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Abstract

The aim of this paper is to learn about some patterns of sectoral and industrial structural change of the Chinese economy over the 1995-2010 period. To such a purpose, we set up a quantitative methodology via input-output modelling, which allows us to decompose gross output into some key demand sources or contributions. It can be shown that the trajectory of the main structural patterns over the period were both not smooth and pretty unbalanced and that they generally responded to both domestic policy and international shocks. Export demand and heavy industry appeared to be the main engines of the economy, which showed massive increases in their share of output, at the expense of domestic demand, services and agriculture. Despite the high growth rates over this period, the Chinese economy seemed to be in need of rebalancing. There is however some indication towards the end of our period that the economy was starting to go that way.

Key Words: China, industrial structural change, input-output decomposition, trajectories over 1995-2010.

JEL Classification: L16, O4, B4, E2

1. Introduction

This paper is both a continuation of our quantitative study of structural change in China and a complement to our previous paper (Albala-Bertrand 2013). The latter focused on the structural change of important indicators such as capital productivity, capital intensity, participation rate and total factor productivity for China and its main regions, at an aggregate level. The present paper focuses on structural change at an inter-industrial level. For the purpose, we use a quantitative approach by means of a decomposition of the input-output model. This model mostly relies on fix coefficients, so its use for forecasting beyond three-to-five years may make it insufficient in any case, let alone in a country undergoing extremely rapid economic and social changes. For our purpose, however, we use the structure of the model rather the model itself, so there is no intention

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to forecast the state of the economy in the future, but to assess what happened in the recent past. To such an aim, we use the available input-output statistics to assess the evolution of the industrial structure of China between 1995 and 2010, which is the period of the most momentous policy thrusts, and just about bounded by two international crisis: the Southeast Asian international crisis of 1997 and the world crisis that started in 2007/8.

There are many studies of structural change in China at different economic levels for similar periods. A good deal of them concentrates on exports (e.g. He and Zhang 2010, Amiti and Freund 2010, Feentra and Wei 2010), others do on employment (e.g. Cai and Wang 2010, Evans and Stavetieg 2009), and others on industrial productivity and change (e.g. Zheng, Wang and Shi 2008, Yueh 2011). A few have also used input-output analysis with its focus on inter-industrial relationships, such as Ichimura and Wang (2003) focusing on interregional analysis for a given years; Pan, Yang and Lin (2012) on technological spillovers for three given years; Pei, Dietzenbacher et al. (2011) on an import growth decomposition over 1997-2005; and there are others that focus on the environment, energy, value chains and the like. The difference with them is that ours, first, use a different kind of decomposition that allows to differentiate consistently from various sources of output demand; second, we use tables for each year of our period (1995-2010), composed of 33 industries, and we show the structural change trajectory of demand sources, economic sectors and main industries over this period.

Our main conclusions are that the main structural trajectories and patterns over the period were both not smooth and pretty unbalanced and that they generally responded to both domestic policy and international shocks. As shown, export demand and heavy industry appear to be the main

engines of the economy, which show massive increases in their share of output, at the expense of domestic demand, services and agriculture, which then show significant decreases in their share of output. So despite the high growth rates over the period, the Chinese economy seemed to be in need of rebalancing. There is however some indication that the economy was starting to rebalance by the end of our period.

The paper is structured as follows. We start by unravelling our methodology (2.), we then present our analysis and results for China in both an aggregate (3.1.) and a disaggregated fashion (3.2.), and then we show the structural evolution over the period by means of graph trajectories of economic sectors and their main sources of demand (3.3.), also backed with the help of two appendixes. We finally present our main conclusions (4.).

2. Methodology

We analyze structural change by means of an empirical decomposition of input-output tables. This tradition started with Chenery (1960) and was later refined by several authors (e.g. Dervis *et al*., 1982; Kubo *et al*., 1986; Sakurai, 1990). The decomposition method used in this paper follows more closely Wyckoff and Sakurai (1992) and Albala-Bertrand (1999, 2006). This method of analyzing structural change, while exploiting most of the advantages of the input-output framework, avoids most of the limitations of the input-output model (Bulmer-Thomas 1982; Ciaschini 1988), especially the standard shortcomings of forecasting on fixed coefficients for countries undergoing momentous economic and social changes, are not relevant here, as we confine the analysis to yearly snapshots within our focus period (1995-2010).

The overall structural change over a period can be decomposed into the demand sources contributing to such a change, both for the whole industrial complex and for each constituent industry. These sources are not be taken as explaining structural change in terms of causality, but only in terms of *ex-post* concomitance. Therefore, these are useful empirical foundations for a structurally comprehensive policy analysis, which is beyond the scope of this paper.

For presentational clarity, the method to assess structural change is divided into three sub-sections. Firstly, we describe the way we use the general input-output framework; secondly, we present the derivation leading to the decomposition of output change; and thirdly, we conclude with the decomposition of output share changes.

2.1 *The General Input-Output Framework*

Input-output tables or matrices are statistical tools that account for all the market transactions that any industry has in an economy, i.e. intermediate transactions with all classified industries and with its demand for final output. This accounts for the total gross output (i.e. intermediate and final) of an economy, disaggregated into industries and/or regions. It also account, at the level of each industry, for the cost of primary inputs or value added. So at the level of intermediate transactions, this gives rise to a symmetrical double-entry table or matrix that contains the same classified industries in both columns (intermediate demands) and rows (intermediate supplies). In addition, it provides another matrix for the final output supplies of all classified industries, and another for primary inputs. Let's then assume that we have available input-output matrices for a given economy for at least two years, i.e. a base year "0" and a comparison year "1." This would include the following matrices: an $n \times n$ matrix W of intermediate demands for the domestic and

imported inputs of all the *n* classified industries; an *n x m* matrix *F* of output for domestic final demands from the same industries, including both domestic and imported commodities; an n x 1 vector *E* of exports from the same industries; an *n x n* matrix M^W of intermediate import usage of all industries; and an *n x m* matrix M^F of imports of final goods and services. Hence, the n x 1 domestic gross output vector *X* of the *n* industries will be given by:

$$X = Wi + Fi + E - M^W i - M^F i \qquad \text{(domestic gross output)}^{(1)} \qquad (1)$$

Where *i* is an *n* x 1 unity vector.

So let a_{ij} represent the input from the i^{th} industry that is required by the j^{th} industry to produce one unit of its output, which in terms of standard technical coefficients is: $a_{ij} = W_{ij} / X_j$. This therefore generates an n x n matrix *A* of coefficients, or rearranging:

$$AX = Wi \qquad (2)$$

Substituting (2) into (1):

$$X = AX + Fi + E - M^W i - M^F i \qquad (3)$$

We then calculate the proportion of imported inputs in total inputs (m^W) and imported final goods/services in total final goods/services (m^F), which at the level of each cell would be $m^W_{ij} = M^W_{ij} / W_{ij}$ and $m^F_{ij} = M^F_{in} / F_{in}$, respectively. So $M^W = m^W * W$ and $M^F = m^F * F$. Then, we have:

$$Mi = M^W i + M^F i = m^W * Wi + m^F * Fi = m^W * AX + m^F * Fi \qquad (4)$$

The asterisk (*) and the stroke ("/") indicate that the multiplication and the division are standard scalar rather than a matrix multiplication and division, respectively[2]. Then substituting (4) into (3) and factoring:

$$X = \left([i] - m^W\right) * AX + \left([i] - m^F\right) * Fi + E \qquad (5)$$

Where [*i*] is an *n x n* unity matrix, i.e. a matrix with a number 1 in each of its cells.

Let's make $U^W = \left([i] - m^W\right)$ and $U^F = \left([i] - m^F\right)$. Notice that these two matrices provide the ratios of domestic-to-total intermediate demands and domestic-to-total final demands, respectively. They can be interpreted as indicators of import substitution. Then equation (5) becomes:

$$X = U^W * AX + U^W * Fi + E \qquad (6)$$

Therefore, solving for *X*, we obtain the input-output model:

$$X = \left(I - U^W * A\right)^{-1}\left(U^F * Fi + E\right) \qquad (7)$$

Where *"I"* is the identity matrix. Let's also drop the unity vector "*i*", which post multiplies *F*, as we will be working with the totals only, i.e. *F* becomes an n x 1 vector, so M^F does too. Notice that the first term on the right-hand side is the Leontief inverse for domestic intermediates only, and represents coefficients or weights, while the second term contains final domestic output for domestic and foreign demands, and represents volumes. In order to use less notation, let $B = \left(I - U^W * A\right)^{-1}$ and $G = \left(U^F * F + E\right)$**.** Then the input-output system becomes:

$$X = BG \qquad (8)$$

2.2 *Decomposition of Output Change*

The decomposition of gross output change, i.e. absolute growth and the growth rate, between two periods amounts to calculating the first difference of equation (8). That is:

$$\Delta X = \Delta(BG) = B_0 \Delta G + \Delta B G_0 + \Delta B \Delta G \qquad (9)$$

Either the first or the second term on the right-hand side can absorb the third term. If the second term absorbs the third, then the calculation will be weighted by the initial year of the structural *B* matrix and the final year of the volume *G* matrix, and *vice versa* if the third term is absorbed by the first term. This is similar to Laspeyres and Paasche index weightings, respectively, i.e.

$$\Delta X = B_0 \Delta G + \Delta BG_1 \qquad \text{(Laspeyres weighting)} \qquad (10)$$

$$\Delta X = B_1 \Delta G + \Delta BG_0 \qquad \text{(Paasche weighting)} \qquad (11)$$

The numerical results from the two alternative weightings are not normally equivalent and can be very different if the third term is large. To correct this index number problem, several methods have been devised, such as re-weighting the terms, creating an appropriate divisia index, etc. However, a simpler method that distributes the third term proportionally into the other two terms is by taking the simple arithmetical average of the Laspeyres and Paasche results. This appears to produce a good approximation, as analyzed by Dietzenbacher and Los (1998). This method has also been used by Chenery and Syrquin (1986) and Wyckoff and Sakurai (1992). We also use it here for all our actual calculations. However, the derivation of the formula for either alternative is analogous, so for presentational purpose only we use the Laspeyres weighting, i.e. letting the third term be absorbed by the second term. The two terms on the right-hand side of equation (10) can be decomposed as:

$$B_0 \Delta G = B_0 \left(U_0^F * \Delta F + \Delta E + U_0^F * F_1 \right) \text{(3)} \qquad (12)$$

and

$$\Delta BG_1 = B_0 \left(\Delta U^W * W_1 i + U_0^W * \Delta AX_1 \right) \text{(4)} \qquad (13)$$

Therefore, the total decomposition for the absolute growth or variation in gross output will be:

$$\Delta X = B_0 U_0^F * \Delta F + B_0 \Delta E + B_0 \Delta U^F * F_1 + B_0 \Delta U^W * W_1 i + B_0 U_0^W * \Delta AX_1 \qquad (14)$$

The decomposition for the gross output growth rate can be obtained by dividing equation (14) by X_0. Each of the five terms on the right-hand side of (14), in variation or growth rate terms, represents the direct and indirect contribution to the gross output of the economy, and has the following meanings:

(i) $B_0 U_0^F * \Delta F$ contribution of final domestic demand expansion (*FDE*);

(ii) $B_0 \Delta E$ contribution of export demand expansion (*EDE*);

(iii) $B_0 \Delta U^F * F_1$ contribution of import substitution of final goods/services (*ISF*)[5] ;

(iv) $B_0 \Delta U^W * W_1 i$ contribution of import substitution of intermediate inputs (*ISW*);

(v) $B_0 U_0^W * \Delta A X_1$ contribution of changes in input-output coefficients (*IOC*) [6].

2.3 *Decomposition of Output Share Changes*

The share change for the i^{th} industry is simply the difference between the gross output share of the terminal year (S_{i1}) minus that of the base year (S_{i0}):

$$\Delta S_i = S_{i1} - S_{i0} = X_{i1} / X_{t1} - X_{i0} / X_{t0} \qquad (15)$$

Where *i*: *1,...,n* (n industries) and subscript *t* denotes "total". Let us first define the following:

$$X_{i1} = X_{i0}(1+g_i) \text{ and } X_{t1} = X_{t0}(1+g_a) \qquad (16)$$

Where g_i and g_a denote the gross output growth rate for the i^{th} industry and the economy's average gross output growth rate, respectively. Replacing X_{t0} with $X_{t1}/(1+g_a)$ in (15) and manipulating yields:

$$\Delta S_i = [X_{i1} - (1+g_a) X_{i0}] / X_{t1} \qquad (17)$$

Or to carry less notation, let $\delta X_i = [X_{i1} - (1 + g_a) X_{i0}]$, then:

$$\Delta S_i = \delta X_i / X_{t1} \qquad (18)$$

The numerator, δX_i, contains the difference between the actual value of X_i in the terminal year and the value of X_i that would have occurred had it grown at the economy's average growth rate (g_a) over the period. Therefore, the equation represents the deviation of each industry's gross output

from balanced growth, normalized by the actual value of the gross output in the terminal year. This allows us to derive the decomposition formula in a closely analogous way to (10) above. In matrix form, the case of Laspeyres weighting yields:

$$\delta X = B_0 \delta G + \Delta B G_1 \qquad (19)$$

While the Paasche weighting leads to:

$$\delta X = B_1 \delta G + \Delta B G_0 (1 + g_a) \qquad (20)$$

Notice that only the volumes of the base year appear multiplied by the coefficient ($1 + g_a$), in the latter weighting. As before, given that the derivation of the formula is analogous for both cases, for presentational purpose only, we use the Laysperes derivation below. Therefore, applying the same solving procedure as before we obtain[7]:

$$\delta X = B_0 \hat{U}_0^F * \delta F + B_0 \delta E + B_0 \Delta \hat{U}_0^F * F_1 + B_0 \Delta \hat{U}_0^W * W_1 i + B_0 \hat{U}_0^W * \Delta A X_1 \qquad (21)$$

Notice that the last three terms on the right-hand side are the same as in equation (14) above. Dividing equation (21) by X_{t1} we are back to equation (18), but in matrix form. The meaning is analogous to equation (14), but refers to the absolute value of the share change (δX) and the relative share change in percentage points ($\delta X / X_{t1}$), rather than the absolute growth (ΔX) and its growth rate ($X^{-1} \Delta X$).

2.4 *Application to China*

For the purpose, we produce both a 33-industry disaggregation and some relevant subgroupings. The analysis focuses on the 1995-2010 period. The source data comes from both the World Input-Output Database (WIOD) and the National Bureau of Statistics of China (NBS). WIOD input-output tables were available in dollar terms for current (1995-2011) and previous year (1996-2009)

basic prices[8]. The latter tables were used to derive implicit price indexes to deflate the current-price series, at an industrial level. Additional prices for 2010 and 2011 were obtained from the National Bureau of Statistics of China (NBS). The latter has only produced tables for four given years with 23 comparable industries (1997, 2000, 2005 and 2010), which were used as a general check. But we prefer WIOD tables as they seem to be more consistent, with a full public documentation of the methodology used (see WIOD). Given our purpose, we transformed the tables into constant Yuan prices of 1995. In addition, to secure further consistency and stability, we calculated a 3-year moving average of the tables for all the period. Not having available a 1994 table for a 3-year average for 1995, we decided to keep the 1995 table as a single year, as this is the base year for the constant series. So our series go from 1995 to 2010[9].

3. Analysis of Results

The analysis below is divided into three parts. Firstly, we analyzed the change between 1995 and 2010 for aggregations of primary, secondary and tertiary sectors. Secondly, we disaggregate such sectors into some key constituent industries to show how they evolved and contributed to the aggregation. And thirdly, we look at the trajectory of changes of these sectors, and some of their main industries, year after year from 1995 to 2010 (see note 9).

3.1 *Aggregate Analysis*

Table No.1 is divided into two panels: the left panel shows the change in the shares ($\delta X/X_{2010}$) of gross output (X), while the right panel shows the growth rates ($\Delta X/X_{1995}$) of gross output (X) for

the 33 disaggregated industries, and for grouped ones into customary sectors, between 1995 and 2010. The share-change panel is expressed in percentage points (pp), while the growth-rate panel is expressed in percentage (%). Although the notes under the table define the terms in the table, let us make sure that there are no confusions in reading it. The first column in the shares panel presents the share changes in the gross output, expressed in percentage points of 2010. The following five columns: *FDE, EDE, ISF, ISW,* and *IOC*, are the demand sources or contributions to such share changes, expressed in percentage points (pp), so that for each industry the addition of the contributions add up to its share change. In turn, the first column in the growth panel presents the growth rates of gross output, expressed in percentage ($\Delta X/X_{1995}$). The five demand contributions are however expressed in percentage points so that their addition amounts to the growth rate in question. The meaning of each of these five terms is as indicated above (p.8). The final two column in the shares panel expresses the share of each sector in the initial year (S_{1995}) and final year (S_{2010}), respectively. In addition, the bottom section regroup the industries in the standard categories of primary, secondary and tertiary sectors, with its main constituent industries. Finally, the bottom row presents the column sums (shares panel) or the column weighted averages (growth panel). Let us then start with the whole economy and then concentrate on the three economic sectors.

The sum total of the first column of the shares panel has to add to zero, indicating that some industries grew faster than average, producing a positive share change, while others grew slower than average, exhibiting a negative share change. For the whole economy, it can then be seen that only the contribution of final domestic demand (*FDE*) was negative, amounting to a massive contraction of 20 percentage points over the period.

Table No.1: Share Changes (percentage points) and Growth Rates (%): 1995-2010.

BP Yuans 10 million

NACE	No	INDUSTRY 1995-2010	SHARE δ 1995-2010 δX/TX 2010	FDE	EDE	ISF	ISW	IOC	S 1995	S 2010	GROWTH RATE Δ 1995-2010 ΔX/X 1995	FDE	EDE	ISF	ISW	IOC
AtB	1	Agriculture, hunting, forestry and fishing	-8.6	-6.5	-0.6	0.0	0.1	-1.6	12.5	3.9	51	62	21	0	3	-36
C	2	Mining and quarrying	-1.6	-0.5	0.0	0.0	-0.4	-0.7	3.1	1.5	130	159	77	3	-31	-79
15t16	3	Food , beverages and tobacco	-0.9	-2.7	-0.4	0.0	0.1	2.1	6.4	5.5	317	202	36	-1	4	75
17t18	4	Textiles and textile products	-0.5	-1.3	-1.0	0.1	0.8	0.9	5.8	5.3	345	113	155	4	39	34
19	5	Leather, leather and footwear	-0.4	-0.3	-0.3	0.0	0.1	0.1	1.4	1.0	261	119	105	4	23	11
20	6	Wood and of wood and cork	0.4	-0.2	-0.1	0.0	0.2	0.5	1.1	1.5	578	282	111	2	57	127
21t22	7	Pulp, paper, paper , printing and publishing	0.1	-0.6	0.0	0.0	0.2	0.5	1.9	2.0	416	218	111	1	34	53
23	8	Coke, refined petroleum and nuclear fuel	-0.5	-0.3	0.1	0.0	0.0	-0.3	1.7	1.2	241	190	102	3	6	-60
24	9	Chemicals and chemical	-0.4	-1.3	0.4	-0.1	0.4	0.1	4.5	4.1	339	176	143	-2	27	-5
25	10	Rubber and plastics	0.6	-0.4	0.3	0.0	0.2	0.5	2.3	2.8	507	218	224	4	24	38
26	11	Other non-metallic mineral	-1.3	-0.8	0.1	0.0	0.0	-0.7	4.4	3.1	239	231	56	3	2	-52
27t28	12	Basic metals and fabricated metal	1.1	-0.7	1.1	0.2	0.5	-0.1	8.1	9.2	450	266	172	9	24	-21
29	13	Machinery nec	2.6	0.1	1.0	0.4	-0.1	1.1	4.0	6.6	693	390	201	32	-6	75
30t33	14	Electrical and optical equipment	11.1	0.6	5.2	0.3	0.9	4.1	5.0	16.1	1460	414	725	17	68	235
34t35	15	Transport equipment	3.3	1.1	0.8	0.0	0.0	1.4	2.6	6.0	995	617	219	4	10	145
36t37	16	Manufacturing nec; recycling	0.1	-0.1	0.3	0.0	-0.1	0.0	0.7	0.8	472	155	354	-10	-23	-3
E	17	Electricity, gas and water supply	0.5	-0.5	0.1	0.0	0.0	0.8	1.9	2.4	514	277	122	4	9	102
F	18	Construction	-0.6	-0.6	0.0	0.1	0.0	-0.1	8.1	7.5	350	347	3	2	0	-2
51	19	Wholesale trade and commission trade, ex motor vehicles	-1.8	-0.8	0.5	0.0	0.1	-1.6	5.2	3.4	216	209	95	3	8	-98
52	20	Retail trade, ex motor vehicles; repair of household goods	-0.4	-0.2	0.1	0.0	0.0	-0.3	1.1	0.7	216	208	95	3	10	-100
H	21	Hotels and restaurants	-0.4	-0.6	-0.1	0.0	0.1	0.2	1.8	1.5	288	203	46	4	16	18
60	22	Inland transport	-0.8	-0.5	0.0	0.0	0.0	-0.3	2.4	1.6	225	190	78	3	2	-47
61	23	Water transport	0.4	0.0	0.1	0.0	0.0	0.3	0.3	0.6	1147	370	410	4	17	346
62	24	Air transport	-0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.3	284	141	166	-1	-20	-3
63	25	Other Supporting and auxiliary transport activities; travel agencies	-0.1	-0.2	-0.2	0.0	0.1	0.2	0.7	0.7	337	208	33	4	44	48
64	26	Post and telecommunications	0.7	0.3	0.0	0.0	0.0	0.4	0.5	1.2	1036	707	129	10	10	179
J	27	Financial intermediation	-1.1	-0.5	0.2	0.0	0.1	-0.9	3.1	2.0	210	205	83	4	11	-93
70	28	Real estate activities	-0.8	-0.5	0.0	0.0	0.0	-0.4	2.0	1.1	177	206	31	2	4	-66
71t74	29	Renting of m&eq and other business activities	0.0	-0.7	0.2	0.0	0.0	0.5	1.8	1.9	395	205	117	0	-3	77
L	30	Public admin and defence; compulsory social security	-0.5	-0.5	0.0	0.0	0.0	0.0	1.9	1.4	264	258	1	3	2	0
M	31	Education	-0.2	-0.3	0.0	0.0	0.0	0.1	1.3	1.2	327	302	7	0	-1	19
N	32	Health and social work	0.0	-0.1	0.0	0.0	0.0	0.1	1.0	1.0	402	359	9	1	5	27
O	33	Other community, social and personal services	0.0	-0.2	-0.1	0.0	0.0	0.4	1.1	1.1	390	260	37	1	8	85
	I	**PRIMARY SECTOR (1,2)**	**-10.3**	**-7.0**	**-0.6**	**0.0**	**-0.4**	**-2.3**	**15.6**	**5.4**	**66**	**81**	**33**	**1**	**-4**	**-45**
	II	**SECONDARY SECTOR (3-18)**	**15.2**	**-7.8**	**7.7**	**1.0**	**3.1**	**11.1**	**59.9**	**75.1**	**508**	**273**	**168**	**6**	**19**	**42**
		Light Industry (3-7)	-1.2	-5.1	-1.7	0.1	1.4	4.1	16.5	15.3	350	171	97	2	25	56
		Medium Industry (8-12)	-0.6	-3.4	2.1	0.2	1.0	-0.5	21.0	20.4	371	228	141	4	19	-21
		Heavy Industry (13-17)	17.6	1.3	7.4	0.7	0.7	7.4	14.2	31.8	985	415	386	16	24	144
		Construction (18)	-0.6	-0.6	0.0	0.1	0.0	-0.1	8.1	7.5	350	347	3	2	0	-2
	III	**TERTIARY SECTOR (19-33)**	**-4.9**	**-4.8**	**0.8**	**0.2**	**0.3**	**-1.4**	**24.4**	**19.5**	**288**	**234**	**70**	**3**	**7**	**-25**
		Domestic Trade (19-21)	-2.6	-1.5	0.5	0.1	0.2	-1.8	8.1	5.5	232	207	84	3	10	-72
		Transport plus (22-25, 26)	0.2	-0.5	0.0	0.0	0.1	0.5	4.2	4.4	406	265	103	4	9	25
		Finance plus (27-29	-1.9	-1.7	0.4	0.0	0.1	-0.8	6.9	5.0	250	206	77	2	6	-41
		Social sectors (30-33)	-0.6	-1.1	-0.1	0.0	0.0	0.6	5.2	4.6	331	288	11	1	3	28
		Average/Total	**0**	**-20**	**8**	**1**	**3**	**7**	**100.0**	**100.0**	**385**	**233**	**123**	**4**	**13**	**12**

BP: basic prices (10 million Yuans)
NACE European Classification of Economic Activities (French achronym)
δX/TX2010: rate of industry deviation from average growth (normalized by total gross output of final year 2010) (%)
ΔX/X1995: rate of growth of gross output (%)
FDE: contribution of domestic demand expansion to either rate
EDE: contribution of export demand expansion to either rate
ISF: contribution of import substitution of final goods either rate (negative sign [-] means import penetration)
ISW contribution of import substitution of intermediate goods to either (negative sign [-] means import penetration)
IOC contribution of changes in direct input-output coefficients to either rate
Note: all contributions in percentage points
S1995 sectoral share in total gross output in the initial year 1995 (%)
S2010 sectoral share in total gross output in the final year 2010 (%)

All the other contributions are positive, especially that due to foreign demand expansion (*EDE*) and also to the increase in mutual input demands of the economy, producing a positive change in input-output coefficients (*IOC*). Imported input and final output substitutions (*ISW* and *ISF*) also played a positive, but secondary role. The growth panel, bottom line, shows that the final domestic demand is the larger contributor to the total growth of gross output over the period(10). But as shown above it has lost 20 percentage points (pp) in its share of gross output, while the foreign demand contribution has increase its share by 8 percentage points.

This is because the growth rate of the former has systematically been below the economy average growth rate (385%), while the latter has systematically been above it, namely 272% and 568%, respectively (not shown in the table). This simply confirms that the economy has moved strongly towards exports and investment (530%) at the expense of domestic consumption, which grew by only 200 % (not shown in the table).

3.2 *Disaggregate Analysis*

The aggregate results above can be disaggregated into the standard main sectors of the economy and some key industries within them. The bottom blocks of both panels of Table No.1 show this for primary, secondary (including construction) and tertiary sectors. It can be seen that the secondary sector increased massively its share in gross output by 15pp at the expense of especially the primary sector (-10pp), but also the tertiary one (-5pp). This hides the very fact that the increase by 15pp was mostly due to heavy industry (18pp) at the expense of light, medium and construction industries. And within heavy industry, the increase was due especially to "Electrical and optical

equipment" (No.14) and "Transport equipment" (No.15), increasing their share by 11pp and 3pp, respectively. In turn, the fall in the primary sector share is mostly due to the non-mining primary sector (No.1), which fell by 8.6pp, while Mining and quarry fell by 1.6pp. As regards the tertiary sector, the main fall in share was due especially to domestic wholesale trade and financial intermediation (Nos.19, and 27), with a slight positive direction by especially Post and telecommunications (No.26).

Focusing now on the decomposition of such share changes, it can be seen that the contribution of domestic demand (*EFE*) fell in all sectors, but still the heavy industry shows a positive contribution to the secondary sector here, and indeed heavy industry is the main participant in all the other contributions of the secondary sector, notably that for foreign demand (*EDE*) and input intermediation coefficients (*IOC*). The latter is especially marked by the same industries above (No 14 and 15) plus "Machinery" (No13). Medium industry shows negative contributions from domestic demand (*EFE*) and input coefficients (*IOC*), while the others contributions are positive, especially from export demand, but also import substitution (both *IFS* and *ISW*). Light industry, in turn, shows also positive contributions from both types of import substitution (*ISF* and *ISW*), especially to "Textiles" (No. 4), and input intermediation (*IOC*), particularly "Food beverages and tobacco" (No. 3). This is an indication of higher domestic reliance, and probably technical sophistication, in these areas. The opposite happens in the primary sector, where all contributions are negative or null, except for a slim positive contribution from imported input substitution (ISW) to the non-mining primary sector (industry No.1). The tertiary sector is more mixed, as foreign demand and both items of import substitution show positive contributions, especially for domestic trade and financial activities.

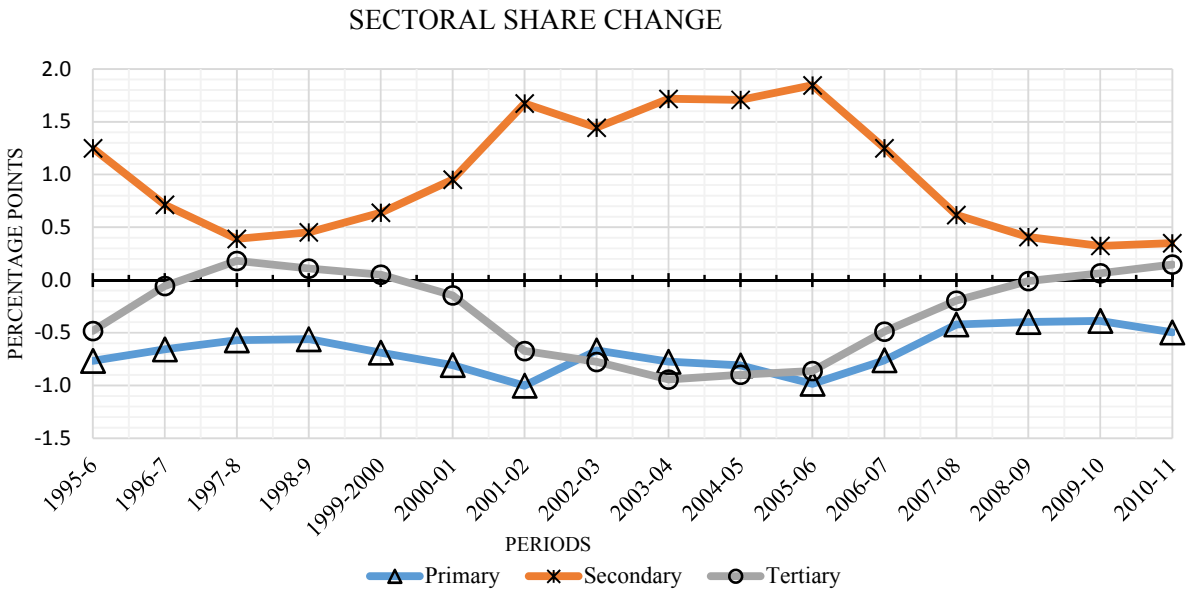
The growth panel (bottom block) shows the same story in growth terms. The secondary sector grew by 508%, well above the total growth average of 385%, while the other sectors were well below such an average, especially the primary sector. The heavy industry within the secondary sector grew by a massive 985% over the period, especially on account of "Electrical and optical equipment" (industry No.14). For all sectors, the main contributors to their growth rates are domestic and foreign demand (*FDE* and *EDE*), the latter especially strong for heavy industry, which also shows an important growth in both input substitution (ISW) and input intermediation (*IOC*), mostly in the said industry No.14, but also in industry No.15 ("Transport equipment"). The tertiary sector shows also gains in both items of import substitution. The last column of the shares panel shows the shares at the end of the period (i.e. 2010). It shows that the secondary sector share grew from 60pp to 75pp, and notably heavy industry more than double its share, from 14pp in 1995 to a massive 32pp in 2010. Except for "Post and telecommunications" (No. 26) and a few members of light industry, all the other industries lost share presence in gross output. Notice however that the growth rate over the period was very high, and the growth rates for each of our industries were positive, so share losses should not be interpreted as losses in the growth of absolute values, but only in relative terms. Next point below will allow us to learn how the results above build up over the period, year after year.

3.3 *Structural Evolution over the Period*

In this section, we show how the results above built up over the 16-year period, by graphically presenting the changes above in terms of periods made of two consecutive years, from 1995-96 to

2010-11 (see note 9), and showing that main policy reforms and world shock can help explain such evolution. Graph 1 below presents the evolution of the share change of the three economic sectors. It can be seen that the secondary sector gained share all over the period (curve over the 0.0 axis), while the primary one did the opposite (curve under the 0.0 axis), and the tertiary sector was for the most part losing representation. Notice again that for each period, the percentage point sum of the three curves has to add to zero. For example, in the period 1998-99, both secondary and tertiary sectors gain share at the expense of the primary sector, while in 2005-06 the secondary sector gains share at the expense of the other two sectors[(11)].

Graph 1: Sectoral Share Change over 1995-2011.

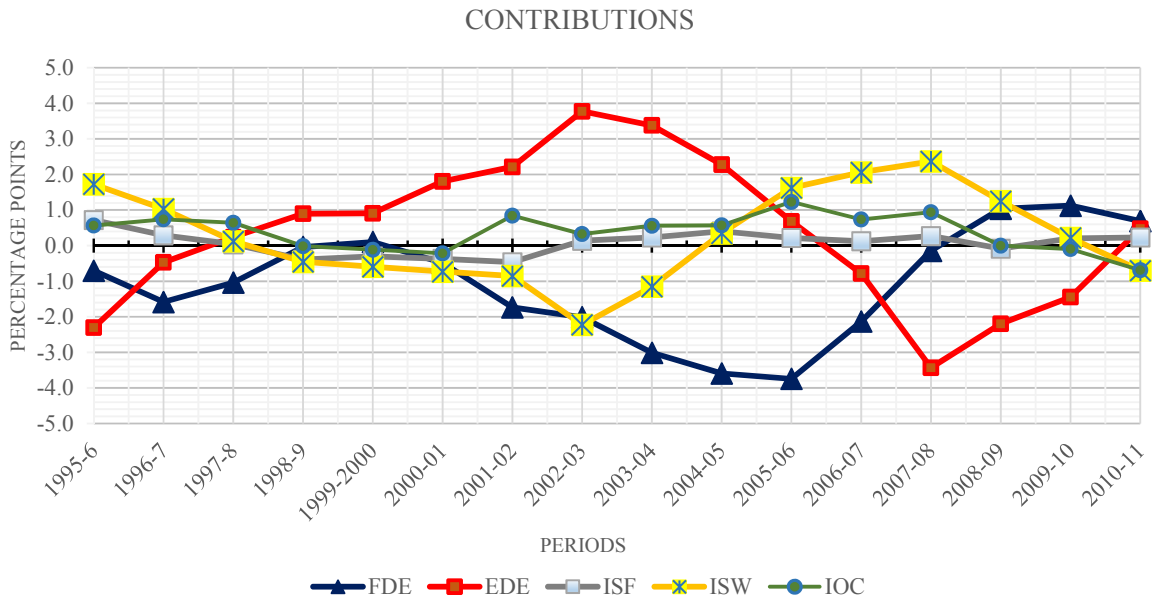


The curve trajectories are however not smooth, showing important changes in certain periods, especially for the secondary sector, which shows increasing share gains in gross output from 1998 to 2007, notably between 2000-01 and 2006-07, reaching a peak in 2005-06. From this peak onwards there is a fast descent in the strength of percentage point gains, but is still on the positive side, so it keeps gaining share but at a slower pace. In turn, the tertiary sector is mostly on the

negative side, almost mirroring the secondary one, except for the period 1997-2000 period and from 2009. Lastly, the primary sector is all along on the negative side, showing its biggest losses of share over the period 2000-07.

Notice again that a fall in shares in some or all the periods does not necessarily mean negative growth rates in such periods. It can be shown that for the three sectors the growth rates were positive all along, except for the primary sector in the period 2006-07 (see Graph I.1 in Appendix I, and also Graph 1.2 in that appendix for illustration of the trajectory of some industries). What are then the main demand contributions that are behind the patterns of Graph 1? Graph 2 below presents the trajectory followed by the five demand contributions over the period. Notice again that for each period, the percentage point sum of the five curves has to add to zero.

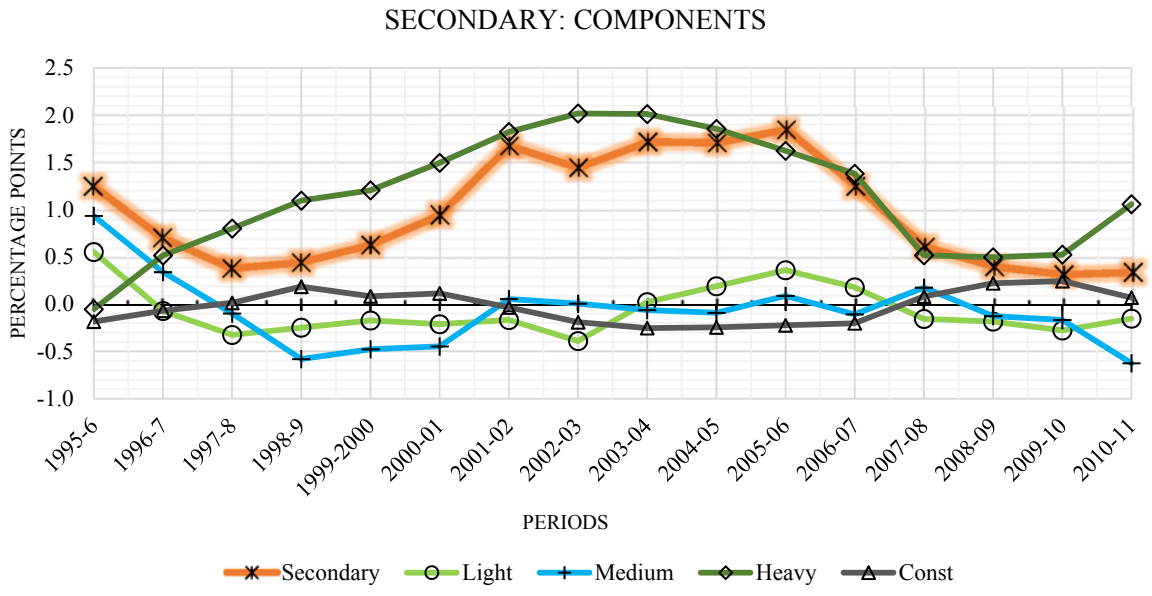
Graph 2: Trajectory of Contributions over 1995-2011.



The first point to note is that the top contribution to the total share change is due to export demand expansion (*EDE*), notable between 2000 and 2006, mostly at the expense of domestic demand

expansion (*FDE*). The latter shows a systematic negative contribution to its share change until 2007-08, when start regaining ground at the expense of *EDE*, reverting some of the lost ground, but at decreasing rates, as it seems that by 2011 the two curves go in opposite directions again. As regards the other three contributions, there is some slow and unstable contribution from import substitution of final goods (*ISF*) and a more significant imported input substitution (*ISW*) between 2005 and 2010. The contribution of input-output coefficients (*IOC*), indicating strength of mutual demands for domestic output, appears mostly positive, but at low percentage point levels. These patterns can be better illustrated by looking at the trajectory of each demand contribution against the three main economic sectors, as presented in Graphs II of Appendix II, which shows the sectoral make up behind the trajectory of Graph 2 for the said contributions. Let us now look at each of the main sectors to learn about the main aggregate components that make up the above sectoral share patterns[(12)]. Graph 3 below shows the secondary sector disaggregated into light, medium, heavy and construction industries.

Graph 3: Secondary Sector Aggregate Industrial Components over 1995-2011.

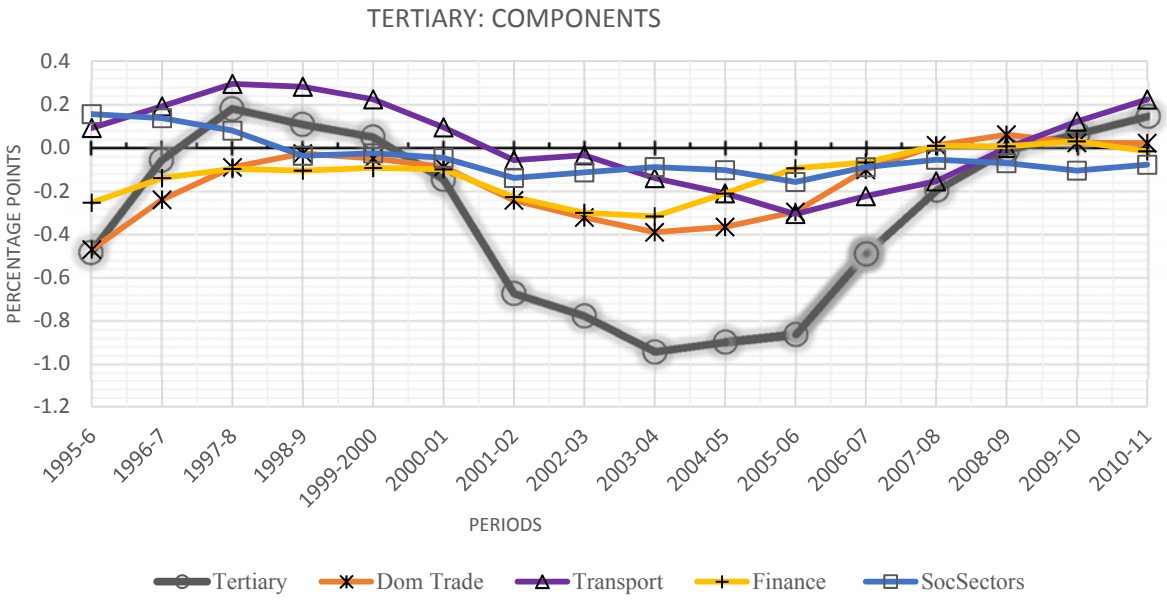


The thick curve (with a glow) is again the secondary sector as in Graph 1, while the other curves are its main components. For each period, the percentage point sum of the latter four curves has to add up to the value of the former. The most striking point here is that almost all of the secondary sector pattern is due to the trajectory of heavy industry. And the heavy industry pattern itself is mostly explained by the "Electrical and optical equipment" industry (No.14), which follows a similar trajectory, picking in 2004-05 (not shown in graph).

At a less salient and unstable levels, transport equipment (No. 15), utilities (No. 17) and non-electrical machinery (No. 13) also contribute to this pattern. I hasten to repeat that the fact that some industries appear to have lost share in the benefit of the heavy industries is only an indication that they grew at a slower pace than the economy unweighted average, which was pretty high by any standards. This can be seen in Table No.1, where all industries exhibit positive growth rates over the period. It can also be shown that the trajectory of growth rates over the period is positive for the three sectors, except for the primary sector in the period 2006-07 (see Appendix I).

The tertiary sector components can be seen in Graph 4 below. As above, the thick curve (with a glow) is the same tertiary sector as in Graph 1, which is disaggregated into domestic trade, transport, finance and social sectors. The fall in tertiary sector share in gross output, especially between 2001 and 2008, seems to be mostly due to falls in domestic trade and finance, and at a slower level social sectors. On the other hand, most of the positive share changes of the tertiary sector seem to be due to transport services, especially up to 2000-01 and from 2008-09. Notice, however, that a curve trajectory close to the 0.0 line means a pretty high growth rate, just about the (unweighted) average of the economy.

Graph 4: Tertiary Sector Aggregate Industrial Components over 1995-2011.



For example post and telecommunications (No. 26), which is part of "Transport plus", grew over the 15 year period by a massive 1036%, as shown in Table No. 1. But given that it started at very low share level, it looks less impressive in terms of the weighted average of the economy. Same with "Financial intermediation" (No. 27), part of "Finance plus", which grew at around 5% until 2003-04, and then jumped to around 13% from 2004-05, ending up with a 210% growth over the period. "Education", and "Health & social work" (Nos. 32 and 33), part of "Social Sectors", show even more impressive (unweighted) growth rates (327% and 402%, respectively), but given their low shares to start with, they don't seem to have made share improvements in total gross output, if anything the opposite. In appendix I, it can be seen the trajectory of growth rates for a few industries of this tertiary sector for the sake of illustrating the point above. This is similar for industries of the other sectors, especially those of the primary one, which lost a significant share

of the economy, but grew at positive but low rates all along, except for the period 2006-08, when it fell by around 3.5% (only industry No.1: non mining primary sector).

The patterns for both the graphs and Table No.1 above respond mostly to domestic policy, domestic dynamics and world conditions. In growth terms, there is a clear slowdown between 1996 and 2000 (Graph I.1) for the three sectors, which in terms of sectoral share change is represented in a significant deceleration of gains by the secondary sector, a short lived gain acceleration by the tertiary sector and rather stable share loss by the primary sector (Graph 1). This corresponds neatly to both the 1997 East Asian crisis, which put a slowdown to exports gains and, among other explanations, sluggish rural income growth and widespread industrial inefficiency that impinged on significant falls in the total factor productivity of the economy (Albala-Bertrand 2013, Yueh 2013, Zhen, Bigsten and Hu 2009). At the time, some reforms were introduced to face the crisis, adopting policies to stimulate domestic demand, especially via construction and services development. From 1994-96, there were important reforms in terms of both a nation-wide liberalization of capital inflows to attract foreign direct investment (FDI) and a massive push towards privatization to develop private domestic business (Prasad and Wei 2005).

Between 1997 and 2001, there were further reforms on this score via a law that let the markets to set or guide prices with outside intervention by the government, as required. In addition, in 2001 China became a member of the WTO, which forced a policy of eliminating direct price controls and export subsidies to agricultural products (Yueh 2010, 2013; Zhang and Tan 2007, OECD 2002). All these plus other associated reforms, like open market agreements with the US and Southeast Asian countries, created the strong platform on which capital intensity and total factor

productivity contributed to the very high growth rates of the economy, especially between 2001 and 2007 (Albala-Bertrand 2013). This especially relied upon heavy industry and exports (Yueh 2010, 2011; Lardy 2006), as also reflected in Graph 1 and Graph 3 above. By 2007, China officially acknowledged that its economic growth was "unsteady, unbalanced, uncoordinated and unsustainable" (Wen Jiabao-Annual Meeting of China's legislature, 2007), which is what both Table No.1 and our graphs clearly reflect. To be sure, this reality check did not just referred to the situation between domestic and foreign demand, and between the secondary and the other economic sector share changes and growth rates, but also about regional disparities, income inequalities, and market and product fragmentation, among others problems (Goodman and Parker 2014, Yueh 2010, Zhang and Tan 2007, World Bank 2005, Fu 2004, Chow and Li 2002).

This official admission coincided with the onset of the international financial crisis (or Great Recession). This brought new policies to counteract it, especially a massive stimulus package for agriculture, construction and services, focusing on housing, rural infrastructure, transportation, education and health, environment, industry, disaster reconstruction, income building, tax cuts and finance (Wong 2011). This is well reflected in Graph 2 above (and Graphs II in the appendix), as there appeared to be a strong, but short lived, structural change reversal, especially from 2007, between final domestic demand expansion (*FDE*) and external demand expansion (*EDE*). This is also reflected in an important domestic substitution of previously imported intermediaries (*ISW*) and also an increasing domestic input intermediation (*IOC*). In terms of sectoral share change, as shown in Graph 1, the tertiary sector starts to reduce its losses and achieves gains after 2008, a recovery of domestic retail and transports being part of this (see Graph 4), while the primary sector keeps losing share representation, but at lower levels.

So, over the period 1995-2011, world and regional international crises, counter and strategic policy packages, and an overall structural change of economy and society, can be generally illustrated with the help of the above analysis, which can complement other approaches (e.g. He and Zhang 2010, Cai and Wang 2010, Zheng, Wang and Shi 2008).

4. Conclusions

The aim of this paper was to learn about some patterns of sectoral and industrial structural change of the Chinese economy over the 1995-2010 period. To such purpose we set up a quantitative methodology via input-output modelling, which allowed us to decompose gross output into its main demand sources or contributions. Noting that the national output growth rates were around 10% over the period, and that on the whole these rates were positive for all sectors and industries, the main observations about structural change are as follows.

(i) Between 1995 and 2010, there was a significant structural change in favour of the secondary sector, and especially its heavy industry. This sector increased its share in grows output by over 15 percentage points (pp) over the period, from 60% to 75%. Two thirds of this change was done at the expense of the primary sector (notably its non-mining industries), which lost over 10pp in output, and one third at the expense of services (notably domestic trade and financial intermediation).

(ii) The main demand sources that contributed positively to the changes above were export expansion EDE (representing 8pp), and increases in domestic input intermediation IOC (7pp), and at a secondary level import substitution of both final goods ISF and industrial inputs ISW (1pp and 3pp, respectively). In turn, the main negative contribution comes from domestic demand, which lost 20 percentage points over the period. The latter loses come from all sectors, except for some industrial components of heavy industry (machinery, electrical, optical and transport equipment) and post and telecommunications of the tertiary sector.

(iii) The above structural change, however, was not linear. The secondary sector, mostly pulled by its heavy industry, has most of its massive share gain over 2001 and 2007. That is between just after the 1997 East Asian crisis together with the liberalization of capital flows plus (guided) market prices, among other opening trade policies, and just before the Great Recession and some policies to rebalance the economy. It is not until 2009 that the tertiary sector appears to regain slightly some of its lost share in output, while the primary sector keeps losing representation, but at lower levels.

(iv) As regards demand contributions, export demand expansion (EDE) and domestic demand expansion (EFE) show an almost mirror trajectory, while the former has a massive share gain the latter shows a massive share loss. From around 2007, for the first time the share change of export demand becomes negative and falls below that of domestic demand, the latter even exhibiting a positive share gain from around 2008 for the very first time in the observed period. But it seems that by 2011, the two

contributions start to revert again. To be also noticed, there is a significant increase in the share of both final and input import substitution, especially the latter, from 2005. This, together with the general increase of domestic input inter-industrial trade (IOC), may be in indication of an economy that moves to a more endogenously sustainable one, which is part of the necessary rebalancing of the Chinese economy.

As shown in the text, all these patterns and trajectories can be generally shown to respond to both international shocks and main domestic policy decisions. Whether the Chinese economy will properly rebalance, as the need for it has been acknowledged by the government, will mostly depend on policies that can sustain stable growth, while domestic demand, especially consumption, becomes the main contributor to growth. The recent decrease in growth rates puts additional pressures and difficulties to achieve such a rebalancing. But there are recent indications that consumption is taking a greater role in the dynamics of China's economic growth (World Bank 2015, 2014; *The Economist* 12/09/2015).

4. Notes

(1) Notice that gross output includes both intermediate and final output, so from the viewpoint of GDP it would be double counting, as GDP already contains all the value-added additions to final output from all the intermediate inputs required for its production. But from the viewpoint of each industry, it represents the actual productive effort to supply both intermediate inputs to other industries and goods/services for final demands.

(2) In previous studies, imports were treated as if each industrial import was to be used by all industries in the same proportion, as normally only the total input usage, at the level of each industry, was available, i.e. the composition of imported inputs in the output of each industry was not known. But given that we have the full import tables for China, we use the full table in our calculations, which is why we have to use scalar multiplication for the purpose. In other words, $m^W * W$ means that each cell of W is multiplied by the same cell of m^W. So M^W is the matrix of imported inputs.

(3) The decomposition of the RHS first-term of equation (12) is as follows:

$$B_0\Delta G = B_0\{[U_1^F * F_1 + E_1] - [U_0^F * F_0 + E_0]\} = B_0\{U_1^F * F_1 - U_0^F * F_0 + E_1 - E_0\} =$$
$$B_0[U_1^F * F_1 - U_0^F * F_1 + U_0^F * \Delta F + \Delta E] =$$
$$B_0[\Delta U^F * F_1 + U_0^F * \Delta F + \Delta E]$$

(4) The decomposition of the RHS second-term of equation (13) is as follows:

$$\Delta B_0 G_1 = [B_0 B_0^{-1} B_1 - B_0 B_1^{-1} B_1] G_1 = B_0 [B_0^{-1} - B_1^{-1}] B_1 G_1 = B_0 [B_0^{-1} - B_1^{-1}] X_1 =$$
$$B_0\{[I - U_0^W * A_0] - [I - U_1^W * A_1]\} X_1 = B_0\{U_1^W * A_1 - (U_0^W * A_1 - U_0^W * A_1) - U_0^W * A_0\} X_1 =$$
$$B_0\{\Delta U^W * A_1 + U_0^W * \Delta A\} X_1 = B_0 [\Delta U^W * A_1 X_1 + U_0^W * \Delta A X_1] =$$
$$B_0 [\Delta U^W * W_1 i + U_0^W * \Delta A X_1]$$

(5) Terms (iii) and (iv) are positive when there is an increase in import substitution over the period i.e. an increase in the proportion of domestic inputs in total inputs and domestic final output in total final output, respectively. This represents a variation in demand exclusively due to variations in import substitution.

(6) This represents the variation in demand over the period, exclusively due to the weighted variations in the (domestic) *direct* input-output coefficients of the system. If this term is positive for a particular industry, then this means that more of the output of this industry is used as input for the production of other industries than in the base year. That is, it represents an increase in the *direct* domestic contribution of this industry towards the system. Hence, it represents a version of *direct* backward domestic linkages (demand) from the rest of the economy to this industry, or alternatively a version of the *direct* forward domestic linkage (supply) of this industry towards the rest of the economy over the period (Hirschman, 1977).

(7) The Paasche calculation would have led to the following result for equation (21):

$$\delta X = B_1 U_1^F * \delta F + B_1 \delta E + B_1 \Delta U^F * (1+g_a) F_0 + B_1 \Delta U^W * (1+g_a) W_0 i + B_1 U_1^W * \Delta A (1+g_a) X_0$$

(8) As the OECD defines it: "the basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer as well as suppliers' retail and wholesale margins". This is considered a better measure of industrial efforts than market (final) prices.

(9) We also add the change over the period 2010-2011. The latter is only used for illustration, but not as a 3-year average, as we have no data for 2012.

(10) Given the input-output model in equation (7), the total final demand (domestic and foreign) has to be the larger contributor to gross output, but not necessarily in growth or percentage points terms. The absolute change decomposition allows us to assess the size of such contributions plus the contributions from the other three factors over the period.

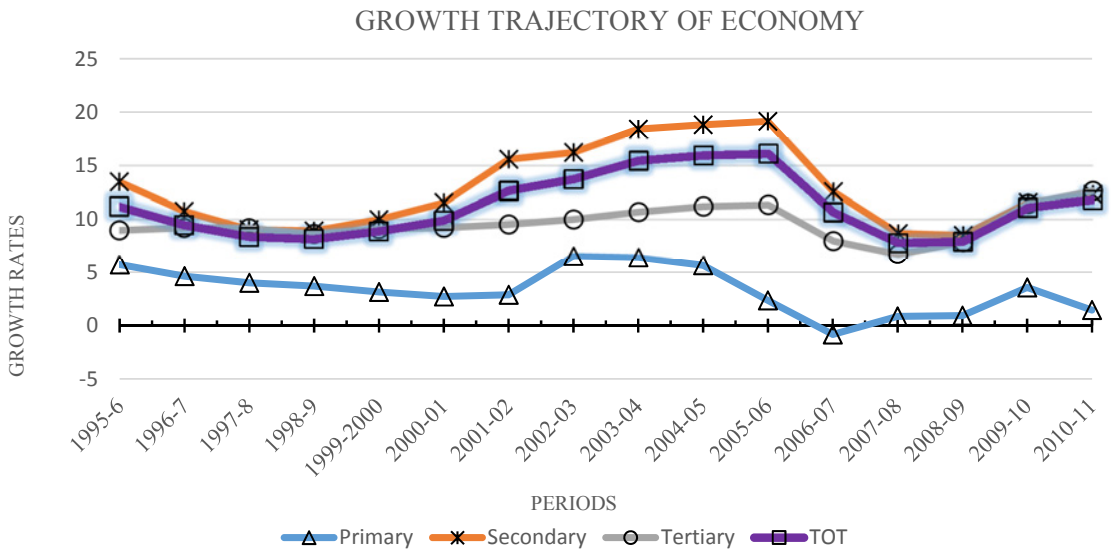
(11) Recall also that, for each year, percentage points on the positive side implies that the sector is growing faster than the average growth of the economy (as measured by gross output), while the opposite is the case with negative percentage points. So we will not clutter this analysis with graphs about growth rates, as we are focusing on structural (share) changes.

(12) The primary sector is mostly "Agriculture, hunting, forestry and fishing" (No.1), as "Mining and quarrying" (No.2) plays a very secondary role. So the trajectory is just about the one in Graph No.2, which is why we don't present a graph for this sector alone.

Appendix I

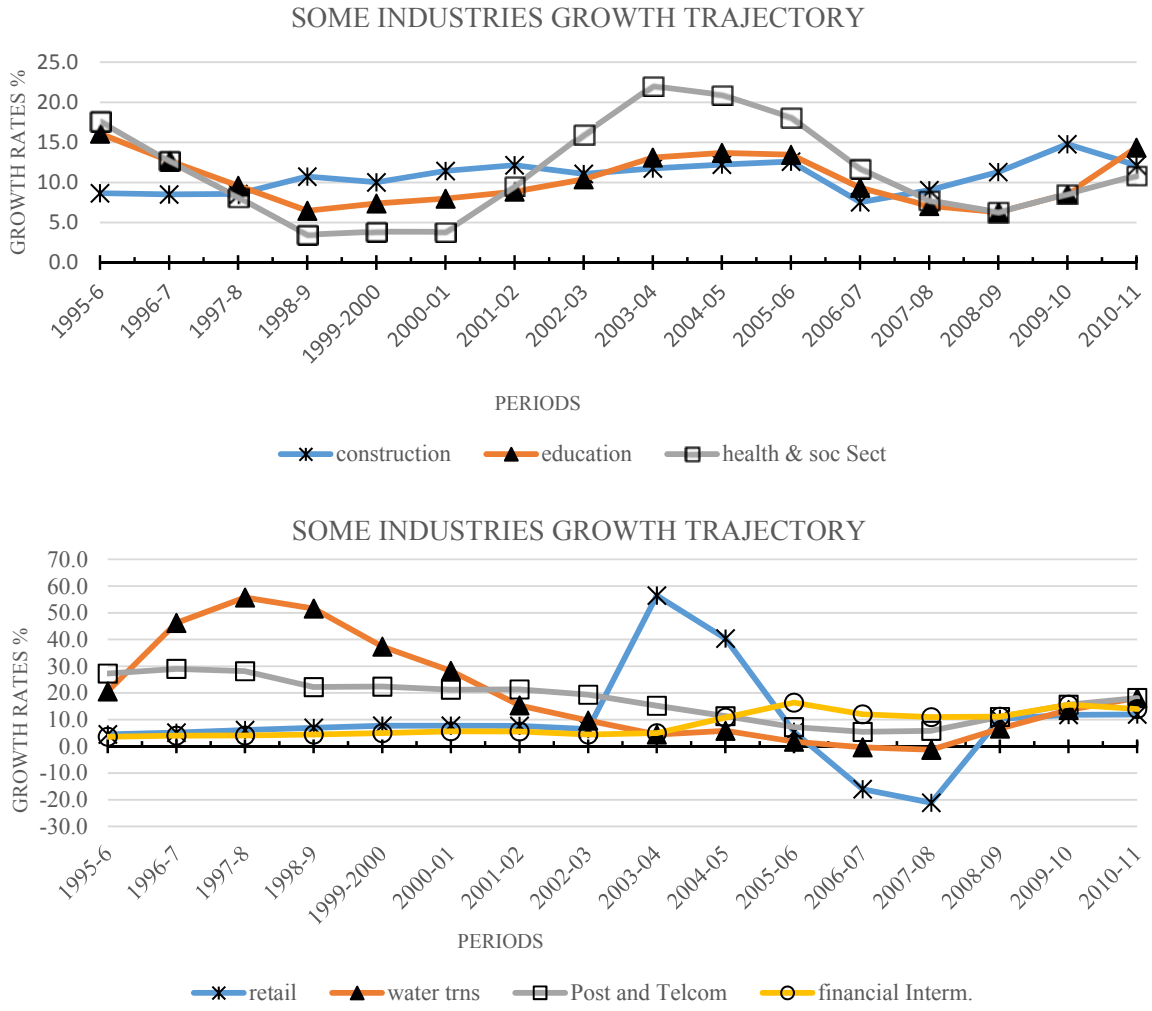
Below we show the growth rate trajectory of the main three sectors and also of some industries over the period. The point here is to illustrate that despite some of them decreasing or not increasing their share in gross output, the growth rates were positive and sometimes pretty high by any standards.

Graph I.1: Sectoral Growth Trajectory of the Chinese Economy over 1995-2011.



The thick curve (with a glow) is the total growth rate of gross output over the period. As it can be seen, this curve is quite high all along, with a downhill from 2005-06 that stabilizes and start increasing again after 2008-09. This is similar, but at different levels for the secondary (very high rates) and tertiary sectors (high rates). The primary sector however shows pretty moderate rates and a downhill that starts in 2002-03 and goes negative in 2006-07. It start increasing again afterwards but a low rates. Notice that the three sectors growth rates do not add up to the total, as the latter is a weighted average, while the former are unweighted. Below we also show the trajectory for some industries as a further illustration.

Graph I.2: Growth Trajectory of Some Industries Over 1995-2011.

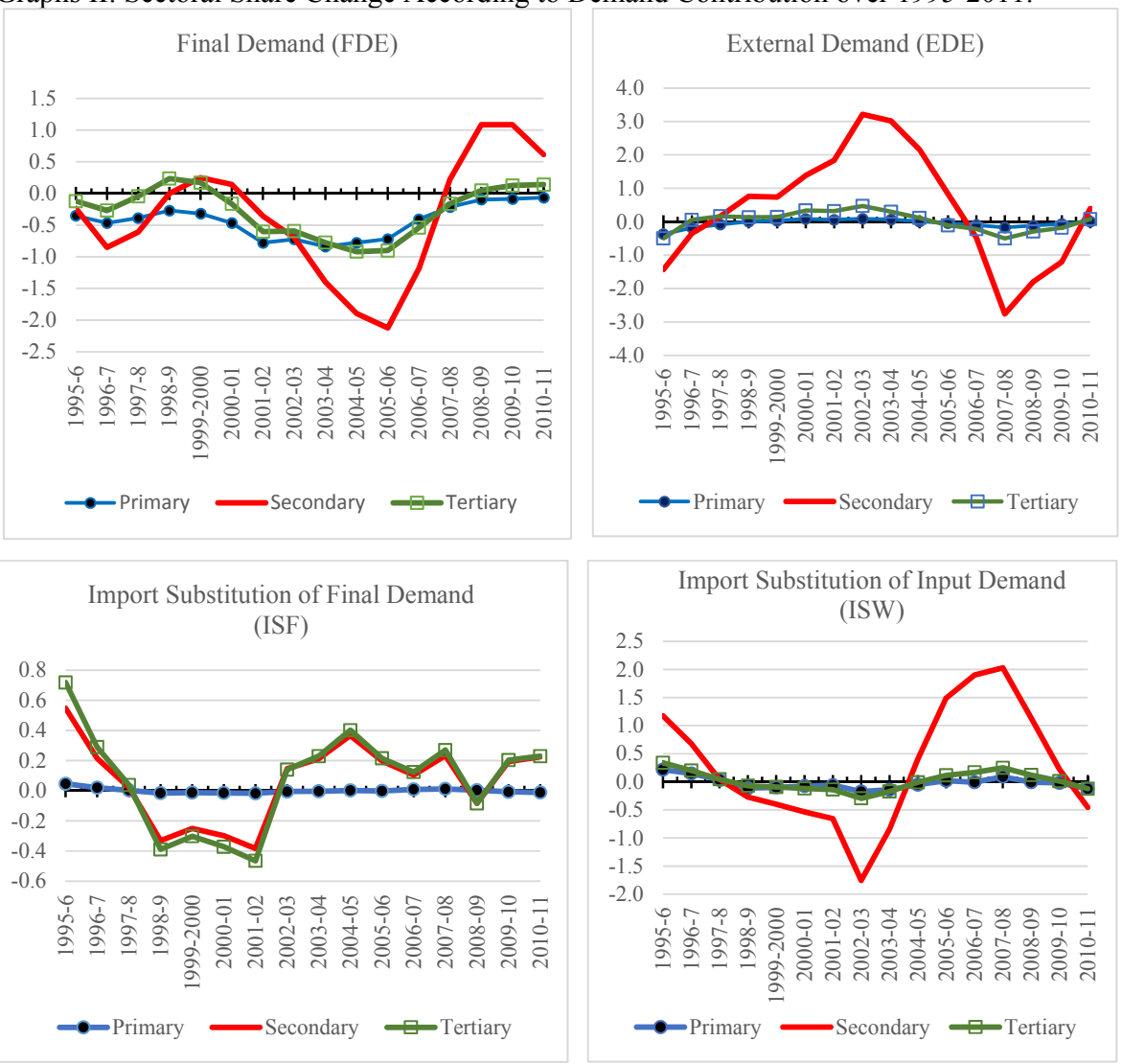


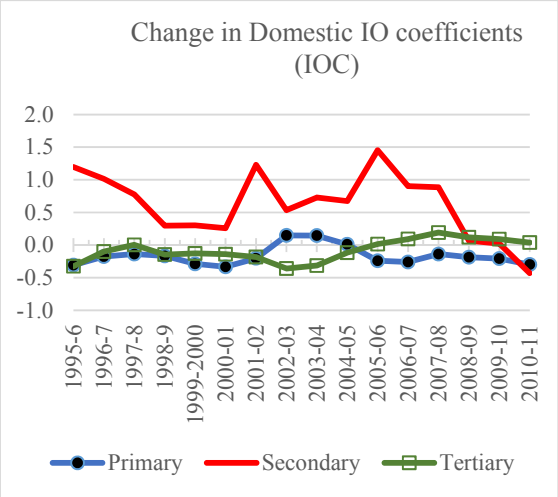
Most variables above appeared to have fallen in growth rates sometime between 2007 and 2009, especially domestic retail trade and water transport that went negative. Financial intermediation, contrary to retail, shows an ever and rather stable increase over the period (from around 4% to 15%, between 1995-6 and 2010-11, respectively). It can be seen that most variables stay positive and sometimes at very high rates over the period. This description is pretty similar for all the variables in Table No.1, despite many of them losing share presence in gross output.

Appendix II

The five graphs below show the share change trajectory of each of the five demand contributions *FDE* (final demand), *EDE* (foreign demand), *ISF* (final import substitution), *ISW* (imported input substitution) and *IOC* (domestic input demand) for the primary, secondary and tertiary sectors of the economy, in terms of gross output (i.e. intermediate plus final output).

Graphs II: Sectoral Share Change According to Demand Contribution over 1995-2011.





The trajectories above can be described as follows:

(i) The primary and tertiary sectors show an about similar trajectory for each of the five contribution, except for *ISF*, and these are near but mostly under the 0.0 percentage point (pp) change, especially for the primary sector. This tallies with the total pp change for these two sectors over the full period, as shown in Table No. 1, i.e. the primary sector lost 10.3pp while the tertiary one 4.9pp. For *ISF*, the latter appears as first losing pp ground (up to 2001-02) and then regaining it (mostly from 2002-03 onwards).

(ii) The Secondary sector however shows a more variable pattern, being mostly and strongly on the positive side. Domestic demand (*FDE*) and external demand (*EDE*) appear to show an about mirror pattern, i.e. as *EDE* increases, *FDE* falls and vice versa. This simply means that most of the positive change in the secondary sector has been due to *EDE* mostly at the expense of *FDE*, and vice versa after 2007-08, when *EDE* has its deepest fall. For *ISW*, this sector shows a positive contribution between 2005 and 2010, peaking in 2007-08. In turn, *IOC* shows a positive pattern

all along except for the period 2009-11. Finally, *ISF* shows a similar trajectory for both secondary and tertiary sectors, being negative between1998 and 2003 and positive between 2003 and 2011, with a dive in 2008-09. This tallies with the massive gain in share of gross output of this sector over the full period, i.e. 15.2pp.

(ii) Given that most of the more notable inflection points happen after 2006-07, then this also shows that the international crisis and policies therein had an important impact on the China economy, as more detailed in the text.

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