

Decomposing China's Economic Growth from 2012 to 2019

- An Applied CGE Analysis

Xiujian Peng and Philip Adams

Centre of Policy Studies, Victoria University

Using a dynamic general equilibrium model of the Chinese economy-CHINAGEM, followed Dixon and Rimmer (2002, 2004 and 2016), this paper decomposes China's economic growth from 2012-2019. We use the decomposition mode of the CHINAGEM model to conduct our research.

1 Historical and decomposition closures

A decomposition simulation heavily relies on historical simulation as policy simulation relies on forecast (base case) simulation. There are mainly two purposes of historical simulation: first, updating model's database; second, finding out the changes of unobservable variables. We tell the model the growth of observable variables such as labour force, investment, private and government consumption, export and import, GDP price deflator and etc, then the model will generate the changes of unobservable variables such as average propensity to consumption, technology and tastes (for example, preference changes for domestic or imported goods). In the decomposition simulation, we then use the generated results from the historical simulation to evaluate the contributions of these unobserved variables to economic growth.

The database of the CHINAGEM model used in this paper is China's 2012 input output table. The movements in the exogenous variables refer to changes over the seven years from 2012 to 2019. Therefore, in these simulations the movements in the endogenous variables refer to the seven years period from 2012 to 2019.

The CHINAGEM model allows many closure choices, that is the choices of $n-m$ variables (n is the total number of variables in the CHINAGEM model and m is the total number of variables which have equations to explain) to be included in the exogenous sets¹. In a historical closure, we include the observable variables in its exogenous set. Observable variables are those for which movements can be readily observed from statistical sources for the period of interest. For example in our 2012 to

¹ Please refer to pages 10-15 in Dixon and Rimmer, (2002) and Dixon and Rimmer, (2004) for the detailed explanation of what variables should include in the exogenous set in historical closure and what variables should include in the exogenous set in decomposition closure.

2019 historical simulation, the observable variables include many macro variables such as investment, import and export. In a decomposition closure, we include in the exogenous set all naturally exogenous variables, for example, variables not normally explained in a CGE model. These may be observable variables such as tax rates and population, or unobservable variables, such as technology and preference variables.

Table 1: Categories of variables in historical and decomposition closures

Selected exogenous variables in the historical simulation $X(H\bar{D})$	Corresponding endogenous variables in the historical simulation $X(\bar{H}D)$
Real household consumption - C (x3tot)	Average propensity to consume out of GNP (apc_gnp)
Real investment - I (x2tot)	Investment/capital ratio (r_inv_cap_u)
Real government consumption - G (x5tot)	Shift variable of the ratio of government consumption/household consumption (f5tot2)
Volume of imports - M (x0imp_c)	Twist towards imported goods (twistsrc_c)
Volume of exports - X (x4tot)	All-factor augmenting technical change (a1primgen)
GDP price deflator (p0gdpxp)	Shift in the foreign demand curve (feq_gen)
Wage share which is the share of nominal wage bill over nominal GDP (wageshr)	Cost-neutral change in labour/capital ratio for all industry (twistlab)
Selected exogenous variables in historical and decomposition closure $X(HD)$	
Population (pop)	
Total employment in person (emp_person)	
Selected endogenous variables in historical and decomposition closure $X(\bar{H}D)$	
Capital growth (cap_at_t_i)	
Real wage rate (realwage)	

Table 1 displays the partitioning of variables adopted for our historical simulation from 2012 to 2019, where x represents variable, H denotes exogenous and $\bar{H}$ denotes endogenous in the historical closure, D denotes exogenous and $\bar{D}$ denotes endogenous in the composition closure.

To start a historical simulation, we have to first make a historical closure. In this closure, the variables listed in Table 1 in the left column and two variables population and total employment in person have to be exogenous². Table 2 shows the shocks for the listed exogenous variables, which are the

² We have to make some swaps to make the listed variable exogenous. Please refer to Peng and Adams (2023) for the

observed movements of these variables between 2012 and 2019. The fourth column is the simulation results of the corresponding endogenous variables and other endogenous variables.

Table 2: Shocks and results of the historical simulation from 2012 to 2019

1 Exogenous macro variables	2 Growth rate (per cent)	3 Corresponding endogenous variables	4 Growth rate (per cent)
Real aggregate household consumption (x3tot)	78.3	Average propensity to consume	8.1
Real aggregate investment (x2tot)	53.9	Investment/capital ratio (r_inv_cap_u)	-5.8
Real aggregate government consumption (x5tot)	69.1	ratio of government/household consumption (f5tot2)	-5.2
Real aggregate imports (x0imp)	25.3	Twist towards imported goods (twistsrc_c)	-52.0
Real aggregate exports (x4tot)	20.8	All-factor augmenting technical change (a1primgen)	-21.2
GDP price index (p0gdpexp)	14.4	Shift in the foreign demand curve (feq_gen)	50.9
Wage share (wageshr)	1.8	Cost-neutral change in labour/capital ratio for all industry (twistlab)	-18.3
Population (pop)	3.4		
Aggregate employment (emp_person)	1.0		
		Capital stock	59.8
		Real wage rate	59.0

Source: data in Column 2 are from World Bank online data. Column 4 are simulation results.

The historical simulation reveals the changes in technology, preference and twist variables from 2012 to 2019. For example, the all-factor augmenting technology has improved by 21.2 per cent in this period. In the decomposition simulation we will calculate how much this all-factor augmenting technology improvement contributed to the GDP growth. The average propensity to consume,

apc_gnp, which is defined as the ratio of total nominal private and government consumption to the nominal GNP, has increased by 8.1 per cent. This means that government and private consumption has increased at a faster rate than GDP. This trend is consistent with the Chinese government's new growth strategy - to rely more on domestic consumption to sustain China's economic growth.

We also notice that the ratio of government consumption/private consumption, represented by the shift variable *f5tot2* has declined by more than 5 per cent, which means that government consumption fell relatively to household consumption between 2012 to 2019. The import/domestic preference variable, *twistsrc_c* declined by 52 per cent, which reveals that there is a strong increase in favour of domestic goods. The demand for China's export is also very strong because the export demand curve moved outward by more than 50 per cent, which suggests a strong increase in export demand for China's goods. The *twistlab* for all industries declined by more than 18 per cent implying the whole economy has a favour for capital because of the increased labour cost which is shown by the increased wage share. Lastly, we notice that the economic wide investment to capital ratio (*r_inv_cap_u*) dropped by nearly 6 per cent, which indicates a slight decline in the investors' confidence. We will find out the contributions of these unobservable variables to the GDP growth between 2012 and 2019 in the next section.

2 The decomposition simulation from 2012 to 2019

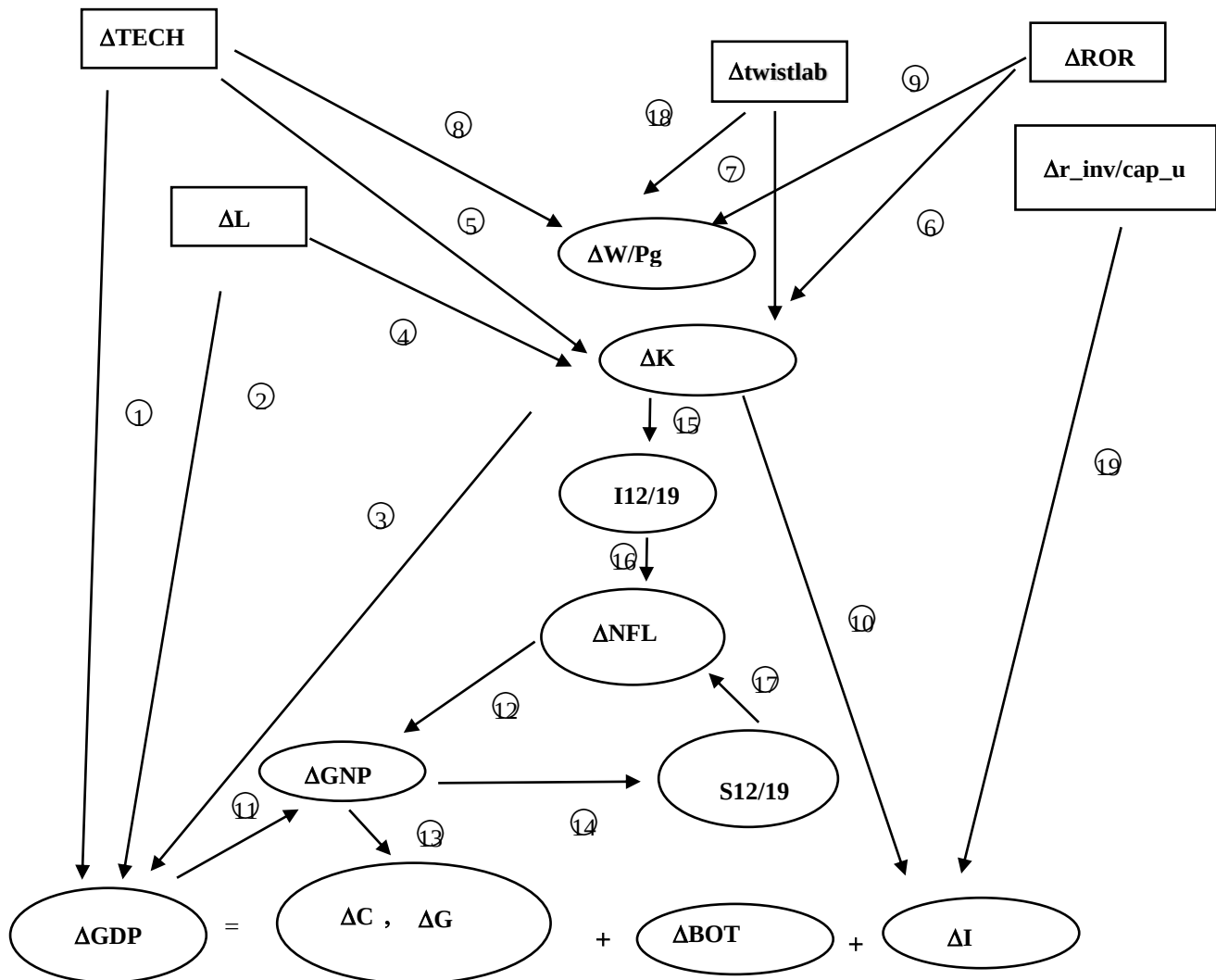
Having completed the historical simulation, we now start the decomposition simulation. In the decomposition closure, technology, taste and twist variables are exogenous as we displayed in Column 2, Table 1. By setting these variables at their values estimated from the historical simulation (Column 4, Table 2), we get the results in the decomposition simulation for consumption, investment and other endogenous variables identical to those in the historical simulation shown in Column 2, Table 1. In this section, we will first discuss the decomposition closure, then we will analyse the macro results in Table 3, column by column.

2.1 Macroeconomic assumption in the decomposition simulation

For understanding the results in Table 3, following Dixon and Rimmer (2002, 2004), we use a flow diagram displayed in Figure 1 to help us. This flow diagram is for a one-commodity CGE model, therefore, it does not illustrate relative-price or other structural effects. While these are important, Figure 1 is, nevertheless, a helpful representation of the main macro assumption underlying our CHINAGEM decomposition simulation.

Exogenous variables in the decomposition closure are represented in Figure 1 by rectangles while endogenous variables are shown in ovals. The change in aggregate employment between 2012 and 2019 (ΔL), for example, is exogenous. Thus we assume that changes in technology and changes in other exogenous variables between 2012 and 2019 did not affect aggregate employment in 2019. We also assume, as is conventional in macro modelling, that employment effects over the medium term are eliminated by adjustments in wage rates.

Figure 1: Macro connections in the decomposition simulation for 2012 to 2019



Lines ①, ② and ③ impose a production function: the change in output (ΔGDP) between 2012 and 2019 is a function of $\Delta TECH$, ΔL and ΔK . We assume that capital earns the value of its marginal product, that is, marginal product of capital (MPK). MPK is the ratio of the rental price of capital to the price of the product (In a one-commodity model, the price of the product can represent the asset price). Therefore, rate of the return on capital (ROR) can be represented by the rental/asset price ratio. Under the constant-returns to scale (assumed in CHINAGEM), MPK is the function of K/L , $TECH$ and $twistlab$. Thus ΔK is determined by $\Delta TECH$, ΔL , ΔROR and $\Delta twistlab$ (lines ④, ⑤, ⑥ and ⑦).

In our decomposition simulation, ΔROR is exogenous as indicated in Figure 1. When we are focused on analysing the effects of particular shocks over periods as long as seven years (2012 to 2019) it is conventional to assume that capital adjusts to restore rates of return. For instance, in isolating the effects of technology changes between 2012 and 2019, we assume that rates of return are unaffected. i.e. $\Delta ROR = 0$.³

With capital earning the value of its marginal product, labour also is paid according to the value of its marginal product. Therefore, via the factor-price frontier (the relationship between the MPK, MPL and $TECH$, Samuelson, 1962), ΔROR and $\Delta TECH$ determined the real wage rate. This is indicated by lines ⑧ and ⑨ in Figure 1.

Exogenisation of the rate of return can be thought of as tying down the capital stock in 2019. While tying down capital stocks for 2019 ties down aggregate investment between 2012 and 2019, it does not determine investment in 2019. We link investment in 2019 to capital in 2019 (line ⑩ in Figure 1). In isolating the effects of changes in technology etc. We assume that such changes have no impact on business confidence. Thus we treat the investment/capital ratio (a reflection of business confidence) as exogenously determined.

Lines ⑪ and ⑫ allow for the calculation of the change in gross national product between 2012 and 2019 (ΔGNP). This is GDP subtracting the change in net interest/dividend payments to foreigners (a proportion of the change in start-of-year net foreign liabilities, ΔNFL).

³ In CHIANGEM decomposition simulation, it is only the average rate of return across industries that is treated exogenously.

We assume in line ⑬ that the changes in household and government consumption (ΔC , ΔG) are exogenously given proportions of the change in GNP (that is Δpc_gnp). With ΔGDP , ΔC , ΔG and ΔI now determined, the change in the balance of trade (ΔBOT) falls out as a residual.

Line ⑭ links accumulated excess savings ($S_{12/19}$) to ΔGNP . $S_{12/19}$ is the difference between the value of the accumulated saving over the period 2012 to 2019 and the value it would have had in the absence of any change over the period in GNP. In deriving the link between $S_{12/19}$ and ΔGNP , we assume that saving in each year between 2012 and 2019 is a fixed proportion of GNP (Δps_gnp). Under a smooth growth assumption applied to GNP, this allows us to specify the accumulated excess savings as a function of ΔGNP .

By again invoking a smooth growth assumption, we can specify in our model the excess accumulated cost of investment ($I_{12/19}$) between the beginning of 2012 and the beginning of 2019 in terms of the change between these two dates in the capital stock (ΔK). The excess cost of investment is the difference in the value of the accumulated investment and the value it would have had in the absence of and change over the period in the aggregate capital stock. The link between $I_{12/19}$ and K is indicated in Figure 1 by line ⑮.

Another set of relations in Figure 1 are lines ⑯ and ⑰. They determine ΔNFL , as a result of investment $I_{12/19}$ subtracting $S_{12/19}$.

In this decomposition exercise, we also involve two exogenous variables *twistlab* and *r_inv_cap_u*. As we explained in the last section, the shock of the *twistlab* will change the demand for capital and labour. It also affects the real wage rate. With exogenous employment (ΔL), the change of *twistlab* ($\Delta twistlab$) will affect capital (line ⑦) and real wage rate (line ⑱). The shock of *r_inv_cap_u* will affect the investment/capital ratio and directly affect investment (line ⑲).

2.2 Decomposition simulation – macro results

The last column in Table 3 shows the final results of the decomposition simulation for macro variables of the Chinese economy from 2012 to 2019. Columns 1 to 8 provide a decomposition of these outcomes computed through simulations 1 to 8 with the closure illustrated in Figure 1.

The main feature of the Chinese economy over the period 2012 to 2019 was rapid growth in consumption relative to GDP whereas the increase in real GDP was 60.2 per cent and the increases in household consumption and government consumption were 78.3 and 69.1 per cent. This is

different from the period 2002 to 2009 when China's trade grew rapidly relative to GDP (the average annual growth rates of exports and imports were 17 and 12 per cent, while the average annual growth rate of GDP was 10 per cent and household consumption was only 7 per cent) (Mai, et al. 2010). We will use our decomposition table to explain the rapid increase in consumption from 2012 to 2019. But first, we will start to analyse the decomposition results by looking at each factor from columns 1 to 8 individually.

Column 1: technical change (all factor augmenting technical change)

The macro effects of the historically estimated movements in technology variable (a_1 primgen – all-factor augmenting technical improvement) are shown in column 1 of Table 3. We notice that China has experienced rapid technical improvements in this period – a remarkable 21.2 per cent improvement. With fixed employment and fixed rates of return on capital, technical improvements increase the real wage rate and increase GDP directly via the production function (line 1, Figure 1) and indirectly via increase in capital stock (Lines 5 and 3). Table 3 shows that technical changes over the period 2012 to 2019 drive the capital stock to increase by 18.4 per cent (row 3, column 1), which is more than one-quarter of the total increase of capital over this period (row 3, column 9). The technical changes also drive the real wage rate to increase by 43.6 per cent (row 2, column 1), which is almost three-quarters of the total increase of the real wage rate over this period (row 2, column 9). The technical change also stimulates the real GDP to increase by 35.7 per cent (row 6, column 1), which is more than half of the total growth over this period (row 6, column 9).

The increase in the real GDP also resulted in an increase in real GNP (lines 11 and 12). Household and government consumption therefore also increased (line 13) (both C and G increased by 34.9 per cent, rows 8 and 9, column 1). With capital growth of 18.4 percent, investment increased as well (line 10) (20.5 per cent, row 4). Based on the GDP identity, with an almost same increase of C, G and GDP, the lower increase in I relative to GDP implies that the balance of trade has to be improved. The mechanism is real devaluation (20.0 per cent, row 1), which stimulates exports (34.1 per cent, row 11) and reduces imports (-5.4 per cent, row 10). The expansion in exports causes a deterioration of the terms of trade (-13.7 per cent, row 15).

Another reason for the change of China's trade is that the strong technology improvement increases the competitiveness of the Chinese goods in the world market, which stimulated exports but decreased imports resulting from the declined demand for import-competing goods.

Column 2: Change in import/domestic preferences

Column 2 displays the macro effects of aggregate import/domestic twist (*twistsrc_c*) from 2012 to 2019. As we discussed in Section 1 there was a strong twist away from imported goods (-52 per cent, column 2, Table 2). The effect of the sharp preference change on import volumes is a huge decline in imports (-20.8 per cent, row 10, column 2, Table 3). With *L*, *ROR* and *TECH* held constant, Figure 1 suggests that the *twistsrc_c* should have little effect on *K* and *I* (rows 3 and 4, column 2). With little impact on *I* there is little impact on the balance of trade. Thus a sharp decline in exports (-21.1 per cent, row 11) is required to match the sharp decline in imports via real appreciation (-13.3 per cent, row 1). The percentage decrease in export volumes exceeds that in import volumes because export contraction causes an increase in the terms of trade (12.6 per cent, row 15). The improvement of terms of trade increase the purchasing power GNP and real household and government consumption.

Another effect of the improvement of terms of trade is to decrease $\frac{P_i}{P_g}$, which causes structural effects on *K*, *I* and GDP. In other words, the terms of trade improvement increases the GDP deflator (P_g) relative to the price deflator of GNE. This is because the GDP deflator includes the prices of exports but excludes the prices of imports, whereas the opposite is true for the GNE deflator. Even with the terms of trade improvement, it is possible for the price deflator of a component of GNE to increase relative to the price deflator for GDP. However, for a relative import-intensive component of GNE (e.g. investment) this is unlikely. In column 2, we see that the investment goods price index P_i (12.2 per cent, row 14) increases less relative to the price deflator for GDP, P_g (15.3 per cent, row 12). With *ROR* (the rental price of capital divided by the asset price) held constant, a decrease in $\frac{P_i}{P_g}$ generates a decrease in the marginal product of capital (*MPK*). This follows from the marginal productivity condition for capital:

$$MPK = \frac{Rental}{P_g} = \frac{Rental}{P_i} * \frac{P_i}{P_g} = ROR * \frac{P_i}{P_g} \quad (1)$$

With employment and technology fixed, a decrease in *MPK* requires an increase in *K* (3.0 per cent, row 3, column 2). This produces an increase in both GDP (0.7 per cent, row 6) and *I* (3.3 per cent, row 4). The real wage rate rises (4.9 per cent, row 2) reflecting the increase in the *K/L* ratio and the consequent increase in the marginal product of labour.

As we just discussed the increase of the purchasing power GNP and real household and public consumption resulting from the improvement of the terms of trade will lead to a higher increase of household and government consumption (1.8 per cent, rows 8 and 9) relative to that of GDP (0.7

per cent, row 6).

Column 3: Shift in the export demand curve (feq_gen)

The third column of Table 3 shows the effects of changes in China's export demand condition over the period of 2012 to 2019. The historical simulation in the last section reveals that there is a large outward movement of the downward slopping export demand curve (50.9 per cent, row 6, column 4, Table 2). This change was favourable to China and stimulated exports which increased by 21 per cent (row 11, column 3, Table 3). The outward shift of the export demand curve, which means the increase in demand for China's goods at the same price, also improved China's terms of trade by 11.7 per cent (row 15, column 3).

Same mechanism as we discussed in column 2, the improvement of terms of trade generates an increase in K, I and real GDP (4.8, 4.7 per cent and 3.3 per cent, rows 3, 4 and 6). With fixed L, the increase in K raises the K/L ratio resulting higher marginal product of labour, which increases the real wage rate (6.9 per cent, row 2).

By generating an increase in the price deflator for GDP relative to the price deflator for private and public consumption (P_g/P_c) (P_g and P_c increased by 15.1 and 13.6 per cent, rows 12 and 13), the terms of trade improvement in column 3 causes an increase in "purchasing-power" GNP ($=\text{GNP} \cdot P_g/P_c$) relative to real GDP. This explains the higher growth in real household consumption and government consumption (4.5 per cent, rows 8 and 9) relative to the growth of real GDP (3.3 per cent, row 6). With a higher increase in household and government consumption and a higher increase in investment relative to the growth of real GDP, the GDP identity implies a decline in the balance of trade via real appreciation (-13.1 per cent, row 1). Since exports grow strongly resulting from the upward movement of the export demand curve, the only way to deteriorate the balance of trade is to let imports increase even higher than export. That is why we see a 34.8 per cent increase in imports (row 10).

Column 4: the effects of employment growth and growth in population

Column 4 of Table 3 displays the effects over the period 2012 to 2019 of growth in employment and population. The increases of total employment in person and population over this historical period were 1.0 and 3.4 per cent. In CHINAGEM model, there is another aggregate employment variable which is measured by using wage bill weight. The shock of one per cent increase in aggregate employment in persons generated a 3.7 per cent increase in the wage bill weighted aggregate

employment. In the CHINAGEM model, it is the variable – wage bill weighted aggregate employment which is used in production function.

With constant return to scale, fixed rates of return (ROR), fixed I/K ratios, no cost-neutral change in labour/capital ratio (*twistlab*) and no change in technology, we would expect the system depicted by lines 1 to 10) in Figure 1 to transform a 3.7 per cent increase in employment into 3.7 per cent increase in K, I and GDP with no change in the real wage rate. However, a larger domestic economy produces more exports with an associated decline in the terms of trade (-1.1 per cent, row 15, column 4). The deterioration of the terms of trade increases $\frac{P_i}{P_g}$ (P_i and P_g decreased by 1.1 and 1.4 per cent, respectively, rows 14 and 12, column 4), thus restricting the increase in K and GDP to 3.2 and 3.3 per cent (rows 3 and 6). With a reduction in the K/L ratio, there is a reduction in the marginal product of labour and in the real wage rate (-1.0 per cent, row 2).

By generating a decrease in the price deflator for GDP relative to the price deflator for private and public consumption (P_g/P_c), the terms of trade deterioration in column 4 cause a decrease in “purchasing-power” GNP ($=GNP \cdot P_g/P_c$) relative to real GDP. This explains the lower growth in real household consumption and government consumption (3.2 per cent, rows 8 and 9) relative to the growth of real GDP (3.3 per cent, row 6). The subdued increase in household and government consumption relative to real GDP requires an increase in the balance of trade facilitated by real devaluation (1.4 per cent, row 1). That’s why we see a higher increase in exports (2.2 per cent, row 11) than in imports (0.9 per cent, row 10) in column 4, Table 3.

Column 5: Cost-neutral change in lab/cap ratios by industry (*twistlab*)

The fifth column of Table 3 shows the effects of cost-neutral changes in the labour/capital ratio for all industries over the period 2012 to 2019. The historical simulation in the last section reveals that all industry has a uniform 18.3 per cent decline in *twistlab* (column 4, Table 2). The negative change of *twistlab* implies that the industries twist away from labour and chose to use more capital. This is the reason for the strong increase in the capital and investment (20.1 and 19.7 per cent, rows 3 and 4, column 5, Table 3)

With no change in employment and technology and with the average share of capital in the primary factor inputs of 48 per cent, the 20.1 per cent increase in capital transformed into a 9.7 per cent increase in real GDP (row 6, column 5). Since there are not much structural effects caused by the change in *twistlab*, therefore no much changes in the price deflator resulting in a similar growth in

real GNP (10.0 per cent, row 7), real household and government consumption (9.7 per cent, rows 8 and 9). With the strong increase in investment resulting from a strong increase in capital, the GDP identity requires a deterioration in the balance of trade facilitated by real appreciation (-1.5 per cent, row 1). The real appreciation reduced exports and stimulated imports (-2.3 and 15.6 per cent, rows 11 and 10). The other reason for the relatively strong increase in imports is that investment is normally import-oriented. The real appreciation also improved the terms of trade (1.2 per cent, row 15).

Columns 6: the change in the ratio of government/household consumption, G/C ($f5tot2$)

Column 6 shows the effects of the change in G/C ratio ($f5tot2$) over the period 2012 to 2019. A negative change of 5.2 per cent which was estimated for this ratio in the historical simulation (column 4, Table 2) indicates a lower growth in government consumption relative to the growth in household consumption. The fall of G/C explains the negative result for government consumption (-3.7 per cent, row 9, column 6, Table 3) and positive result for household consumption (1.5 per cent, row 8, column 6, Table 3). Since the government-related sectors are all labour intensive, the decline in government consumption will spare more labour to move to other sectors. The employment reallocation causes a structural effects on the economy. But with fixed employment and technology, the structural effect on K , GDP and I are very small (0.04, 0.1 and 0.3 per cent, rows 3, 6 and 4). With tiny increases in GDP , C and I and a relatively large fall in G , the GDP identity requires an improvement of the balance of trade via real appreciation (-0.1 per cent, row 1). Real appreciation explains the expansion in imports (0.2 per cent, row 10), contraction in exports (-0.1 per cent, row 11) and improvement in the terms of trade (0.1 per cent, row 15). Overall the effects of change in G/C on the economy is very mild.

Column 7: the changes in the ratio of average propensity to consume, $(C+G)/GNP$ (apc_gnp)

Column 7 shows the effects of change in average propensity to consume ($C+G/GNP$) over the period 2012 to 2019. The historical simulation reveals an 8.1 per cent increase in the average propensity to consume (column 4, Table 2). This positive change explains the strong increase in household and government consumption (10.7 per cent, rows 8 and 9) in column 7, Table 3. Again as we explained in the last paragraph, with fixed employment and technology, the structural effects caused by the increase in the consumption only generate small impacts on K , GDP and I (3.0, 1.9 and 4.3 per cent, rows 3, 6 and 4). With a large increase in C and G , the GDP identity requires a decrease in the balance of trade facilitated by a real appreciation (-7.2 per cent, row 1). Real appreciation explains

the strong expansion in imports (14.0 per cent, row 10), large contraction in exports (-11.1 per cent, row 11) and improvement in the terms of trade (6.0 per cent, row 15).

Column 8: the change in the investment/capital ratio, I/K (r_inv_cap_u)

The historical simulation shows a 5.8 per cent decline in the I/K ratio (Column 4, Table 2). The effects of the change in this ratio are displayed in Column 8, Table 3. The fall of the I/K ratio reduces the investment directly (-6.9 per cent, row 4). As we discussed above, again with fixed employment and technology, the structural effects caused by the fall in the investment only generate small impacts on K and GDP (-0.9 and -0.7) per cent, rows 3 and 6). Consistent with GDP, GNP and C and G also suffered a very small decline. With a slight fall in real GDP, C and G , and the large fall in I , the GDP identity requires an increase in the balance of trade facilitated by a real devaluation (3.4 per cent, row 1). Real devaluation reduces imports (-7.3 per cent, row 10), stimulates exports (5.6 per cent, row 11) and deteriorates the terms of trade (-2.7 per cent, row 15).

2.3 Cross-column analysis – growth of China's economy from 2012 to 2019

China's economy has experienced remarkable growth from 2012 to 2019 (real GDP increased by more than 60 per cent, row 6, column 9, Table 3). We discussed the effects on the macro economy of changes in each individual factor through columns 1 to 8 in Table 3 in the last section. Now we will focus on the cross-column analysis and try to understand why China's economy grew so fast between 2012 and 2019.

The first 6 rows in Table 4 are directly copied from Table 3. The seventh row shows the percentage change in the volume of trade in China as the average percentage change in exports and imports. The last row is the percentage change in trade relative to GDP calculated by subtracting the percentage increase in GDP from the percentage change in trade.

Column 9 in Table 4 shows the growth of the macro variables during this period, the outstanding feature is the fast growth of household consumption and government consumption (78.4 and 69.2 per cent, rows 8 and 9, column 9). Investment growth is also remarkably strong (53.9 per cent, row 4), though a bit slower than the real GDP growth. While China's trade has a relatively slower growth compared with the three components of GNE.

Why did China's economy grow so fast over this period? From row 1 in Table 4 we notice that three factors stand out for contributing to the rapid GDP growth. The first factor is the technical change. The significant technology improvement contributed 35.7 percentage points, which is more than half

of the total growth of real GDP (60.2 per cent). As we explained in the last section, the technology improvement generates a higher real GDP directly through production function and also indirectly by stimulating capital growth. The second factor is the cost-neutral change in the labour/capital ratio, which contributed 9.7 percentage points to the real GDP growth. As we discussed in the last section, the negative cost-neutral change in the labour/capital ratio generates a higher real GDP via capital growth. Employment is the third factor, which contributed 3.3 percentage points to the real GDP growth by direct stimulate GDP growth and indirectly via capital growth. The outward shift in the export demand curve also contributed positively to China's economic growth (3.3 percentage points). China's strategy of increasing domestic consumption to sustain economic growth is successful given that increase in the average propensity to consume contributed 1.9 percentage points to GDP growth. The preference change towards domestically produced goods is another positive factor that contributed to the economic growth (0.7 percentage points). The small business confidence decline is the only factor that contributed negatively to China's economic growth (-0.7 percentage points, column 8, row 1).

Now we will discuss why the household and government consumption has even faster growth than real GDP. When we compare the contribution of the above factors to the real GDP with their contribution to real household and government consumption, we noticed that except for average propensity to consume, the other factors make more or less similar contributions to both real GDP and real consumption. The increase in the propensity to consume contributed 10.7 percentage points to the growth of consumption while it only contributed 1.86 percentage points to real GDP. This is the main reason for the faster growth of consumption relative to the GDP over the period 2012 to 2019.

Now let's look at China's trade during this period. The growth of trade is only 23 per cent (column 9, row 7, Table 4), which is far below the growth of real GDP. This led to the trade as a share of GDP decreased by more than 37 per cent (column 9, row 8). There are several reasons for the change:

- The strong technology improvement which stimulated GDP growth significantly also promoted export considerably. This is because the strong improvement of total-factor productivity makes China's goods more competitive in the world market, which stimulates exports (34.1 per cent). But meanwhile, it also decreases imports for the import-competing goods (-5.4per cent). The combined change of exports and imports made a negative 21.3 percentage points contribution to the decline in trade relative to GDP (row 8, column 1).
- The significant increase in the preference towards domestically produced goods made the largest negative contribution to the decline in trade relative to GDP (-21.7 percentage points,

column 2, row 8). The preference changes towards domestically produced goods directly reduced imports and indirectly reduced exports via real appreciation (see discussion of column 2 in the last section).

- The large outward shift of the export demand curve increased exports directly. It also expanded imports via real appreciation (see the discussion of column 3 in the last section). The significant increase in both exports and imports makes the outward shift of the export demand curve the only positive factor which contributed to the change of trade relative to GDP (nearly 25 percentage points, column 3, row 8).
- Though growth in employment drove both imports and exports to increase, however, their growths are lower than those of GNE (consumption and investment) and GDP. The lower growth of trade explains the negative contribution to the decline in trade relative to GDP (-1.7 percentage points, column 4, row 8).
- The negative cost-neutral change in the labour/capital ratio, which is twisted toward capital, directly stimulates capital to growth, resulting in a strong increase in investment. Since the investment is normally import-intensive, which generates a higher import growth. But the decline in exports via real appreciation (as the discussion in column 5 in the last section) offset the positive contribution of imports to trade. As a result, the negative cost-neutral change in the labour/capital ratio contributed a negative 3.1 percentage point to the decline in trade relative to GDP (column 5, row 8, Table 4).
- The decline of business confidence (negative change in the investment/capital ratio) reduced investment directly, which is the reason for the contraction of the imports. The expansion of export could not offset the negative impact of imports on the trade. As a result, the decline of business confidence makes a negative 0.2 percentage points to the decline in trade relative to GDP (column 8, row 8, Table 4).
- The increase in the average propensity to consume and the decline in the government/household consumption ratio all contributed to the contraction of trade relative to GDP, though their effects on very small (-0.4 and -0.03 percentage points, respectively, columns 6 and 7, row 8, Table 4).

3 Summary

This paper focused on using the decomposition function of the CHINAGEM model to decompose China's economic growth from 2012 to 2019. To do so, we have to conduct a historical simulation to estimate the changes of the factors such as technology, twists and preferences variables, which contributed to China's economic growth. Using the estimated results of these variables, we then run the decomposition simulations individually and explain the effects of each variable on the macro economy. At the end, we decompose the effects of these variables on China's economic growth during this period by a cross-column analysis.

We notice that technology improvement, cost-neutral change towards capital and employment growth are the main factors that contributed to China's remarkable growth over the period 2012 to 2019, among which technology improvement is the most important factor. This finding is particularly useful for the policy maker given the backdrop of China's labour force has started to decline since 2018.

The increased export demand for China's products from the rest of the world and the strong preference change towards domestically produced goods also made a considerable contribution to China's economic growth, though the latter is the main reason for the decline in China's trade relative to GDP in the period 2012-2019.

The faster growth of consumption relative to GDP is the main feature of the Chinese economy during this period. The Chinese government's strategy of stimulating domestic consumption to grow is the main answer to this feature.

Table 3 Results of the decomposition simulations from 2012 to 2019 (per cent, macro variables)

	1	2 Changes in	3 Shift in	4 Growth in	5 Cost neutral	6 Change in	7 Change in	8 change in	9 Total
	Technology	import/domestic	export	employment	change in	government/household	average	investment/capital	
	change	preferences	demand		labour/capital	consumption ratio	propensity to	ratio	
			curve		ratio		consume/GNP		
1 Real devaluation	20.0	-13.3	-13.1	1.4	-1.5	-0.1	-7.2	3.5	-12.7
2 Real wage rate (Pg deflated)	43.6	4.9	6.9	-1.0	-1.3	-0.01	3.5	-1.6	59.2
3 Capital stock (K)	18.4	3.0	4.8	3.2	20.1	0.04	3.0	-0.9	59.9
4 Real investment (I)	20.5	3.3	4.7	3.2	19.7	0.3	4.3	-6.9	54.1
5 Employment (L-wage bill weight)	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	3.7
6 Real GDP	35.7	0.7	3.3	3.3	9.7	0.1	1.9	-0.7	60.3
7 Real GNP (Pg deflated)	32.6	2.5	5.5	3.1	10.0	0.1	3.0	-1.1	63.2
8 Real Household consumption (C)	34.9	1.8	4.5	3.2	9.7	1.5	10.7	-0.9	78.4

....continued

Table 3 continued

	1 Technology change	2 Changes in import/domestic preferences	3 Shift in export demand curve	4 Growth in employment	5 Cost neutral change in labour/capital ratio	6 Change in government/household consumption ratio	7 Change in average propensity to consume/GNP	8 change in investment/capital ratio	9 Total
9 Real									
government consumption (G)	34.9	1.8	4.5	3.2	9.7	-3.7	10.7	-0.9	69.2
10 Imports, Volume	-5.4	-20.8	34.8	0.9	15.6	0.2	14.0	-7.3	25.2
11 Exports, volume	34.1	-21.1	21.0	2.2	2.3	-0.1	-11.1	5.6	20.8
12 GDP price deflator(Pg)	-16.7	15.3	15.1	-1.4	1.6	0.1	7.7	-3.3	14.5
13 Consumer price indicator (P3)	-15.9	14.0	13.6	-1.2	1.8	0.1	7.1	-3.0	13.1
14 Price deflator for investment(Pi)	-13.0	12.2	11.4	-1.1	1.0	0.04	5.9	-2.6	12.0
15 Terms of trade	-13.7	12.6	11.7	-1.1	1.2	0.1	6.0	-2.7	11.8

Source: simulation results

Table 4 Decomposition of China's economic growth from 2012 to 2019 (per cent)

	1 Technology change	2 Changes in import/domestic preferences	3 Shift in export demand curve	4 Growth in employment	5 Cost-neutral change in labour/capital ratio	6 Change in government/household consumption ratio	7 Change in average propensity to consume/GNP	8 change in investment/capital ratio	9 Total
1 Real GDP	35.7	0.7	3.3	3.3	9.7	0.1	1.9	-0.7	60.3
2 Real investment (I)	20.5	3.3	4.7	3.2	19.7	0.3	4.3	-6.9	54.1
3 Real Household consumption (C)	34.9	1.8	4.5	3.2	9.7	1.5	10.7	-0.9	78.4
4 Real government consumption (G)	34.9	1.8	4.5	3.2	9.7	-3.7	10.7	-0.9	69.2
5 Imports, Volume	-5.4	-20.8	34.8	0.9	15.6	0.2	14.0	-7.3	25.2
6 Exports, volume	34.1	-21.1	21.0	2.2	-2.3	-0.1	-11.1	5.6	20.8
7 Trade	14.4	-21.0	27.9	1.6	6.6	0.1	1.5	-0.9	23.0
8 Trade/GDP	-21.3	-21.7	24.7	-1.7	-3.1	-0.03	-0.4	-0.2	-37.3

Source: simulation results

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