 1994-2003 is from Mitchell, B.R. *op. cit*. 2004-2010 enrolments data is from WDI, *op. cit*.

Secondary
1870-1946 enrolment was backdated using the first 20-year average growth rate from 1947; 1947-1991, 1992-1993 is growth interpolated and 1994-2003 is from Mitchell, B.R. *op. cit*. Enrolment data for 2004-2010 is from WDI, *op. cit.*

Tertiary
1870-1949 enrolment was backdated using the first 20-year average growth rate from 1950. Data for 1951-2003 was sourced from Mitchell, B.R. *op. cit*., while the enrolment figures for 2004-2010 are from the WDI, *op. cit*.

Taiwan

Primary
1870-1909 enrolment was backdated using the first 20-year average growth rate from 1910. Combined primary and secondary enrolment data for 1910-1937 is from Mitchell, B.R. *op. cit*. This was subsequently decomposed using constant 1938 proportions. Enrolment data for 1938-1940 and 1946-1949 is also from Mitchell, B.R. *op. cit*., and 1950-2010 was obtained from the Taiwan Statistical Yearbook, 2011. All intervening gaps are growth interpolated.

Secondary
1870-1909 enrolment was backdated using the first 20-year average growth rate from 1910. Combined primary and secondary enrolment for 1910-1937 from Mitchell, B.R. *op. cit*. was decomposed using constant 1938 proportions. 1938-1940 and 1946-1949 enrolment is from Mitchell, B.R. *op. cit*.; 1950-2010 is from Taiwan Statistical Yearbook, 2011. All intervening gaps are growth interpolated.

Tertiary
1870-1919 enrolment was backdated using the first 20-year average growth rate from 1920. Enrolment for 1920, 1926, 1931, 1935, 1940 and 1946-49 is from Mitchell, B.R. *op. cit*., while 1950-2010 was sourced from the Taiwan Statistical Yearbook, 2011. All intervening gaps are growth interpolated.

Domestic Patent

WIPO: Patent Application by Patent Office, by resident and non-resident, http://www.wipo.int/ipstats/en/statistics/patents.

Per Capita Real GDP Growth Rate

Madison Historical GDP Database (http://www.worldeconomics.com/Data/MadisonHistoricalGDP) for population and Real GDP data except Singapore Real GDP 1900-1960: Sugimoto, I., 2011, Economic Growth of Singapore in the Twentieth Century, Historical GDP Estimates and Empirical Investigations, World Scientific Publishing Co. Pte. Ltd., Singapore.

Real interest rate: Nominal interest rate in a long-term government bond minus contemporaneous consumer inflation rate.

Nominal interest rate:

India

1870-1894 same as 1895. 1895-1906: Calculated from Price of 3.5% Indian Government Bond in London, SARBI (various issues). 1907-1929: Interpolated. 1930-1954: Treasury Bills Rate, Homer, S., Sylla, R., A History of Interest Rates, John Wiley and Sons Inc. 1955-1989: Official Discount Rate, Homer, S., Sylla, R., *op. cit.* 1990-1993: Interpolated. 1994-2011: 3-Month Treasury Bill Rate, Datastream (Thomson Reuters).

Indonesia

India 1870-1970 spliced with 1970. 1970-2011: Deposit interest rate, World Development Indicator (WDI) Database.

Korea

Japan 1870-1948 spliced with 1948. 1948-1964: International Financial Statistics (supplement to 1965/66 issues). 1965-1999: interpolated. 2000-2011: 1 Year Government Bond Rate, Datastream (Thomson Reuters).

Singapore

Japan 1870-1977 spliced with 1977. 1977-1989: Deposit interest rate, World Development Indicator (WDI) Database spliced with 1989. 1989-2011: 3-Month Treasury Bill Rate, Datastream (Thomson Reuters).

Taiwan

Japan 1870-1982 spliced with 1982.1982-2011: 3-Month Money Market Rate. (Thomson Reuters).

Consumer inflation rate: Calculated from Consumer Perice Index (CPI)

India

1870-1940: kumar, D., Desai, M. 1982, The Cambridge Economic History of India 1757-1970, volume 2, Cambridge University Press spliced with 1940-2005: Mitchell, B. R., 2007. International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York spliced with 2005-2011: International Financial Statistics.

Indonesia

Cost of Living Index for Indonesia 1870-1925: Williamson, J., 2000, Real Wages and Relative Factor Prices in the Third World 1820-1940: Asia published as: Globalization, Factor Prices and Living Standards in Asia Before 1940, in A.J.H. Latham and H. Kawakatsu (eds.), Asia Pacific

Dynamism 1500-2000 (London: Routledge, 2000): 13-45 spliced with 1925-2005: Mitchell B.R. *op. cit*. spliced with 2005-2011: International Financial Statistics.

Korea

1870-1906: CPI Japan spliced with Cost of Living Index of Korea 1906-1912: Williamson, J., 2000 *op. cit.*, spliced with 1912-2005: Mitchell B.R. *op. cit*. spliced with 2005-2011: International Financial Statistics.

Singapore

1870-1880: CPI Japan spliced with 1880. 1880-2011: 1880-1900: Sugimoto, I. Estimates of Private Final Consumption Expenditure in the Colony of Singapore, 1880-1939: Progress and Perspective, Soka University spliced with 1900-1961: Sugimoto, I. 2011, Economic Growth of Singapore in the Twentieth Century, Historical GDP Estimates and Empirical Investigations, World Scientific Publishing Co. Pte. Ltd. spliced with 1961-2005: Mitchell B.R. *op. cit*. spliced with 2005-2011: International Financial Statistics.

Taiwan

1870-1897: CPI Japan spliced with Cost of Living Index of Taiwan 1897-1903: Williamson J., 2000, op. cit. spliced with 1903-2005: Mitchell B.R. *op. cit*. spliced with 2005-2011: Taiwan Statistical Data Book 2012, downloaded from: http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0017349.

CPI of Japan 1870-1906: Mitchell B.R. *op. cit*.

Life Expectancy at the Age of 10

India

1870-1880 same as 1881. 1881-1891: Gupta, P. D., 1971, Estimation of Demographic Measures for India, 1881-1961, Based on Census Age Distributions, Population Studies, 25(3), pp. 395-414. 1891-1999: Human Lifetable Database, (www.lifetable.de). 1999-2010: WHO data downloaded from http://apps.who.int/gho/data/view.main.

Indonesia

1870-1960 same as India. 1961-2010: WHO data: http://apps.who.int/gho/data/view.main.

Korea

1870-1926 spliced with Japan. 1926-1931: Dublin, L. I., Lotka, A. J., Spiegelman, M., 1949, Length of Life: A Study of the Life Table, Ronald press company, New York. 1931-1938: Demographic Year Book, United Nations, New York. 1938-1970: Human Lifetable Database, (www.lifetable.de). 1970-2010: Korea Statistics Office (KOSIS), downloaded from http://kosis.kr/nsieng/view/stat10.do .

Singapore

1870-1956 spliced with Netherland. 1957-1962: Keyfitz, K., Flieger, W., 1968, World Population: An Analysis of Vital Data, The University of Chicago Press, Chicago. 1963-1969 Interpolated. 1970-2009: Human Lifetable Database, (www.lifetable.de). 2010: WHO data, downloaded from http://apps.who.int/gho/data/view.main .

Taiwan

1870-1925 spliced with Netherland. 1926-2007: Human Lifetable Database, (www.lifetable.de). 2008-2010: Taiwan Life Table, downloaded from http://sowf.moi.gov.tw/stat/english/elife/elist.htm.

Gender Ratio: Ratio of the number of males to females in the age between 10 and 24

India

1870-1880 same as 1881. 1881, 1891, 1901, 1911, 1921, 1931, and 1951: Mitchell, B. R., 2007, International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York. 1882-1890, 1892-1900, 1902-1910, 1912-1920, 1922-1930, 1932-1950 interpolated. 1951-2010: United Nations' Population Division (http://esa.un.org/unpd/wpp/Excel-Data/population.htm) spliced with 1951: Mitchell, B. R., *op.cit*.

Indonesia

1870-1950: Gender ratio Japan spliced with 1950: United Nations' Population Division, *op. cit*. 1950-1961: United Nations' Population Division, *op. cit*. spliced with 1961: Mitchell B.R. *op. cit*. 1961, 1971, 1980, 1993, 1995, and 2003: Mitchell B.R. *op. cit*. 1962-1970, 1972-1979, 1981-1992, 1994, and 1996-2002 interpolated. 2003-2010: United Nations' Population Division, *op. cit*. spliced with 2003: Mitchell, Africa, Asia and Oceania, 2007, *op.cit*.

Korea

1870-1930: Gender ratio Japan spliced with 1930: Mitchell B.R. *op. cit*. 1930, 1944, 1960, 1975, 1980, 1994 and 2003: Mitchell B.R. *op. cit*. 1931-1943, 1945-1959, 1961-1974, 1976-1979, 1981-1993, and 1995-2002 interpolated. 2003-2010: United Nations' Population Division, *op. cit*. spliced with 2003: Mitchell B.R. *op. cit*.

Singapore

1870-1931: Gender ratio Japan spliced with 1931: Gender ratio Malay, Mitchell B.R. *op. cit*. Gender ratio Malay, 1931, 1957: Mitchell B.R. *op. cit*. 1932-1956 interpolated. 1950-2010: United Nations' Population Division, *op. cit*. spliced with 1950: Mitchell B.R. *op. cit*.

Taiwan

1870-1905: Gender ratio Japan spliced with 1905: Mitchell B.R. *op. cit*. 1905, 1915, 1920, 1930, 1940, 1956, 1966, 1970 and 1980: Mitchell B.R. *op. cit*. 1906-1914, 1916-1919, 1921-1929, 1931-1939, 1941-1955, 1957-1965, 1967-1969 and 1971-1979 interpolated. 1980-2010: Taiwan Statistical year book 2011 spliced with 1980: Mitchell B.R. *op. cit*.

Japan

1870-1883 same as 1884. 1884, 1893, 1903, 1913, 1920, 1930, 1940, 1950: Mitchell B.R. *op. cit*. 1885-1892, 1894-1902, 1904-1912, 1914-1919, 1921-1929, 1931-1939, 1941-1949 interpolated. 1950-2010: United Nations' Population Division, *op. cit*. spliced with 1950: Mitchell B.R. *op. cit*.

Hours worked: Total Working Force multiplied by Hours Worked per Worker.

India

Total Working Force: 1870-1951: Roy, B., 1996, An Analysis of Long Term Growth of National Income and Capital Formation in India (1850-51 to 1950-51), Firma KLM Private Limited, Calcutta, India. 1952-1959: Interpolated. 1960-2011: The Conference Board Total Economy Database, 2013, http://www.conference-board.org/data/economydatabase/

Hours Worked Per Worker: 1870, 1900: Huberman, M., Lewis, F., 2007, Bend It Like Beckham: Hours and Wages across Forty Eight Countries in 1900, Queen's Economics Department Working Paper no. 1229. 1871-1899: Interpolated. 1901-2011: same as 1900.

Indonesia

Total Working Force: 1870-1880: Population from Madison Historical GDP Database (http://www.worldeconomics.com/Data/MadisonHistoricalGDP) spliced with 1880. 1880-2008: van der Eng, P., 2010, The Sources of Long Term Economic Growth in Indonesia, 1880-2008, Explorations in Economic History, 47, 294-309 spliced with 2008-2011: The Conference Board Total Economy Database *op. cit.*

Hours Worked per Worker: 1870-2011: same as India.

Korea

Total Working Force: 1870-1955: Population from Madison Historical GDP Database (http://www.worldeconomics.com/Data/MadisonHistoricalGDP) spliced with 1955. 1955-1960: Mitchel, B. R., 2007, International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York.

Hours Worked per Worker: 1870-1949: same as 1950, 1950-1960: The Conference Board Total Economy Database *op. cit.*

Total Annual Hours Worked: 1963-2011: The Conference Board Total Economy Database *op. cit.* 1961-1962: Interpolated.

Singapore

Total Working Force: 1870-1947: Population from Madison Historical GDP Database (http://www.worldeconomics.com/Data/MadisonHistoricalGDP) spliced with 1947. 1947-1957: Mitchel, B. R., 2007, *op. cit.*

Hours Worked per Worker: 1870-1949: same as 1950, 1950-1957: The Conference Board Total Economy Database *op. cit.*

Total Annual Hours Worked: 1960-2011: The Conference Board Total Economy Database *op. cit.* 1958-1959: Interpolated.

Taiwan

Total Working Force: 1870-1905: Population from Madison Historical GDP Database (http://www.worldeconomics.com/Data/MadisonHistoricalGDP) spliced with 1905. 1905-1956: Mitchel, B. R., 2007, *op. cit.*

Hours Worked per Worker: 1870-1949: same as 1950, 1950-1956: The Conference Board Total Economy Database *op. cit.*

Total Annual Hours Worked: 1960-2011: The Conference Board Total Economy Database *op. cit.* 1957-1959: Interpolated.

Real Investment – GDP Ratio: Ratio of real investment (Residential Investment excluded) to Real GDP.

India

1870-1951: Roy, B., 1996, An Analysis of Long Term Growth of National Income and Capital Formation in India (1850-51 to 1950-51), Firma KLM Private Limited, Calcutta, India. spliced with 1951-1967 Mitchell, B. R., 2007, International Historical Statistics: Africa, Asia and Oceania, 1750-2005, 5th Ed. Palgrave Macmillan, New York spliced with 1967-1980: World Development Indicator (WDI) Database spliced with 1980-2010: Statistical Abstract India, Central Statistical Organization, Department of Statistics, Ministry of Planning and Program Implementation, Government of India, New Delhi.

Indonesia

1870-1879: Same as 1880. 1880-2008: van der Eng, P., 2010, The Sources of Long Term Economic Growth in Indonesia, 1880-2008, Explorations in Economic History, 47, 294-309 spliced with 2008-2011: World Development Indicator (WDI) Database.

Korea

Japan real investment to real GDP ratio 1870-1913 spliced with 1913-1994: Timmer, M. P., Ark, B. V., 2000, Capital Formation and Productivity Growth in South Korea and Taiwan: Beating Diminishing Returns through Realizing the Catch-Up Potential, Groningen Growth and Development Centre spliced with 1994-2010: OECD Database.

Singapore

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