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# STRUCTURAL TRANSFORMATION AND ITS IMPLICATIONS FOR THE CHINESE ECONOMY

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## Abstract

This study applies a two-sector model to examine the conditions under which the excess labour force can be reallocated from the tradable to the nontradable sector during structural transformation. We find that to maintain employment stability, output in the nontradable sector should be 1.9-to-3.5 percentage points higher than in the tradable sector, if labour shares in the two sectors approach the level of major developed economies in the next one and a half decades. Such output differentials mean the productivity increment in the nontradable sector should reach as high as 1.5 percentage points at the start, if job loss in the tradable sector is associated with negative investment shocks, or 1 percentage points if job loss is associated with an improvement in efficiency. In the absence of technological progress in the nontradable sector, the government should increase its consumption of nontradables by as much as 4 percentage points to help maintain employment. While the pure labour reallocation has a small effect on aggregate output, the shrinking working population and an improvement in efficiency in the tradable sector have larger effects on aggregate output. Price falls only slightly and the real exchange rate change is small during structural transformation. Although the structural transformation goal seems achievable, it is important to revive high-end tradable industries through product innovations to reduce employment pressure on the nontradable sector.

**Keywords**: Structural Transformation, Tradable, Nontradable, Real Exchange Rate, Employment, Fiscal Policy, Switching Cost

**JEL classification**: F31, F32, J11, O11, O14, O23

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# 1. Introduction

The Chinese economy is experiencing a structural transformation witnessed by a growing tertiary industry and a slowly shrinking secondary industry, along with a huge decline in output share of the primary industry (Figure 1). Although this structural change is partly attributable to global downturn and international competition in the tradable goods market, it has, as its inherent driving force, domestic demand for service goods, which increases with higher household income and productivity gains. The changing industrial structure is accompanied by a changing employment pattern. Specifically, employment continues to grow in the tertiary industry, while employment in the primary industry falls. Secondary industry employment has reached its turning point and started to decline (Figure 2). These are stylised facts of structural transformation once observed in developed economies (See Herrendorf, *et al*., 2014).

In anticipation of growing job loss in the secondary industry due to a reduction in production capacity and an improvement in process efficiency, a crucial question is under what circumstances job creation could be large enough to offset job loss so that, on an aggregate level, employment remains stable. Historically, the primary industry is a pure source of surplus labour in the past two decades, while the secondary and tertiary industries are net labour receivers. As employment capacity in the secondary industry has reached its turning point, the tertiary industry must bear the pressure of providing opportunities for a labour force migrating from other industries. The underlying argument is that structural transformation and employment stability may not be automatically achieved in an open economy. Macro and industrial policies， therefore， must play a role in promoting growth to accommodate employment shifting. In this regard, to tackle this question has important policy implications.

We apply a two-sector model to explore this issue. To do this, we classify industries into tradable and nontradable sectors, where the tradable sector consists of most sub-industries of manufacturing and mining, while the remaining industries, including agriculture and service, belong to the nontradable sector. This classification implies that our focus is labour force movement between manufacturing and non-manufacturing sectors, rather than between the agriculture and non-agriculture sectors. The question in this context is under what circumstances the excess labour force in the tradable sector can be absorbed by the nontradable sector.

The production in each sector is carried out by constant return to scale technologies under free labour and capital mobility.[1] Meanwhile, the demand side is described by a CES utility function. We expect that in one and a half decades, the employment share in the nontradable sector will increase from the current 58% to 70% (i.e., the share in major developed economies), which is equivalent to a labour transfer of 2.1% annually from the tradable sector.[2] Considering the shrinking working age population (or the natural labour force adjustment) after 2017, the excess labour force the nontradable sector must absorb will be less than that moving out of the tradable sector.

We consider two scenarios, one is reduction in production capacity (called investment shocks), the other is improvement in process efficiency (called efficiency changes)，both of which tend to reduce hiring in the tradable sector. To absorb the excess labour force migrating from the tradable sector, the nontradable sector must grow faster than the tradable sector. The resultant output differential curve is downward sloping, where the annual output growth in the nontradable sector has to be 3.5 percentage points higher than in the tradable sector at the start to meet labour reallocation requirement, when the natural labour force adjustment is considered. Such output differentials suggest that productivity growth in the nontradable sector must add as much as 1.5 percentage points to meet labour reallocation requirements, if job loss in the tradable sector is caused by negative investment shocks. The required productivity growth in the nontradable sector will be smaller if job loss in the tradable sector is caused by efficiency changes in the tradable sector. In the absence of technological progress in the nontradable sector, government could increase its expenditure on nontradables to expand output to absorb the excess labour force. The required government consumption increment in general is declining. It must reach 4 percentage points at the start after considering the natural working population changes, if the tradable sector faces negative investment

[1] While free capital mobility is assumed throughout the paper, labour mobility could be costly, which we will discuss later.

[2] We assume an even labour transfer from the tradable sector per annum. However, we may assume uneven labour transfer rate if necessary.

shocks. The required government consumption increment is much lower if the tradable sector faces efficiency changes. The fiscal expansion is welfare improving for consumers if job switching is not cost prohibitive, although it will increase budget deficit in the short-to-medium run.

Consistent with the balanced growth theory, we find that the pure labour reallocation has only a very small effect on aggregate output growth if the labour force remains stable. However, the natural labour force adjustment could drag down aggregate output growth significantly. If job loss in the tradable sector is caused by an improvement in process efficiency, then such an improvement would dominate other factors and lead to output gains by 1.5-2.1 percentage points each year during the transformation period. Meanwhile, the transformation process would result in a moderate price fall and overall small real exchange rate movements, no matter whether the job loss in the tradable sector is caused by efficiency changes or negative investment shocks.

The paper is organised as follows. In Section 2 we review the related literature on structural transformation. In Section 3 a two-sector supply-side framework is applied to describe the relationship between labour reallocation and output differentials. In Section 4 a CES utility function is introduced into the model so output becomes endogenous and labour reallocation condition is associated with productivity growth in both the tradable and nontradable sectors. In Section 5, consumption is divided into private and public consumption, so the role of government expenditure on nontradables in labour reallocation can be analyzed. Further discussions are followed in Section 6 on the aggregate output, inflation and the real exchange rate under strcutural transformation, cost and benefit of fiscal policy, and the effectiveness of fiscal policy in the presence of switching costs. In Section 7 we discuss whether and how employment stability goal can be achieved. Section 8 concludes.

## 2. Related literature

Structural transformation refers to resource re-allocations across broad sectors (i.e., agriculture, manufacturing and services) in the process of economic growth. During the transformation period, the economy in industry disaggregation is characterised by Kuznets facts in terms of employment, output and consumption. Specifically, employment is shifting from agriculture to manufacturing and services. However, the share of employment in manufacturing appears to increase in the early stage of development before flatting out and then declining in the late stage of development, while the share of employment in services does not show a hump shape, as does in manufacturing. Meanwhile, shares of output and consumption expenditure show patterns more or less similar to the share of employment. Despite the sectoral resource re-allocation, the characteristics of balanced growth at a steady state, known as the Kaldor facts, are generally maintained in the aggregate level (See Kongsamut *et al*. (2001), and Herrendorf *et al*. (2014)).[3]

The main driving forces behind structural transformation are income effects and relative price effects. Income effects are in general introduced in theoretical models by various specifications of non-homothetic utility function, so a change in income would lead to a change in expenditure shares and in output shares without relative price changes (See Herrendorf *et al*. (2014), Kongsamut *et al*. (2001), Echevarria (1997), Boppart (2014), Foellmi and Zweimuller (2008), and Hall and Jones (2007)). Under certain conditions, these models can mimic some of the Kuznets facts at the disaggregate level and Kaldor facts at the aggregate level. Empirical studies suggest that income effect cannot be ignored for structural transformation in the US (Dennis and Isan (2009), and Herrendorf *et al*. (2013)).

Relative price effects refer to the effects of relative output price change on output, consumption and employment across sectors along the balanced growth path. The relative output price change could originate from productivity shocks at differential rates across sectors (See Ngai and Pissarides (2007)), or from relative input price changes (even without productivity shocks) if sectors possess different input intensity (See Caselli and Coleman (2001), and Acemoglu and Guerrieri (2008)). Besides technology progress and input intensity, the elasticity of substitution between inputs could also be important in explaining relative price effects (See Alvarez-Cuadrado *et al*. (2016)). Buera and Kaboski (2012) alternatively introduce skill intensity differences in the production side as a source of relative price effects, ascribing the rising share of services to the rising consumption demand for more skill-

[3] Kaldor facts claim that at a steady state, per-capita output growth, the capital-output ratio, the real return to capital, and the labour (and capital) share in national income are roughly constant.

intensive output associated with higher skill premium for workers, which occurs only at higher income level. Nevertheless, heterogeneity in skill intensity for different types of output can be regarded as a measure of productivity differentials across sectors. Empirical analysis suggests technological differences, capital intensity and elasticities of substitution contribute to structural transformation, among which the technological differential is the main contributor (Herrendorf *et al*. (2013)).

There are also some studies focusing on China's structural transformation. For example, Cao and Brirchenall (2013) analyze China's economic transformation by a two-sector neoclassical model featuring non-homothetic preferences and heterogeneous productivity. They find the higher productivity growth in agriculture is the prominent driving force for labour movement. Dekle and Vandenbroucke (2012) incorporate the public sector and moving costs to a two-sector neoclassical model along with non-homothetic preferences and heterogeneous productivity growth, arguing that, in addition to high productivity growth in agriculture, the shrinking public sector and lowering moving barriers also contribute to employment shifts.

Other than focusing on agriculture and non-agriculture, Brandt and Zhu (2010) and Song *et al*. (2011) primarily investigate the role of the private sector in economic transformation. Brandt and Zhu (2010), by using a three-sector growth model, find labour reallocation from the state to non-state sectors contributes to aggregate labour productivity growth more than reallocation from agriculture to non-agriculture. Song *et al*. (2011) examine the impact of financial market frictions on resource reallocation between two types of industries (within manufacturing) with different capital intensities in an open economy. They find that private firms with high productivity growth but facing financial restrictions eventually specialise in labour-intensive industries, while SOEs able to access the credit market end up with capital-intensive industries. Liao (2014) dichotomises services into distribution services and personal services and compares the role of the income effects and relative price effects in structural transformation. The simulation shows that the income effect dominates the relative price effect.

Our paper complements the existing literature by addressing how to maintain employment stability in an open economy and its implications for macroeconomy during the transformation period. We rely on productivity differentials of the relative price effects rather than non-homothetic preferences to address structural transformation. Unlike the existing literature, unemployment emerges due to disinvestment or efficiency changes in the tradable sector. We start with a model setting as in Obstfeld and Rogoff (1996) and reach labour reallocation conditions in terms of output differentials, productivity growth and government consumption in a unified framework. In this framework, we can directly observe the effect of the natural labour force adjustment on employment conditions, which is significant in its magnitude, especially as time passes.[4] Besides the model setting, this study supplements the exisiting literature in terms of various macroeconomic and policy implications of structural transformation. While there are studies on output, inflation and the real exchange rate movements under structural transformation (see for example, Obstfeld and Rogoff (2007), Obstfeld (2011), Dekle and Ungor (2013)), analysis on economic transition with employment stability in china is few, and the effectiveness of fiscal policy for employment stability under economic transition is even fewer. our study fills this gap.

# 3. Labour reallocation under a supply-side framework

There is a direct link between labour and output as labour is an input for production. Changes in output of a sector would cause labour to flow in or out of it. In this section, we only consider labour determination from supply side. Given wage and the labour income share, the output differential is sufficient to determine the relative size of employment across sectors.

### 3.1. Relative size of employment and output differentials

We start with a typical two-setor model setting analogous to Obstefeld and Rogoff (1996) and the existing literature on structural transformation, with one sector being called the tradable sector and the other the nontradable sector. The sectoral classification is based on trade flows, where an industry is classified into the tradable sector if its gross trade accounts for at least 10 percent of its value added, otherwise it is classified into the nontradable sector. According to this classfication, the tradable sector consists of manufacturing and mining industries except tobaco-alcohol-and-food

[4] Fujita and Fujiwara (2016) analyze the impact of declining labour force entry rate (i.e., the share of workers between 15 and 24 in the total labour force) on the low-frequency behavior of the Japanese economy. With a heterogeneous labour structure in a search and matching model, they show that the demographic change accounts for 40% of the decline in per capita consumption growth and the real interest rate during 1970-2010. We, however, focus on the change in total working-age population with homogeneous labour structure.

processing, while the nontradable sector consists of the remaining industries. [5] This classification suggests labour reallocation, for example, from the primary industry into the tertiary industry and tobaco-alcohol-and-food processing or the reverse is treated as intra-sectoral labour mobility, and will not be considered in this model.

The tradable and nontradable production functions, *f*(.) and *g*(.) with capital and labour being the only inputs, are Hicks neutral. Let $k_T$ (or $k_N$) be the capital labour ratio, $w_T$ (or $w_N$) the nominal wage in the tradable (or non-tradable) sector, and *r* the world interest rate in terms of tradable goods, then under perfect foresight and perfect capital mobility, the first order conditions combined with the zero-profit condition yield[6]

$$y_T = Y_T/L_T = A_T f(k_T) = rk_T + w_T \qquad (1)$$

$$q\, y_N = q\, Y_N/L_N = qA_N g(k_N) = rk_N + w_N \qquad (2)$$

where *q* is the price of domestic non-tradable goods relative to domestic tradable goods (or, IRER, the internal real exchange rate), and $A_T$ and $A_N$ are the total factor productivity (TFP) of the tradable and non-tradable sectors respectively. Static analysis with respect to *A*, *k*, and *w* after log-differencing Equations (1)-(2) (with *r* being internationally given) yields

$$\hat{A}_T = \frac{w_T}{A_T f(k_T)}\hat{w}_T = s_T \hat{w}_T \qquad (3)$$

$$\hat{q} + \hat{A}_N = \frac{w_N}{qA_N g(k_N)}\hat{w}_N = s_N \hat{w}_N \qquad (4)$$

where a "hat" over a variable denotes log-difference, $s_T = \frac{w_T L_T}{Y_T} = \frac{w_T}{A_T f(k_T)}$ and $s_N = \frac{w_N L_N}{qY_N} = \frac{w_N}{qA_N g(k_N)}$ are the respective share of labour income in the total output of the tradable and non-tradable sector. We denote $m = \frac{\hat{w}_N}{\hat{w}_T}$, and from Equations (3)-(4) the change in the relative price can be written as

$$\hat{q} = m\frac{s_N}{s_T}\hat{A}_T - \hat{A}_N \qquad (5)$$

[5] De Gregorio *et al*. (1994), He et al. (2014) and Johnson (2017) apply this classification to their studies. In developing countries, agriculture could be classificed in the tradable sector as a result of free trade. China is an exception, with its agricultural production having been largely in a self-sufficient mode, and its agricultural prices do not necessarily move in tandem with international prices.

[6] We may alternatively assume monopolistic competition in model, but the constant price markup under this assumption will drop out once expressions are log-differenced. Furthermore, capital depreciation has no effect on employment conditions.

Equation (5) states that the relative price is determined by productivity differentials. The higher productivity growth in the tradable sector, the higher relative price will be. Contrarily, higher productivity growth in the nontradable sector leads to a lower relative price.

We assume Cobb-Douglas production schemes for tradables and nontradables, i.e.,

$$Y_T = A_T K_T^{1-s_T} L_T^{s_T}, \qquad (6)$$

and

$$Y_N = A_N K_N^{1-s_N} L_N^{s_N}, \qquad (7)$$

which can be rewritten as

$$\hat{L}_T = \hat{Y}_T - \hat{A}_T - (1 - s_T)\hat{k}_T \qquad (8)$$

and

$$\hat{L}_N = \hat{Y}_N - \hat{A}_N - (1 - s_N)\hat{k}_N \qquad (9)$$

where $k_T$ and $k_N$ are the respective capital-labour ratio in the tradable and nontradable sectors. The corresponding marginal product of labour in the form of growth rate in the tradable sector is given by

$$\hat{w}_T = \hat{A}_T + (1 - s_T)\hat{k}_T \qquad (10)$$

while, in the nontradable sector, it is given by

$$\hat{w}_N = \hat{q} + \hat{A}_N + (1 - s_N)\hat{k}_N \qquad (11)$$

Substituting $\hat{\mathrm{k}}_{\mathrm{T}}$ from Equation (10) into Equation (8) and $\hat{\mathrm{k}}_{\mathrm{N}}$ from Equation (11) into Equation (9) results in

$$\hat{L}_T = \hat{Y}_T - \hat{w}_T \qquad (12)$$

and

$$\hat{L}_N = \hat{q} + \hat{Y}_N - \hat{w}_N \qquad (13)$$

Equations (12)-(13) indicate that the relative size of employment is

$$\hat{L}_N - \hat{L}_T = [(\hat{q} + \hat{Y}_N) - \hat{Y}_T] - (\hat{w}_N - \hat{w}_T) \qquad (14)$$

Equation (14) states that the relative size of employment is determined by output differentials adjusted by wage differentials.[7]

### 3.2. How large should output differentials be to absorb the excess labour force?

To maintain stable employment, a reduction in employment in one sector must be matched by at least an equal rise in labour demand in the other sector. In other words, the job creation in the nontradable sector must be no less than the job loss in the tradable sector, i.e.,

$$L_N \hat{L}_N - (-L_T \hat{L}_T) \geq 0 \tag{15}$$

or

$$\hat{L}_N \geq \tfrac{L_T}{L_N}(-\hat{L}_T) = \tfrac{1-\theta_N}{\theta_N}(-\hat{L}_T) \tag{15'}$$

where $\theta_N = \dfrac{L_N}{L_T + L_N}$ is the labour share of the nontradable sector, which is time-variant due to labour reallocation. In this context, $\hat{L}_N \geq 0$ (i.e., jobs are created in the nontradable sector) and $\hat{L}_T \leq 0$ (i.e., jobs are destructed in the tradable sector). Substituting $\hat{L}_N$ from Equation (14) into Inequality (15') gives rise to the necessary condition for the nontradable sector to fully absorb the job loss in the tradable sector, when the total labour force is fixed:

$$\theta_N \{[(\hat{q} + \hat{Y}_N) - \hat{Y}_T] - (\hat{w}_N - \hat{w}_T)\} \geq (-\hat{L}_T) \tag{16}$$

Now consider the case when the total labour force is changing over time. Denote the natural growth rate of labour force as $\lambda$, then Inequality (16) should be morphed into

$$\tilde{\theta}_N \{[(\hat{q} + \hat{Y}_N) - \hat{Y}_T] - (\hat{w}_N - \hat{w}_T)\} \geq (-\hat{L}_T) + \lambda \tag{16'}$$

where $\tilde{\theta}_N = 1 - \frac{1-\theta_N}{1-\lambda}$ is the labour share of the nontradable sector, which is corresponding to the labour share of the tradable sector $\tilde{\theta}_T = \frac{1-\theta_N}{1-\lambda} = \frac{L_T}{(1-\lambda)(L_T + L_N)}$. When $\lambda = 0$, $\tilde{\theta}_N = \theta_N$, Formula (16') is the same as Formula (16). In view of the aging population in China, $\lambda \leq 0$, so the job loss in the tradable

[7] Alternatively, Equation (14) can be obtained from the share of labour income in the total output. The share of labour income in the tradable sector relative to the nontradable sector, $\frac{s_N}{s_T} = \frac{w_N}{w_T}\frac{L_N}{L_T}\frac{Y_T}{qY_N}$, suggests $\hat{L}_N - \hat{L}_T = [(\hat{q} + \hat{Y}_N) - \hat{Y}_T] - (\hat{w}_N - \hat{w}_T) + (\hat{s}_N - \hat{s}_T)$. When the shares of labour income are constant, this expression is the same as Equation (14).

sector will, in part, be mitigated by naturally occurring retirement, and the additional jobs required in the nontradable sector will be less than otherwise. We see below that the impact of $\lambda$ is pretty large on resource reallocation.

Before quantifying the employment stability conditions in a time horizon, it is necessary to make assumptions about some variables, such as job loss, labour income, labour share, wages and total labour force based upon our sectoral classification.

(a) Labour share and the job loss rate

The overall labour share of the nontradable sector, $\theta_N$, rose gradually from 0.53 in 2009 to 0.58 in 2014, largely reflecting an increasing service demand in urban areas (Figure 3). However, the labour share of the nontradable sector is still low compared to main developed economies. For example, the labour share of the nontradable sector in1991 was 85.2% in the US, 83.7% in the UK, 75.6% in Japan and 75.7% in Germany, according to our sectoral classification.

We assume $\theta_N$ will increase to 70% from the current 58% in one and a half decades in China. This share approaches that in Japan and German in early 1990s. It means that the annual job loss rate in the tradable sector, $-\hat{L}_T$, will be 2.1%, which is largely in line with international experience in major developed economies (Table 1). For instance, the annual job loss in the UK during the last one and a half decades was 2.6%, while in the U.S. it was 1.6%. The job loss in Germany and Japan was in between.[8] We assume that the annaul job loss rate is independent of the natural labour adjustment.

(b) Wages

Wages in the tradable and nontradable sectors have been moving in tandem with each other (Figure 4). During 2004-2014 the annual wage growth was 14.1% in the tradable sector and 13.1% in the nontradable sector. While the average wage in the nontradable sector was slightly higher than in the

[8] Industrial firm data shows the total job loss in the tradable sector was 5.2 million during 2013-mid 2015, or 4% a year. However, such a dramatic job loss should better be regarded as a short-term phenomenon.The job loss in the tradable sector in the UK during 1980-2014 was 2.6%. In Japan during the same period it was 1.2%, which suggests that Japan's job loss in the tradable sector was more severe during 1990-2014.

tradable sector, they are expected to converge, given continued high labour mobility. In our simulation, we assume wages are equalised across sectors.[9]

(c) Natural labour force adjustment

According to the projection by the United Nations, China's working age population (i.e., 15-64 years old) will start to decline in 2017 and maintain downtrend thereafter. Initially the change of the working age population is small, around 0.11% of the total. But in 2031, it will reach 0.85% of the total working age population (Figure 5). Therefore, the effect of the change of the working age pupulation will become larger as time passes. We assume the labour participation rate is constant so the natural labour force adjustment rate $\lambda$ is the same as the percentage change of working age population .

Our simulation spans one and a half decades and the results are shown in Figure 6.[10] The growth rate in the nontradable sector should be 3.7 percentage points higher than that in the tradable sector in the first year to absorb the excess labour force when the total labour force is fixed.The required output differential will reduce to 3.1 percentage points at the end of the period. When the natural labour force adjustment is considered, the curve of the required output differentials moves down. Specifically, the required output differential would be 3.5 percentage points at the start, and reduce to 1.9 percentage points at the end of the period.[11]

The impact of the natural labour force adjustment appears to be pretty large. At the beginning, a decline in the total labour force by 0.11% lowers the required output differential by 0.2 percentage point. At the end of the period, a decline in the total labour force of 0.85% lowers the required output differentials by 1.2 percentage points, almost 40% less than the former 3.1 percentage points.

[9] Alternatively we may assume a 1-percentage-point differential of the wage growth rate in the simulation horizon, which would only cause a parallel shift of our results. We will come back to this later.

[10] The labour share of the nontradable sector is plotted with the case when the total labour force is fixed.

[11] If we assume the wage growth differential of 1 percentage point persist, then the curves for output growth differentials will have a parallel shift-up by one percentage point, so the nominal growth rate in the nontradable sector should be 4.1-4.7 percentage points higher than that in the tradable sector if the total labour force is fixed, or 2.9-4.5 percentage points higher when the total labour force is changing.

# 4. Labour Reallocation under a demand-supply framework

The supply-side model reveals the linkage between labour force reallocation and output differentials, but it does not tell how to reach such output differentials. In this section, we will incorporate demand factors into the model to link labour reallocation to productivity growth. Specifically, output of nontradables is matched by domestic consumption, which is pinned down by the relative price and household expenditure. The relative price and household expenditure are affected by productivity growth. Due to the symmetry of job loss in the tradable sector and job creation in the nontradable sector, we only need to consider job creation in the nontradable sector, from which the output differential obtained from the previous section is preserved. Since each period we have targeted labour reallocation from the tradable to the nontradable sector, intertemporal optimality is not applicable here, and the framework is based upon intra-temporal optimality to address resource reallocation across sectors. However, the analysis is able to be conducted in a dynamic way, as financial wealth, capital, and working age pupulation evolve over time.

### 4.1. Consumption scheme and labour demand in the nontradable sector

Following Obstfeld and Rogoff (1996), we assume a representative consumer possess a CES utility function subject to her budget constraint *Z*, i.e.,

$$U(C_{T,}C_N) = \left[\gamma^{1/\theta} C_T^{(\theta-1)/\theta} + (1-\gamma)^{1/\theta} C_N^{(\theta-1)/\theta}\right]^{\theta/\theta-1} \quad (17)$$

$$s.t.\ Z = C_T + q\, C_N \quad (18)$$

where $\gamma \epsilon (0,1)$ is the share of consumption in tradables, and $\theta$ is the elasticity of substitution between tradables and nontradables. The optimal condition is given by

$$\frac{\gamma C_N}{(1-\gamma)C_T} = q^{-\theta} \quad (19)$$

which leads to the demand functions for tradables and nontradables:

$$C_T = \frac{\gamma Z}{\gamma + (1-\gamma)q^{1-\theta}} \quad (20)$$

$$C_N = \frac{(1-\gamma)Zq^{-\theta}}{\gamma + (1-\gamma)q^{1-\theta}} \quad (21)$$

Equations (20)-(21) are classical demand functions, where consumption is positively related to the total expenditure and negatively related to the relative price. Log-differencing Equation (21) with the initial value of *q* to be unity yields[12]

$$\hat{C}_N = \hat{Z} - [\gamma\theta + (1-\gamma)]\hat{q} \tag{22}$$

Remember that consumption expenditure *z* can be expressed in terms of the return on financial wealth *Q* and wage income, i.e.,

$$Z = rQ + wL \tag{23}$$

Therefore a deviation from the steady state expenditure could be accompanied by a change in wage income and financial wealth, i.e.,

$$\hat{Z} = \varphi_1\hat{w} + \varphi_2\hat{Q} = \varphi_1\frac{\hat{A}_T}{s_T} + \varphi_2\hat{Q} \tag{24}$$

where $\varphi_1$ and $\varphi_2$ are the share of labour and financial income in the total income in the previous period respectively.

Now we assume that the growth rate of consumption and output of nontradables are equal, i.e.,

$$\hat{C}_N = \hat{Y}_N \tag{25}$$

Combining Equations (3), (5), (9) and (11) with Equations (22)-(25) gives rise to the labour demand in the nontradable sector in terms of productivity growth：

$$\hat{L}_N = \hat{Z} - [s_N\gamma(\theta-1)+1]\frac{\hat{A}_T}{s_T} + \gamma(\theta-1)\hat{A}_N \tag{26}$$

or

$$\hat{L}_N = \varphi_2\hat{Q} + [\varphi_1 - s_N\gamma(\theta-1)-1]\frac{\hat{A}_T}{s_T} + \gamma(\theta-1)\hat{A}_N \tag{27}$$

It should be aware that $\widehat{Q}$ is also endogenous depending on the evolution of capital and net foreign assets, i.e.,

[12] Log-differencing Equation (20) yields $\hat{C}_T = \hat{Z} - (1-\theta)(1-\gamma)\hat{q} = \hat{C}_N + \theta\hat{q}$. In fact, $C_N = (1-\gamma)\left(\frac{q}{p}\right)^{-\theta} C$ and $C_T = \gamma\left(\frac{1}{p}\right)^{-\theta} C$, where $p = [\gamma + (1-\gamma)q^{1-\theta}]^{\frac{1}{1-\theta}}$ is the consumption based price index and, $C = \frac{Z}{P}$ is the total real consumption.

$$Q_t = NFA_t + K_t, \quad (28)$$

where subscript t denotes period. Q can further be expressed as

$$Q_t = (1+r)NFA_{t-1} + Y_{t-1} - C_{t-1} + K_{t-1} \quad (28')$$

with

$$NFA_t = (1+r)NFA_{t-1} + Y_{t-1} - C_{t-1} - I_{t-1} \quad (29)$$

The dynamics of $\hat{Q}$ can be traced out given the initial value of *NFA*, *Y*, *C*, and *K*, yet we will not write it down explicitly.

**4.2. How large should productivity growth be to absorb the excess labour force?**

Plugging $\hat{L}_N$ in Equation (27) into Equation (15') yields the condition for productivity growth to absorb the excess labour force from the tradable sector:

$$\frac{\theta_N}{1-\theta_N}\{\varphi_2\hat{Q} + [\varphi_1 - s_N\gamma(\theta-1) - 1]\frac{\hat{A}_T}{s_T} + \gamma(\theta-1)\hat{A}_N\} \geq (-\hat{L}_T) \quad (30)$$

When the natural adjustment in the total labour force is considered, Formula (30) should be morphed into

$$\frac{\tilde{\theta}_N}{1-\tilde{\theta}_N}\left\{(\varphi_2\hat{Q}) + [\varphi_1 - s_N\gamma(\theta-1) - 1]\frac{\hat{A}_T}{s_T} + \gamma(\theta-1)\hat{A}_N\right\} \geq \left(-\hat{L}_T\right) + \frac{\lambda}{1-\tilde{\theta}_N} \quad (30')$$

Again we calibrate the model before conducting simulations. As shown in Table 2, $s_N$ and $s_T$ possess a V-shaped movement during 2002-2012, but remain stable during 2010-2012.[13] While $\gamma$ is less than 0.40 on average, the urban income structure reveals the share of wage income $\varphi_1$ has declined from 0.71 in 2000 to 0.64 in 2013 (Figures 7-8). Accordingly in our simulation for dynamic forecasting purpose, we set these variables to their recent values, i.e., $S_N$ = 0.6, $S_T$ = 0.5, $\gamma$ = 0.3, and $\varphi_1$ = 0.64.[14] We estimate that $\theta$ is around 4.9 (See Appendix 1 for more details), which means $\varphi_1$ –

[13] The ratio, $s_N/s_T$, remains pretty stable especially during 2007-2012, which supports our method to estimate output differentials in the supply-side framework.

[14] The value of parameters depends on sectoral classification. Liao (2014),by using I-O tables for the period of 1984-2007, estimates that labour income share in agriculture, manufacturing, distribution services and personal services is 0.85, 0.40, 0.47 and 0.42 respectively. While Dekle and Vandenbroucke (2012) calibrate the labour income share in agriculture and manufacturing to be 0.76 and 0.46 respectively, Brandt and Zhu (2010) , Chang et al. (2016) and Song et al. (2011) assume that labour income share to be 0.5 across sectors. On the other hand, Liao (2014) calibrates consumption share of manufacturing goods to be 0.84 when consumption of agriculture goods is excluded in calculation, while Brandt and Zhu (2010) and Dekle and Vandenbroucke (2012) calibrate consumption share of all non-agriculture goods to be 0.85 and 0.95 respectively.

$s_N\gamma(\theta-1)-1<0.$[15] It follows that a positive $A_T$ shock would reduce employment in the nontradable sector, other things being equal. Similarly, a positive $A_N$ shock would increase employment in the nontradable sector, as the falling relative price induces demand for nontradables.

To capture the wealth effect $\hat{Q}$, we have to determine the initial values for output, capital, consumption and net foreign assets. we estimate the initial $L_N$ and $L_T$ according to employment in urban non-private firms and township enterprises in 2014. We normalize the initial productivity level $A_N$ and $A_T$ to be unity, and assume the world real interest rate $r$ = 3% (which is close to the average benchmark lending rate net of CPI inflation rate in China during 2007-2016), so that we are able to back out the initial capital stock $K_T$ from the first order condition for capital in the tradable sector and calculate the inital output $Y_T$ accordingly. We back out the initial capital stock $K_N$ and the relative price $q$ from the first order condition for capital in the nontradable sector and, calculate the inital output $Y_N$ with the ratio of $Y_N$ to $Y_T$ being consistent with the actual data in 2014. The initial consumption $C_T$ (or $C_N$) is obtained by multiplying the initial output $Y_T$ (or $Y_N$) by the corresponding actual consumption-to-output ratio in 2014. Similarly, the initial net foreign asset position *NFA* is obtained by multiplying the initial output (i.e., $Y_T$+$qY_N$) by the actual *NFA*-to-output ratio in 2014. We set the initial current account to be zero, so that the initial investment coul be calibrated by using the current account identity.

We conduct two scenarios below. In Scenario 1, the job loss is triggered by negative investment shocks in the tradable sector, which is associated with weak internal and external demand and hence the over-capacity problem. In Scenario 2, the job loss is triggered by improvement in process efficiency in the tradable sector, which can occur, for example, when more automation technologies are applied in the tradable sector to replace human power.

#### *4.2.1. Scenario with initial investment shocks*

In this scenario, $\hat{A}_T=0$, which means constant capital intensity in both sectors.[16] The excess labour force is generated by disinvestment in the tradable sector in view of the weak demand，which would

[15] In a model with three sectors (i.e., agriculture, manufacturing, and services), Liao (2014) calibrates the elasticity of substitution between manufacturing and distribution services to be 0.7 in China, while the elasticity of substitution between personal services and home production goods to be 4.05. Dekle and Vandenbroucke (2012) assume the elasticity of substitution between agriculture and manufacturing to be unity in China, while Chang et al. (2016) assume the elasticity of substitution between retail goods to be 10.

further cause layoffs in the nontradable sector as consumption of service goods drops due to wealth effect. We assume that half of disinvested goods can be consumed. Simulations show the required productivity increment in the nontradable sector is declining. When the natural adjustment of the labour force is considered, the required additional productivity growth is around 1.5 percentage points at the start. At the end of the simulation period, productivity increment reduces to 0.3 percentage points, as the natural labour force declines significantly (Figure 9). It is natural that the required productivity increment would be higher without labour force adjustment.

Figures 10-14 list the response of other variables to productivity shocks in the process of labour reallocation, taking into consideration the natural labour adjustment. The positive productivity shocks to the nontradable sector cause the relative price of nontradables to fall, though at a decelerating pace, while wages remain unchanged in the absence of productivity shocks to the tradable sector (Figure 10). Output of nontradables increases mainly due to the falling relative price, whereas output of tradables shrinks at the rate of job loss in the sector, which is 2.1% annually, with output differentials being preserved (Figure 11). Consumption of nontradables moves in tandem with output of nontradables, while consumption of tradables declines due to relative price shifts (Figure 12). The constant capital intensity means that the change in capital stock is governed by labour force changes in each sector (Figure 13).[17] The reduction in production capacity also causes financial wealth to decline (Figure 14).

#### *4.2.2. Scenario with initial efficiency changes*

This scenario differs from the previous one in that the excess labour force is generated by an improvement in process efficiency in the tradable sector, where capital stock remains unchanged. We assume the effect of efficiency changes is asymmetric in that they will induce investment in the nontradable sector without changes in employment. Under this setting, the required productivity increment in the nontradable sector to absorb the excess labour force from the tradable sector is lower than that in the previous scenario, as efficiency gains in the tradable sector result in a rise in

[16] This simple treatment is useful for our analysis. In reality, external shocks could cause changes in tradable productivity growth and financial wealth each period.

[17] The model setting implies that $\hat{k}_N = \hat{k}_T = \hat{w} = \frac{\hat{A}_T}{s_T}$.

financial wealth. The required productivity increment in the nontradable sector is close to 1.2 percentage points at the highest without labour force adjustment and declines slowly thereafter. However, it reduces to 1 percentage point after labour force adjustment is considered. In 13 years, no more productivity increment in required as the natural labour force adjustment offsets job loss completely (Figure 15).

The relative price of nontradables is decreasing in the whole period (Figure 16). The output in the nontradable sector rises while the tradable sector remains unchanged (Figure 17). Consumption of tradables and nontradables possesses a similar pattern to that in the previous scenario. The response of the capital stock is similar to that of output (Figure 18). The efficiency changes lead to accumulation of financial wealth (Figure 20).

# 5. Role of government expenditure on structural transformation

In the previous section we assume that both consumption and output of nontradables are in the balanced growth path, and there is no role for government to play in labour reallocation. In reality, government can affect labour demand and other macro variables by its expenditure on consumption and investment. In this section we examine the role of government consumption of nontradables, $\mathrm{G_N}$, on economic transition.[18]

We rewrite consumption of nontradables as the summation of private and government consumption:

$$C_N^h + G_N = C_N \tag{31}$$

so that

$$\alpha \hat{C}_N^h + (1-\alpha)\hat{G}_N = \hat{Y}_N \tag{32}$$

[18] Investment is endogenous in this setting and we do not specifically model public investment under this framework, nor public consumption of tradables.

where $\alpha$ and $(1-\alpha)$ are respectively the time-varying share of private and government consumption of nontradables. Combining Equation (31) with Equations (9) and (11) and using $\hat{k}_N = \frac{\hat{A}_T}{s_T}$ leads to the labour demand in the nontradable sector[19]

$$\hat{L}_N = \alpha \hat{C}_N^h + (1-\alpha)\hat{G}_N - \frac{1-s_N}{s_T}\hat{A}_T - \hat{A}_N \qquad (33)$$

which suggests that the necessary condition for the nontradable sector to absorb the excess labour force would be

$$\frac{\theta_N}{1-\theta_N}[\alpha \hat{C}_N^h + (1-\alpha)\hat{G}_N - \frac{1-s_N}{s_T}\hat{A}_T - \hat{A}_N] \geq (-\hat{L}_T) \qquad (34)$$

or,

$$\frac{\tilde{\theta}_N}{1-\tilde{\theta}_N}\left[\alpha \hat{C}_N^h + (1-\alpha)\hat{G}_N - \frac{1-s_N}{s_T}\hat{A}_T - \hat{A}_N\right] \geq \left(-\hat{L}_T\right) + \frac{\lambda}{1-\tilde{\theta}_N} \qquad (34')$$

when the natural adjustment in the total labour force is considered. If the government expenditure follows the rule $\hat{G}_N = \hat{C}_N^h$ ex ante, which is equivalent to a subsidy to consumers, then the results obtained in the last section would remain intact, provided that the consumption represents private and government consumption combined. If however, $\hat{G}_N$ is set independent of the private consumption, then Equations (34) and (34') should be rewritten as

$$\frac{\theta_N}{1-\theta_N}\{\alpha\varphi_2\hat{Q} + [\alpha\varphi_1 - \alpha s_N(\gamma\theta - \gamma + 1) - (1-s_N)]\frac{\hat{A}_T}{s_T} + [\alpha\gamma\theta + \alpha(1-\gamma) - 1]\hat{A}_N + (1-\alpha)\hat{G}_N\} \geq (-\hat{L}_T)$$

(35)

or as

$$\frac{\tilde{\theta}_N}{1-\tilde{\theta}_N}\{\alpha\varphi_2\hat{Q} + [\alpha\varphi_1 - \alpha s_N(\gamma\theta - \gamma + 1) - (1-s_N)]\frac{\hat{A}_T}{s_T} + [\alpha\gamma\theta + \alpha(1-\gamma) - 1]\hat{A}_N + (1-\alpha)\hat{G}_N\} \geq$$

$$(-\hat{L}_T) + \frac{\lambda}{1-\tilde{\theta}_N} \qquad (35')$$

when the natural adjustment in the total labour force is considered. Given $\alpha$ and other parameters applied in the previous section, $\alpha\varphi_1 - \alpha s_N(\gamma\theta - \gamma + 1) - (1-s_N)$ is negative and $\alpha\gamma\theta + \alpha(1-\gamma) - 1$ slightly greater than zero.[20]

[19] In this case the budget constraint of Equation (23) should be modified as *Z= (1-τ)*(rQ+wL)*, whereτ is the tax rate. We assume the aggregate tax rate is constant in the simulation period, so Equations (24) and (24') remain unchanged. It should be noted that the tax income for the government may not equal its expenditure each period, which would lead to fiscal surplus or deficit. We will discuss the fiscal balance later.

Suppose the share of government expenditure on nontradables in the total government expenditure is the same as the share of consumption of nontradables in the total consumption, which is 78.8%, then the share of government expenditure in the total consumption (or output) of nontradables is around 0.46, given the total government expenditure of RMB15.2 trillion and the consumption of RMB25.9 trillion of nontradables in 2014. We assume that other parameters remain the same as in the previous sections. Our following simulation is based on these calibrated parameters. Again, we examine two scenarios, one with initial investment shocks, the other with initial efficiency changes, in the tradable sector.

### 5.1. Government consumption with initial investment shocks

In this scenario, we have $\hat{A}_T = 0$. In the absence of productivity shocks, the pace of expansion in the government consumption required for labour reallocation is determined by the rate of job loss in the tradable sector and financial wealth. Figure 21 shows the increment of government consumption of nontradables necessary to absorb excess labour force from the tradable sector. At the start the government has to increase its consumption of nontradables by 4 percentage points when the natural labour force adjustment is considered. At the end of the simulation period, the government consumption increment reduces to 0.7 percentage points.

Since capital intensity remains unchanged in the absence of productivity shocks, output and capital stock will adjust the same as the labour force in each sector, while output differentials obtained in Section 3 are preserved (Figures 22-23). The absence of productivity shocks also means the relative price of nontradables remains unchanged, so the consumption of tradables and nontradables will be affected only by total expenditure with the same magnitude, which is, in turn, affected by financial wealth (Figures 24-25).

### 5.2. Government consumption with initial efficiency changes

[20] The dynamics of financial wealth should be modified as $Q_t = (1+r)NFA_{t-1}+Y_{t-1}-C_{t-1}-G_{t-1}+K_{t-1}$ with $NFA_t = (1+r)NFA_{t-1}+Y_{t-1}-C_{t-1}-G_{t-1}-I_{t-1}$.

In this scenario, the required increment of government consumption of nontradables after labour force adjustment is lower than that in the scenario with initial investment shocks due to the wealth effect brought by an improvement in process efficiency (Figure 26).

As efficiency changes are assumed to take effect through employment channels in the tradable sector, output and capital stock adjustment occur only in the nontradable sector (Figures 27-28). While consumption of nontradables increases more than that in the scenario with initial investment shocks, consumption of tradables falls less (Figure 29). Financial wealth accumulates over time (Figure 30).

# 6. Macro implications of structural transformation: further discussion

In this section we examine the aggregate output, inflation and the real exchange rate during the transformation period, and discuss the welfare aspects of fiscal policy. We find the nature of the shocks associated with job losses in the tradable sector and the nature labour force adjustment have profound effects on aggregate output, but moderate effects on inflation and the real exchange rate. Fiscal policy is welfare improving as long as job switching is not cost prohibitive, despite it will cause fiscal deficit to increase.

### 6.1. Aggregate output and inflation under economic transition

Output growth in period t can be calculated as $\hat{Y}_t = x(\hat{q}_t + \hat{Y}_{N,t}) + (1-x)\hat{Y}_{T,t}$ with $x = \frac{q_{t-1}Y_{N,t-1}}{Y_{T,t-1}+q_{t-1}Y_{N,t-1}}$ being the weight for nontradables. In the first scenario, when wages are equalised across sectors and productivity shock $\hat{A}_T = 0$, $\hat{q}_t + \hat{Y}_{N,t} = \hat{L}_{N,t}$ and $\hat{Y}_{T,t} = \hat{L}_{T,t}$, which implies that the change in output growth comes from labour reallocation and the natural labour force adjustment. We calculate $\hat{Y}_t$ with and without the natural labour force adjustment respectively, between which the difference is the contribution of labour force adjustment. Figure 31 shows output gains slightly by labour reallocation when employment level is maintained. However, the contribution of the natural labour force adjustment is relatively large, leading to a fall in output growth. The fall in output growth during structural transformation ranges from 0.1 percentage points to 0.8 percentage points, and it becomes more significant as time passes.

In the second scenario, when job loss in the tradable sector is caused by efficiency changes $\hat{A}_{T,t}$, $\hat{q}_t + \hat{Y}_{N,t} = \hat{L}_{N,t} + \frac{\hat{A}_{T,t}}{s_T}$ and $\hat{Y}_{T,t} = \hat{L}_{T,t} + \frac{\hat{A}_{T,t}}{s_T}$, based upon this, and the formula for $\hat{q}_t$, we re-calculate the aggregate output growth. Output growth shifts up comparing to the scenario with initial investment shocks. The aggregate growth increment ranges from 1.3 to 2.1 percentage points (Figure 32).

The growth in the two scenarios can be viewed as lower bound and upper bound of output growth respectively in the following one and a half decades. In reality, the weak demand for tradable goods and technological progress in the tradable sector co-exist, which means the actual output growth would stand between the two simulated results. At this stage, it appears weak demand dominates technological progress, leading to a fall in output growth, though at a slow pace.

As mentioned earlier, $p = [\gamma + (1-\gamma)q^{1-\theta}]^{\frac{1}{1-\theta}}$ is the consumption-based price index, according to which we calculate price changes. In both scenarios, inflation is calculated with productivity growth $\hat{A}_N > 0$ to stabilize employment. While initial negative investment shocks in the tradable sector have no effects on *q*, initial efficiency changes in the tradable sector will cause *q* to fall. Meanwhile, $\hat{A}_N > 0$ in both scenarios will depress *q*. As a consequence, structural transformation tends to cause prices to fall, but the magnitude of its impact appears to be small (Figures 33-34).[21]

### 6.2. Real exchange rate under economic transition

Obstfeld and Rogoff (1996) have discussed the Harrod-Balassa-Samuelson effect, the linkage between productivity differentials and the real change rate movement. Obstfeld and Rogoff (2007) and Obstfeld (2011) further show how the current account and net foreign assets affect the real exchange rate through the terms of trade and the relative price of tradables and nontradables (which essentially is the Harrod-Balassa-Samuelson effect) in a two-country model, where tradables are differentiated into home and foreign produced ones. Dekle and Ungor (2013) conduct a counter-factual analysis on China-US bilateral real exchange rate in a two-country, three-sector model of structural transformation, where the transition is driven by sectoral labour productivities. Lane (2011) conducts an empirical

[21]. If $\hat{A}_N = 0$ and fiscal policy is applied to stablize employment, then inflation is zero in the first scenario and price falls even less in the second scenario.

study on the links between Japan's long-run real exchange rate and its economic indicator, including net foreign assets, the terms of trade (captured by the real oil price), and productivity differantials.

We examine the real exchange rate impact of the current account and net foreign asset movements following Obstfeld and Rogoff (2007). Due to the analytical framework set earlier, we are not able to differentiate between the import price and the export price, and hence to estimate the exchange rate impact through the channel of the terms of trade. Nevertheless, the current account and net foreign asset movements in one economy can still affect the relative price of nontradables in the other economy in this general equilibrium model setting.

In this two-country model, home represents China and foreign the rest of the world. The structure of home economy has been described in former sections. For foreign country, only consumption structure is outlined in the model while production side not explicitly defined. To be consistent with convention in exchange rate literature, here the domestic tradable price and foreign tradable price are denoted as $P_T$ and $P_T^*$ respectively with $P_T = €P_T^*$ , where € is the nominal exchange rate. Suppose home's tradable output is distributed across the border as

$$Y_T = \phi\Lambda_T + (1-\phi^*)\Lambda_T^* \qquad (36)$$

where $\Lambda_T$ $(\Lambda_T^*)$ is home's (foreign) domestic absorption of tradables, and $\phi$ $(\phi^*)$ the share of $\Lambda_T$ $(\Lambda T^*)$ produced at home (in foreign economies), then

$$P_T Y_T = \phi P_T \Lambda_T + (1-\phi^*)€P_T^*\Lambda_T^* \qquad (37)$$

As home' s current account can be expressed as

$$CA = rNFA + P_T Y_T - P_T\Lambda_T \qquad (38)$$

it follows that

$$\phi(1+rb - ca) + (1-\phi^*)(1/\Omega_T - rb + ca) = 1 \qquad (39)$$

where $\Omega_T = Y_T / Y_T^*$, $b = NFA/Y_T$, and $ca = CA/Y_T$. In addition, we assume a CES utility function for foreign country similar to that for home, the equilibrium in foreign nontradable market is then characterized by[22]

$$€P_N^* Y_N^* = \frac{1-\gamma*}{\gamma*}\left(\frac{P_N^*}{P_T^*}\right)^{1-\theta^*}(€P_T^* Y_T^* - rNFA + CA) \qquad (40)$$

[22] For simplicity, we do not distinguish between government and private consumption of nontradables in foreign country.

which can be rewritten as

$$\Omega_N^* = \frac{1-\gamma*}{\gamma^*}\left(\frac{P_N^*}{P_T^*}\right)^{-\theta^*}(1-\Omega_T rb + \Omega_T ca) \qquad (41)$$

where $\Omega_N^* = \frac{Y_N^*}{Y_T^*}$, $\gamma^*$ and $\theta^*$ are respectively the share of consumption of nontradables and the elasticity of substitution between tradables and nontradables in foreign country.[23] Combining Equation (39) with Equation (41) yields the relative price $q^*$ in foreign country:

$$q^*=\frac{P_N^*}{P_T^*} = \left\{\frac{1-\gamma^*}{\gamma^*}\frac{1-\phi(1+rb-ca)}{\Omega_N^*[\emptyset^*+(1-\phi-\emptyset^*)(1+rb-ca)]}\right\}^{\frac{1}{\theta^*}} \qquad (42)$$

In the presence of $P_T$ and $P_T^*$, the consumption based price index at home and in foreign country is $P_T\left[\gamma+(1-\gamma)q^{1-\theta}\right]^{\frac{1}{1-\theta}}$ and $P_{\mathrm{T}}^*\left[\gamma^*+(1-\gamma^*)(q^*)^{1-\theta^*}\right]^{\frac{1}{1-\theta^*}}$ respectively. Given $P_T = €P_{\mathrm{T}}^*$, the real exchange rate $ER$ can be expressed as

$$ER = \frac{\left[\gamma+(1-\gamma)q^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma^*+(1-\gamma^*)(q^*)^{1-\theta^*}\right]^{\frac{1}{1-\theta^*}}} \qquad (43)$$

By using World Development Indicators complied by the World Bank, we estimate that in 2015, $\Omega_N^*$ =2.66, $\phi^*=0.98$, $\phi=0.3$, and assume they remain unchanged in the following 15 years. [24] As in Obstfeld and Rogoff (2007), we set $\theta^*$ to be 0.5 as the lower bound and 2 as the upper bound for foreign country. We also set $\gamma^*=\gamma=0.3$. The real exchange rate changes in two scenarios corresponding to section 5 (i.e., government consumption with initial investment shocks and government consumption with initial efficiency changes) are listed in Table 3, where a negative number means depreciation of home currency. It appears that the real exchange rate impact of structural transformation is small except in the first period when the movments in current account and net foreign assets cause a jump in the rate.

### 6.3. Fiscal position and its effect on private consumption

[23] Symmetrically, foreign tradable output is distributed across the border as $Y_T^* = (1-\phi)\Lambda_T + \phi^*\Lambda_T{}^*{}_T$ , and foreign current account can be expressed as $-CA = -rNFA + €P_T{}^*Y_T{}^* - €P_T{}^*\Lambda_T{}^*$. The equilibrium in home nontradable market is characterized by Equation (19).

[24] We take industrial output in the World Devlopment Indicators as tradable output to estimate $\Omega_N^*$. It should be mentioned that Industry in the World Development Indicators includes utilities which are classified as nontradables at home.

The after-tax budget constraint in the previous section, i.e., *Z= (1-τ)*(rQ+wL)*, means the percentage change of the government revenue equals $\hat{Z}$. We assume that, at the start, the fiscal budget is balanced so $G_N = \tau^*(rQ+wL)$, which implies the tax rate τ=14.5%.[25]

In both scenarios, the increase in government consumption of nontradables leads to a fiscal deficit (Figure 35). However, the fiscal deficit is lower in the scenario with initial efficiency changes than that with initial investment shocks, since improvement in efficiency delivers output growth through productivity gains and hence the government revenue. The annual fiscal deficit in the scenario with initial investment shocks could reach as much as 7.5% of the output, comparing with only 1.1% as much with initial efficiency changes.

Despite the rising fiscal deficit, the increase in government consumption of nontradables helps mitigate the volatility of private consumption. In the absence of government stimulus, the unemployment associated with the job loss in the tradable sector when $\hat{A}_N = 0$ would be persistent, which means the average private expenditure of the representative agent based on the overall income change becomes

$$\hat{Z} = \varphi_1[\widehat{w} + (1-\theta_N)\hat{L}_T + \theta_N\hat{L}_N^s] + \varphi_2\hat{Q}, \qquad (44)$$

where $\hat{L}_N^s$ is the job loss in the nontradable sector incurred by persistent job loss $\hat{L}_T$. This budget constraint in the absence of government stimulus means consumption of the representative agent will be lower than that in the presence of government stimulus, if we compare Figure 36 with Figure 24, and Figure 37 with Figure 29. In other words, fiscal policy helps mitigate consumption loss in both scenarios.

### 6.4. Switching cost and the effectiveness of fiscal policy

The employment dynamics described above are based on the assumption that the job switch from the tradable sector to the nontradable sector is costless. In reality, job switch could be associated with unemployment spells as well as searching and retraining costs. For example, Ge and Lehmann (2013) examine a survey dataset, the Rural to Urban Migration in China (RUMC), finding that job switch

[25] The tax rate derived from I-O tables is around 18% of output. Here the tax rate is the percent of output and interest income from net foreign assets. We do not consider government consumption of tradables.

leads to 6-to-8.5-month unemployment spells for urban residents. Dekle and Vandenbroucke (2012) estimate the cost for job switch from agriculture to manufacturing in China to be 55% of annual income in manufacturing by 2003. Lee and Wolpin (2006) build a multi-sector multi-occupation competitive model to explain a large shfit in occupation from manufacturing to services in the U.S. without sizeable wage differentials between the two sectors. They find that the switching cost is around 75% of the annual income.

Besides a pure estimation of switching costs, one interesting question is to what extent the switching cost would affect the effectiveness of fiscal policy aiming to create employment. It is obvious that larger switching costs require more fiscal input to promote employment, i.e., $G_N = G_N(k)$ is an increasing function of the switching cost *k*. When the switching cost is high enough, fiscal policy may not be worthy of consideration as the benefit brought forth by the policy is smaller than the social welfare loss from unemployment. In this section, we estimate the threshold switching cost associated with fiscal policy under two scenarios (i..e, with initial negative investment shocks and initial efficiency changes). Similar to Lee and Wolpin (2006) and Dekle and Vandenbroucke (2012), we allow the switching cost to enter the budget constraint directly. Suppose each worker's switching cost is *s*, then the total switching cost is $sL[(1-\theta_N)\hat{L}_T + \theta_N \hat{L}_N^s]$, and the first order approximation of the overall income change net of switching cost is

$$\hat{Z} = \varphi_1\{\hat{w} + k[(1-\theta_N)\hat{L}_T + \theta_N \hat{L}_N^s]\} + \varphi_2 \hat{Q}, \qquad (45)$$

where $k=s/w$ is the switching cost per worker relative to wages, and wealth change $\hat{Q}$ is a function of *k*. The term $\varphi_2 \hat{Q}$ characterizing employment dynamics in functions (27) and (27'), (30) and (30'), (35) and (35'), should be modified as $\varphi_1 k[(1-\theta_N)\hat{L}_T + \theta_N \hat{L}_N^s] + \varphi_2 \hat{Q}$ accordingly.

Rather than evaluating the threshold switching cost year by year, we estimate the threshold for the whole simulation period in terms of the present value of utility. As stated above, if the switching cost *k* is large enough, government will not use fiscal policy to promote employment, i.e., $\hat{G}_N = 0$. In this case, job loss is persistent and the budget constraint of the representative agent is characterized by Equation (45) with $k$=1, which is equivalent to Equation (44). The corresponding present value of utility is denoted by PV($U(C_T, C_N)|k=1, \hat{G}_N=0$). On the other hand, if the switching cost *k* is acceptable, then government will use fiscal policy to promote employment, i.e., $\hat{G}_N = \hat{G}_N(k) > 0$. In this case the budget constraint is characterized by Equation (45) with $k$ being a free parameter. The corresponding present value of utility is denoted by PV($U(C_T, C_N)|k, \hat{G}_N(k) > 0$). The condition for government to exert fiscal policy to promote employment is therefore

$$\text{PV}(U(C_T, C_N)\,|\,k{=}1, \hat{G}{=}0) \leq \text{PV}(U(C_T, C_N)\,|\,k, \hat{G}_N(k){>}0) \qquad (46)$$

The threshold value of $k$ can be solved numerically by taking the equal sign in Formula (46). To calculate the present value of utility, we use the real interets rate of 3% as the discount rate. The solutions are displayed in Table 4. In the presence of initial negative investment shocks in the tradable sector, the threshold switching cost is around half of the annual wage income. However, In the presence of efficiency changes in the tradable sector, the threshold switching cost is much higher, around one and a half times the annual wage income. These results suggest that, when the job loss is accompanied by technological progress in the tradable sector, it is desirable to use fiscal policy to promote employment even with higher switching costs, as output gains from technological progress are also much higher.

# 7. Is employment stability achievable during structural transformation?

We have put forth the necessary conditions for the nontradable sector to absorb excess labour force from the tradable sector in terms of output differentials, productivity growth and government expenditure. In general, these requirements could be satisfied.

### 7.1. Job creation in the nontradable sector

In Section 3, we have estimated that output growth in the nontradable sector has to add 1.9 to 3.5 percentage points relative to the tradable sector to absorb excess labour force. According to our classification, the growth rate in the nontradable sector has been higher than that in the tradable sector in recent years (Figure 38). Given the growth differential in 2014 of 4.8 percentage points, the additional 1.9 to 3.5 percentage points mean 6.5 to 8.3 percentage point growth differential in the following one and a half decades. Historically, the largest growth differential was 8.7 percentage points in the last two decades. Therefore, expansion in the nontradable sector by an additional 1.9-to-3.5 percentage points is feasible from a retrospective view.

In the long run, productivity growth is the key to employment. To achieve the employment goal, the non-tradable sector must raise its total factor productivity growth by an additional 1.5 percentage points at most in the following decade. In reality，the productivity growth in the two sectors was trending down after 2006, while the nontradable productivity growth was 2.7 percentage points lower than that in the tradable sector during 2006-2010 (He *et al*., 2014). Given such productivity differentials, an increase in the productivity growth in the nontradable sector by 1.5 percentage point at most seems practical, if economic structure in China would converge to advanced economies where productivity differentials are much lower. For example, during 1990-2004, the annual productivity growth in the tradable sector was 0.7 percentage point higher than in the nontradable sector in the U.S., while in the EU and Japan, it is even lower in the tradable sector than in the nontradable sector (Figure 39).

One way to promote productivity growth in the nontradable sector is institutional reform, removing entry barriers and allowing competition among service companies to improve efficiency. Another way is to upgrade public service infrastructure, including internet infrastructure. As revealed in the "learning by doing" model, the public infrastructure may generate the sector-wide (or economy-wide) externalities that raise the marginal product of capital throughout the whole sector (or economy).[26] In this regard, the effect of public infrastructure upgrading is equivalent to efficiency changes or technological progress in the nontradable sector.

As demonstrated earlier, government could expand its expenditure or subsidise consumers to increase demand for nontradables in order to create jobs, in the absence of positive productivity

[26] Although each individual firm is still subject to decreasing return to scale to its input, the production function for the whole sector may exhibit constant return to scale in firm-specific capital intensity and the public capital intensity combined. According to Barro (1990) and Barro and Sala-i-Martin (2004), the traditional Cobb-Douglas function for each firm *i* is augmented by total public capital stock $K_{NG}$ in the nontradable sector, i.e., $Y_N^i = A_N^i K_N^{i,1-s_N} L_N^{i,s_N} K_{NG}^{s_N}$. Since the marginal product of capital is equal across firms, each firm would reach the same capital intensity and the aggregate production function would be $Y_N = A_N K_N^{1-s_N} L_N K_{NG}^{s_N}$, where $K_{NG} = k(\frac{K_{NG}}{Y_N})^{\frac{1}{1-s_N}}(A_N L_N)^{\frac{1}{1-s_N}}$. With constant capital intensity *k* and investment-output ratio, an increase in $K_{NG}$ would lead to a rise in $L_N$.

growth in the nontradable sector. In 2014， government expenditure increased by 8.3%, the lowest in the past one and a half decades, during which the average growth rate was 17.8% (Figure 40). Since the required increment in government expenditure is 4 percentage points at the start and decays quickly, such an increase would not change the overall government fiscal scheme very much, and hence is feasible.

**7.2. Employment revival in the tradable sector**

So far we do not clearly distinguish two types of productivity gains, one is product innovations, the other process innovations. The efficiency changes belong to process innovations, which would cause job losses. Product innovations increase product variety and would increase employment with little displacement (See Acemoglu and Autor (2011), Jaumandreu (2003), Peters (2004) and Harrison *et al*. (2014)). In this regard, product innovations are crucial to revive employment in the tradable sector.

While some low-end tradable industries in China are losing competitiveness, some high-end tradable industries are gaining market share through management and technological innovations. Examples of such successful firms include Foxconn and Huawei, both of which are big product innovators, and have a profound impact on employment in the manufacturing industry in China.

Foxconn started to build its plants in Shenzhen in 1988. It invented the eCMMS (e-enabled Components, Modules, Moves and Services) business model, which vertically integrates JDSM (Joint Design Manufacture), JDVM (Joint Development Manufacture), GLM (Global Logistics Management) and ASS (After-Sales Service) to raise economic efficiency and lower costs. It has been expanding sundry varieties from a single product of electrical connector at the beginning to its present 3C (computer, communication, and Consumer) product series. It is now the world largest semiconductor foundry.

Contrarily to Foxconn, which manufactures a variety of products, Huawei, created in late 1980s, has its own brand name with its core business focusing on information and network solutions. By 2012, it had become the world’s largest telecommunication equipment producer.

Despite the difference in their business models, there is a common factor that drives their fast growth: R&D input. Although Foxconn is a sundry firm, it maintained innovation. In 2014 it invested USD1.4 billion in R&D and its number of patents surpassed 10,000. Huawei's R&D is more significant. It invested US$6.5 billion in 2014 and US$9 billion in 2015, accounting for14.2% and 15.1% of annual sales respectively. It employs about 170,000 workers, of which 45% are scientific researchers. The huge R&D input has generated more than 80,000 patents, ahead of other IT-related companies.

China has the potential to revive the tradable sector owing to its large human capital. In the last two decades, China has accumulated human capital a level other countries can hardly compare with. For example, more than 5 million students a year have obtained a bachelor's degree since 2008. Also starting from 2008, the number of students who received overseas education and returned to China jumped (Figure 41). Such human capital, if fully utilised, could push up productivity growth in both sectors.

# 8. Conclusion

Labour mobility is an important issue of structural transformation. The surplus labour freed from the rural areas has contributed to China's modernisation and urbanisation process. However, the dynamic economic structure requires the excess labour force be diverted from shrinking industries to fast growing industries or those with increasing demand for their products. This paper studies how to reallocate excess labour force from the tradable to the nontradable sector, while maintaining employment stability in the aggregate level. We find that in order to maintain employment levels, the annual output growth in the nontradable sector should be 1.9-to-3.5 percentage points higher than in the tradable sector, if employment share in the nontradable sector approaches the level of major developed economies in one and a half decades. Correspondingly, productivity growth in the nontradable sector should increase as much as 1.5 percentage points at the start in order to absorb the excess labour force, and the required increment is decaying over time. In the absence of technological progress in the nontradable sector, the government could increase its consumption of nontradables by 4 percentage points at most to help labour reallocation and maintain employment stability. Although the fiscal balance may deteriorate in the short-to-medium run, the government expenditure is welfare improving for households, if job switching is not cost prohibitive.

We confirm that, during the transformation process, the pure labour reallocation has a small effect on aggregate output, which is consistent with the balanced growth theory. However, the shrinking working age population has a significant effect on aggregate output. Furthermore, if job loss is caused by an improvement in efficiency in the tradable sector, then such productivity gains will dominate other factors and promote aggregate output dramatically. Price falls only slightly during structural transformation, and the real eachange rate impact of strutrual transformation is small.

While the required job creation in the nontradable sector seems achievable, it is also important to revive high-end tradable industries by product innovations that will expand employment opportunities and help relieve employment pressure on the nontradable sector.

# References


Acemoglu, Daron, and David Autor (2011), Handbook of Labour Economics, Volume 4b, Orley Ashenfelter and David E. Card (eds), Elsevier, Amsterdam.

Acemoglu, Daron, and Veronica Guerrier (2008), “Capital Deepening and Non-balanced Economic Growth”, *Journal of Political Economy*, 116, pp.467-498.

Alvarez-Cuadrado, Francisco, Ngo Van Long, and Markus Poschke (2016), “Capital-Labour Substitution, Structural Change, and Growth”, Working Paper, Department of Economics, McGill University.

Barro, Robert J., and Xavier Sala-i-Martin (2004), Economic Growth, 2nd Edition, MIT Press, Cambridge, Massachusetts.

Barro, Robert J. (1990), “Government Spending in a Simple Model of Endogenous Growth”, *Journal of Political Economy*, 98, October, Part II, S103-S125.

Boppart, Timo (2014), Structural Change and the Kaldor Facts in a growth Model with Relative Price Effects and Non-Gorman Preferences, Econometrica, V8(6), pp. 2167-2196.

Brandt, Loren, and Xiaodong Zhu (2010), “Accounting for China’s Growth”, IZA Discussion Paper, 2010.

Buera, Francisco J., and Joseph P. Kaboski (2012), “The Rise of the Service Economy”, *American Economic Review* 102(6), pp. 2540-2569.

Cao, Kang H., and Javier a. Birchenall (2013), “Agricultural productivity, Structural Change, and Economic Growth in Post-Reform China”, *Journal of Development Economics*, 104, pp. 165-180.

Caselli, Francesco, Wilbur Hohn Coleman (2001), “The U.S. Structural Transformation and Regional Convergence: A Reinterpretation”, *Journal of Political Economy*, 109, pp. 584-616.

Chang, Chun, Zheng Liu, Mark M. Spiegel, and Jingyi Zhang (2016), “Reserve Requirements and Optimal Chinese Stabilization Policy", Federal Reserve Bank of San Francisco Working Paper 2016-10, http://www.frbsf.org/economic-research/publications/working-papers/wp2016-10.pdf.

Dekle, Robert, and Murat Ungor (2013), “The Real Exchange Rate and the Structural Transformation of China and the U.S.”, *International Economic Journal*, V27(2), pp. 303-319.

Dekle, Robert, and Guillaume Vandenbroucke (2012), “A Quantitative Analysis of China’s Structural Transformation”, *Journal of Economic Dynamics and Control*, 36(1), pp. 119-135.

De Gregorio, J., A. Giovannini and H. C. Wolf (1994), “International Evidence on Tradables and Non-Tradables Inflation”, *European Economic Review*, 38(6): 1225-44.

Dennis, Benjamin N., and Talan B. Iscan (2009), “Engle versus Baumol: Accounting for Structural Change Using Two Centuries of U.S. Data”, *Explorations in Economics History*, 46, 186-202.

Echevarria, Cristina (1997), “Changes in Sectoral Composition Associated with Economic Growth”, *International Economic Review*, 38, pp. 431-452.

Foellmi, Reto, and Josef Zweimuller (2008), “Structural Change, Engel’s Consumption Cycles, and Kaldor’s Facts of Economic Growth”, *Journal of Monetary Economics*, 55, pp. 1317-1328.

Fujita, Shigeru, and Ippei Fujiwara (2016), "Declining Trends in the Real Interest Rate and Inflation: The Role of Aging", Working Paper, Federal Reserve Bank of Philadelphia, http://cepr.org/sites/default/files/Fujiwara%20-%20FF-August2015.pdf.

Ge, Yuhao and Hartmut Lehmann (2013), "The Costs of Worker Displacement in Urban Labour Markets of China", *IZA Journal of Labour & Development*, V2(4), pp. 1-23.

Haltiwanger, J. (2012), "Job Creation and Firm Dynamics in the United States", Innovation Policy and the Economy, Volume 12, Josh Lerner and Scotts Stem (eds), University of Chicago Press, pp. 17-38.

Haltiwanger, J., R.S. Jarmin and J. Miranda (2013), "Who Creates Jobs? Small Versus Large Versus Young", *The Review of Economics and Statistics*, 95(2) 347-361.

Hall, Robert E., and Charles I Jones (2007), "The Value of Life and the Rise in Health Spending", *The Quarterly Journal of Economics*, 122, pp. 39-72

Harrison, Rupert, Jordi Jaumandreu, Jacques Mairesse, and Bettina Peters (2014), "Does Innovation Stimulate Employment? A Firm-Level Analysis Using Comparable Micro Data from Four European countries", *International Journal of Industrial Organization*, V35, pp.29-43.

He, Dong, G. Han, T. Wu, and W. Zhang (2014), "Productivity Growth of the Non-tradable Sectors in China", *Review of Economic Developmen*t, V18(4).

Herrendorf, Berthold, Richard Rogerson, and Akos Valentinyi (2014), "Growth and Structural Transformation", in Agion, Phillipe, and Steven Durlauf (eds), Handbook of Economic Growth and Structural Transformation, Universidad Carlos III de Madrid e-Archivo, V2, pp. 855-941.

Herrendorf, Berthold, Richard Rogerson, and Akos Valentinyi (2013), "Two Perspectives on Preferences and Structural Transformation", *American Economic Review*, V103(7), pp. 2752-89.

Jaumandreu, J. (2003), "Does Innovation Spur Employment? A Firm Level Analysis Using Spanish CIS Data", Mimeo, University Carlos III De Madrid.

Johnson, Noah N. (2017). Tradable and Nontradable Inflation Indexes: Replicating New Zealand's Tradable Indexes with BLS CPI Data. *Monthly Labour Review*, May.

Kilian, Lutz (2009), "Not All Oil Prices Are alike: Disentangling Demand and Supply Shocks in the Crude Oil Market", *American Economic Review*, 99:3, 1053-1069.

Kongsamut, Piyabha, Sergio Rebelo, Danyang Xie (2001), "Beyond Balanced Growth", *Review of Economic Studie*s, 68, pp.869-882.

Lane, Philip R. (2011), "International Financial Integration and Japanese Economic Performance", In Hamada koichi, Kashyap Anil K, and Weinstein David E, ed., Japan's Bubble, Deflation, and Long-term Stagnation, Cambridge, MA: MIT press.

Lee, Donghoon and Kenneth I. Wolpin (2006), "Intersectoral Labour Mobility and the Growth of the Service Sector", *Econometrica*, V74(1), pp.1-46.

Liao, JunMiao (2014), "The Rise of the Service Sector: Expansion of Distribution and personal services", Working Paper of Washington University in St. louis, https:// editorialexpress.com/cgi-bin/conference/download.cgi?db_name=MWMFall2014&paper_id=126.

Nari, L. Rachel, and Christopher A. Pissarides (2007), "Structural Change in a Multisector Model of growth", *American Economic Review*, 97, pp. 429-443.

Obstfeld, Maurice (2011), “Time of Troubles: The Yen and Japan’s Economy, 1985-2008”, In Hamada koichi, Kashyap Anil K, and Weinstein David E, ed., Japan’s Bubble, Deflation, and Long-term Stagnation, Cambridge, MA: MIT press.

Obstfeld, Maurice, and Kenneth Rogoff (2007),“The Unsustainable U.S. Current Account Position Revisted”, In Richard H. Clarida, ed., G7 Current Account Imbalances, Chicago: University of Chicago Press, pp. 339-366.

Obstfeld, Maurice, and Kenneth Rogoff (1996), Foundations of International Macroeconomics, 4th Edition, MIT Press, Cambridge, Massachusetts.

Peters, B. (2004), “Employment Effects of Different Innovation Activities: Microeconometric Evidence”, ZEW Discussion Paper 04-73.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti (2011), “Growing Like China”, *American Economic Review*, 101, pp. 202-241

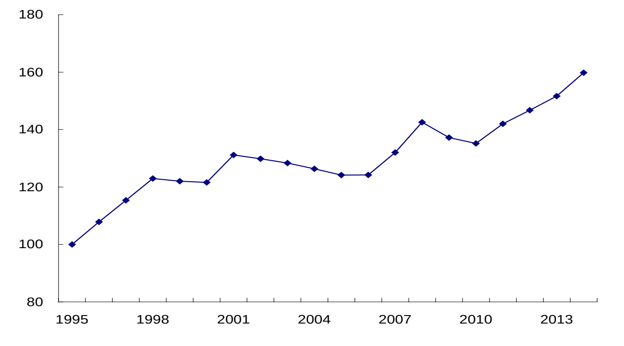
# Appendix 1: Elasticity of substitution between tradables and nontradables

We estimate $\theta$ in the following regression based on Equation (12):

$$\widehat{\left(\frac{C_{Nt}}{C_{Tt}}\right)} = -\theta\widehat{q_t} + \beta\ \widehat{\left(\frac{Y_{Nt}}{Y_{Tt}}\right)} + \varepsilon_t \qquad \text{(A1)}$$

where the control variable $\widehat{\left(\frac{Y_{Nt}}{Y_{Tt}}\right)}$ is the log change of the tradable-nontradable output ratio. We construct $q$, $C_N$, $C_T$, $Y_N$, $Y_T$ from the data originated from CEIC. While the nontradable sector includes agriculture, food processing, utilities, construction, real estate, healthcare, transportation and communication, education, sports and recreation, hotel and catering, and finance, the tradable sector includes quarry and mining, raw material, and manufacturing excluding food processing. We back out the tradable price index from the overall PPI in principle that, the overall PPI is a weighted average of the tradable price index and the price indices for processing food and utilities, where the value added is the weight (note: as the CPI series is longer than the PPI series in the database, we use the CPI instead for utilities). The nontradable price index is constructed as the weighted average of producer price indices for agricultural products and processing food, FAI price index for construction, and consumer price indices for other nontradable goods. The corresponding internal real exchange rate $q$, the nontradable price relative to the tradable price, is shown in Figure A1.

**Figure A1: Internal real exchange rate (1995=100)**




Sources: CEIC and staff estimates

The consumption series are constructed as follows. In the first step, the nominal GDP for secondary industry net of the output of food processing and utilities is treated as the nominal tradable output, and the total nominal GDP net of the nominal tradable output is the nominal nontradable output. In the second step, the ratio of the tradable FAI to the nontradable FAI is treated as the ratio of the tradable gross capital formation to the nontradable gross capital formation, which is used to decompose the overall nominal gross capital formation into the tradable and nontradable components. The nominal nontradable consumption is obtained by the nominal nontradable output minus the nominal nontradable gross capital formation, adjusted for service trade recorded in the balance of payments, and the nominal tradable consumption is obtained by the total nominal consumption minus the nominal nontradable consumption. The real consumption $C_N$ and $C_T$ are obtained by deflating their nominal counterparts by nontradable and tradable price indices respectively (Table A1).

**Table A1: Nominal consumption and output (RMB bn)**

| Year | Nontradable output | Tradable Output | Nontradable consumption | Tradable consumption |
|---|---|---|---|---|
| 1996 | 4,512.21 | 2,645.02 | 2,868.4 | 1,267.7 |
| 1997 | 5,007.54 | 2,935.40 | 2,931.1 | 1,551.0 |
| 1998 | 5,471.96 | 3,016.40 | 3,169.4 | 1,832.2 |
| 1999 | 5,858.45 | 3,160.32 | 3,445.0 | 2,175.9 |
| 2000 | 6,432.92 | 3,544.71 | 3,704.8 | 2,471.5 |
| 2001 | 7,189.22 | 3,837.82 | 3,884.1 | 2,827.6 |
| 2002 | 7,970.19 | 4,130.01 | 4,373.8 | 2,869.7 |
| 2003 | 9,013.40 | 4,643.07 | 4,697.6 | 2,882.9 |
| 2004 | 9,567.02 | 6,504.42 | 3,759.8 | 4,551.8 |
| 2005 | 12,211.63 | 6,377.95 | 5,552.5 | 3,399.3 |
| 2006 | 14,277.53 | 7,488.13 | 6,426.9 | 3,316.2 |
| 2007 | 17,857.34 | 8,944.59 | 7,310.0 | 3,035.1 |
| 2008 | 21,017.82 | 10,657.36 | 8,019.6 | 3,630.1 |
| 2009 | 23,551.14 | 11,011.79 | 8,650.3 | 4,287.7 |
| 2010 | 27,560.35 | 13,329.94 | 9,414.3 | 4,801.2 |
| 2011 | 32,539.31 | 15,873.04 | 10,805.3 | 5,638.7 |
| 2012 | 36,547.57 | 16,864.73 | 12,317.4 | 6,193.9 |
| 2013 | 40,958.12 | 17,843.75 | 13,601.3 | 6,767.0 |
| 2014 | 44,914.96 | 18,698.92 | 14,857.6 | 7,521.1 |

Sources: CEIC and staff estimates

The GMM method is used to estimate $\theta$ with the lagged global oil supply shock, the lagged independent variable as the instrument variables. Following Kilian (2009), we construct a three-variable VAR with the world oil production, the global real activity index and the real oil price (where the world oil production is obtained from the US Energy Information Administration, and both the global real activity (proxied by the Baltic Dry index) and the oil price are obtained from Bloomberg. The value of the latter two series is converted into RMB and deflated by Chinese CPI). The VAR is postulated as a recursive one, with the world oil production being placed as the first variable, the world real activity index as the second, and the real oil price the third one. The residual of the first variable is regarded as a pure supply factor after the impact of the global demand and oil demand is controlled for. The regression (where over-identification condition is satisfied) shows that the estimate of$\theta$ has the right sign and statistically significant (Table A2).

**Table A2: Estimate of the elasticity of substitution between tradables and nontradables**

| Variable | Coefficient | T-Statistic |
|---|---|---|
| $\widehat{q_t}$ | -4.94* | -1.97 |
| $\widehat{\left(\frac{Y_{Nt}}{Y_{Tt}}\right)}$ | 1.68*** | 3.66 |
| Observation | 17 | |
| R-square | 0.19 | |

Note: *** p<0.01, * p<0.10. Source: Staff estimates

**Table 1. Job loss rate in the tradable sector (%)**

| | | |
|---|---|---|
| US | 1990-2014 | 1.6 |
| UK | 1990-2014 | 2.6 |
| Germany | 1991-2014 | 1.5 |
| Japan | 1990-2014 | 1.8 |

Source: CEIC and staff estimates

**Table 2: Labour income share**

| Year | Nontradable ($s_N$) | Tradable ($s_T$) | Ratio ($s_N/s_T$) |
|---|---|---|---|
| 2002 | 0.587 | 0.520 | 1.129 |
| 2005 | 0.528 | 0.400 | 1.318 |
| 2007 | 0.514 | 0.427 | 1.206 |
| 2010 | 0.591 | 0.489 | 1.209 |
| 2012 | 0.597 | 0.501 | 1.192 |

Sources: NBS I-O tables and staff estimates

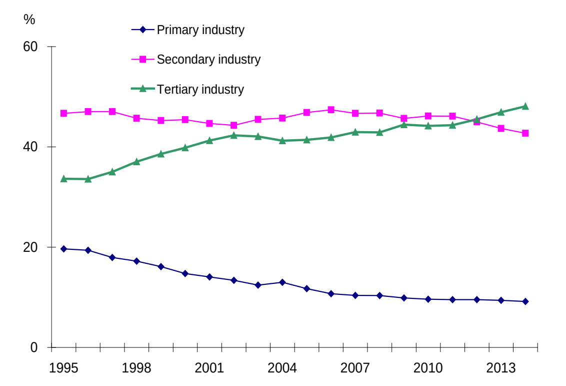
**Table 3: Real Exchange rate changes under structural transformation (%)**

| Period | with initial investment shocks | | With initial efficiency changes | |
|---|---|---|---|---|
| | $\theta^*=0.5$ | $\theta^*=2$ | $\theta^*=0.5$ | $\theta^*=2$ |
| 1 | 0.65 | 0.17 | 5.42 | 1.41 |
| 2 | -0.15 | -0.04 | -0.67 | -0.26 |
| 3 | 0.06 | 0.02 | -0.34 | -0.18 |
| 4 | 0.18 | 0.05 | -0.16 | -0.13 |
| 5 | 0.18 | 0.05 | -0.17 | -0.13 |
| 6 | 0.13 | 0.03 | -0.26 | -0.16 |
| 7 | 0.10 | 0.03 | -0.32 | -0.18 |
| 8 | 0.02 | 0.01 | -0.43 | -0.21 |
| 9 | -0.04 | -0.01 | -0.51 | -0.23 |
| 10 | -0.08 | -0.02 | -0.57 | -0.24 |
| 11 | 0.03 | 0.01 | -0.42 | -0.21 |
| 12 | -0.09 | -0.02 | -0.56 | -0.24 |
| 13 | -0.26 | -0.07 | -0.75 | -0.30 |
| 14 | -0.35 | -0.09 | -0.82 | -0.32 |
| 15 | -0.08 | -0.02 | -0.74 | -0.30 |

**Table 4: Threshold switching costs relative to wages**

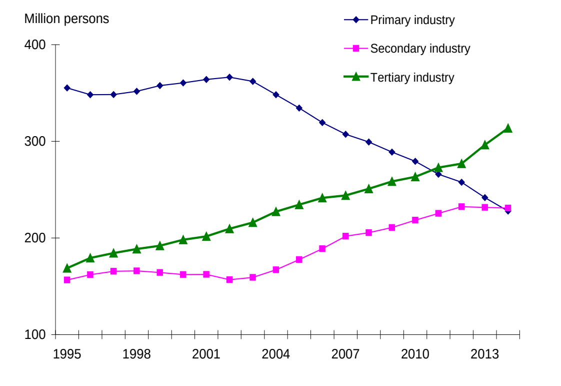
| | Without natural labour force adjustment | With natural labour force adjustment |
|---|---|---|
| With initial investment shocks | 0.77 | 0.61 |
| With initial efficiency changes | 1.55 | 1.55 |

**Figure 1: Share of output in total GDP**



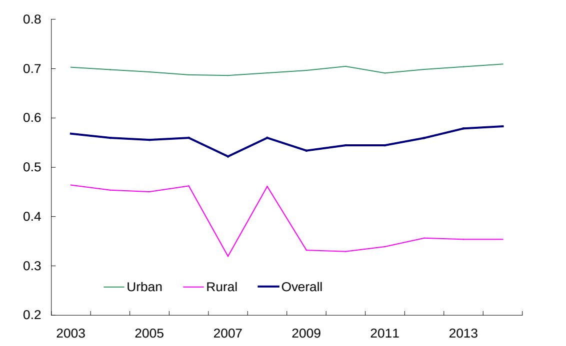

Sources: CEIC and staff estimates

**Figure 2: Employment dynamics**



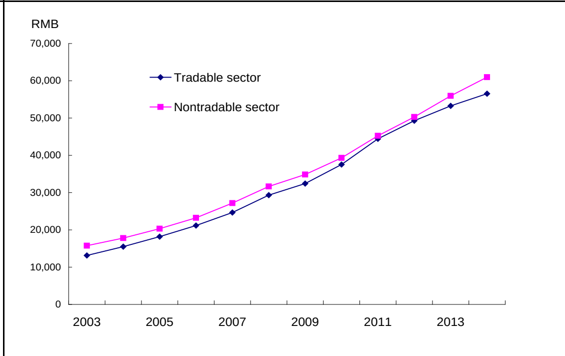

Sources: CEIC and staff estimates

**Figure 3: Labour share of the nontradable sector ($\theta_N$)**



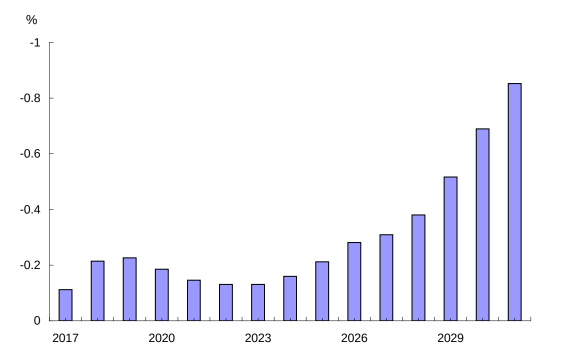

Sources: CEIC and staff estimates

**Figure 4: Wage in levels in urban non-private firms**



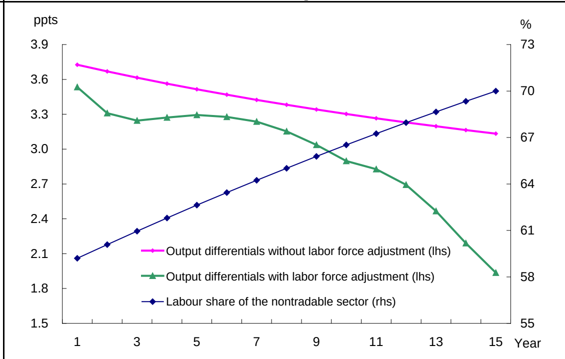

Sources: CEIC and staff estimates

**Figure 5: Change in working age population in China (in reverse order)**



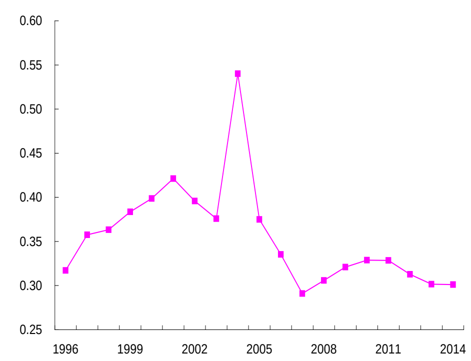

Sources: CEIC and staff estimates

**Figure 6: Required output growth differentials to absorb job losses**



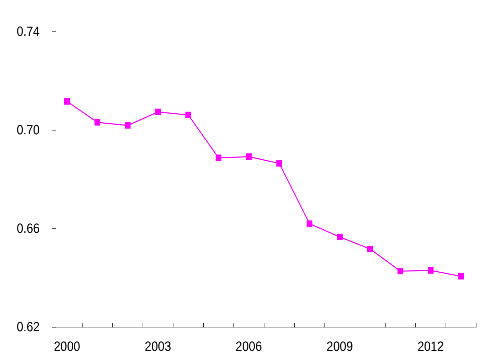

Sources: CEIC and staff estimates

**Figure 7: Share of consumption of tradables ($\gamma$)**



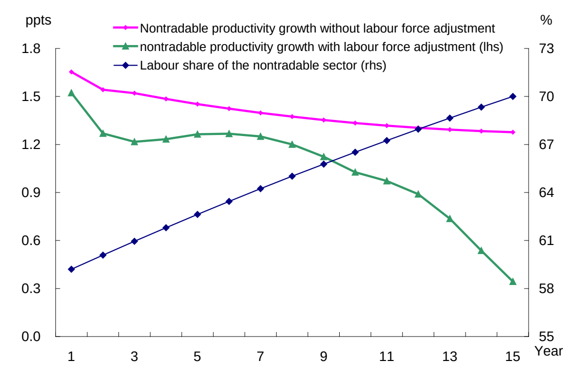

Sources: CEIC and staff estimates

**Figure 8: Share of wage income in urban areas ($\varphi_1$)**



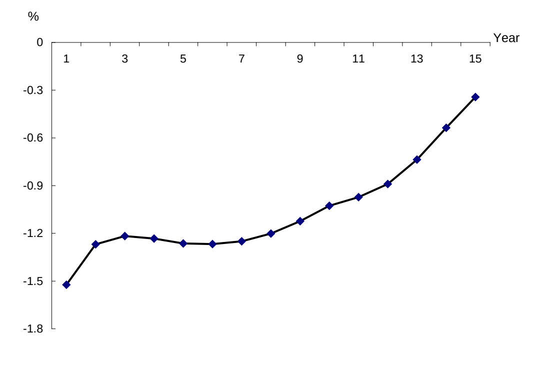

Sources: CEIC and staff estimates

**Figure 9: Required productivity increment with initial investment shocks**



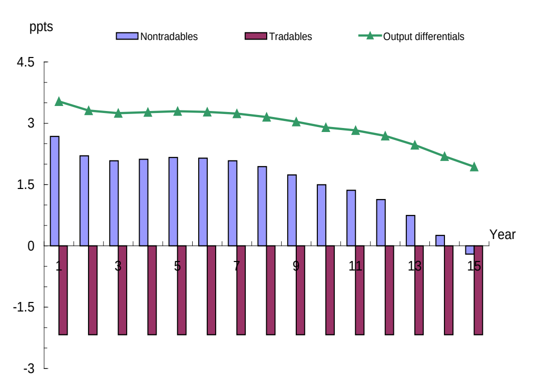

Sources: CEIC and staff estimates

**Figure 10: Relative price *q* with initial investment shocks**



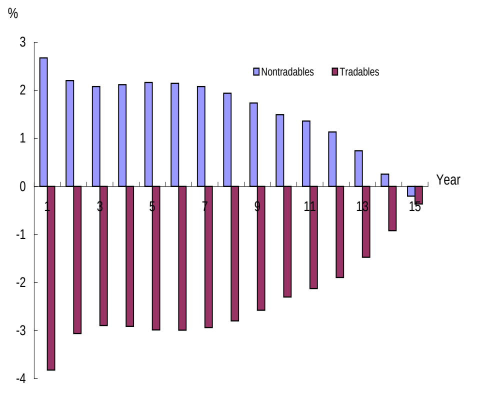

Sources: CEIC and staff estimates

**Figure 11: Changes in output with initial investment shocks**



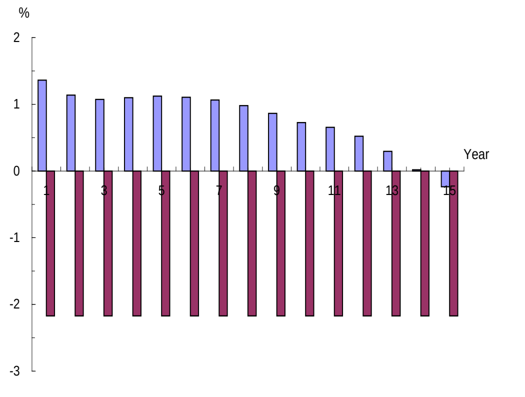

Sources: CEIC and staff estimates

**Figure 12: Changes in consumption with initial investment shocks**



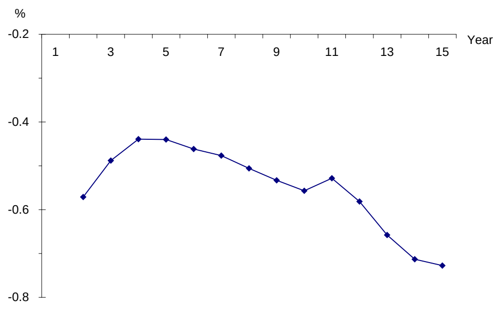

Sources: CEIC and staff estimates

**Figure 13: Changes in capital stock with initial investment shocks**



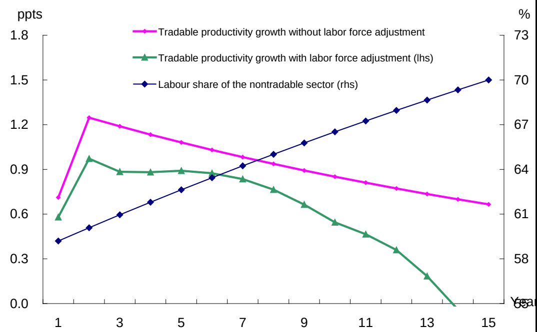

Sources: CEIC and staff estimates

**Figure 14: Financial wealth with initial investment shocks**



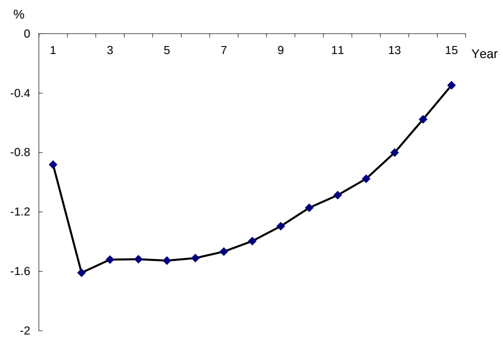

Sources: CEIC and staff estimates

**Figure 15: Required productivity increment with initial efficiency changes**



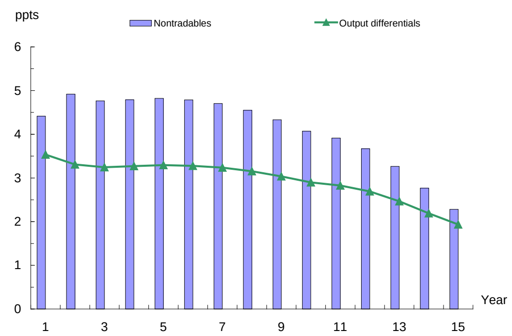

Sources: CEIC and staff estimates

**Figure 16: Relative price *q* with initial efficiency changes**



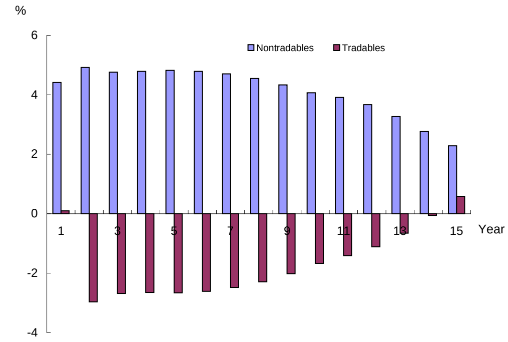

Sources: CEIC and staff estimates

**Figure 17: Output with initial efficiency changes**



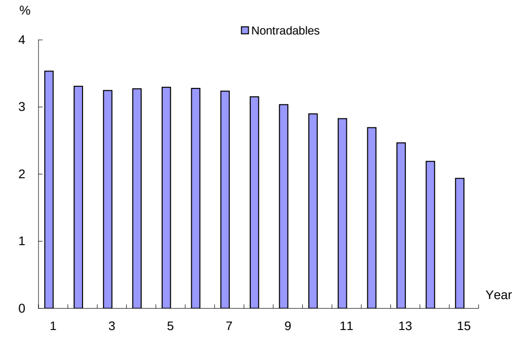

Sources: CEIC and staff estimates

**Figure 18: Consumption with initial efficiency changes**



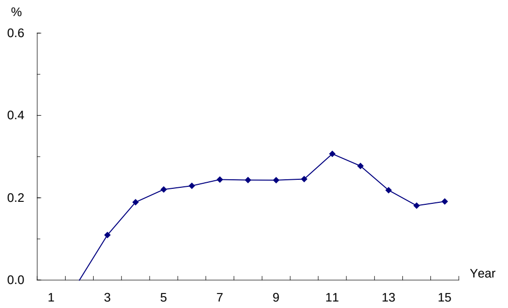

Sources: CEIC and staff estimates

**Figure 19: Capital stock with initial efficiency changes**



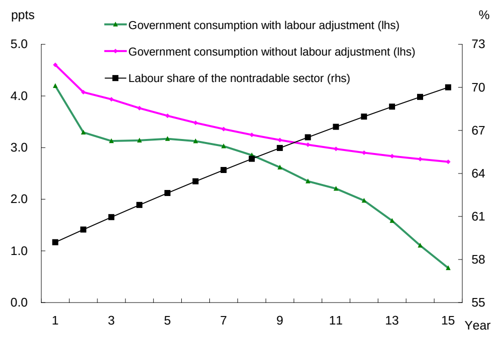

Sources: CEIC and staff estimates

**Figure 20: Financial wealth with initial efficiency changes**



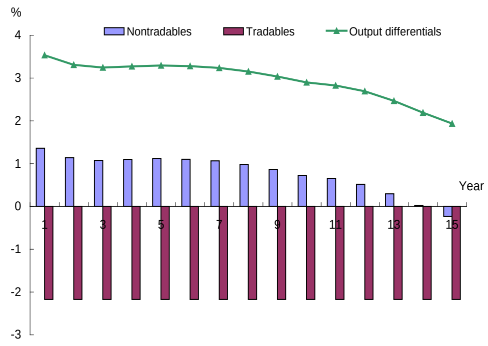

Sources: CEIC and staff estimates

**Figure 21: Required government consumption increment with initial investment shocks**




Sources: CEIC and staff estimates

**Figure 22: Response of output to government consumption increment with initial investment shocks**

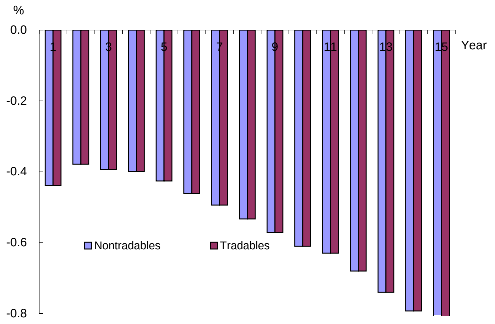



Sources: CEIC and staff estimates

**Figure 23: Response of capital stock to government consumption increment with initial investment shocks**

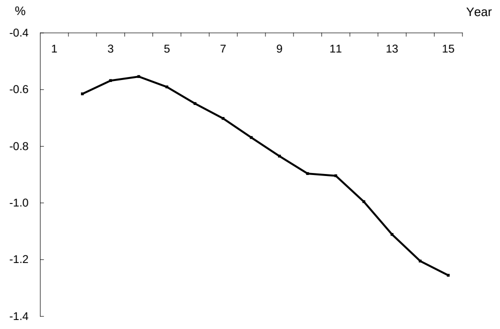

Sources: CEIC and staff estimates

**Figure 24: Response of private consumption to government consumption increment with initial investment shocks**



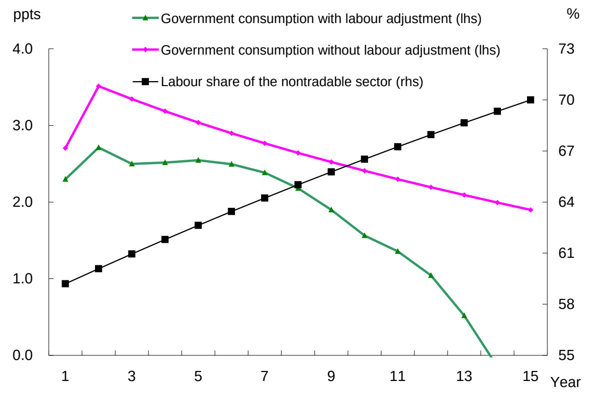

Sources: CEIC and staff estimates

**Figure 25: Response of financial wealth to government consumption increment with initial investment shocks**



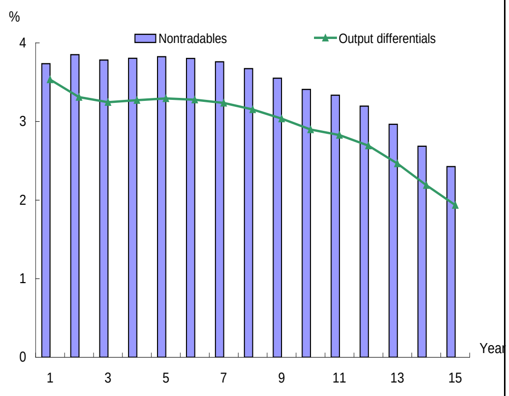

Sources: CEIC and staff estimates

26: Required government consumption with initial productivity shocks



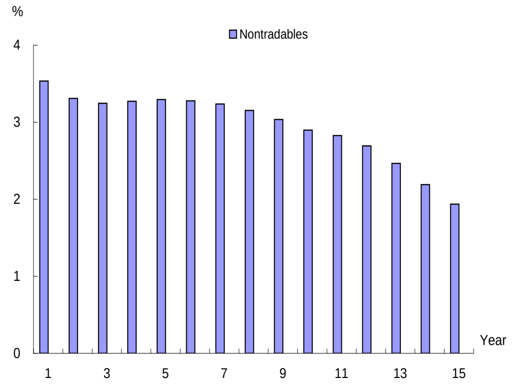

Sources: CEIC and staff estimates

**Figure 27: Response of output to government consumption increment with initial efficiency changes**



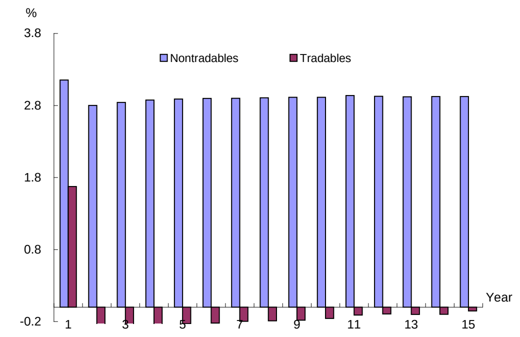

Sources: CEIC and staff estimates

**Figure 28: Response of capital stock to government consumption increment with initial efficiency changes**



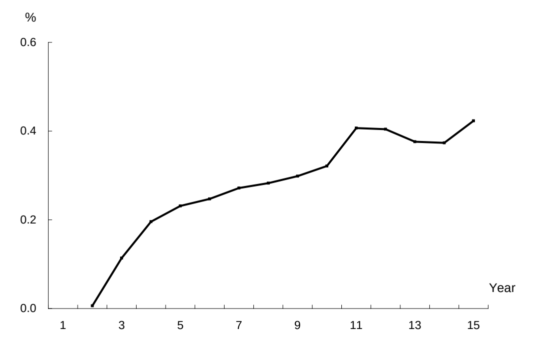

Sources: CEIC and staff estimates

**Figure 29: Response of private consumption to government consumption increment with initial efficiency changes**



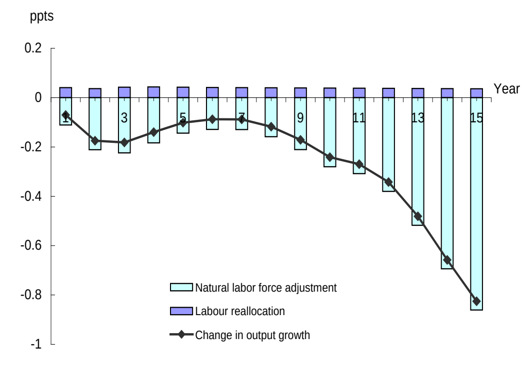

Sources: CEIC and staff estimates

**Figure 30: Response of financial wealth to government consumption increment with initial efficiency changes**



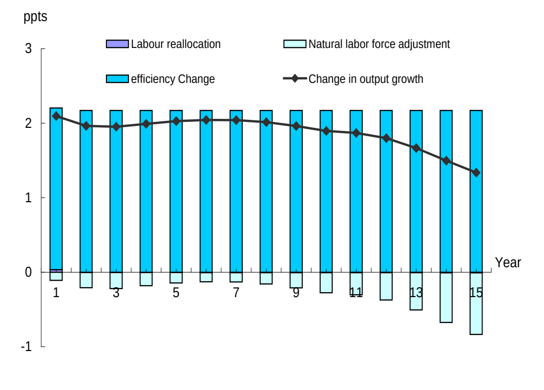

Sources: CEIC and staff estimates

**Figure 31: Contribution to overall output growth with initial investment shocks**



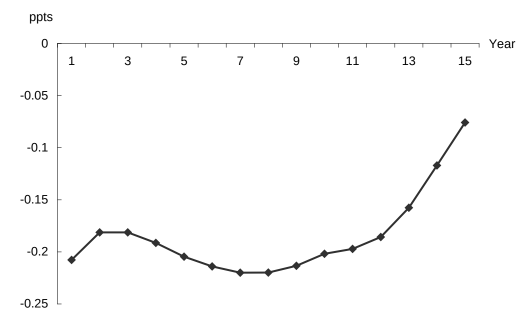

Sources: CEIC and staff estimates

**Figure 32: Contribution to the overall output growth with initial efficiency changes**



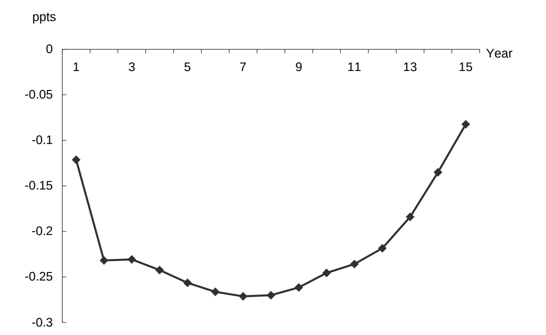

Sources: CEIC and staff estimates

**Figure 33: Inflation rate with initial investment shocks**



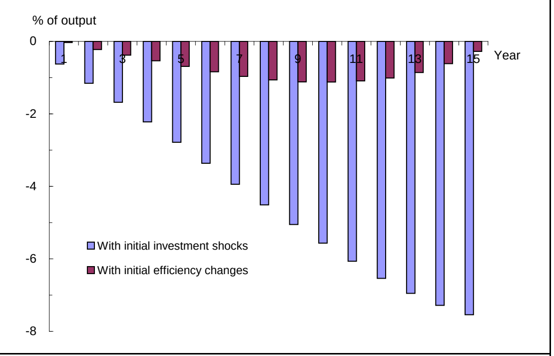

Sources: CEIC and staff estimates

**Figure 34: Inflation rate with initial efficiency changes**



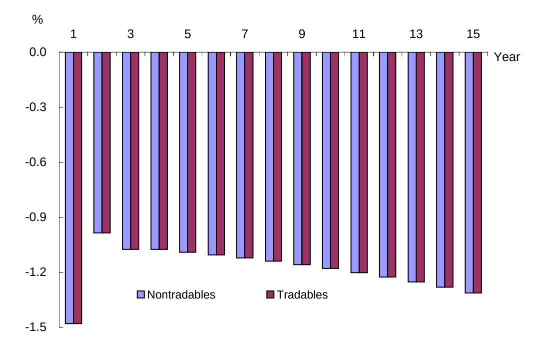

Sources: CEIC and staff estimates

**Figure 35: Fiscal balance in the presence of government spending**



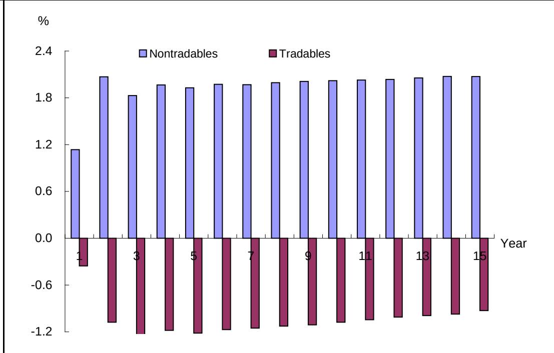

Sources: CEIC and staff estimates

**Figure 36: Private consumption with initial investment shocks in the absence of government spending**



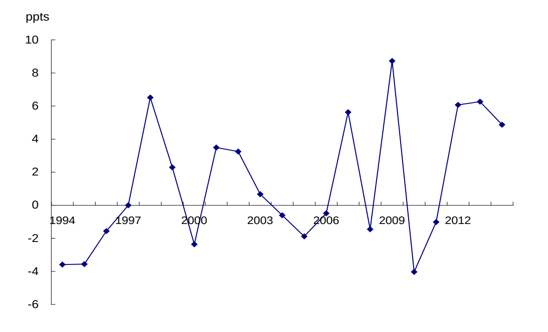

Sources: CEIC and staff estimates

**Figure 37: Private consumption with initial efficiency changes in the absence of government spending**



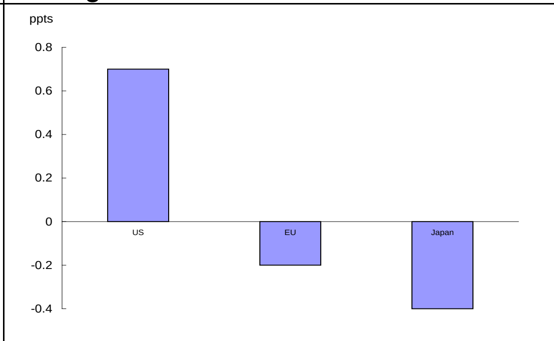

Sources: CEIC and staff estimates

**Figure 38: Output differentials between nontradable and tradable sectors**

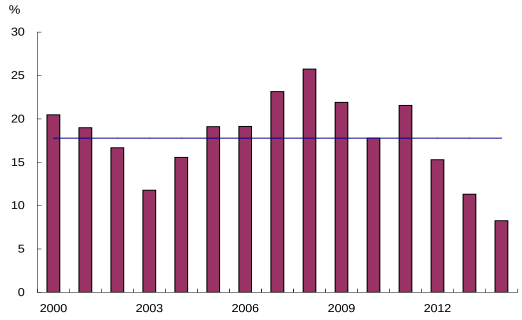
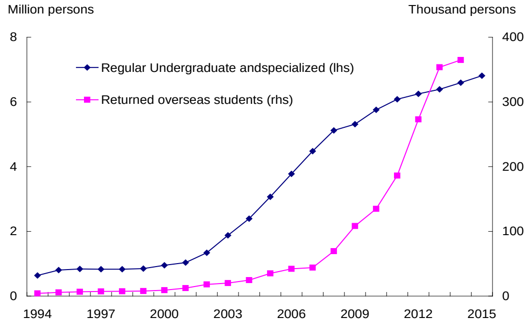



Sources: CEIC and staff estimates

**Figure 39: Productivity differentials during1990-2004**




Sources: CEIC and staff estimates

| **Figure 40: Growth in government expenditure** | **Figure 41: Human capital accumulation in China** |
| --- | --- |
|  |  |
| Sources: He *et al*. (2014) and staff estimates | Sources: CEIC and staff estimates |