Contribution of factor structure change to China's economic growth: evidence from the time-varying elastic production function model

Shangfeng Zhang, Yaoxin Liu & Duen-Huang Huang

Published online: 18 Dec 2019.

Submit your article to this journal ⍟

Article views: 2706

View related articles ⍟

View Crossmark data ⍟

Citing articles: 10 View citing articles ⍟

Routledge
Taylor & Francis Group

OPEN ACCESS   Check for updates

Contribution of factor structure change to China's economic growth: evidence from the time-varying elastic production function model

Shangfeng Zhang[a,b], Yaoxin Liu[a,b] and Duen-Huang Huang[c]

[a]School of Statistics and Mathematics, Zhejiang Gongshang University, Hangzhou, China; [b]Institute of Quantitative Economics, Zhejiang Gongshang University, Hangzhou, China; [c]Department of Information Management, Hsinchu, Taiwan, Republic of China

ABSTRACT

The time-varying factor share runs through the entire process of the Chinese economic miracle, unlike the 'Kaldor Facts' in developed countries. Following the new structural economics theory, we construct a time-varying elastic production function model that characterises the structural changes of China's economic element, and decompose the driving force of economic growth to measure the contribution of factor structure. We found that, from 1978–2017, the average contribution of capital, labour, technological progress, and factor structure change to the GDP was 67.01%, 10.38%, 23.08%, and −0.47%, respectively. The measurement results can aptly portray the impact of policy changes in China's unique gradual reform process, such as the economic market reforms in 1992, the global financial crisis in 2008, and the policy changes of the new economic normal in 2014. Meanwhile, the results reveal that improving factor allocation can accelerate the total factor productivity and promote high-quality development of China's economy.

1. Introduction

Since the reform and opening up, China's economy has been growing. The gross domestic product (GDP) increased from 367.87 billion RMB in 1978 to 827.12 billion RMB in 2017, an increase of 223.8%, and the per capita GDP increased from 385 RMB in 1978 to 59,660 RMB in 2017, an increase of about 154%, which is known as 'a miracle never seen in the history of human economy'. During this period, the economic structure changed throughout the process. The economic growth rate has shifted, the development mode has changed, the economic structure has been adjusted, and the growth momentum has been transformed, especially since China's economy entered the 'new normal' in 2014. A more complex, more structured phase

of evolution has appeared. Against this backdrop, the integration of 'stable growth' and 'adjustment structure' has become one of the main contents of policy orientation.

The economic structure is not only the allocation of various production factors, but also the macroscopic manifestation of institutional changes and technological progress. Structural transformation is a core variable that helps understand the difference between economic development in developing and developed countries, and it is also the essential requirement for less-developed countries to accelerate economic development (Chenery & Elkington, 1979). 'Kuznets Facts', one of the two typical characteristic facts[1] of modern economic growth, describe the distributional changes of production factors among different industries in the process of economic growth. The movement of factors of production to sectors with high productivity or high productivity growth will promote productivity and accelerate economic growth, which means changes in industrial structure drive economic growth (Kuznets, 1973). Therefore, analysis of the potential for economic growth based on industrial structure has become a common research concept for economic structural changes (Dudzevičiūtė, Mačiulis, & Tvaronavičienė, 2014; Haraguchi et al., 2017; Nie & Sun, 2012; Peneder, 2003; Zhao & Tang, 2015). Since the 1980s, the share of labour income has continued to decline worldwide (Guscina, 2006; Karabarbounis & Neiman, 2014; Krueger, 1999; Rodriguez & Jayadev, 2010). In China, Luo and Zhang (2009) argue that the impact of industrial structure changes from 1996–2003 on the decline in China's overall labour income share is as high as 63.54%. Bai and Qian (2009) also found that the effect of industrial restructuring during the period 1995–2003 on the decline in China's overall labour income share was about 61.31%.

However, the robust explanation cannot conceal the limitations of the theory of industrial structural change (Wang & Yuan, 2018). In recent years, China's labour income ratio has not continued to decline but has risen again after reaching a low point in 2004. Although the output structure of the industrial sector has changed, it has not been significant. The theory of industrial structure change does not explain the reversal of China's labour income share (Wang & Yuan, 2018; Zhou, 2011). Obviously, there are more important factors behind the changes, which can explain the impact of such changes on factor income distribution, and also explain the changes in labour income share in the process of China's economic growth.

According to the law of diminishing marginal returns, long-term economic growth depends on technological progress, the so-called total factor productivity (TFP) growth (Aghion & Howitt, 2009; Caselli, 2005; Hall & Jones, 1999; Hsieh & Klenow, 2010). Due to the focus on TFP in developed countries, the mainstream development trend and the theory behind it is ignoring the structural changes in developing countries, and it is a matter of course to keep the total production function constant (Fu, 2017). In fact, the optimal economic structure of the economy at different stages of development is different. It needs to be consistent with the endowment structure of the economy and varies with the level of development (Lin, 2002; Ren, 2012), which macroscopically reflects the fact that the overall production function is endogenous, and it may change with time (Lin & Liu, 2003). The main reason for the difference in the form of the function is that the labour share in the mainstream practice visual function remains relatively unchanged in the theoretical model, in growth and

development accounting, and in some empirical calibrations, which is consistent with the situation in developed countries, that is, the Kaldor Facts (Fu, 2017). On the contrary, the economic structure of developing countries is being upgraded, including the internal structure of technological progress and the industrial structure, which are all endogenous to the endowment structure (Fu, 2014). However, regrettably, the facts based on the characteristics of Kaldor in developed countries and the neoclassical model ignore this point (Fu, 2017).

In summary, for developing countries, the more important issue may be structure changes. Therefore, the internal structure of industrial structure and technological progress are inherently derived from the factor endowment structure (Fu, Ye, & Wang, 2016) and the functional form itself may change with time (Lin, 2002; Wang, 2013; Zhao & Wang, 2018), which is one of the core ideas of the third wave of development economics, namely the theory of new structural economics (Lin, 2012). Therefore, from the perspective of factor endowment structure change, this study attempts to separate the factor structure from the economic aggregate growth effect via the time-varying elastic production function model, and measures factor structure change to economic aggregate growth and per capita output growth, respectively. This is an attempt to provide new ideas and methods for the measurement of factor structure effects in the process of economic growth in developing countries.

The rest of this paper is organised as follows. Section 2 provides a literature review, which is divided into three parts: structural effects and economic growth, the measurement of China's economic structural effects, and China's unique structural changes. In section 3, based on the development law of China's time-varying factor income share, the Cobb-Douglas production function is improved, and the time-varying elastic production function model is introduced. From the perspective of factor structure change, the economic aggregate and the average economic growth are respectively decomposed using a time-varying elastic production function model. Section 4 is an empirical analysis of China's economic growth experience data from 1978 to 2017. Finally, concluding remarks are presented in section 5.

2. Literature review

2.1. Structural effect and economic growth

The study of structural effects has always been a hot topic for scholars. Massell (1961) subdivided the US macro economy into 19 divisions, decomposed its macro TFP growth, and found that the technical effect contributed approximately two-thirds and the structural effect contributed the remaining third. The World Bank decomposes TFP into resource re-allocation efficiency and residuals. The former is the productivity increase from lower productivity sectors (labour surplus agriculture and redundant state-owned enterprises) to higher productivity sectors (non-agricultural industries and start-ups), contributing 16% to economic growth. The latter is an unexplained factor (incentive improvement and technological advancement) contributing 30% (Cai, 2017). Montobbio (2002) and Ngai and Pissarides (2007) analysed the dynamic structural changes in the process of economic growth by constructing a multi-sectoral growth model and re-characterised the evolution of industrial structure

and its impact on macro-productivity growth using a mathematical model. Fagerberg (2000) used shift-share analysis to demonstrate the impact of structural transformation on the productivity increase of 24 industries in 39 countries. The study found that structural conversion has no significant effect on productivity, on average. Peneder (2003) decomposes the labour productivity index into static structural transformation effects, dynamic structural transformation effects, and industrial advancement effects. Based on the empirical results of 28 OECD countries, structural changes have positive and negative effects on productivity.

For China, Han and Li (2015) found that from 1994 to 2011, the contribution of labour input structure changes to labour productivity growth and industrial TFP growth was 12.23% and 23.09%, respectively. Cai and Fu (2017) decomposed the macro TFP growth rate expression into 'technical effect' and 'structural effect' from the mathematical viewpoint. It was found that the overall quality of China's economic growth was high between 1978 and 2014, and about one third of the growth momentum comes from the general improvement of the technical level, and the structural effect is one fifth of the technical effect.

Thus, structural changes have little impact on the productivity of developed countries such as OECD countries. However, in China, structural effects have a relatively high contribution rate to labour productivity and TFP growth. What are the reasons for this?

2.2. Measurement of china's economic structural effects

Labour transfer to form resource reconfiguration efficiency is a typical feature of industrial structure changes in Asian economies (Mcmillan & Rodrik, 2012), and constitutes an important component of TFP and labour productivity improvement during China's reform and opening up (Bosworth & Collins, 2008), which has significant contributions to economic growth during this period (Cai, 2017). In this regard, with the rapid development of measurement tools and the accumulation of structuralist empirical research results, scholars have quantitatively portrayed the structural effects brought about by labour transfer (Bai & Qian, 2009; Luo & Zhang, 2009). Shift-share analysis (Liu & Zhang, 2008; Singh & Lakhwinder, 2004), residual measurement analysis (Liu & Zhu, 2003), division of industrial sector subsystems (Brondino, 2018; Ge, Wang, Yuan, & Fang, 2000), dynamic panel estimation (Fu et al., 2016), a resource reconfiguration effect model (TRE) (He & Yao, 2008; Li & Chen, 2007; Wen & Zhang, 2010), a fixed effects model (Gan, Zheng & Yu, 2011), a stochastic frontier production function model (Yao, 2009; Zhang & Xu, 2009), and other methods are used to quantitatively measure the contribution of structural changes to economic growth. Among them, Liu and Zhang (2008) used shift-share analysis to decompose technological progress and industrial structure change from factor productivity and found that the impact of industrial structure changes on China's economic growth was very significant. Cai (2017) calculated the three periods of 1978–1990, 1991–2003, and 2004–2015, and found that the effects of structural changes were significant in the first and third periods. Among the structural change factors (39.2%) in the first period, the static effect contribution, which was 25.8%, was outstanding. In

the middle period, industrial contribution was in an absolute dominant position. In the third period, the contribution rate of structural change returned to a higher level.

In general, scholars have confirmed that economic structural changes are a major driving force for China's sustained and rapid economic growth (Aoki, 2012; Fu, 2014; Gan et al., 2011, 2018; Lei, 2007; Liu, 2016; Sachs & Woo, 1994). However, even if the law of structural change is widely accepted, a large number of quantitative studies on this have already been conducted, but comprehensive research on China and the understanding of the unique evolution path are still insufficient (Cai, 2017).

2.3. China's unique changes in factor structure

According to neoclassical economic growth theory (Barro & Sala-I-Martin, 1991, 1992; Solow, 1958), as the marginal return of capital declines, an economy with lower initial per capita income will have a greater potential for faster future economic growth than an economy with higher initial per capita income, which is the inherent convergence mechanism of economic growth (Lin & Liu, 2003). According to Krugman (1994), this kind of economic growth, which relies mainly on the increase of factor inputs, and whose technological progress has not played a significant role, is unsustainable. However, after 1998, China's economic growth model has increasingly demonstrated its own sustainability (Liu & Zhang, 2008). Specifically, in 2004, the Chinese economy welcomed the Lewis turning point characterised by labour shortages and rising wages. At this time, the central and local governments significantly increased the re-distributive policy (Cai, 2016), and the transfer of labour from agriculture to non-agricultural industries has brought about an increase in TFP, contributing to economic growth as high as 21% (Cai & Wang, 1999). This is the impact of the economic structure of neoclassical economic growth theory that does not take the effects of the characteristics of development strategy on economic growth into account (Cai, 2017).

The reason is that, overall, from the neoclassical economic growth model to the endogenous economic growth theory, the model assumption of the 'Kaldor facts[2] 'steady-state equilibrium growth has become a common starting point for almost all economic growth theories (Zhang, 2006). The economic growth and development of OECD countries are in line with the characteristics of the Kaldor facts (Fu, 2017). However, Zhang (2015) demonstrated that between 1996 and 2014, China's quarterly labour income share fluctuated between 45.6% and 55.1%, which means that the output of about 10 percentage points in the past 20 years has changed between the two elements of capital and labour. The accounting studies of Xiao and Hao (2009) and Zhang and Xu (2015) also reveal that China's economic growth is not in line with Kaldor, showing unsteady growth, which is the empirical fact of developing countries in the process of continuous structural change (Fu, 2017). The third wave of development economics, the new structural economics theory, also explains this point (Fu, 2017; Lin, 2012). Therefore, based on the time-varying elastic production function model (Zhang & Xu, 2009), this study attempts to decompose the economic growth dynamics from the perspective of factor structure and analyse the contribution of time-varying factor structure effects to economic growth.

3. Model framework

Stigliz (1995) suggested that capital, labour, technology, and production structure are the four major factors of economic growth. When Y, K, L, A, and F represent output, capital, labour, technological progress, and production structure respectively, economic growth can be abstracted into a production function: Y = F(K, L, A). In 1928, the American economist P.H. Douglas and the mathematician C.W. Cobb proposed the famous Cobb-Douglas production function, which has the advantages of simple structure, obvious economic significance, and easy estimation, and is therefore widely used.

3.1. Classic Cobb-Douglas production function

Assuming that there are only capital and labour production factors, the Cobb-Douglas production function with constant return is as follows:

$$Y_t = A_t K_t{}^\alpha L_t{}^\beta (\alpha + \beta = 1) \tag{1}$$

Among (1), Y_t, A_t, K_t, and L_t represent the actual output, technical level, capital investment, and labour input of the t-th period, respectively. It is assumed that the technical level A_t is represented by an exponential linear combination of a set of controllable variables: $\ln A_t = \sum_{i=1}^{m} \lambda_i Z_{it}$.[3] Taking the natural logarithm on both sides of (1), we get:

$$\ln Y_t = \sum_{i=1}^{m} \lambda_i Z_{it} + \alpha \ln K_t + \beta \ln L_t (\alpha + \beta = 1) \tag{2}$$

The equations are derived for $\ln K_t$ and $\ln L_t$, respectively, and α and β represent the output elasticity of the t-th capital and labour, respectively:

$$\alpha = \frac{\partial \ln Y_t}{\partial \ln K_t} = \frac{\partial Y_t}{\partial K_t} \cdot \frac{K_t}{Y_t} = \frac{\partial Y_t / \partial K_t \cdot K_t}{Y_t}, \beta = \frac{\partial \ln Y_t}{\partial \ln L_t} = \frac{\partial Y_t}{\partial L_t} \cdot \frac{L_t}{Y_t} = \frac{\partial Y_t / \partial L_t \cdot L_t}{Y_t} \tag{3}$$

Under perfectly competitive market equilibrium conditions, capital and labour receive returns r and w based on marginal output MPK and MPL:

$$r_t = MPK_t = \partial Y_t / \partial K_t, w_t = MPL_t = \partial Y_t / \partial L_t \tag{4}$$

The income share of capital and labour factors is equal to:

$$\frac{w_t . L_t}{Y_t} = \frac{MPL_t . L_t}{Y_t} = \frac{\partial Y_t / \partial L_t . L_t}{Y_t}, \frac{r_t . K_t}{Y_t} = \frac{MPK_t . K_t}{Y_t} = \frac{\partial Y_t / \partial K_t . K_t}{Y_t} \tag{5}$$

Therefore, under the assumption of a perfectly competitive market, the capital elasticity α is numerically equal to the capital share, and the labour elasticity β is numerically equal to the labour share.[4]

$$\frac{r_t.K_t}{Y_t} = \frac{\partial Y_t/\partial K_t.K_t}{Y_t} = \alpha, \frac{w_t.L_t}{Y_t} = \frac{\partial Y_t/\partial L_t.L_t}{Y_t} = \beta \qquad (6)$$

The value of α and β estimated by the Cobb-Douglas production function is a fixed constant, which can characterise the distribution of production factors in the neoclassical steady-state economic growth model and has strong time stability characteristics (Gollin, 2002; Leandro & Joan, 2003; Lucas, 1988; Romer, 1986; Samuelson & Solow, 1956). To a certain extent, it can better describe the steady state development of the economic structure in the economic growth of developed countries, namely the 'Kaldor Facts'.

However, can the classic Cobb-Douglas production function also portray the characteristics of China's economic growth? To this end, this study introduces the structural test method of econometrics and uses the CHOW test method to determine whether the model of the Cobb-Douglas production function has undergone structural changes. This method divides the time series data into two parts, and the dividing point is the critical point for checking whether structural changes are present in the model. We select year t^* as the demarcation point and analyse whether the regression coefficient changes significantly after t^*, and introduce the qualitative dummy variable D:

$$D_t = \begin{cases} 1 & t \geq t^* \\ 0. & t < t^* \end{cases} \qquad (7)$$

We establish a constant variable compensation Cobb-Douglas production function virtual variable model:

$$\ln\left(Y_t/L_t\right) = \sum_{i=1}^{m} \gamma_i Z_{it} + \alpha \ln\left(K_t/L_t\right) + \alpha_1'.D_t + \alpha_2'.D_t.\ln\left(K_t/L_t\right) + \varepsilon_t \qquad (8)$$

If the continuity of economic variables and structural adjustment are considered, we can establish a critical indicator dummy variable model to reflect:

$$\ln\left(Y_t/L_t\right) = \sum_{i=1}^{m} \gamma_i Z_{it} + \alpha \ln\left(K_t/L_t\right) + \alpha_3'.D_t.[\ln\left(K_t/L_t\right) - \ln\left(K_t/L_t\right)] + \varepsilon_t \qquad (9)$$

The CHOW test results of the virtual variable model and the critical indicator virtual variable model all indicate that the structural changes of the Chinese Cobb-Douglas production function are ubiquitous, consistent with Zhang (2015), which means that the classic Cobb-Douglas production function does not describe the time-variation of the elasticity of production factors in China's economic growth.

3.2. Time-varying elasticity production function

This study follows the familiar invariant parameter Cobb-Douglas production function form and expands to the variable parameter Cobb-Douglas production function with explicit mathematical expressions:

$$Y_t = A_t K_t^{\alpha(t)} L_t^{\beta(t)} \tag{10}$$

It is assumed that the skill level A_t is represented by an exponential linear combination of a set of controllable variables, $\ln A_t = \sum_{i=1}^{m} \lambda_i Z_{it}$, which means that the technical level of the point in time can be determined according to the factor endowment structure at each point in time.

Take the natural logarithm on both sides of (10):

$$\ln Y_t = \sum_{i=1}^{m} \gamma_i Z_i + \alpha(t) \ln K_t + \beta(t) \ln L_t \tag{11}$$

Equation (11) is essentially a semi-parametric variable coefficient model. One of the advantages of this model is to avoid 'Dimension Disaster' and to avoid previous model setting errors. The variable coefficient part is still linear with respect to the regression variable, but its coefficient is a function of the observation time position corresponding to the observation values of all n regression variables. In addition to the observation value information of the regression variable itself, it also contains the information of observation points 'time position'.

For the time-varying elasticity production function model, we can see from Equation (11) that the elasticity of the t-th capital expenditure is:

$$\frac{\partial Y_t / Y_t}{\partial K_t / K_t} = \frac{\partial Y_t}{\partial K_t} \cdot \frac{K_t}{Y_t} = \frac{\partial \ln Y_t}{\partial \ln K_t} = \alpha(t) \tag{12}$$

The t-th labour output elasticity is:

$$\frac{\partial Y_t / Y_t}{\partial L_t / L_t} = \frac{\partial Y_t}{\partial L_t} \cdot \frac{L_t}{Y_t} = \frac{\partial \ln Y_t}{\partial \ln L_t} = \beta(t) \tag{13}$$

Among them, the estimated α_t and β_t respectively represent the time-varying output elasticity of capital and labour in the period t, which is in line with the economic significance (Zhang & Xu, 2009). This study uses the profile local polynomial estimation method proposed by Fan and Huang (2005) to estimate the unknown parameters and function coefficient values.

If $\{(Z_i, K_i, L_i, Y_i), i = 1, \ldots, n\}$ n samples have been observed, for a given linear part coefficient, Equation (11) can be written as:

$$(\ln Y_t)^* = \alpha(t) \ln K_t + \beta(t) \ln L_t + \varepsilon_t \tag{14}$$

Here, $(\ln Y_t)^* = \ln Y_t - \sum_{i=1}^{m} \gamma_i Z_i$, such that (11) is a classic variable coefficient model. For the smooth function coefficients $\alpha(t)$ and $\beta(t)$, a local polynomial estimation method is used, which is locally linearly expanded at t_0:

$$\alpha(t) = a_1 + b_1(t - t_0) \tag{15}$$

$$\beta(t) = a_2 + b_2(t-t_0) \tag{16}$$

Let $X_{1t} = \ln K_t$, $X_{2t} = \ln L_t$, the estimate problems in (11) can be converted to local weighted least squares to minimise:

$$\text{Min} \sum_{t=1}^{n} \{(\ln Y_t)^* - \sum_{i=1}^{2}(a_i + b_i(t-t_0)X_{it})\}^2 K_{\mathbf{h}} \tag{17}$$

Where $K_{\mathbf{h}} = K(\bullet/h)/h$ is the kernel function and h is the window frame. Remember

$$\mathbf{Y} = (Y_1, \ldots, Y_n)^T, \mathbf{Z} = (Z_1, \ldots, Z_n)^T, \mathbf{Z}_i = (Z_{i1}, \ldots, Z_{im})^T$$

$$\mathbf{X} = (X_1, \ldots, X_n)^T, \mathbf{X_i} = (X_{i1}, X_{i2})^T, \mathbf{a}(t) = (\alpha(t), \beta(t))^T,$$

$$W = diag(K_{\mathbf{h}}(t_1-t), \ldots, K_{\mathbf{h}}(t_n-t))$$

$$\mathbf{M} = \begin{pmatrix} \mathbf{a}^T(t)X_1 \\ \vdots \\ \mathbf{a}^T(t)X_n \end{pmatrix} \mathbf{D} = \begin{pmatrix} X_1^T & \dfrac{t_1-t}{h}X_1^T \\ \vdots & \vdots \\ X_n^T & \dfrac{t_n-t}{h}X_n^T \end{pmatrix}$$

Then (11) can be written as:

$$Y - Z\gamma = M + \varepsilon \tag{18}$$

The estimate for $\widehat{M}$ is:

$$\hat{\mathbf{M}} = \begin{pmatrix} (X_1^T0)\{\mathbf{D^TWD}\}^{-1}\mathbf{D^TW} \\ \vdots \\ (X_n^T0)\{\mathbf{D^TWD}\}^{-1}\mathbf{D^TW} \end{pmatrix} (\mathbf{Y} - \mathbf{Z}\gamma) = \mathbf{S}(\mathbf{Y} - \mathbf{Z}\gamma) \tag{19}$$

$\mathbf{S}$ is usually called a smooth matrix, and (20) is substituted into (19), and the linear partial coefficient estimate can be obtained.

$$\hat{\gamma} = \{\mathbf{Z^T(I-S)^T(I-S)Z}\}^{-1}\mathbf{Z^T(I-S)^T(I-S)Y} \tag{20}$$

$$\hat{\mathbf{M}} = \mathbf{S}(\mathbf{Y} - \mathbf{Z}\hat{\gamma}) \tag{21}$$

The estimated values of the corresponding function coefficients for the local linear expansion of $\alpha(t)$ and $\beta(t)$ at t_0 are:

$$(\hat{a}_1, \hat{a}_2, h\hat{b}_1, h\hat{b}_2) = \{\mathbf{D^T W D}\}^{-1} \mathbf{D^T W (Y - Z\hat{\gamma})} \tag{22}$$

Using the profile local polynomial method, the final estimate of the unknown parameters and function coefficients $\alpha(t)$ and $\beta(t)$ can be obtained.

3.3. Decomposition formula

3.3.1. Continuous economic aggregate growth decomposition formula

Considering the continuous time case, the economic growth rate decomposition formula of the time-varying elasticity production function is:

$$\underbrace{\frac{\partial \ln Y_t}{\partial t}}_{\dot{Y}} = \underbrace{\frac{\partial A_t}{\partial t}}_{T\dot{P}} + \underbrace{\alpha'(t)\ln K_t + \beta'(t)\ln L_t}_{SC} + \underbrace{\alpha(t)\frac{\partial \ln K_t}{\partial t}}_{\dot{K}} + \underbrace{\beta(t)\frac{\partial \ln L_t}{\partial t}}_{\dot{L}} \tag{23}$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{TFP}$$

If we assume that the scale return does not change: $\alpha_t + \beta_t = 1$, then Equation (23) can be further simplified to:

$$\underbrace{\frac{\partial \ln Y_t}{\partial t}}_{\dot{Y}} = \underbrace{\frac{\partial A_t}{\partial t}}_{T\dot{P}} + \underbrace{\alpha'(t)\ln K_t + (1-\alpha'(t))\ln L_t}_{SC} + \underbrace{\alpha(t)\frac{\partial \ln K_t}{\partial t}}_{\dot{K}} + \underbrace{\beta(t)\frac{\partial \ln L_t}{\partial t}}_{\dot{L}} \tag{24}$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{TFP}$$

At this point, the economic aggregate growth is decomposed into the sum of capital (K), labour (L), technological progress, and structural change contributions.

3.3.2. Decomposition of discrete economic aggregate growth

Since the economic accounting process usually uses discrete time series in years, the economic growth rate decomposition formula considering the discrete time case can be written as follows. Let $\dot{Y}_t = \ln Y_t / Y_{t-1}$ be the economic growth rate of the t-th period, and the economic growth rate can be expressed as:

$$\dot{Y}_t = \ln Y_t / Y_{t-1} = \ln Y_t - \ln Y_{t-1}$$
$$= \ln A_t + \alpha(t)\ln K_t + \beta(t)L_t - [\ln A_{t-1} + \alpha(t-1)\ln K_{t-1} + \beta(t-1)L_{t-1}]$$
$$= [\ln A_t - \ln A_{t-1}] + [\alpha(t)\ln K_t - \alpha(t-1)\ln K_{t-1}]$$
$$+ [\beta(t)\ln L_t - \beta(t-1)L_{t-1}]$$
$$= [\ln A_t - \ln A_{t-1}] + [\alpha(t)\ln K_t - \alpha(t)\ln K_{t-1} + \alpha(t)\ln K_{t-1} - \alpha(t-1)\ln K_{t-1}]$$
$$+ [\beta(t)\ln L_t - \beta(t)\ln L_{t-1} + \beta(t)\ln L_{t-1} - \beta(t-1)L_{t-1}]$$
$$= \underbrace{\ln A_t / A_{t-1}}_{\dot{A}} + \underbrace{[\alpha(t) - \alpha(t-1)]\ln K_{t-1} + [\beta(t) - \beta(t-1)]\ln L_{t-1}}_{SC_t} + \underbrace{\alpha(t)\ln K_t / K_{t-1}}_{\dot{K}} + \beta(t)\underbrace{\ln L_t / L_{t-1}}_{\dot{L}}$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{TF\dot{P}_t}$$

If the scale return is assumed to be constant: $\alpha_t + \beta_t = 1$, the above formula can be further simplified to:

$$\underbrace{\underbrace{\ln A_t/A_{t-1}}_{\dot{A}} + \underbrace{[\alpha(t) - \alpha(t-1)]\ln K_{t-1}/L_{t-1}}_{SC_t}}_{T\dot{FP}_t} + \alpha(t)\underbrace{\ln K_t/K_{t-1}}_{\dot{K}} + \beta(t)\underbrace{\ln L_t/L_{t-1}}_{\dot{L}} \qquad (25)$$

Let $\dot{K}_t = \ln K_t/K_{t-1}$ be the t-term capital growth rate; $\dot{L}_t = \ln L_t/L_{t-1}$ be the t-th labour growth rate; $\dot{A}_t = \ln A_t/A_{t-1}$ be the t-th technological progress growth rate. It should be noted that here, we let $SC_t = [\alpha(t) - \alpha(t-1)]\ln K_{t-1}/L_{t-1}$ be the t-th element structure; $T\dot{FP}_t$ is the t-th growth rate of TFP, which is equivalent to the sum of the technology progress growth rate and factor structure change: $T\dot{FP}_t = \dot{A}_t + SC_t$. Therefore, based on the time-varying elasticity production function, the economic growth rate is found to equal to the sum of capital, labour, technological progress, and factor structure contribution:

$$\dot{Y}_t = \dot{A}_t + SC_t + \alpha(t)\dot{K}_t + \beta(t)\dot{L}_t \qquad (26)$$

Among them, $\alpha(t)\dot{K}_t$ is the contribution of capital, measuring the contribution of capital investment growth to economic growth; $\beta(t)\dot{L}_t$ is the contribution of labour, measuring the contribution of labour input growth to economic growth; $\dot{A}_t$ is the contribution of technology, measuring the contribution of technological progress to economic growth; SC_t is the contribution of structural change, measuring the contribution of economic structural change to aggregate economic growth.

3.3.3. Continuous economic mean growth decomposition formula

Considering that, in the process of economic accounting, economic growth is usually expressed by the increase in per capita output, under the condition that the economic scale returns the same ($\alpha(t) + \beta(t) = 1$), the improved Cobb-Douglas production function $Y_t = A_t K_t^{\alpha(t)} L_t^{\beta(t)}$ can be simplified to $Y_t = A_t K_t^{\alpha(t)} L_t^{1-\alpha(t)}$, the equations are divided by L_t, and we obtain per capita output:

$$y(t) = A(t)k(t)^{\alpha(t)} \qquad (27)$$

Similarly, by deriving the logarithm of (23), we can obtain the growth accounting formula for the variable total production function.

$$\underbrace{\frac{\dot{y}_t}{y_t}}_{\dot{y}} = \underbrace{\underbrace{\frac{\dot{A}_t}{A_t}}_{\dot{A}} + \underbrace{(\alpha(t)\ln k(t))\frac{\dot{\alpha}(t)}{\alpha(t)}}_{sc_t}}_{TFP_t} + \alpha(t)\underbrace{\frac{\dot{k}_t}{k_t}}_{\dot{k}} \qquad (28)$$

At this point, per capita output growth has been broken down into technological advances ($\dot{A}$), per capita capital ($\dot{k}$), and changes in factor structure (SC_t), where the

elemental structure $(\alpha(t)\ln k(t))\frac{\dot{\alpha}(t)}{\alpha(t)}$ is the driving force behind the upgrading of production structure, which is the unique and critical growth driver of developing countries. Given this, the change in factor structure has been more intuitively portrayed in the time-varying elasticity production function model.

3.3.4. Decomposition of discrete economic mean growth

The economic accounting process usually uses discrete per capita output to increase the expansion of economic growth. For the previous formula (27), $y(t) = A(t)k(t)^{\alpha(t)}$, and $\dot{y}_t = \ln y_t/y_{t-1}$ is the t-per capita output growth rate, then the per capita economic growth rate can be expressed as:

$$
\begin{aligned}
\dot{y}_t = \ln y_t/y_{t-1} &= \ln y_t - \ln y_{t-1} \\
&= \ln A_t + \alpha(t)\ln k_t - [\ln A_{t-1} + \alpha(t-1)\ln k_{t-1}] \\
&= \ln A_t - \ln A_{t-1} + \alpha(t)\ln k_t - \alpha(t-1)\ln k_{t-1} \\
&= \ln A_t/A_{t-1} + [\alpha(t)\ln k_t - \alpha(t)\ln k_{t-1}] + [\alpha(t)\ln k_{t-1} - \alpha(t-1)\ln k_{t-1}] \\
&= \underbrace{\ln A_t/A_{t-1}}_{\dot{A}} + \underbrace{[\alpha(t) - \alpha(t-1)]\ln k_{t-1}}_{sc_t} + \underbrace{\alpha(t)\ln k_t/\ln k_{t-1}}_{\dot{k}}
\end{aligned}
\tag{29}
$$

$$\underbrace{\hphantom{\ln A_t/A_{t-1} + [\alpha(t) - \alpha(t-1)]\ln k_{t-1}}}_{TFP_t}$$

Let $\dot{A}_t = \ln A_t/A_{t-1}$ be the growth rate of technological progress in the t-th period; $\dot{k}$ is the contribution rate of per capita capital growth, and $SC_t = \alpha(t)\ln k_t - \alpha(t-1)\ln k_{t-1}$ is the structural structure of the t-th period. Based on the time-varying elasticity production function, the growth rate of per capita output is found to be equal to the sum of the contribution of technological progress and structural change:

$$
\dot{y}_t = \dot{A}_t + \dot{k} + sc_t
\tag{30}
$$

4. Empirical research

4.1. Data and time-varying elasticity

Empirical research uses China's statistical data from 1978 to 2017: (1) gross domestic product Y (unit: 100 million yuan): base period of actual GDP in 1952; (2) capital stock K (unit: 100 million yuan): The base stock of capital in 1952 was 80.7 billion yuan (according to the estimation results of Zhang, Wu, and Zhang (2004)), the economic depreciation rate was 9.6% (using Zhang, et al.'s (2004) method), and the legal residual rate was 4% (refer to Cao (2008). Capital input is derived via a simple arithmetic mean of the fixed capital stock at the beginning of the year and the fixed capital stock at the end of the year. (3) Labour input L (unit: 10,000 people) expressed as the average of the number of employed persons at the beginning and end of the year. (4) The technical level is represented by a linear combination of the constant term Z_1, the degree of marketisation Z_2 (the proportion of the non-state owned economy in the total industrial output value), and the economic structure Z_3 (the proportion of the labour input of tertiary industry). The above data are taken from 'China
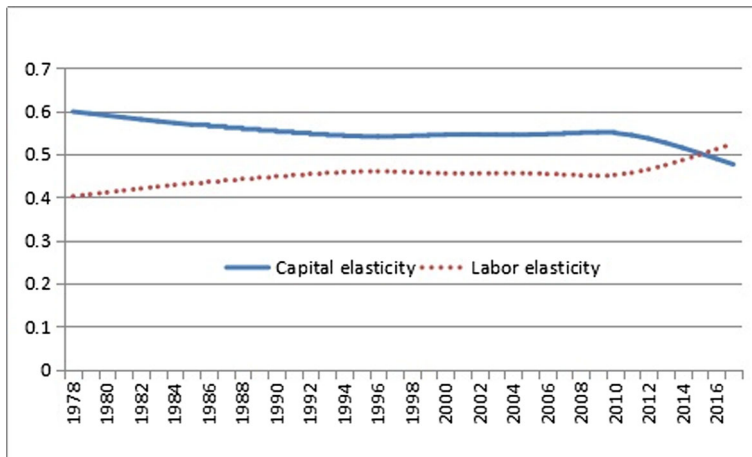
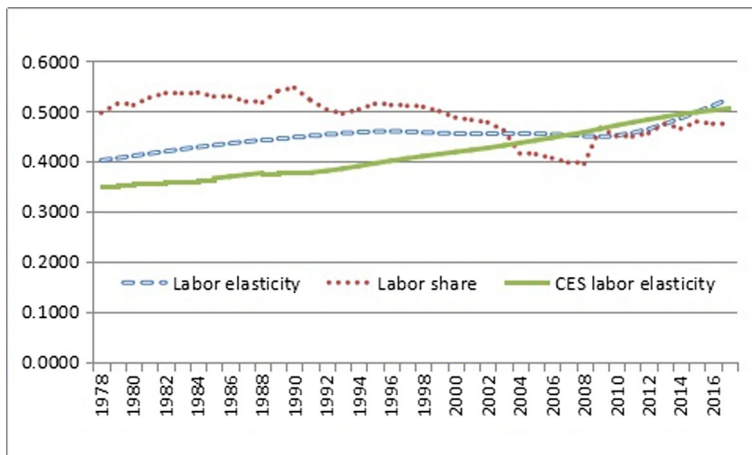**Figure 1.** Time-varying elasticity trend.

Figure 2. Comparison of labour elasticity trends.

Statistical Yearbook 2018' (Budget & Accounting and Statistics, 2018), '*China's Gross Domestic Product Accounting Historical Data*', and '*New China's Fifty-Five Years Statistical Data Collection*'.

Using Fan and Huang's (2005) profile estimation method, the Gaussian kernel function is selected, the window frame is selected according to the Silverman method, and the time-varying capital output elasticity of the time-varying elastic production function (11) is estimated by the local linear estimation method. According to $\beta(t) = 1 - \alpha(t)$, the time-varying labour output elasticity is obtained (Figure 1). Meanwhile, the estimated output elasticity is compared with the labour elasticity estimated by the CES production function (Figure 2). To intuitively compare the variation of theoretical labour income share[5] and real wage with the time-varying elastic production function model, the trend graph is shown in Figure 3.

It can be seen from Figure 1 that during the period from 1978 to 2017, China's capital and labour output elasticities were not fixed constants but showed non-linear
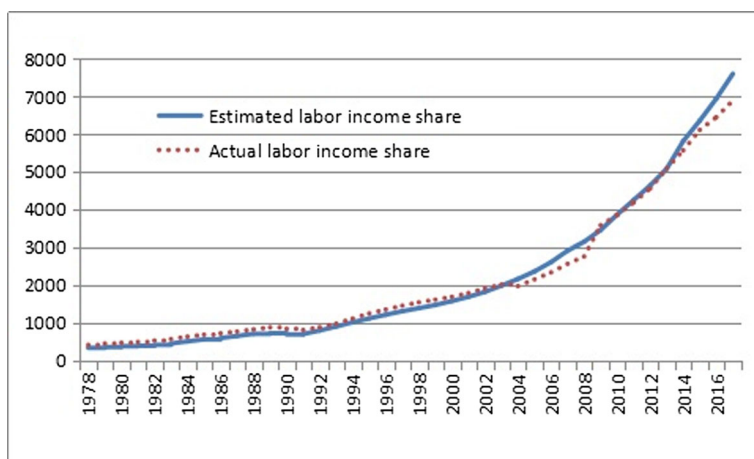
Figure 3. Comparison of estimated labour income share and real wage.

changes over time. One of the explanations is that China is in a period of economic transformation. With the reduction in the flow restriction of production factors and the liberalisation of prices, the quantity and price of capital and labour change over time. Therefore, the share of capital and labour in different periods will also exist to a certain extent. The change (Zhang, 2015), which means that the time-varying factor output elasticity is one of the inevitable phenomena in China's economic growth process.

The CES production function can also describe the change in factor elasticity over time. Comparing the labour elasticity estimated by the time-varying elastic production function model with the CES function, we can clearly see that the actual labour share declined first between 1978 and 2017. The post-rising trend, by contrast, is basically consistent with the trend of the time-varying elastic production function model. Moreover, the model estimates the results more smoothly. The reason is that the CES production function actually implies that the capital and labour output elasticity are respectively a linear function of the labour capital or a log-linear combination function. This assumption is too strict and very unreasonable and does not conform to China's national conditions.

Further, according to Figure 3, the estimated theoretical labour income share is strikingly consistent with real wage data and trends. The correlation coefficient of the two is 0.91, which means that the time-varying elastic production function model is used to estimate the factor income share with certain feasibility, accuracy, and stability (Zhang & Xu, 2010).

4.2. Decomposition of economic aggregate growth

To describe the above phenomenon of structural changes more intuitively, we measure the contribution of each factor during this period, based on formula (28), calculate capital (K), labour (L), technological progress (A), and structural change (SC) (Table 1), and Figure 4 shows the contribution rate of each element of the economic aggregate and its changing trend.

Table 1. Economic (total) growth rate decomposition.

Year	Economic contribution rate（%）				
	K	L	A	SC	TFP
1979	67.30	11.40	10.07	11.22	21.29
1980	64.17	14.60	10.40	10.82	21.22
1981	86.76	25.90	−28.24	15.58	−12.66
1982	46.77	16.22	28.20	8.81	37.01
1983	41.95	12.34	38.71	7.00	45.71
1984	35.22	9.44	50.62	4.73	55.35
1985	45.06	12.20	37.92	4.82	42.74
1986	69.41	15.92	8.21	6.46	14.67
1987	54.89	11.36	29.28	4.47	33.75
1988	56.37	11.96	27.57	4.10	31.67
1989	117.44	26.26	−53.60	9.89	−43.71
1990	91.26	107.97	−108.82	9.60	−99.22
1991	41.90	41.73	12.31	4.06	16.37
1992	35.17	3.65	58.61	2.57	61.18
1993	45.51	3.48	48.80	2.22	51.02
1994	55.14	3.64	39.50	1.73	41.22
1995	67.39	4.13	27.40	1.09	28.49
1996	71.62	5.29	23.00	0.09	23.09
1997	71.50	6.57	22.72	−0.78	21.94
1998	79.19	7.32	14.75	−1.27	13.49
1999	77.76	6.92	16.34	−1.01	15.33
2000	67.85	5.70	26.88	−0.43	26.45
2001	68.71	6.45	24.91	−0.07	24.84
2002	65.77	5.94	28.22	0.07	28.29
2003	66.07	4.55	29.34	0.05	29.39
2004	70.25	4.65	25.11	0.00	25.11
2005	68.21	4.25	27.51	0.03	27.54
2006	63.03	3.27	33.51	0.20	33.70
2007	58.07	2.82	38.69	0.42	39.11
2008	82.16	3.66	13.39	0.78	14.17
2009	87.01	−3.86	16.58	0.26	16.85
2010	80.78	−4.11	24.62	−1.30	23.33
2011	84.38	2.00	18.18	−4.56	13.62
2012	94.08	2.45	13.59	−10.13	3.47
2013	88.52	2.32	23.99	−14.84	9.16
2014	52.71	1.52	58.12	−12.34	45.78
2015	74.11	2.29	48.49	−24.88	23.60
2016	62.72	1.78	63.89	−28.38	35.50
2017	56.99	0.96	71.51	−29.45	42.06
Average	67.01	10.38	23.08	−0.47	22.61

According to Table 1 and Figure 4, first, the average order of economic growth is generally in the order of capital, technological progress, labour, and factor structure change, which are 67.01%, 10.38%, 23.08%, and −0.47%, respectively. Among them, capital contribution has an absolute position, which is consistent with China's long-term reform and opening up, mainly relying on capital investment to drive the economy's extensive economic growth mode. It is worth noting that the average contribution rate of factor structure changes during the inspection period is actually negative, which has become the main factor to reduce economic growth.

Further, according to the gradual reform and modernisation process of China's economy,[6] the staged analysis of the contribution rate of each factor is shown in Table 2.

Based on Figure 4 and Table 2, we find that (1) The contribution of capital has always occupied an absolute dominant position, especially after the 2008 financial
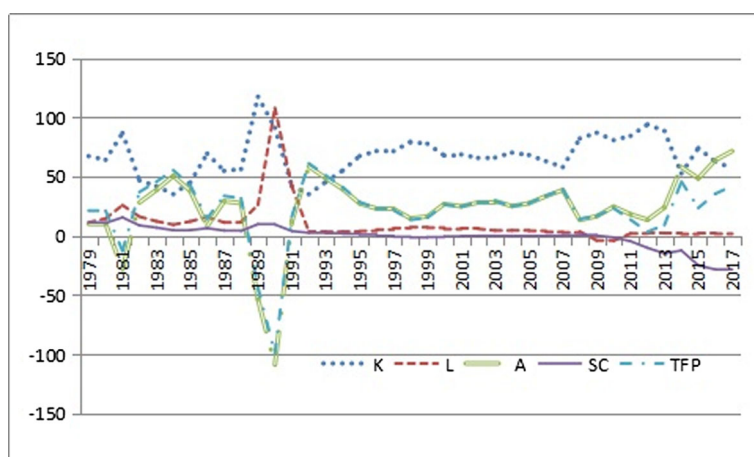
Figure 4. Contribution rate of each element of economic aggregate.[7]

Table 2. Stage contribution rate of economic (total) growth momentum.

	Contribution rate （%）				
Year	K	L	A	SC	TFP
1979–1992	60.98	22.93	8.66	7.44	16.10
1993–2008	67.39	4.92	27.50	0.20	27.70
2009–2013	86.95	−0.24	19.39	−6.11	13.29
2014–2017	61.63	1.64	60.50	−23.76	36.74

crisis. Influenced by the 'four trillion plan,' which is an ambitious economic stimulus package, investment in capital has promoted steady and rapid economic growth. (2) The peak period of labour contribution is the initial stage of reform and opening up due to the advancement of urbanisation; the rural and agricultural labour force has continued to shift to urban and non-agricultural industries. The temporary demographic dividend has greatly promoted rapid economic growth. However, since 2011, the demographic dividend has disappeared, labour costs have risen, and the rate of return on investment has fallen, and China, whose economy has gradually shifted from high-speed to medium-to-high-speed growth, has entered the critical period of the Lewis turning point; the contribution of labour has also rapidly declined. (3) Technological progress is the core force of China's economic growth. Its contribution rate has increased rapidly, especially since 2014, even with the contribution rate of capital, which has greatly improved the TFP and the high-quality development of China's economy. These factors have laid a good foundation for continued economic growth. (4) As for the factor structure, the average contribution rate was 7.44% in 1979–1992, which is inseparable from the development of urban-rural dual economic structure in China's reform and opening up process. During this period, production factors, especially labour force, moved to the sectors with high productivity or high productivity growth, which increased productivity and accelerated the economic growth to some extent. From 1993 to 2008, the contribution of the factor structure decreased rapidly. The average contribution rate during the period is 0.20%. The

Table 3. Economic (average) growth rate decomposition.

Year	Contribution rate (%)			
	k	sc	A	TFP
1979	70.39	15.60	14.00	29.6
1980	67.07	16.79	16.14	32.93
1981	133.65	41.41	−75.07	−33.66
1982	39.68	14.36	45.97	60.33
1983	35.52	9.88	54.60	64.48
1984	29.00	6.07	64.93	71
1985	40.44	6.71	52.85	59.56
1986	76.88	10.18	12.94	23.12
1987	54.47	6.03	39.50	45.53
1988	56.59	5.62	37.79	43.41
1989	206.55	24.12	−130.67	−106.55
1990	29.55	−6.81	77.26	70.45
1991	−118.43	54.19	164.24	218.43
1992	33.47	2.79	63.74	66.53
1993	44.77	2.40	52.83	55.23
1994	55.23	1.88	42.90	44.78
1995	68.70	1.19	30.10	31.29
1996	73.91	0.10	25.99	26.09
1997	74.40	−0.91	26.51	25.6
1998	83.94	−1.51	17.57	16.06
1999	81.93	−1.19	19.26	18.07
2000	69.76	−0.49	30.73	30.24
2001	71.06	−0.08	29.02	28.94
2002	67.47	0.08	32.46	32.54
2003	67.35	0.05	32.60	32.65
2004	72.04	0.00	27.96	27.96
2005	69.62	0.04	30.34	30.38
2006	63.68	0.21	36.11	36.32
2007	58.29	0.45	41.26	41.71
2008	84.57	0.85	14.58	15.43
2009	84.48	0.24	15.27	15.51
2010	78.62	−1.19	22.57	21.38
2011	85.75	−4.77	19.01	14.24
2012	96.34	−10.69	14.35	3.66
2013	90.37	−15.60	25.23	9.63
2014	52.75	−12.74	59.99	47.25
2015	75.26	−26.08	50.82	24.74
2016	63.22	−29.41	66.19	36.78
2017	57.16	−30.00	72.84	42.84
Average	65.27	2.05	32.69	34.73

reason is that, from a macro perspective, the demographic dividend may gradually disappear, and the efficiency of resource allocation will gradually decline. In 2009–2013, the impact of the 'four trillion plan' and the governments intervention began to be highlighted. It inhibits the flow of production factors in the market. The phenomenon of resource mismatches in the process of economic development began to intensify, and the factor structure began to have a negative effect (−6.11%). What is even more concerning is that since the Chinese economy entered the new normal in 2014, the aftermath of the long-term extensive economic growth mode has become more obvious. The contribution of the factor structure is actually −23.76%, which is comparable to the impact of structural effects on TFP in the results of Cai and Fu (2017). On this basis, we further discuss the case in which the factor structure effect is zero, and find that under the condition of no distortion of the element structure, the TFP can be increased by 1.97 percentage points on average, and the economic
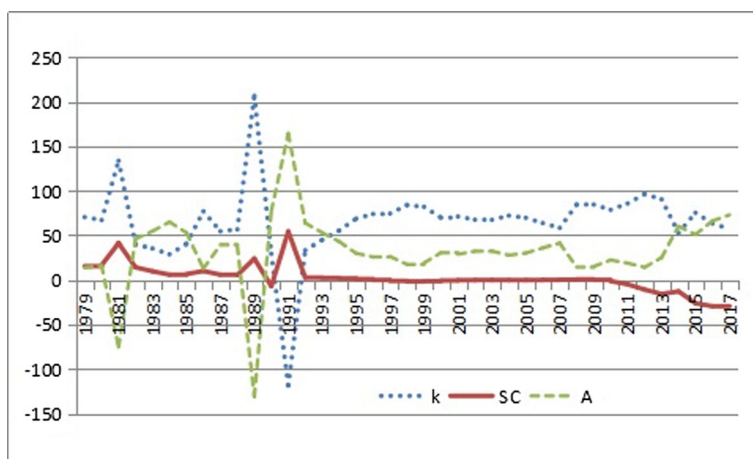
Figure 5. Per capita output growth rate decomposition.

Table 4. Stage contribution rate of economic (average) growth momentum.

Year	Contribution rate （%）			
	k	sc	A	TFP
1979–1992	53.92	14.78	31.30	46.08
1993–2008	69.17	0.19	30.64	30.83
2009–2013	87.11	−6.40	19.29	12.88
2014–2017	62.10	−24.56	62.46	37.90

growth can increase by at least 0.016 percentage points. Similarly, Cao and Lou (2012) also argue that if we eliminate the mismatch factors of all mismatched years, China's GDP growth rate will increase by an average of 0.90 percentage points per year. This is indeed a matter worth considering.

4.3. Decomposition of economic mean growth

Further, considering the economic accounting process, per capita output is usually regarded as an effective tool for understanding and grasping the macroeconomic performance of a country or region. Therefore, according to formula (30), the per capita output increment is decomposed into per capita capital investment (k), technological progress (A), and structural change (SC), and their respective contribution rates (Table 3) and their trends (Figure 5).

As shown in Table 3 and Figure 5, the average contribution of per capita capital investment, technological progress, and factor structure change is 65.27%, 32.69%, and 2.05%, respectively. Capital investment is indeed the core driving force of per capita output growth. Again, from the perspective of the trend of change, it can be roughly divided into four stages.

Based on the above, we can conclude that: (1) In 1979–1992, the contribution of per capita capital investment and technological progress to economic growth alternated, and the contribution of both to the growth of per capita output displayed a 'chasing each other' trend. During this period, although there are certain fluctuations

in the change of factor structure, the overall impact is weak. (2) From 1993 to 2008, due to the influence of economic marketisation, the contribution of per capita capital investment increased rapidly, and the contribution of technological progress also increased dynamically. The two jointly promoted the rapid growth of per capita output, while the factor structure effect was negligible. (3) In 2009–2013, similarly, under the influence of the 'four trillion plan', the contribution of capital peaked once again, the contribution of technological progress at this stage began to decline, and the factor structure effect began to show negative values. To a certain extent, it is a macroscopic manifestation of the negative impact of government intervention in the market economy. (4) In 2014–2017, China's economy entered a new normal, and the contribution of technological progress exceeded capital investment, becoming the primary productive force, the transformation of growth momentum, and the gradual transformation of economic structure. However, it is worth noting that the element structure's contribution at this stage is −24.56%, which means that in the process of economic restructuring, the allocation of production factors is distorted, and there are serious resource mismatches.

5. Conclusion

This study improves the classical Cobb-Douglas production function by combining the contribution of the change in China's factor income share from the perspective of the change of factor structure. In addition, this study decomposes the momentum of economic growth and analyses the relationship between factor structure and China's economic growth based on the time-varying elastic production function model. The main conclusions are as follows.

First, in terms of the decomposition of the driving force of economic growth, between 1978 and 2017, the contribution of capital, technological progress, labour, and factor structure changes to the economic aggregate growth rate are 67.01%, 10.38%, 23.08%, and −0.47%, respectively. Among them, capital contribution plays a significant role, which is consistent with China's long-term reform and opening up, mainly relying on capital investment to drive the economy's extensive growth mode. However, since the Chinese economy entered a new normal in 2014, the contribution of technological progress has grown more quickly, even surpassing capital contribution, becoming the primary productive force. The growth momentum and the economic structure has gradually transformed. It is worth noting that the average contribution rate of factor structure changes during the survey period is negative, especially since entering the new normal. The negative effect is more obvious, which means that during this period, there are serious resource mismatches in China's factor structure.

Secondly, the measurement results of this study can reasonably describe the changes in the structural structure of key time points in the process of China's economic gradual reform. From 1979 to 1992, the contribution rate of factor structure (7.44%) originated from the development of urban and rural dual economic structure. From 1993 to 2008, the contribution of factor structure decreased rapidly, with an average contribution rate of 0.20% during the period. From a macro perspective, the

reason may be that the demographic dividend is gradually disappearing, and the efficiency of resource allocation is gradually decreasing. In 2009–2013, the effects of the 'four trillion plan' began to be highlighted and the government intervened to some extent, and the phenomenon of resource mismatch began to intensify in the process of economic development. The factor structure began to have a negative effect (−6.11%), the contribution of TFP has also been lowered, and economic growth has also shifted from high-to-medium and high speed. Since the Chinese economy entered the new normal in 2014, the impact of long-term extensive economic growth has become more apparent, and the contribution of factor structure has reduced to −23.76%.

Thirdly, the measurement results of the factor structure effect reveal that if the factor structure distortion is completely eliminated, the TFP can be increased by 1.97% on average, and the aggregate economic growth rate can be increased by at least 0.016%, which means that improving the allocation of factors can increase the TFP and thus promote the high-quality development of the Chinese economy.

This study uses the time-varying elastic production function and its decomposition formula to accurately and reasonably measure the contribution rate of factor structure effect to economic growth, which provides an alternative new method for the characterisation of the structural changes in China's economic growth process and its contribution measurement. However, the research on the 'steady growth' and 'structural composition' of the Chinese economy remains an unfinished task. It is hoped that this study will inspire more in-depth research.

6. Future research direction

1. The model approach in this study is currently only used to characterise the utility of factor structure changes in the process of economic structural transformation in developing countries like China. Further, as for the direction of China's economic future, we will continue to track and compare the universality of the model.

2. In the research conclusions, factor resource mismatch is the resistance of economic growth in recent years, and how to adjust the factor structure to increase the TFP will be an interesting and worthy topic. Further, considering the impact of the evolution of the nominal and real exchange rates of the renminbi on this basis is also an interesting question.

Notes

1. Since the 1970s, there have been two characteristic facts in the process of modern economic growth, namely the Kaldor Facts and the Kuznets Facts.
2. In 1961, Kaldor summed up the typical facts of six aspects of developed countries in the process of economic development: (1) steady growth of labour productivity; (2) steady growth of labour capital; (3) stable return on capital; (4) the ratio of capital to output is also stable; (5) the share of capital and labour in national income remains stable; and (6) there are differences in labour productivity and total output growth rate in different countries. Among them, the summary of the typical facts regarding economic growth in a country and region is mainly reflected in the first five aspects, and the fifth typical fact,

that is, the stability of capital share and labour share in national income is the core content of the 'Kaldor facts.'

3. To maintain the coherence of the full-text research without affecting the research results, this study examines this hypothesis. The technical level is represented by an exponential linear combination of a constant term Z_1, a degree of marketisation Z_2, and an economic structure Z_3.

4. According to the statistical principle, when the national accounting data of capital and labour income share is missing, the Cobb-Douglas production function can be used to estimate the output elasticity, which can be used instead of the income share for the application of TFP accounting.

5. According to the statistical principle, when the national accounting data of capital and labour income share is missing, the Cobb-Douglas production function can be used to estimate the output elasticity to replace the income share, and the application research of TFP accounting (Zhang & Xu, 2015).

6. Stage division basis: 1978, China's reform and opening up; 1992, market economic reform; 2013, dual economic transformation (system transformation and development transformation); in 2014, China's economy entered a new normal (transformation of development mode, optimisation of economic structure, transformation growth momentum).

7. From a statistical viewpoint, in order to reflect the level of urbanisation in China accurately, the urban population statistics of the four censuses in 1982, 1990, 2000, and 2010 were inconsistent. The direct reference to the population data of the statistical yearbook will lead to large fluctuations in the contribution rate of each growth momentum in recent years. However, every change in the urban population statistics occurs on a national macro basis, and the comparability of historical data is fully considered (Yu, 2002). Therefore, this study does not specify the year in which the change first occurred.

Disclosure statement

Funding

References

Aghion, P., & Howitt, P. (2009). *The Economics of Growth*. Cambridge, MA: The MIT Press.

Aoki, M. (2012). *The five phases of economic development and institutional evolution in China, Japan, and Korea. Institutions and comparative economic development*. UK: Palgrave Macmillan.

Bai, C. G., & Qian, Z. J. (2009). Who is occupying the income of residents: Analysis of the income distribution pattern of Chinese nationals. *Social Sciences in China 2009*(5), 99–115.

Barro, R. J., & Sala-I-Martin, X. (1991). Convergence across states and regions. *Brookings Papers on Economic Activity*, *1991*(1), 107–182. doi:10.2307/2534639

Barro, R. J., & Sala-I-Martin, X. (1992). Convergence. *Journal of Political Economy*, *100*(2), 223. doi:10.1086/261816

Bosworth, B., & Collins, S. M. (2008). Accounting for growth: Comparing China and India. *Journal of Economic Perspectives*, *22*(1), 45. doi:10.1257/jep.22.1.45

Brondino, G. (2018). Productivity growth and structural change in China (1995-2009): A subsystems analysis. *Structural Change and Economic Dynamics*. doi:10.1016/j.strueco.2018.09.001

Budget, D. G. O., & Accounting and Statistics. (2018). *Statistical yearbook of the Republic of China*.

Cai, F. (2016). *China's economic growth prospects: From demographic dividend to reform dividend*. Cheltenham, UK: Edward Elgar Publishing.

Cai, F. (2017). Reform effects in China: A perspective of labor reallocation. *Economic Research Journal*, *52*(7), 4–17.

Cai, C., & Wang, D. W. (1999). Sustainability of china's economic growth and labor contribution. *Economic Research 1999*(10), 62–68.

Cai, Y. Z., & Fu, Y. F. (2017). The technical and structural effects of TFP growth: Measurement and decomposition based on China's macro and sector data. *Economic*, *2017*(01), 74–90.

Cao, J. Y. (2008). China's gross production function and contribution rate of technological progress. *Research on Quantitative Economy*, *2008*(11), 37–46.

Cao, Y. S., & Lou, D. W. (2012). Misallocation, structural change and China's economic transition. *China Industrial Economics*, *2012*(10), 5–18.

Caselli, F. (2005). Accounting for cross-country income differences. *Documentos De Trabajo*, *1*(05), 679–741.

Chenery, H. B., & Elkington, H. (1979). *Structural Change and Development Policy*. Jerusalem: Folk Institute for Economic Research.

Dudzevičiūtė, G., Mačiulis, A., & Tvaronavičienė, M. (2014). Structural changes of economies: Lithuania in the global context. *Technological and Economic Development of Economy*, *20*(2), 353–370. doi:10.3846/20294913.2014.915597

Fan, J., & Huang, T. (2005). Profile likelihood inferences on semiparametric varying-coeffient partially linear models, *Bernoulli*, *11*(6), 1031–1057. doi:10.3150/bj/1137421639

Fu, C. H. (2014). An analytical framework of the costs and benefits of development strategy: On the dream, controversy and expanding of new structural economics. *South China Journal of Economics*, (1), 29–48.

Fu, C. H. (2017). New structural economics: a structure revolution to economics—A way to unscramble via endogenous aggregate production function by pde. *Economic Review*, *2017*(3), 81–103.

Fu, Y. H., Ye, X. S., & Wang Z. X. (2016). Structure changes in manufacturing industry and efficiency improvement in economic growth. *Economic Research Journal*, *51*(8), 86–100.

Gan, C. H., Zheng, R. G., & Yu, D. F. (2011). The impact of China's industrial structure change on economic growth and volatility. *Economic Research*, *46*(5), 4–16.

Gan, C. H., & Wang, Q. (2018). Changes in China's industrial structure since the reform and opening-up: Retrospect and prospect. *Research on Economics and Management*, *39* (8), 3–14.

Ge, X. Y., Wang, D. H., Yuan, Q., & Fang, F. K. (2000). A quantitative analysis on the contribution of Chinese economic structure change to the economic growth. *Journal of Beijing Normal University (Natural Science)*, (1), 43–48.

Guscina, A. (2006). Effects of globalization on labor's share in national income. *IMF Working Papers*, *06*(294), 1. doi:10.5089/9781451865547.001

Hall, R. E., & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics*, *114*(1), 83–116.

Han, G. Z., & Li, G. (2015). Misallocation and the growth of China's industry. *Economic Problems*, (1), 69–76.

Haraguchi, N., Cheng, C. F. C., & Smeets, E. (2017). The importance of manufacturing in economic development: Has this changed? *World Development*, *93*, 293–315. doi:10.1016/j.worlddev.2016.12.013

He, D. X., & Yao, Z. Q. (2008). The effect of China's industrial structure adjustment, optimization and upgrade targets and policy measures. *China Industrial Economy 2008*(05), 46–56.

Hsieh, C. T., & Klenow, P. J. (2010). Development accounting. *American Economic Journal: Macroeconomics*, *2*(1), 207–223. doi:10.1257/mac.2.1.207

Kaldor, N. (1961). Capital accumulation and economic growth. The Theory of Capital. UK: Palgrave Macmillan.

Karabarbounis, L., & Neiman, B. (2014). The global decline of the labor share. *The Quarterly Journal of Economics*, *129*(1), 61–103. doi:10.1093/qje/qjt032

Krueger, A. B. (1999). Measuring labor's share. *American Economic Review*, *89*(2), 45–51. doi:10.1257/aer.89.2.45

Krugman, P. (1994). The myth of Asia's miracle. *Foreign Affairs*, *73*(6), 62–78. doi:10.2307/20046929

Kuznets, S. (1973). Modern economic growth: Findings and reflections. *Simon Kuznets*, *63*(3), 247–258.

Leandro, P. E., & Joan, R. R. (2003). Wage and labor income in history：A survey, economic history and institution, (6), 3–10.

Lei, Q. L. (2007). China's economy structure change and its growth effects. *Statistical Research*, (11), 8–14.

Li, X. P., & Chen, Y. (2007). Labor flow, capital transfer and productivity growth: An empirical test of China's industrial structural dividend hypothesis. *Statistical Research 2007*(07), 22–28.

Lin, J. Y. (2012). New structural economics. *The World Bank Research Observer 2012*(2), 193–221. doi:10.1093/wbro/lkr007

Lin, Y. F. (2002). Viability, economic transition and reflections on neo-classical economics. *Economic Research Journal*, *2014*(1), 29–48.

Lin, Y. F. (2015). The transformation and upgrading of China's economy under the new normal: A perspective of new structural economics (in Chinese). *New Finance 2015*(06), 4–8.

Lin, Y. F., & Liu, P. L. (2003). Chinese development strategy and economic convergence. *Economic Research Journal*, *2003*(03), 19–25.

Lingxiang, Z., & Xiaotong, Z. (2011). Cyclical fluctuations and nonlinear dynamics of inflation rate. *Economic Research Journal*.

Liu, X. H. (2016). The supply-side structural reforms will promote china's economic growth — Macroeconomic analysis and reflections of 2015. *Academic Monthly*, *48*(04), 54–62.

Liu, W., & Zhang, H. (2008). Structural change and technical advance in China's economic growth. *Economic Research Journal 2008*(11), 4–15.

Liu, Y. C., & Zhu, R. (2003). Changes in China's industrial institutional system, market structure and industrial economic growth: an econometric and empirical study. *Trends in Economics*, (4), 9–12.

Luo, C. Y., & Zhang, J. (2009). Labor income share and economic development: An empirical study based on Chinese industry-level data. *Social Sciences in China*, *2009*(04), 65–79.

Massell, B. F. (1961). A disaggregated view of technical change. *Journal of Political Economy*, *69*(6), 547–557. doi:10.1086/258575

Mcmillan, M., & Rodrik, D. (2012). Globalization, structural change, and productivity growth. *IFPRI Discussion Papers*. No. 17143. NBER (http://www.nber.org/papers/w17143), June 2011.

Montobbio, F. (2002). An evolutionary model of industrial growth and structural change. *Structural Change and Economic Dynamics*, *13*(4), 387–414.

Ngai, R., & Pissarides, C. A. (2007). Structural change in a multisector model of growth. *The American Economic Review*, *97*(1), 429–443.

Nie, P. Y., & Sun, P. (2012). Monopoly innovation with exhaustible resource and labor input. *Economic Research-Ekonomska Istrazivanja*, *25*(3), 690–705.

Peneder, M. (2003). Industrial structure and aggregate growth. *Structural Change and Economic Dynamics*, *14*(4), 427.

Rodriguez, F., & Jayadev, A. (2010). The declining labor share of income. *Journal of Globalization and Development*, *3*(2), 1–18.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94*(5), 1002–1037. doi:10.1086/261420

Sachs, J., & Woo, W. T. (1994). Structural factors in the economic reforms of China, Eastern Europe, and the Former Soviet Union. *Economic Policy*, 9(18), 102–145.

Samuelson, P. A., & Solow, R. M. (1956). A complete capital model involving heterogeneous capital goods. *Quarterly Journal of Economics*, 70(4), 537–562.

Singh, & Lakhwinder. (2004). Technological progress, structural change and productivity growth in the manufacturing sector of South Korea. *World Review of Science, Technology and Sustainable Development*, 1(1), 37. doi:10.1504/WRSTSD.2004.004854

Solow, R. M. (1958). A skeptical note on the constancy of relative shares. *The American Economic Review*, 48(4), 618–631.

Stigliz, J. E. (1995). *Economics. Translation of the economics Department of Renmin University of China. Beijing*, China Renmin University Press, 1–55.

Wang, Y. (2013). New insights of new structural economics. *Economic data translation*, (2), 99–106.

Wang, L. H., & Yuan, L. (2018). Directed technical change, industrial structural transformation and factor shares in China (in Chinese). *Economic Research Journal*, 53(11), 115–131.

Wen, J., & Zhang, J. H. (2010). Resource allocation effect of China's industrial structure change. *China Soft Science 2010*(06), 57–67.

Xiangsong, Y. E. (2016). Structure changes in manufacturing industry and efficiency improvement in economic growth. *Economic Research Journal*.

Xiao, H. Y., & Hao, F. (2009). The primary distribution structure of China's income and its international comparison. *Finance & Trade Economics 2009*(02), 13–21.

Xinyuan, G., Dahui, W., Qiang, Y., & Fukang, F. (2000). A quantitative analysis on the contribution of Chinese economic structure change to the economic growth. *Journal of Beijing Normal University (Natural Science)*.

Yao, Z. Q. (2009). Productivity growth and factor reconfiguration effect: An empirical study in China. *Economic Research*, 44(11), 130–143.

Yu, H. W. (2002). Discussion on urban population statistics in China's population census. *Population and Economy*, (6), 3–8.

Zhang, P. (2006). Choice in the fog of growth: Difficult to know and difficulty——A comment on Wu Jinglian's choice of China's economic growth model. *Economic Research 2006*(02), 120–125.

Zhang, J., & Wu, G. Y. (2004). The estimation of China's provincial capital stock: 1952-2000. *Economic Research Journal*.

Zhang, J., Wu, G. Y. & Zhang, J. P. (2004). Estimation of interprovincial physical capital stock in China: 1952-2000. *Economic Research Journal*, 2004(10), 35–44.

Zhang, S. (2009). Production functions with time-varying elasticities and under the catch-up consensus: Total factor productivity. *China Economic Quarterly*, 8(02), 551–568.

Zhang, S. F., & Xu, B. (2009). Production functions with time-varying elasticities and under the catch-up consensus: Total factor productivity. *China Economic Quarterly*, 8(2), 551–568.

Zhang, S. F., & Xu, B. (2010). Labor shares estimation in the initial distribution. *Statistical Research*, 27(08), 74–78.

Zhang, S. F., & Xu, B. (2015). Analysis of China's unbalanced economic growth. *The Journal of Quantitative & Technical Economics*, 32(03), 94–110.

Zhao, J., & Tang, J. (2015). Industrial structural change and economic growth in China, 1987-2008. *China & World Economy*, 23(2), 1–21. doi:10.1111/cwe.12104

Zhao, Q. Y., & Wang, Y. (2018). The theoretical origin and progress of new structural economics – celebrating the 30th anniversary of professor Lin Yifu's return to China as a professor. *Finance and Economics Research*, 44(9), 4–40.

Zhou, M. H. (2011). Measurement and mechanism analysis of changes in labor income share in China (Doctoral dissertation). Zhejiang University.