Avoid pitfalls in China's transition of its growth model[1]

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Abstract:

The pace of GDP growth in China has shifted downward, from the average of 10 per cent as registered during the three decades of 1980-2010, to less than 7 per cent most recently. This change is to some extent desirable, if the moderated growth reflects a transition in the Chinese economy towards a more efficient, inclusive and sustainable path of growth. However, certain interpretations of and guidance for the transition in China's growth model are problematic. This article rebuts a particular notion that China needs to replace its investment-driven growth by consumption-driven growth. This notion is erroneous both theoretically and empirically. If China follows this notion as the guidance, its growth path in the future years may fall much deeper than intended, failing to narrow further the gap in the standards of living between China and the advanced economies. Policymakers should avoid such pitfalls.

Keywords: economic growth, growth theory, Chinese economy, investment, consumption

JEL Classification: O47, E21, E22

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Outline

Annotated presentation

1. **Introduction**

Slide 1

In this paper, we would rebut a populous notion about how China should make a transition in its growth model, namely, the notion that China needs to change from investment-driven growth to consumption-driven growth. We argue that raising the level of consumption is an important objective, as well as outcome of economic growth, but there is no consumption-driven growth model. Investment is always a crucial determinant of long-term growth.

Slide 2

OUTLINE

1. Introduction
2. System of National Accounts
3. Empirical evidence
4. Determinants of growth in economic theories
5. Consumption and economic growth
6. A few simulated scenarios
7. Concluding remarks

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After defining the issue in the introduction, we are going to refer to the system of national accounts, to be followed by some findings from the data of economic growth for a large number of countries in the past decades.

We will revisit various growth theories to see how investment is identified as a key determinant of economic growth, along with other factors.

We will also discuss the relationship between consumption and economic growth.

We will present a few model-based simulated scenarios for China's growth path in the next decades, based on different assumptions about the ratios of consumption and investment relative to GDP.

We will conclude with a few remarks on how to avoid pitfalls in China's transition of its growth model.

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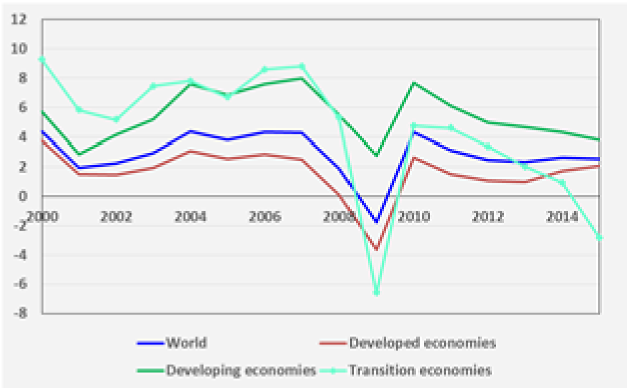
SLOWDOWN IN GDP GROWTH WORLDWIDE



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In the aftermath of the global financial crisis, GDP growth worldwide has been trending downward.

The magnitude of slowdown in developing countries and the economies in transition is significant.

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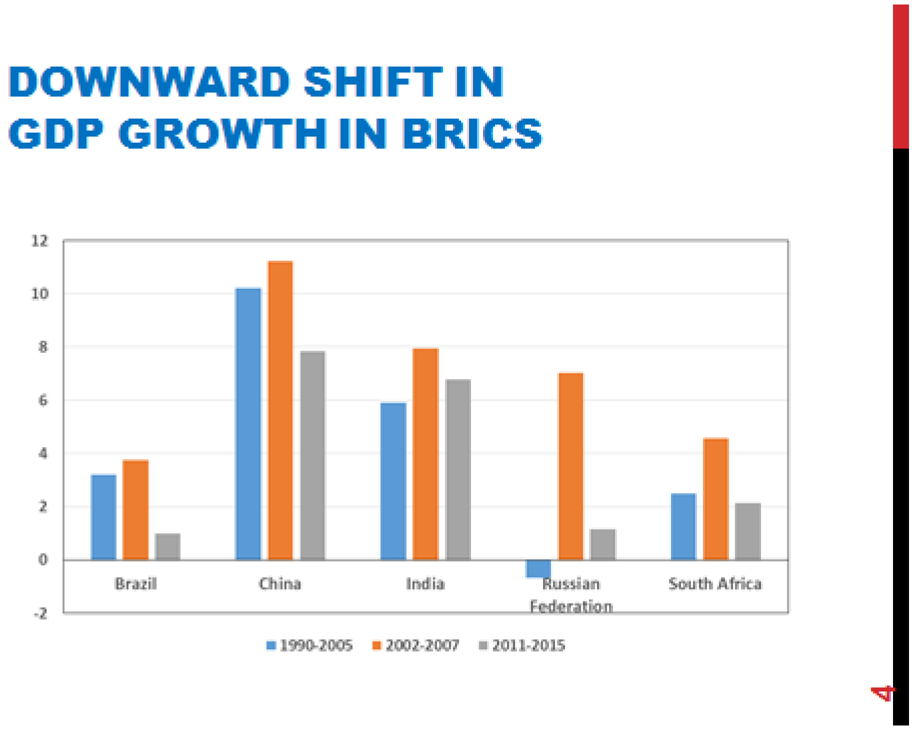

The BRICS, namely, Brazil, Russia, India, China and South Africa, which once led the boom of the global economy in the two decades prior to the global financial crisis, have experienced a substantial shift in their growth in the past few years, except for India, which has bucked the trend. Brazil and Russia have been in a deep recession for the past two years. China's growth has also tapered off noticeably, from the average of 10 per cent endured for three decades before the global financial crisis to less than below 7 per cent most recently.

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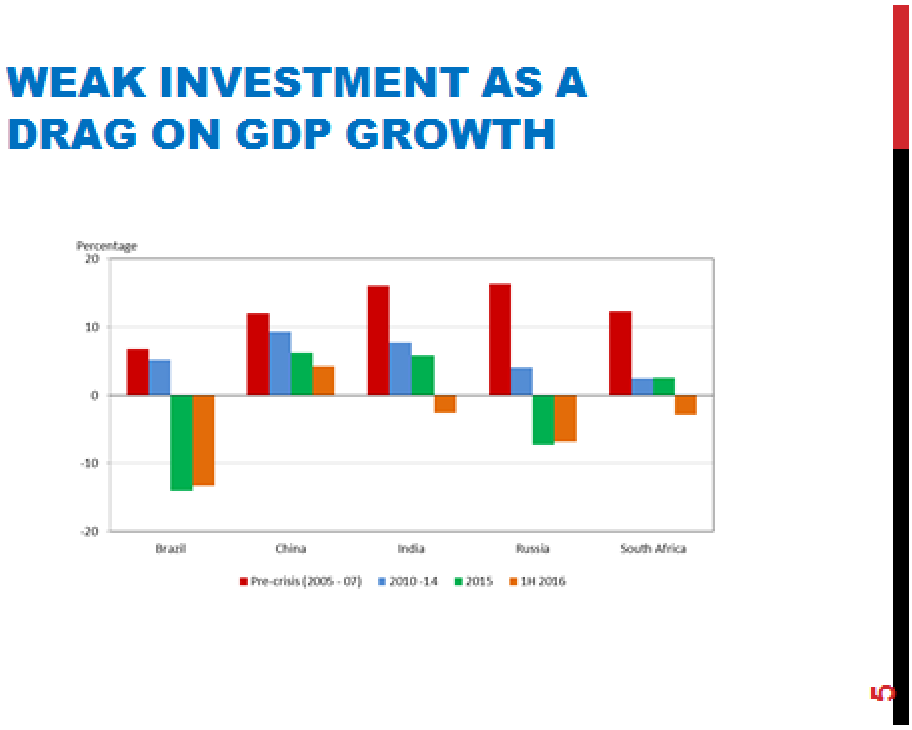

One salient factor behind the recent slowdown is the weakening of business investment.

Growth of the fixed investment formation in emerging economies has declined by half in the period of 2011-2015, compared with the period of 1990-2007.

Among the BRICS, four countries have registered an outright decline in the fixed investment in 2016.

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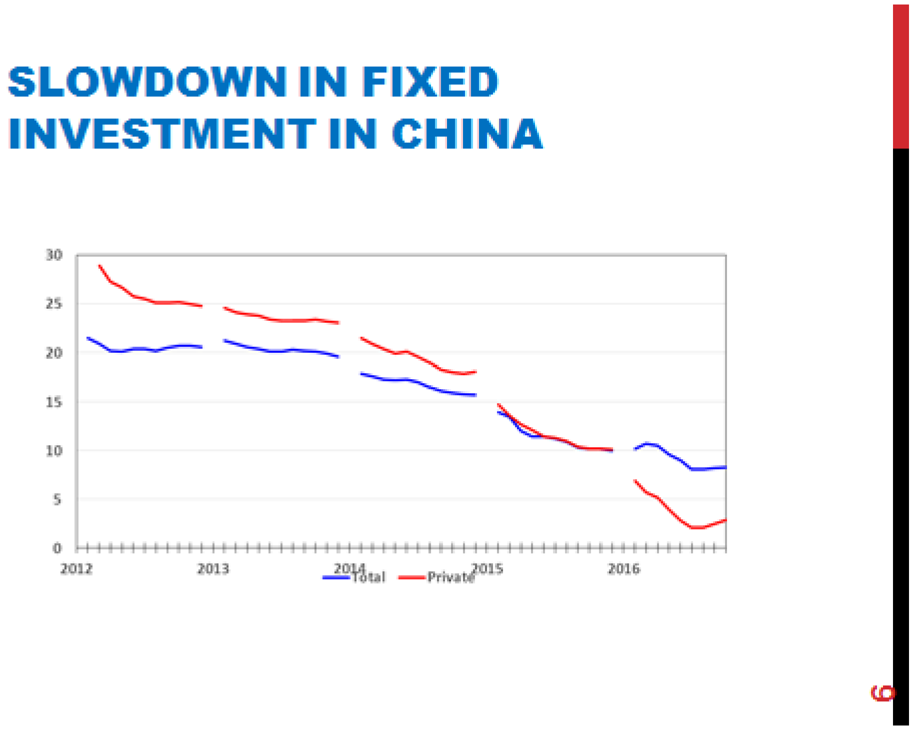

China used to lead the world with extremely high growth of fixed investment, but recently, the fixed investment has also decelerated substantially.

Particularly, fixed investment by private sector has faltered at an alarming rate.

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A POPULAR NOTION ON CHINA'S GROWTH TRANSITION

1. From investment-driven to consumption-driven
2. From export-driven to domestic demand-driven
3. From manufacturing-driven to services-driven

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There has been a consensus among economists and policymakers that China's super-high growth of 10 per cent averaged during the three decades before the global financial crisis was a miracle, but it cannot sustain forever.

The recent slowdown to a pace of about 7 per cent is desirable, particularly if the moderated growth is a result of the transition in China's growth model towards a growth which is more structurally balanced, more socially inclusive and more environmentally sustainable.

However, some views about how China should make the transition of its growth model are problematic.

For example, there is a very popular view which suggests China should change from investment-driven growth to consumption-driven growth, from export-driven growth to domestic demand-driven growth, and from manufacturing-driven growth to services-driven growth (Roach, Stephen, 2013).

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SYSTEM OF NATIONAL ACCOUNTS (1)

Expenditure of GDP

Y= C+ I + X

$$\frac{\Delta Y}{Y} = \frac{\Delta C}{C} \times \frac{C}{Y} + \frac{\Delta I}{I} \times \frac{I}{Y} + \frac{\Delta X}{X} \times \frac{X}{Y}$$

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This view is based on the notion that "in all economies the expansion of output is the sum of the growth of consumption (both private and government) plus investment plus net exports of goods and services." (Lardy, 2006)

By this notion, GDP growth can be decomposed by the "contribution" of consumption, investment and net exports respectively.

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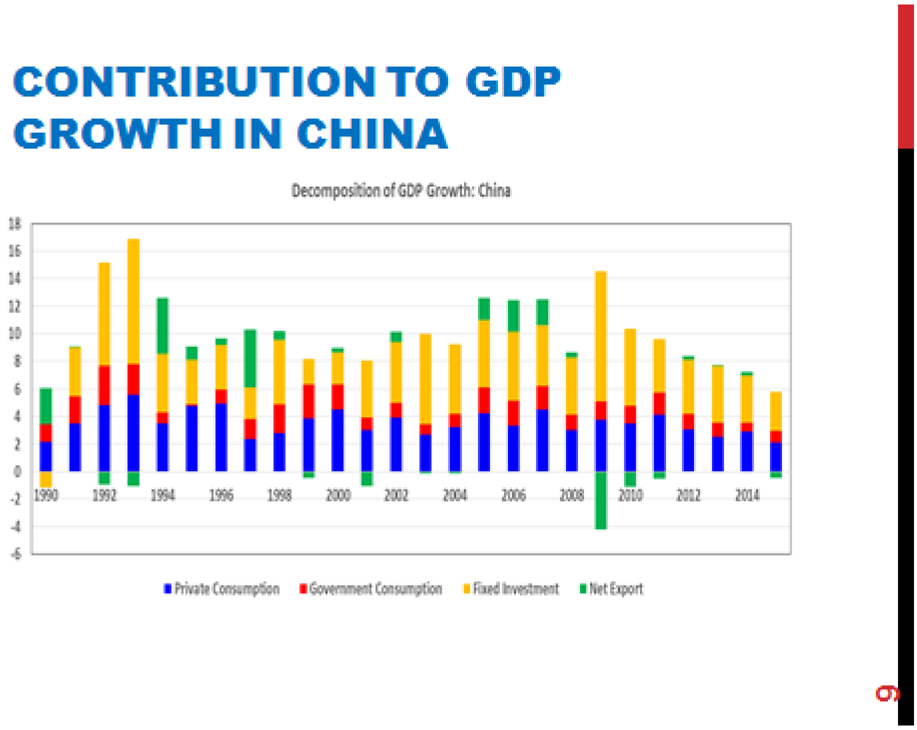

This notion is widely used among business economists.

For example, when China registered a GDP growth of 6.9 per cent for 2015, some analysts would make comments that investment has contributed 2.8 percentage points, and private consumption has contributed 2.1 percentage points, etc.

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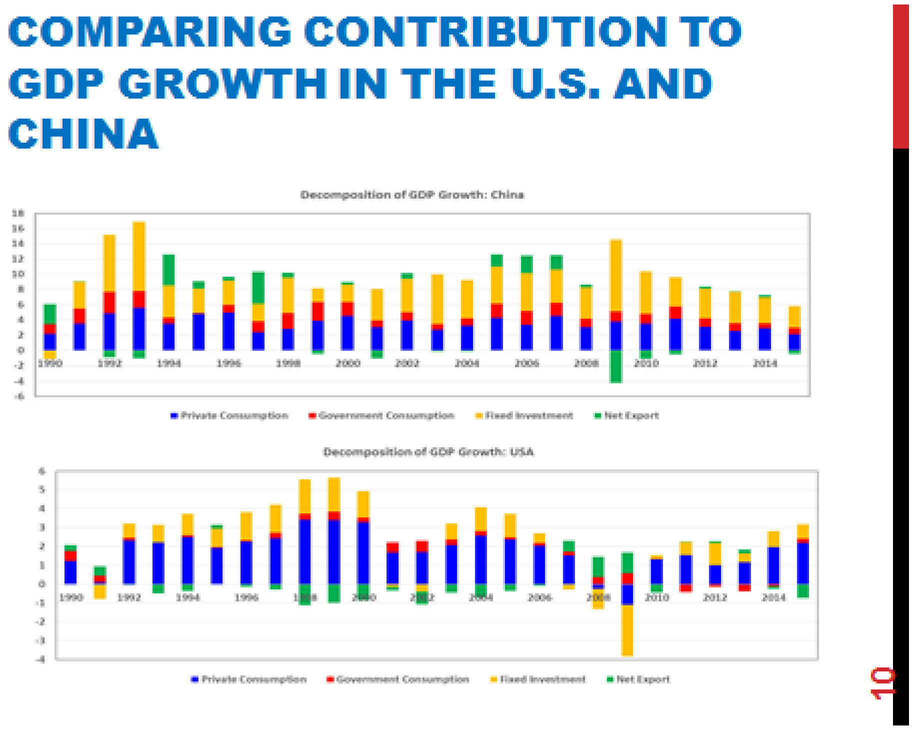

When comparing China with the United States, some analysts would point out that investment is the major driver of GDP growth in China, while in the United States, consumption is the major driver of GDP growth.

2. **System of national accounts**

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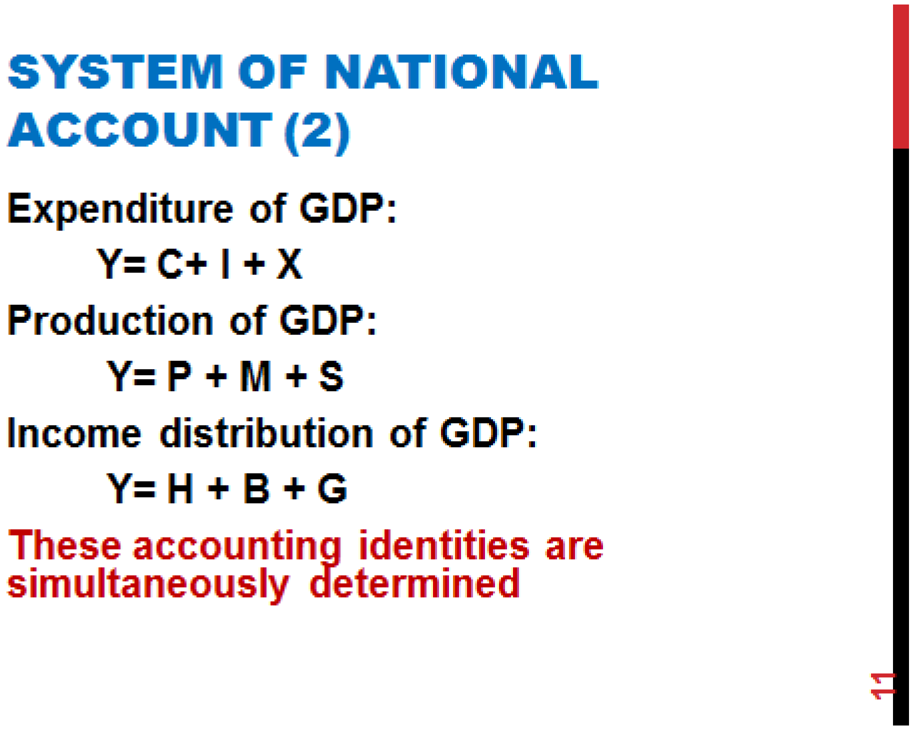

Unfortunately, however, this notion about GDP growth is wrong.

There are three accounting identities to define GDP in the System of National Accounts (SNA).

The expenditure identity defines how GDP is spent, among consumption, investment and net exports.

The production identity defines how GDP is produced, as the sum of the value-added produced by primary sector, manufacturing sector and services sector respectively

The income identity defines how GDP is distributed in terms of income among households, businesses and governments.

These three accounting identities are simultaneously and interdependently determined.

Most analysts are focused only on the expenditure accounting identity of GDP, ignoring the accounting identities for GDP production and income.

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SIMULTANEITY AMONG Y, C, I, AND X

$$Y = C + I + X$$

$$C = f(Y, Z)$$

$$I = g(Y, V)$$

$$X = h(Y, W)$$

$$d(Y - (f(Y,Z) + g(Y,V) + h(Y,W)) = 0$$

$$\xcancel{\frac{\Delta Y}{Y} = \frac{\Delta C}{C} \times \frac{C}{Y} + \frac{\Delta I}{I} \times \frac{I}{Y} + \frac{\Delta X}{X} \times \frac{X}{Y}}$$

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Moreover, even if we consider the expenditure accounting identity only, this identity does not define the causality between GDP and its expenditure components.

The equation does not suggest that GDP on the left-hand side be "caused" by consumption, investment and net exports on the right-hand side.

By economic theories and empirical studies, consumption is a function of disposable income, plus other variables, such as wealth. Consumption is a function of GDP and other variables.

Investment and net export are also respectively a function of GDP and other variables.

In this case, the relationship between GDP growth and the growth of consumption, investment and net export can only be derived by differentiating the implicit equation below.

$$d(Y - (f(Y,Z) + g(Y,V) + h(Y,W)) = 0$$

In other words, the conventional notion to interpret GDP growth as "contributed" by its expenditure components is wrong, in terms of the causality between GDP growth and growth of its expenditure components.

The correct way of explaining the expenditure accounting identity of GDP is as follows.

Taking the example earlier, when China's GDP increased by 6.9 per cent for 2015, we should comment that 2.8 percentage points of the increase in GDP were allocated to the increase in investment and 2.1 percentage points were used for the increase in consumption.

3. Some empirical evidence from data

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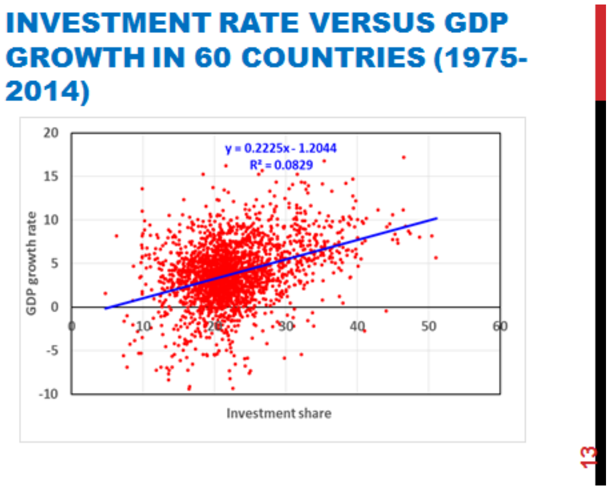

We have collected data from the SNA of 60 sizeable individual countries, including 30 developed countries and 30 developing countries, for the period of four decades from 1975 to 2014.

The scatter plot shows a positive correlation between investment rate and GDP growth, namely, the higher the investment share in GDP, the higher the GDP growth.

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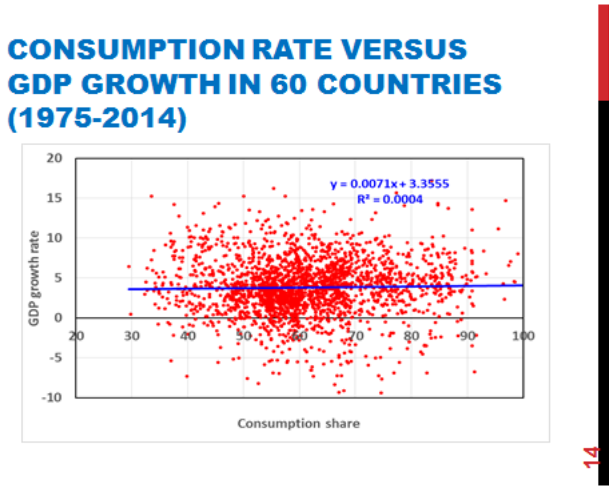

However, the correlation between consumption share in GDP and GDP growth is zero.

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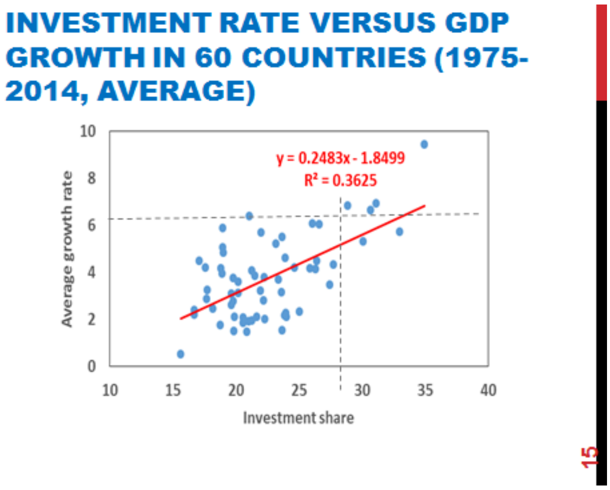

When we take the average of these variables for the period as a whole, the picture is less messy.

Only four countries have registered the average GDP growth higher than 6 per cent during the period of four decades, and each of them also maintained an investment rate higher than nearly 30 per cent of GDP.

Of course, this correlation can only suggest that investment be a necessary condition for GDP growth, but not a sufficient one.

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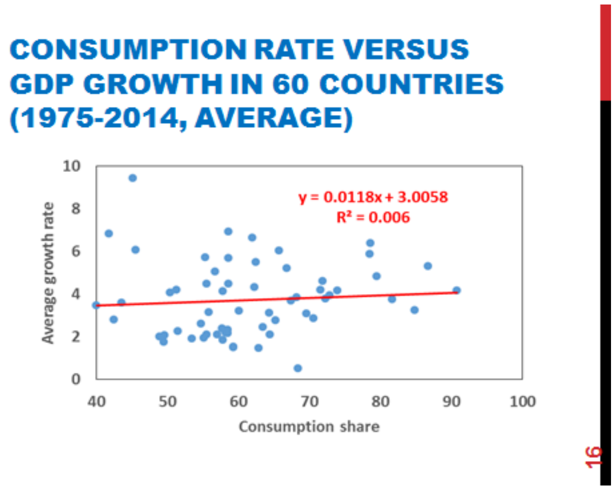

Again, in terms of average, there is no correlation between consumption rate and GDP growth for these countries.

4. Key determinants of long-run growth by economic theories

Let's review some economic theories on economic growth, to see how the respective roles of investment and consumption in determining long-run economic growth.

Since World War II, there have been at least three major waves in economic theory on growth models: the work of Harrod and Domar in the 1940s; the neoclassical growth model associated with the work of Solow in the 1950s to 1960s; and the endogenous growth models by the work of Lucas, Romer and others in the late 1980s.

There have also been a prodigious number of volumes of theoretical and empirical studies of economic growth.

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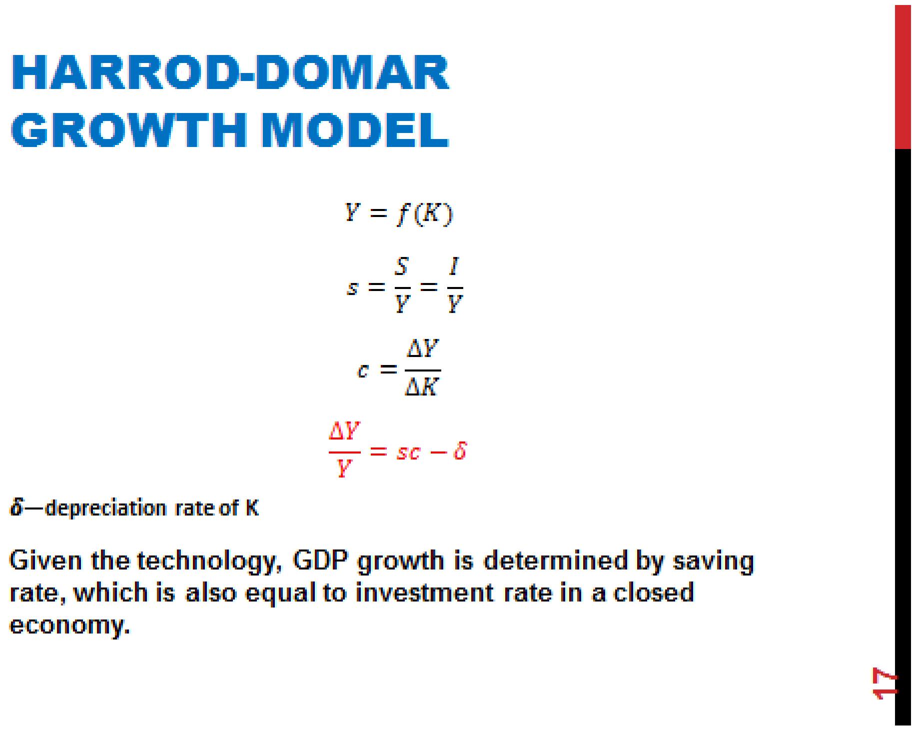

Harrod-Domar (HD) growth model

$$Y = f(K)$$

$$s = \frac{S}{Y} = \frac{I}{Y}$$

$$c = \frac{\Delta Y}{\Delta K}$$

$$\frac{\Delta Y}{Y} = sc - \delta$$

Where δ is the rate of depreciation of capital stock.

Developed in the 1940s, Harrod-Domar (HD) model assumes that capital and labour are used in a fixed technical relationship, and that output is related to the capital stock in terms of the capital-output ratio.

This model attributes the growth rate of an economy directly to two ratios: saving rate(s), which is behavioural, and the incremental capital-output ratio (c, or ICOR), which is technological.

Given an ICOR, the higher the saving rate, the higher the growth rate, or, given a saving rate, the lower the ICOR, the higher the growth rate.

Because of its simplicity, the HD model has been used in many countries in planning and forecasting: for a target growth rate and an ICOR, it is easy to find the saving rate that must be realized to attain the target growth rate.

In a closed economy, saving is equal to investment. Therefore, Harrod-Domar model considers investment as a key factor for economic growth.

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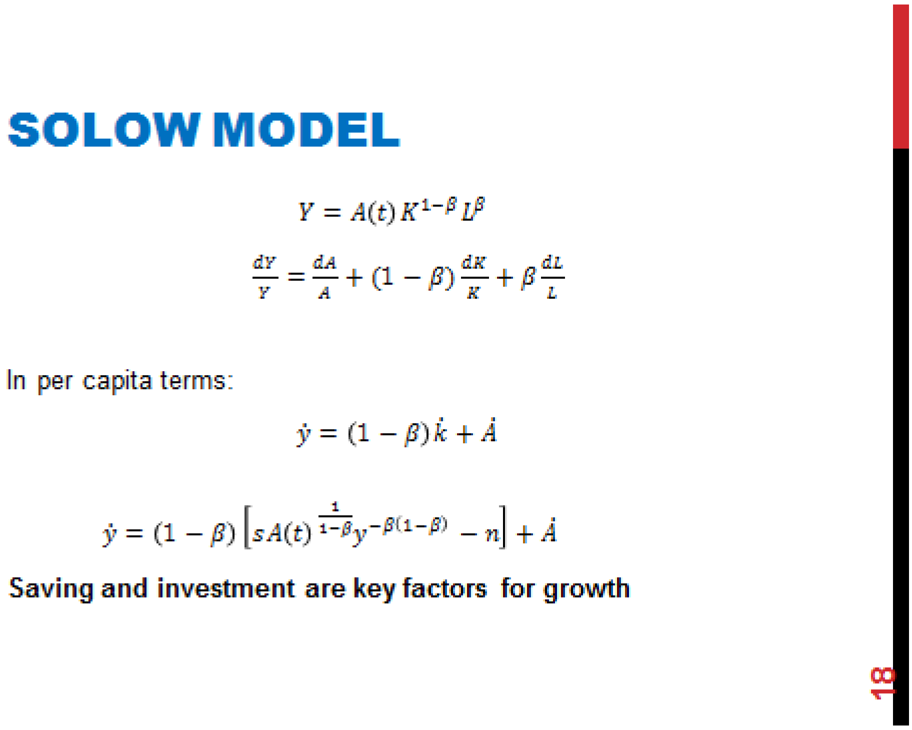

Solow Model

In the HD model, the assumption of a fixed capital-output ratio implies that the long-run steady-state growth rate stands on a razor's edge, which is not stable: the economy would spend most of time experiencing either a prolonged period of increasing or falling unemployment rates and/or a prolonged period of rising or falling capacity utilization.

The neoclassical growth model a la Solow resolved this problem, by making the capital-output ratio an endogenous variable. The centre piece of the standard neoclassical model is the neoclassical production function, which defines output as a function of capital, labour and technological progress. Capital and labour are assumed to be perfectly substitutable and technology is assumed exogenous.

$$Y = A(t)K^{1-\beta}L^{\beta}$$

$$\frac{dY}{Y} = \frac{dA}{A} + (1-\beta)\frac{dK}{K} + \beta\frac{dL}{L}$$

Let y = Y/L denote output per worker and let k = K/L denote capital per worker. Let n denote the rate of growth of the labour force. Let $\dot{y}$ denote its exponential rate of growth.

$$\dot{y} = (1 - \beta)\dot{k} + \dot{A}$$

$$\dot{y} = (1 - \beta)\left[sA(t)^{\frac{1}{1-\beta}} y^{-\beta(1-\beta)} - n\right] + \dot{A}$$

Where Y denotes net national product, K denotes the stock of capital, L denotes the stock of labour, and A denotes the level of technology, s is the savings rate, n is the growth rate of the labour force.

With a set of assumptions, such as diminishing returns to each productive factor, constant return to scale etc., the production function would be well behaved so that the economy approaches a steady state over time.

Given rates of saving, population growth and technological progress, the neoclassical model implies the following main features for the economy.

The long-run steady state, which is defined as the state where the output per efficient labour becomes constant, is independent of initial conditions; The per-capita income level in the steady state depends positively on the saving rates and negatively on population growth; The growth rate of per-capita income in the steady state depends only on the rate of technological progress, independent of saving rates and population growth;

In the steady state, the capital stock grows at the same rate as income, the marginal product of capital is constant, but the marginal product of labour grows at the rate of technological progress;

When the economy is deviated from the steady state, caused by some shocks, it will converge to the steady state at a rate which is defined by the rate of technological progress, the rate of population growth and the steady-state capital share of income.

In Solow model, saving and investment are the key factors for growth.

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ENDOGENOUS GROWTH MODELS

Lucas

$$Y = A(t)\,K^{1-\beta}\,(lhL)^{\beta}$$

Romer

$$Y = A(R)\,f(R_j, K_j, L_j)$$

$$Y = F(R, K, L)$$

Investment remains an important factor for growth in endogenous models

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Endogenous growth models

The neoclassical growth model received challenges in mid 1980s.

One challenge was the unsatisfactory results obtained from empirical testing of the neoclassical model against cross-country historical data. The second was the theoretical shortcoming of the assumption of exogenous technological advance, which determines the long-run growth rate.

A few new growth models emerged in which the technological progress and the long-run growth rate are determined endogenously: namely, endogenous growth models.

Pioneered by Romer (1986), Lucas (1988), Grossman and Helpman (1991), and others, several different endogenous growth models have been developed.

In these models, aggregate output is still defined as a function of capital, labour and technological progress, but technology itself is endogenously defined as a function of other factors, such as capital, research and development spending, and human capital, which is defined different from ordinary labour, according to the level of education workers received.

For example, Lucas (1988) presents a growth model in which output is generated via a production function of the form:

$$Y = A(t)K^{1-\beta}(lhL)^{\beta}$$

Where l is defined as the proportion of total labour time spent working, and h is what Lucas called the stock of human capital.

The production function can be rewritten in per-capita terms as

$$y = A(t)k^{1-\beta}(lh)^{\beta}$$

Capital accumulation proceeds through the differential equation as follows:

$$\dot{k} = y - c - \delta k$$

Romer (1986) assumed that aggregate output could be written as

$$Y = A(R)f(R_j, K_j, L_j)$$

Rj stands for the stock of results from expenditure on research and development by firm j. He assumed that it is spill-overs from private research efforts that lead to improvements in the public stock of knowledge A.

If the part of knowledge that firms control as an ordinary input in production—that is, as an input that is rival and hence is not associated with increasing returns, the model can be written as

Y=F(R, K, L)

Research R, physical capital K, and human capital H are assumed as ordinary inputs.

Investment remains an important factor for growth in these endogenous growth models.

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Determinants of economic growth as identified by other studies

In addition to those growth models, there have also been many other studies on the determinants of economic growth.

For example, many empirical studies run regression analyses of the cross country data to identify variables which determine the differences in the steady state income levels and in the long run growth rates among countries.

We can summarise in several groups the key factors many empirical studies have found to be important for determining economic growth.

Factors in the first group are related to physical capital accumulation, including saving rate, investment rate, financial system development (as measured by the ratio of liquidity asset to income, etc.), investment risk and incentive related policies, such as fiscal (government spending and taxation) and monetary policies and macroeconomic stability conditions, such as inflation rate;

The second group is related to human capital, including school enrolment, education spending;

The third group is related to labour force, including fertility rate, life expectancy, women participating rate;

The fourth group is related to technological progress, including research and development spending, property right protection, international trade, or openness in general (which is assumed to affect international technological transmission);

The fifth group is related to social institutions, including general market development (distortion, black market etc.), degree of low enforcement, democracy development, anti-corruption, equality (Gini coefficient), and political stability;

The final group is related to external conditions, including terms of trade, private and public foreign capital flows (including foreign aids).

Among these studies, investment is evidently found to be important for long-run growth.

In contrast, no studies have shown that consumption is among the key factors which dominate long-run growth, at least not explicitly.

We may consider consumption spending on education and healthcare as important for promoting human capital, which is a crucial factor for economic growth in the long run.

5. Consumption and economic growth

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CONSUMPTION AND ECONOMIC GROWTH

$$Max\ E_t \sum_{j=0}^{T-t} \beta^j U(C_{t+j}, Z_{t+j}, V_{t+j})$$

$$subject\ to\ A_{t+j+1} = A_{t+j}(1 + R_{t+j}) + Y_{t+j} - C_{t+j}$$

$$U'_{c_t} = E_t[U'_{c_{t+1}} \beta (1 + R_{t+1})]$$

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Although those studies about long-run growth have not found consumption as an important driver for growth, we cannot claim consumption has nothing to do with economic growth. In fact, the decision-making of individual consumers in allocating their disposable resources has very important effect on GDP growth, in both short and long run.

Individual consumers need to decide how to allocate their disposable resources in two dimensions: the intertemporal dimension of lifecycle and the dimension of an array of different types of goods and services. Their decision in the intertemporal dimension will have an important implication for the dynamics of GDP growth, while their decision in the second dimension will influence the structure of the economy.

If we focus only on the intertemporal dimension, a consumer's decision-making process can be formalized as a dynamic optimization problem, in which the consumer is supposed to maximize expected utility over lifecycle, subject to intertemporal budget constraints (Attanasio, 2000) as follows.

$$Max \ E_t \sum_{j=0}^{T-t} \beta^j U(C_{t+j}, Z_{t+j}, V_{t+j})$$

$$subject\ to\ A_{t+j+1} = A_{t+j}(1 + R_{t+j}) + Y_{t+j} - C_{t+j}$$

In the framework above, E_t is the expectation operator conditionally based on information at time t. C is a homogeneous consumption good. A is the asset the consumer can invest with a rate of return R. Y is labor income received by the consumer. In addition to C, the utility is assumed to be also a function of other variables, as denoted by Z for a vector of observable variables and by V for unobservable variables. β is the discount factor.

The necessary condition for the intertemporal maximization problem above to have a solution defines the following equation, namely, the Euler equation.

$$U'_{c_t} = E_t[U'_{c_{t+1}} \beta(1 + R_{t+1})]$$

U' is the partial derivative of the utility function with respect to consumption. It implies that marginal utility of consumption follows a first order Markov process.

The share of income a consumer would like to allocate to consumption for a given period is not arbitrary, but an outcome of his optimal intertemporal decision on the tradeoff across his lifetime.

According to the intertemporal budget constraints above, it is clear that, the more the consumer allocate his disposable resources to consumption in the current period, the less he would accumulate in his assets for the future, and thus the less he will consume in the future.

From this perspective, at the aggregate level, the ratio of consumption to GDP should also be considered dynamically as the outcome of an optimal allocation of resources by all the consumers in the economy over the long run.

The optimal ratio of consumption to GDP can vary considerably across countries, depending on their development stage and other factors.

Clearly, we cannot claim that a country with a higher ratio of consumption to GDP is better off than a country with a lower consumption ratio.

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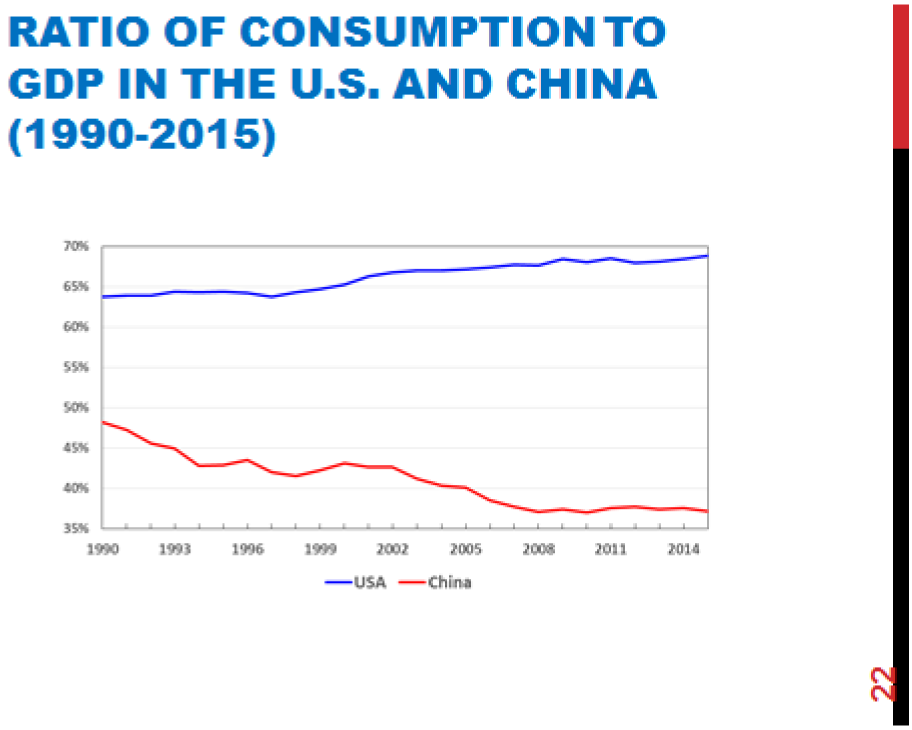

For example, consumption accounts for about 70 per cent of GDP in the United States, and less than 40 per cent in China.

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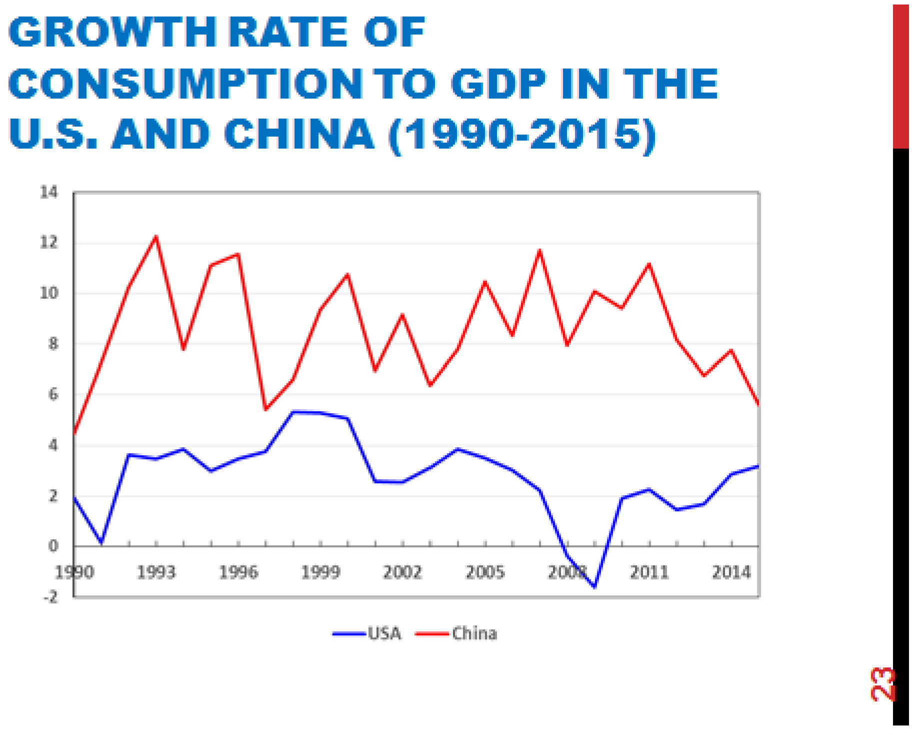

However, consumption level has been growing in China by an average of 8.7 per cent per annum in the past three decades, while it has been growing only by 2.7 per cent in the United States.

With a lower ratio of consumption to GDP, and a higher investment rate, China managed to narrow the gap in consumption level with the United States over time.

6. A few scenarios based on model simulations

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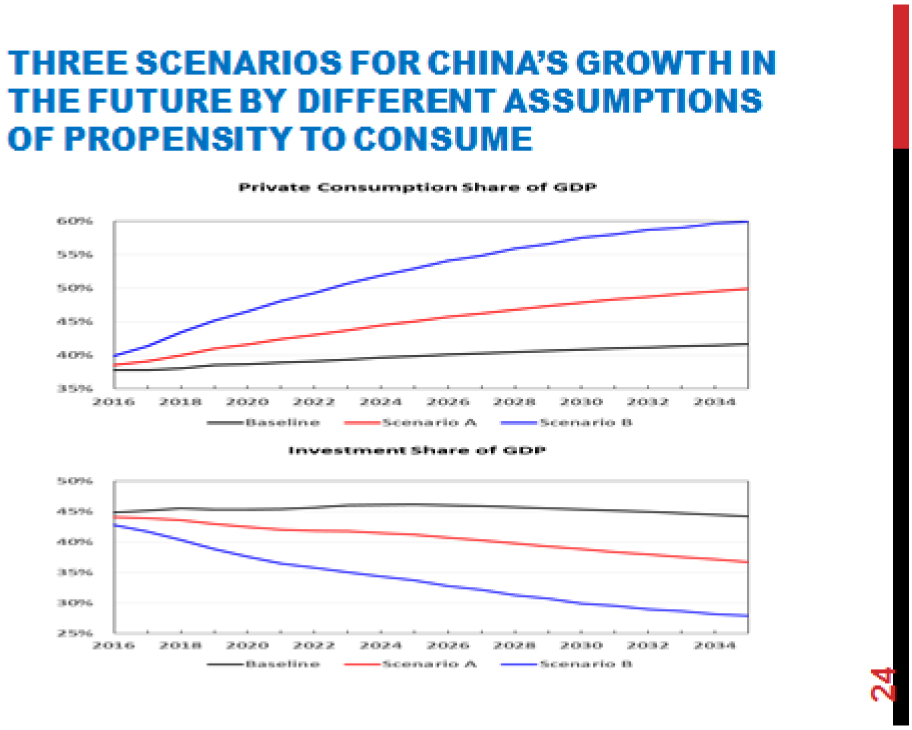

To illustrate the impact of a change in consumers' propensity to consume on the long-run GDP growth of China, we simulated a few scenarios by using the United Nations World Economic Forecasting Model (Altshuler, Clive et al. 2016), with some alternations in the specification of certain equations in the model (Annex).

We made three different assumptions on the change in the propensity to consume for the next 25 years.

In baseline, we assume consumers in China will maintain their current propensity to consume for the next 25 years. This assumption may not be realistic, as the current ratio of consumption to GDP is indeed too low to sustain, but this assumption is made for the purpose of comparison with the other two scenarios.

In scenario A, we assume the propensity to consume will increase gradually in a pace that the ratio of consumption to GDP in China will increase by about 0.5 percentage points per year in the next 25 years. By 2040, this ratio will rise to above 51 per cent, from 38 per cent of 2015.

In scenario B, we assume the propensity to consume will increase at a rate which is twice of the rate in scenario A. By 2040, the ratio of consumption to GDP in China will reach 62 per cent.

The figure also shows the change in the ratio of investment to GDP corresponding to the change in the ratio of consumption to GDP in the different scenarios, as generated by the model based on the intertemporal budget constraint (or, more precisely, the System of National Accounts at the macro level).

For example, in scenario A, as the ration of consumption to GDP increases, the ratio of investment will decline from 45 per cent of 2015 to 35 per cent by 2040.

In scenario B, the ratio of investment to GDP will drop even faster, to 26 per cent by 2040.

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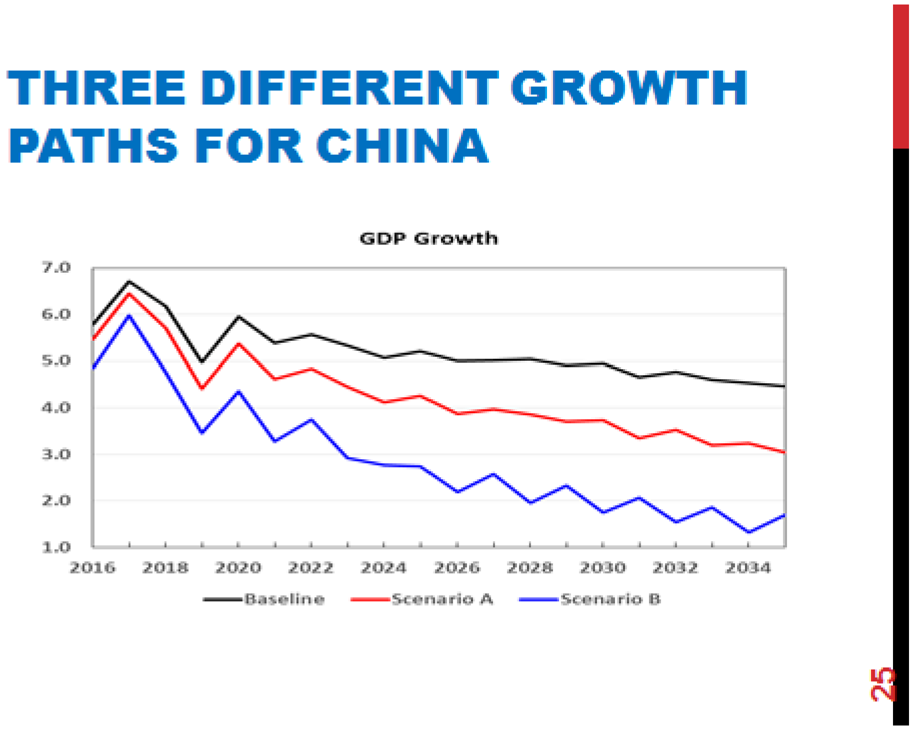

With the different assumptions on the propensity to consume, the GDP growth path for China in the next 25 years will also differ considerably.

In scenario A, as the ratio of consumption to GDP increases and the ratio of investment declines, GDP growth will taper off to a rate of 3 per cent by 2040.

In scenario B, as the ratio of consumption to GDP increases rapidly and the ratio of investment drops quickly, GDP growth will decelerate to about 1 per cent by 2040.

7. Concluding remarks

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As China becomes an upper-middle income economy, narrowing both the income gap and technological gap with advanced economies, China needs to make a transition in its growth model. However, the transition cannot be characterised by a change from "investment-driven" growth to "consumption-driven" growth. In every country, investment plays a key role in driving long-run economic growth, while consumption is the outcome of growth.

The ratio of consumption to GDP, as well as the ratio of investment to GDP, in an economy is the result of the trade-off made by consumers when they decide on the intertemporal allocation of disposable resources. The higher consumers prefer the ratio of consumption to GDP today, the lower they would invest today and thus, *ceteris paribus*, the lower GDP growth in the future.

Maintaining a relatively high level of investment relatively to GDP is the necessary condition for China to ensure a relative high GDP growth in the years to come, so as to continue narrowing its income gap with advanced economies.

Instead of focusing on the ratio of consumption to GDP (or the ratio of investment to GDP), policymakers, when they consider policies for the transition of China's growth model, should focus on how to improve economic efficiency, social inclusiveness and environmental sustainability.

Annex

Key modifications of the Chinese model in the WEFM

The World Economic Forecasting Model (WEFM) at the United Nations is developed and used in the Development Policy Analysis Division of the Department of Economic and Social Affairs to produce consistent world economic forecasts for its flagship publication, *World Economic Situation and Prospects* (WESP). The WEFM evolved from the original Project LINK programme, which started in the 1960s, and linked together individual country macro-models from up to 80 different countries in order to compute a joint global forecast. The WEFM is also used to produce alternative scenarios around the central forecast.

As explained in details in Altshuler et al (2016), the WEFM is featured by:
Long-run relationships are specified in line with standard macroeconomic theory, imposing cross-equation restrictions where required; Core behavioural relationships are specified as error-correction processes, and equations are estimated individually within a restricted environment; Cointegrating relationships are estimated either as part of a 2-step process, applying dynamic OLS procedures to first identify the long-run equations and then fitting the dynamics around the cointegrating relationships, or by applying instrumental variable techniques in a single equation framework that jointly estimates the cointegrating relationships and the dynamics; Dynamic and static homogeneity properties are imposed in the price system where appropriate; Expectations are modelled as an adaptive process; Policy variables can be endogenized via rule-based processes.

The individual country models in the WEFM contain four sectors: households, firms, government and a foreign sector, which generate aggregate demand and supply for the economy. The sectors are linked together through behavioural relationships and accounting identities to ensure overall consistency of the system.

We used the Chinese model in the WEFM to simulate different scenarios for China's GDP growth path according to different assumption on the ratio of investment/GDP. We have made changes in a few equations in the Chinese model as follows.

1. We replaced the long-run GDP trend equation by following the Lucas endogenous growth model (see Zhu, 2012 for more details).

$$Y = A(t)K^{1-\alpha}(hL)^{\alpha}$$

Y is the long-run GDP trend, K is physical capital stock, L is labour (number of workers), h is the average level of human capital, A is total factor productivity (TFP), and α is the output elasticity of physical capital, which is usually measured by capital's share of national income.

The production function can be rewritten in per-capita terms as

$$\frac{Y}{POP} = \frac{L}{POP}\ (Y/K)^{\alpha/(1-\alpha)} h\ A^{1/(1-\alpha)}$$

Growth rate of per capita GDP = growth rate of labor participation rate
+ $\alpha/(1-\alpha)$ growth rate of the capital/output ratio
+ growth rate of average human capital
+ $1/(1-\alpha)$ growth rate of total factor productivity

In the EView coding:

```
dlog(CHN_YFIT_TREND) = dlog(CHN_LNN/CHN_POP)
                     + ALPHA/(1-ALPHA)* dlog(CHN_KSR/ CHN_YFIT_TREND)
                     + CHN_HK
                     +  1/(1-ALPHA)* CHN_TFP
                     + dlong(CHN_POP)
```

2. We replaced the GDP expenditure identity (YER) by YER = YFT, as in this study we are interested in the long-run GDP trend only, but not the short-run fluctuation of the GDP.

3. We add a new equation for capital stock accumulation:

   CHN_KSR = (1-DEPKSR)*(CHN_KSR(-1)+ CHN_ITR

4. We changed the equation for the consumption function CHN_PCR:

```
dlog(CHN_PCR)  =  - 0.0262528 - 0.060950*(log(CHN_PCR(-1))-log(CHN_RPDI(-1)))+
CHN_PCRRATIO*dlog(CHN_RPDI)
+ (1- CHN_PCRRATIO)*dlog(CHN_POP) - 0.1*(dlog(CHN_HIC)-log(CHN_INFT/100+1))
```

5. We replaced the investment function for CHN_ITR: by the budget identity:

```
@IDENTITY CHN_ITR = CHN_YER –(CHN_PCR + CHN_GCR + CHN_SCR +
CHN_XTR - CHN_MTR)
```

By doing so, we have introduced three new variables:

CHN_KSR: Total capital stock, real
CHN_HK: Growth rate of human capital

CHN_PCRRATIO: propensity to consume
We have also introduced two parameters:
AlPHA is a constant.
DEPKSR is a constant, capital depreciation rate.
We followed the study by *Zhu (2012)* to initiate the new variables and parameters as follows.
ALPHA=0.5
DEPKSR =0.06
CHN_HK = 0.011 (human capital is assumed to grow at an annual rate of 1.1%)
Initiate CHN_KSR for the base-year 2015 recursively as follows:
CHN_KSR (2015) = (1-DEPKSR)*(CHN_KSR(2014)+ CHN_ITR(2015)
CHN_KSR (2014) = (1-DEPKSR)*(CHN_KSR(2013)+ CHN_ITR(2014)
CHN_KSR (2013) = (1-DEPKSR)*(CHN_KSR(2012)+ CHN_ITR(2013)
Until:
CHN_KSR (1996) = (1-DEPKSR)*(CHN_KSR(1995)+ CHN_ITR(1996)
Assume the investment made before 1996 has depreciated to zero by 2015.

Instead of assuming CHN_TPF = 0.03 as in Zhu (2012), we linked the total factor productivity to fixed investment formation:

CHN_TPF = 0.074 * ((1/5)*(CHN_ITR/ CHN_YFIT_TREND + CHN_ITR(-1)/ CHN_YFIT_TREND(-1) + CHN_ITR(-2)/ CHN_YFIT_TREND(-2)+ CHN_ITR(-3)/ CHN_YFIT_TREND(-3) + CHN_ITR(-4)/ CHN_YFIT_TREND(-4)) -0.0011
We initiated **CHN_PRCRATIO** = 0.659366, according to the coefficient in the existing model, for producing the baseline, but we increased the propensity to consume for producing the alternative scenarios.

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