

Industrial Interdependence: China 1995-2010

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Abstract

This paper is a continuation of our study of structural change in China and deals with the changes of domestic industrial/sectoral backward and forward linkages (i.e. the pull and push of the economy) as well as the changes in their domestic and imported components (i.e. via import substitution/penetration) over the 1995-2010 period. We present the results in terms of rates of change for the period as a whole as well as for their yearly evolution over such a period. The main conclusions are that the secondary sector has become the main pull engine of the economy by far, with the tertiary sector also increasing its pull, and that there are three distinctive periods for the evolution of import substitution/penetration, which seem to correspond to both international crises and domestic reform.

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 papers. Those focussed 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 (Albala-Bertrand 2013); and on structural change at an inter-industrial level (Albala-Bertrand 2016). As the latter one, the present paper focusses on inter-industrial activity via the input-output model. In the same vein, there is no intention 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 and via the input-output model we attempt to assess the evolution of the industrial interdependence of China, in terms of backward and forward linkages, between 1995 and 2010. This is in turn the period of the most momentous policy thrusts, and just about bounded

by two international crises: the Southeast Asian crisis of 1997 and the world crisis that started in 2007/8.

Apart from our own studies mentioned above, many other studies of structural change in China have been produced in especially the last 15 years or so. Some concentrate on exports (e.g. He and Zhang 2010, Amiti and Freund 2010, Feentra and Wei 2010), on employment (e.g. Cai and Wang 2010, Evans and Stavetieg 2009), or on industrial productivity and change (e.g. Zheng, Wang and Shi 2008, Yueh 2011). And some has also used input-output analysis, such as Ichimura and Wang (2003) on interregional analysis; Pan, Yang and Lin (2012) on technological spillovers; and Pei, Dietzenbacher et al. (2011) on an import growth decomposition. Others have focussed on vertical specialization (Hummels et al. 2001; Dean et al., 2011; Yang et al., 2015), and others on the environment, energy, and the like. The difference with the ones that use input-output analysis is that ours, first, propose a useful decomposition of total intermediate input linkages that allows to differentiate consistently between domestic and foreign sources; second, we use tables for each year of our period (1995-2010), composed of 33 industries; and we show the structural change trajectory of linkages over the period. This type of study has not been done before or China and offers a good deal of information for complementary studies in the area.

Our main conclusions is that the the secondary and tertiary sector shows a positive increase in both the pull of backward linkages and the push of forward linkages, showing some important levels of absolute import substitution. This is especially the case for the pull of light and heavy industry on the economy and for domestic trade. Given the high output share of the secondary sector, this makes it the main engine of the economy by far. In addition there are three distinctive periods of import substitution/import penetration, which seems to

correspond to the East-Asian crisis of 1997 and the global crisis of 2008 as well as the main reform and policies of the period.

For presentational clarity, the method to assess industrial interdependence is divided into two sub-sections. Firstly, we describe the way we use the general input-output framework (2.1); and, secondly, we define backward and forward linkages and present the final form of their decompositions into domestic and imported inputs (2.2), reserving derivations and other aspects to Appendix I. After its application to China, we proceed to analyze the resulting data by means of Table No.1 and associated charts via the growth rates of backward and forward linkages between 1995 and 2010 (3). This latter is divided into three sections: an aggregate analysis (3.1), a sectoral analysis (3.2) and an analysis of the linkage trajectories over the period (3.3). We end up with our conclusions (4) and also an appendix (Appendix II) that deals with direct statistics of import intermediate inputs.

2. Methodology

The method to evaluate structural changes in industrial interdependence, i.e. structural change for intermediate market interactions, is based on multiplier analysis leading to backward and forward linkages. The main difference between our analysis and standard linkage analysis is that, in input-output theory, the latter represent an *ex-ante* approach to the planning potentials for economic expansion (Hirschman 1958, 1977; Syrquin 1992). In our version, given that our focus is the analysis of the effective change of structural linkages overtime, the linkages represent the *actual* or *effective* (or *ex-post*) interdependence of the economy over the 1995-2010 period. This greatly reduces the restrictiveness of the assumptions required for standard analysis (see also Albala-Bertrand 1999). In addition, we decompose total interactions into

domestic and imported interactions. This allows to assess how dependent the domestic industrial (gross) output is on intermediate imports and how this evolved over our focus period.

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 $n \times m$ matrix F of output for domestic final demands from the same industries, including both domestic and imported commodities; an $n \times 1$ vector E of exports from the same industries; and an $n \times n$ matrix M of intermediate and final imports of all industries. Hence, the $n \times 1$ domestic gross output vector X of the n industries will be given by:

$$X = Wi + Fi + E - Mi \quad (\text{domestic gross output})^{(1)} \quad (1)$$

Where i is an $n \times 1$ 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 $n \times n$ matrix A of coefficients, or rearranging in matrix terms:

$$W = AX \tag{2}$$

Substituting (2) into (1):

$$X = AX + Fi + E - Mi \tag{3}$$

In turn, the *input-mix* or *production-cost* viewpoint includes: the same $n \times n$ matrix W of intermediate demands for the domestic and imported inputs of all the n classified industries, the $1 \times n$ row vector V' of value added (associated to labor and capital) of the same industries, and finally the $1 \times n$ row vector $M^{W'}$ of imports of intermediates for the said industries. The prime sign (" $'$ ") indicates a row vector. The $1 \times n$ domestic gross output vector X' of the n industries will be given by:

$$X' = i'W + V' - M^{W'} \text{ (domestic gross output: } \textit{production cost} \text{ viewpoint)} \tag{4}$$

2.2 Industrial or Sectoral Interdependence

We analyze two kinds of linkages: backward linkages and forward linkages. Both operate at the level of intermediate transactions and are defined and calculated as follows.

Backward Linkages. We define the *backward linkage (BL)* as the direct and indirect *input demand* dependence that all industries have on a particular industry, as the latter requires intermediate inputs from them to satisfy its own production. So an industry will demand intermediates from many other industries to satisfy its output requirement (direct linkage). But by doing so all these industries will have to demand intermediates from many other industries to satisfy the requirement of this first industry, and so on (indirect linkage). This direct and indirect demands are measured by the column sum of the Leontief matrix. We expect dynamic industries to increase their backward demand, becoming more specialized as they develop, whether because they demand more of a more varied input-mix or because they “unbundle” production previously conducted in-house. Leading industries with strong domestic backward linkages are then expected *to pull* all the economy with them and, if they are technologically advanced, increase the technological sophistication of the overall economy. To assess how the *BLs* change over time, we simply calculate the first difference of *BL* between any two given years. However, as matrix *B* contains both domestic and imported intermediates, a useful decomposition is necessary to discriminate between the two. That is:

$$\Delta BL = i' \Delta C = i'(C_0 \Delta A^d C_1) + i'(C_0 \Delta A^m C_1) \quad (\Delta BL \text{ decomposition})^{(2)} \quad (9)$$

The superindexes *d* and *m* stand for “domestic” and “imported,” respectively. Following the nomenclature from Appendix I.1, Equation (9) is then a row vector of backward linkage differences between two years, “0” and “1”, decomposed into domestic and imported contributions. This can be more usefully presented in terms of growth rates (or rates of change) by dividing equation (9) by the *BL* of the initial year, as it is used in the Table No.1 below.

Forward Linkages. Analogously to backward linkages, we define *forward linkage (FL)* as the direct and indirect *input supply* dependence that many industries have on a particular industry, as they require intermediate inputs from it to satisfy their own production. That is, a particular industry (say agriculture) supplies intermediates to its direct customer industries, say textile, hotels and chemicals (direct linkage). These latter industries then use these intermediates to produce their own output and so supply their own customer industries. By doing so, they generate input supplies all over the economy (indirect linkage). The addition of direct and indirect supply linkages, which is measured by the row sum of the Leontief inverse (calculated in different way than above) is then the measure of forward linkages at a given time. Leading industries with strong forward linkages are then expected *to push* all the economy. Given that *BL* and *FL* do not have to exhibit a similar strength, we have to calculate also *FL* for a more complete picture about overall intermediate transactions. As with *BL*, we calculate the first difference disaggregated into domestic and imported linkages.

$$\Delta FL = (\Delta C^*)_i = (C^*_0 \Delta A^{*d} C^*_1)_i + (C^*_1 \Delta A^{*m} C^*_1)_I \quad (\text{AFL Decomposition})^{(3)} \quad (10)$$

This equation is a column vector of forward linkage differences between two years, “0” and “1”, decomposed into domestic and imported contributions. Following the numeration from Appendix I.2, equation (10) can also be more usefully presented in terms of growth rates (or rates of change) by dividing it by the *FL* of the initial year, as in Table No.1 below.

Notice that it is the pull of backward domestic linkage the most important consideration for an economy that “globalizes” domestically, i.e. integrate industries and sectors into the national economy, which may have been fragmented or non-existing otherwise, creating useful multisectoral and multiregional interdependences. Notice also that if backward

linkages are significantly made of imported inputs, this cannot benefit this integrative process, as the demands only benefit industries abroad. This does not mean that intermediate imported inputs are not necessary, as they are an integral process of industrial development in a globalized world, but it does mean that a portion of such industrial value added does not accrue to the importing country (Yang et al., 2015). On the other hand, foreign forward linkages may stimulate output and interdependence. That is, if a firm (e.g. clothes), learns that now the supply of required intermediates (e.g. fabrics) is more available, it might stimulate it to increase its production, and if so this will start a new process of (other) backward intermediate demands. But ultimately this will depend on whether it can sell it. So at the end it is the existing or potential demand for final output (clothes) that will determine such a decision. So it will be included in *ex-post* backward linkages.

2.3 Application to China

We produce both a 33-industry disaggregation and some relevant sectoral 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⁽⁴⁾. 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 (WIOD, 2015). 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.

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 year after year from 1995 to 2010.

3.1 *Aggregate Analysis*

Table No.1 is divided into two panels: the left panel shows relevant indicators of the backward linkages (BL) of the economy between 1995 and 2010, while the right panel shows that for forward linkages (FL). The initial two columns are the share of each industry and sector in total gross output (SX) for 1995 and 2010 respectively, so it represent their weight in those years. For the left panel, the columns from left to right are as follows: BL: level of backward linkages in the base year 1995; DOM/BL: domestic proportion of total BL in 1995; $\Delta BL/BL_{1995}$: rate of change of BL over the period for each industry and sector; DOM and IMP: BL rate of change of domestic and imported origin, respectively; DBL: domestic BL; DFL: domestic FL; and DBLW: sectoral/industrial BL weight in total domestic BL. The right panel columns are the equivalent for forward linkages. 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 either averages or sums for the whole economy.

TABLE No.1: Backward and Forward Linkages 1995-2010 (BP Yuans 10 million)

NACE	1995-2010		BACKWARD LINKAGES (BL)										FORWARD LINKAGES (FL)										
	No	INDUSTRY	SX ₁₉₉₅	SX ₂₀₁₀	BL ₁₉₉₅	DOM/BL	ABL/BL ₁₉₉₅	DOM IMP	DBL ₁₉₉₅	DBL ₂₀₁₀	DBLW ₁₉₉₅	DBLW ₂₀₁₀	FL ₁₉₉₅	DOM/FL	AFL/FL ₁₉₉₅	DOM IMP	DFL ₁₉₉₅	DFL ₂₀₁₀	DFLW ₁₉₉₅	DFLW ₂₀₁₀			
A61	1	Agriculture, hunting, forestry and fishing	12.5	3.9	1.9	92	27	28	15	1.8	2.3	9	3	2.2	95	41	41	57	2.1	3.1	11	4	
C	2	Mining and quarrying	3.1	1.5	2.3	91	85	82	108	2.1	3.8	3	2	4.4	87	58	27	273	3.8	5.5	5	3	
1505	3	Food , beverages and tobacco	6.4	5.5	2.6	94	-1	-1	-3	2.4	2.4	7	5	1.8	96	41	42	11	1.8	2.6	5	5	
1708	4	Textiles and textile	5.8	5.3	3.0	89	4	17	-104	2.6	3.1	6	6	2.3	83	23	46	-90	1.9	3.4	5	5	
19	5	Leather, leather and footwear	1.4	1.0	3.1	89	2	14	-96	2.8	3.1	2	1	1.9	84	20	34	-53	1.6	2.6	1	1	
20	6	Wood and of wood and cork	2.0	1.1	1.5	2.8	90	0	9	-74	2.5	2.7	1	1	3.1	87	21	34	-68	2.7	4.1	1	2
2102	7	Pulp, paper, paper , printing and publishing	1.9	2.0	2.8	91	1	4	-27	2.6	2.7	2	2	3.7	89	21	31	-58	3.3	4.8	3	3	
23	8	Coke, refined petroleum and nuclear fuel	1.7	1.2	2.8	87	24	14	86	2.4	2.8	2	1	3.9	92	22	19	48	3.6	4.6	3	2	
24	9	Chemicals and chemical	4.5	4.1	2.9	90	32	32	36	2.6	3.4	5	5	3.9	83	15	25	-33	3.2	4.8	6	6	
25	10	Rubber and plastics	2.3	2.8	3.1	90	1	4	-31	2.7	2.9	3	3	3.3	92	20	23	-22	3.0	4.0	3	4	
26	11	Other non-metallic mineral	4.4	3.1	2.8	93	-1	-2	10	2.6	2.5	5	3	2.6	100	3	1	1306	2.6	2.7	5	3	
2708	12	Basic metals and fabricated metal	8.1	9.2	3.1	91	3	1	26	2.9	2.9	10	10	3.7	91	7	10	-24	3.3	4.0	11	12	
29	13	Machinery, nec	4.0	6.6	3.0	91	-3	-4	4	2.7	2.6	5	6	2.7	93	9	5	63	2.5	2.8	4	6	
3033	14	Electrical and optical equipment	5.0	16.1	3.2	88	-6	-7	3	2.8	2.6	6	15	2.6	68	16	31	-14	1.8	3.4	4	13	
3435	15	Transport equipment	2.6	6.0	3.2	91	-6	-5	-12	2.9	2.7	3	6	2.5	90	6	6	7	2.2	2.6	2	5	
3607	16	Manufacturing nec; recycling	0.7	0.8	2.9	90	-17	-13	-56	2.6	2.3	1	1	2.3	95	1	-13	240	2.1	2.0	1	1	
E	17	Electricity, gas and water supply	1.9	2.4	2.4	92	55	52	86	2.2	3.3	2	3	3.8	100	28	26	1106	3.8	4.7	3	4	
F	18	Construction	8.1	7.5	3.0	92	36	37	26	2.7	3.7	9	10	1.1	98	-3	-4	30	1.1	1.1	4	3	
51	19	Wholesale trade and commission trade, ex motor vehicles	5.2	3.4	2.3	92	-5	-4	-17	2.1	2.0	5	2	2.9	99	-5	-7	229	2.9	2.7	6	3	
52	20	Retail trade, ex motor vehicles; repair of household goods	1.1	0.7	2.3	92	-5	-4	-17	2.1	2.0	1	1	2.9	99	-7	-7	-12	2.9	2.7	1	1	
H	21	Hotels and restaurants	1.8	1.5	2.4	94	23	24	7	2.2	2.8	2	1	2.2	88	25	33	-29	1.9	2.9	1	1	
60	22	Inland transport	2.4	1.6	2.1	91	17	18	4	1.9	2.3	2	1	3.1	98	15	10	341	3.1	3.5	3	2	
61	23	Water transport	0.3	0.6	2.6	90	8	8	1	2.3	2.5	0	1	2.7	97	22	23	-15	2.6	3.4	0	1	
62	24	Air transport	0.3	0.3	2.6	91	37	36	43	2.3	3.2	0	0	2.6	83	19	6	81	2.1	2.7	0	0	
63	25	Other Supporting and auxiliary transport activities; travel agencies	0.7	0.7	2.2	92	23	24	10	2.0	2.5	1	1	2.6	80	0	14	-59	2.1	3.0	1	1	
64	26	Post and telecommunications	0.5	1.2	2.1	89	19	18	20	1.8	2.2	0	1	3.0	95	-12	-14	35	2.8	2.5	1	1	
J	27	Financial intermediation	3.1	2.0	2.0	92	-5	-3	-24	1.8	1.7	2	1	3.4	99	5	5	44	3.3	3.5	4	3	
70	28	Real estate activities	2.0	1.1	1.6	93	16	15	35	1.5	1.7	1	1	2.1	100	-15	-16	1758	2.1	1.8	2	1	
1074	29	Renting of m&eq and other business activities	1.8	1.9	2.5	87	62	72	-11	2.2	3.8	2	3	2.5	93	38	34	91	2.3	3.4	2	2	
L	30	Public admin and defence; compulsory social security	1.9	1.4	2.4	92	25	28	-11	2.2	2.8	2	1	1.0	93	13	4	9	0.9	1.1	1	1	
M	31	Education	1.3	1.2	2.0	91	43	42	54	1.9	2.6	1	1	1.2	100	13	11	535	1.2	1.3	1	1	
N	32	Health and social work	1.0	1.0	2.7	90	45	48	18	2.5	3.6	1	1	1.1	86	29	35	-4	0.9	1.5	0	0	
O	33	Other community, social and personal services	1.1	1.1	2.4	91	48	50	29	2.2	3.2	1	1	1.8	93	47	49	20	1.7	2.7	1	1	
I PRIMARY SECTOR (1,2)			15.6	5.4	2.1	92	59	58	69	1.9	3.1	12	5	3.3	94	52	32	240	3.1	4.3	16	7	
II SECONDARY SECTOR (3-18)			59.9	75.1	2.9	91	7	9	-11	2.6	2.9	67	77	2.8	90	16	20	-17	2.5	3.4	60	75	
Light Industry (3-7)			16.5	15.3	2.9	91	1	9	-69	2.6	2.8	18	15	2.6	89	24	37	-65	2.3	3.5	14	16	
Medium Industry (8-12)			21.0	20.4	2.9	91	11	10	28	2.7	2.9	24	22	3.5	91	14	16	-10	3.2	4.0	28	27	
Heavy Industry (13-17)			14.2	31.8	2.9	90	2	3	0	2.6	2.7	16	30	2.7	84	14	12	29	2.3	3.1	14	29	
Construction (18)			8.1	7.5	3.0	92	36	37	26	2.7	3.7	9	10	1.1	98	-3	-4	30	1.1	1.1	4	3	
III TERTIARY SECTOR (19-33)			24.4	19.5	2.3	92	24	26	9	2.1	2.6	21	18	2.3	94	10	10	18	2.2	2.6	24	18	
Domestic Trade (19-21)			8.1	5.5	2.3	93	5	6	-11	2.1	2.3	7	4	2.7	97	3	3	-11	2.6	2.7	9	5	
Transport plus (22-26)			4.2	4.4	2.3	91	21	21	16	2.1	2.5	4	4	2.8	94	9	8	20	2.6	3.0	5	5	
Finance plus (27-29)			6.9	5.0	2.0	91	28	32	-6	1.8	2.4	5	4	2.7	98	10	8	90	2.6	2.9	8	5	
Social sectors (30-33)			5.2	4.6	2.4	91	40	42	21	2.2	3.1	5	5	1.3	92	28	35	10	1.2	1.7	3	3	
Average/Total			100.0	100	2.6	91	17	19	0.23	2.3	2.8	100	100	2.6	90	17	17	16	2.4	3.1	100	100	

BP: basic prices (10 million Yuans)
 NACE: European Classification of Economic Activities
 SX: gross output share in total gross output in 2010 (%)
 BL₁₉₉₅: total backward linkages in 1995
 FL₁₉₉₅: total forward linkages in 1995
 DOM/BL₁₉: domestic-to-total 1995 BL (%)
 DOM/FL₁₉: domestic-to-total 1995 FL (%)
 ABL/BL₁₉₉: backward linkages sectoral/industrial rate of change (%)
 AFL/FL₁₉₉₅: forward linkages sectoral/industrial rate of change (%)

DOM: domestic sectoral/industrial rate of change (%)
 IMP: imported sectoral/industrial rate of change (%)
 DBL₂₀₁₀: domestic BL in 2010
 DFL₂₀₁₀: domestic FL in 2010
 DBLW: domestic sectoral/industrial BL weights (%)
 DFLW: domestic sectoral/industrial FL weights (%)

With a view to analyze orderly this table, we resort to visual charts. Chart 1 below shows the sectoral share change over the period in terms of percentage points.

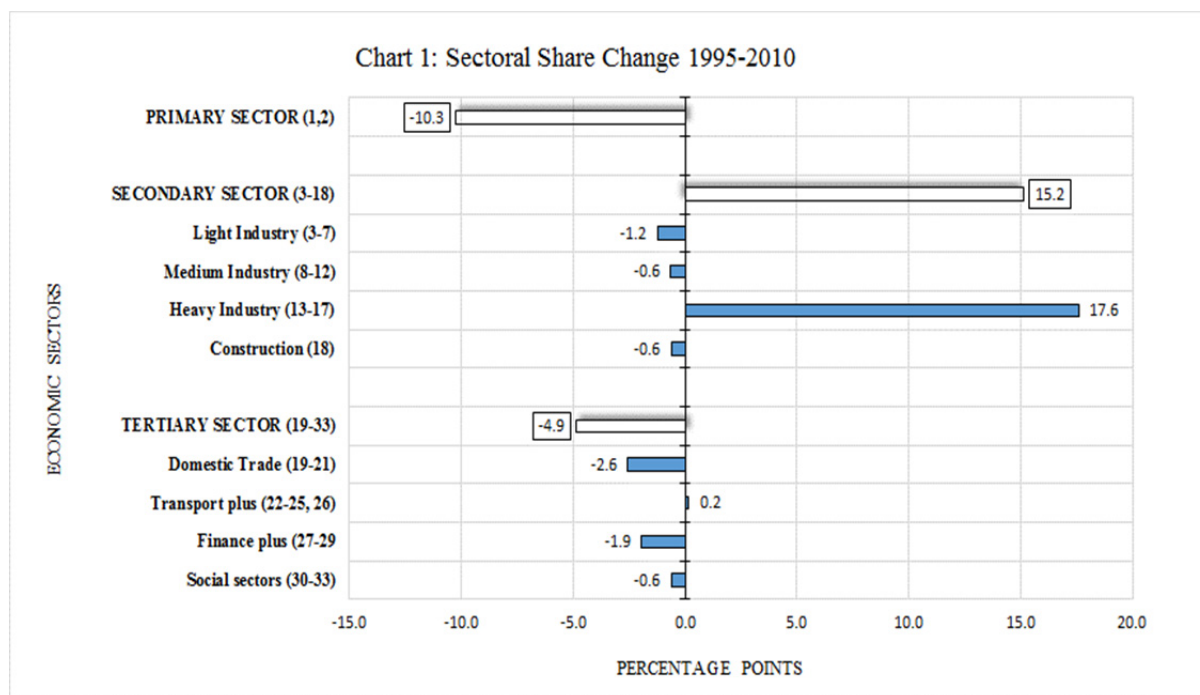


Chart 1 shows that in terms of gross output shares (SX), the secondary sector increased massively its share in gross output at the expense of especially the primary sector. The secondary sector increase was due to heavy industry (17.6pp) [pp: percentage points] at the expense of light, medium and construction industries. As shown in Table No.1, within heavy industry, the increase was especially due to “Electrical and optical equipment” (No.14) and “Transport equipment” (No.15), increasing their share by 11pp and 3pp, respectively. All sectors and subsectors, however, had significant gross output growth rates over the period, which on a weighted average amounted to some 385% for the economy (not shown in table). That is, the fact that some sectors, subsectors and industries fell in share terms does not mean that they had negative growth rates (Albala-Bertrand 2016)⁽⁵⁾. Over such basis, the aim of this paper is to learn about the importance and evolution of backward and forward linkages.

Table No.2 derives from Table No.1 and presents the sectoral domestic BL and FL weights (DBLW and DFLW) in the economy for 1995 and 2020.

TABLE No.2: Sectoral BL and FL weights in the economy – 1995 and 2010

	2010	SX ₂₀₁₀	SX ₁₉₉₅	BL ₁₉₉₅	DBL ₁₉₉₅	DBL ₂₀₁₀	DBLW ₁₉₉₅	DBLW ₂₀₁₀	DBLW ₁₉₉₅ /SI	DBLW ₂₀₁₀ /SI
BL	SI	5	16	2.1	1.9	3.1	12	5	1	1
BL	SII	75	60	2.9	2.6	2.9	67	77	6	15
BL	SIII	20	24	2.3	2.1	2.6	21	18	2	3
Average/Total				2.6	2.3	2.8	100	100		

	2010	SX ₂₀₁₀	SX ₁₉₉₅	FL ₁₉₉₅	DFL ₁₉₉₅	DFL ₂₀₁₀	DFLW ₁₉₉₅	DFLW ₂₀₁₀	DFLW ₁₉₉₅ /SI	DFLW ₂₀₁₀ /SI
FL	SI	5	16	3.3	3.1	4.3	16	7	1	1
FL	SII	75	60	2.8	2.5	3.4	60	75	4	11
FL	SIII	20	24	2.3	2.2	2.6	24	18	2	3
Average/Total				2.6	2.4	3.1	100	100		

SI,SII,SIII	economic sectors	DFL	domestic forward linkages
BL	backward linkages	DBLW	domestic BL weight in the economy (%)
FL	forward linkages	DFLW	domestic FL weight in the economy (%)
SX	Sectoral share in total gross output (%)	DBLW/SI	sectoral DBLW with respect to DBLW of SI (number of times)
DBL	domestic backward linkages	DFLW/SI	sectoral DFLW with respect to DFLW of SI (number of times)

The economy had a weighted average BL of 2.6 in 1995, i.e. an increase of one unit of output for final demand would create 2.6 input demands over the economy. The secondary sector had the largest BL pull (2.9), with all industrial subsectors having a similar strength; then the tertiary one (2.3), with similar pull for its subsectors, although slightly lower for finance; and only then the primary one (2.1). But as indicated above, backward linkages (BL) only make integrative sense if they are domestic, as imported input cannot exert a pull on domestic producers. Table No.1 shows the gross output sectoral shares (SX), the 1995 domestic proportion of BL (DOM/BL), and the rate of change of BL over the period (Δ BL/BL₁₉₉₅), which allows to calculate both the 1995 and 2010 sectoral/industrial domestic BL weights in the total (DBLW), and the same for forward linkages. Table No, 2 shows that for the three sectors of the economy. The primary sector (SI) has the largest DBL in 2010, but its domestic pull is significantly lower than in 1995 given its fall in output share. It actually fell from 12% in 1995 to only 5% in 2010. This is then the case of a sector that while becoming better domestically integrated, its share decline makes its pull significantly less influential for the whole

economy. The secondary sector (SII), in turn, has become by far the one with the highest domestic pull weight in the economy, representing 77% of total pull of the economy. The table above shows that the secondary sector in 1995 had 6 times more pull weight than the primary sector and 3 times more than that of the tertiary one. By 2010 this weight became 15 times as large as that of the primary sector and 3 times that of the tertiary sector (DBLW/SI). The later sector lost some of its domestic pull weight over this period, although it also increased its relative pull as compared to the primary sector.

Regarding forward linkages (FL), in 1995 the economy had similar FL for the secondary and tertiary sectors as above, but the primary sector had a stronger push value. But again, the domestic weight push is significantly lower given its reduced output share. The rest of this story can be seen directly from Table No.2, which Table No.1 shows in a more disaggregated fashion. It is to be stressed that, *ex ante* and so for policy purposes, the FL is less important than BL, as the former represents only a possible demand incentive, while the latter represents an effective demand incentive⁽⁶⁾. However, an increase in available imports, if taken up, may *ex ante* stimulate also the domestic economy⁽⁷⁾. Lastly, a sector/industry can have large forward linkages but small backward ones. This means that the sector/industry has a large domestic input supply push contribution downstream (to all industries), but a small domestic input demand pull upstream over the economy.

Table No1 shows the domestic proportion of BL and FL in 1995. For BL, this is 91%, with all industries around it. For FL this is 94% and slightly more uneven for all industries, but with all of them larger than 80%. The largest proportion is in the primary sector (94%) and the lowest in the secondary one (90%). So the question is how this has evolved over the period and what proportion of it is imported. Table No.3 helps us to assess the structural trade

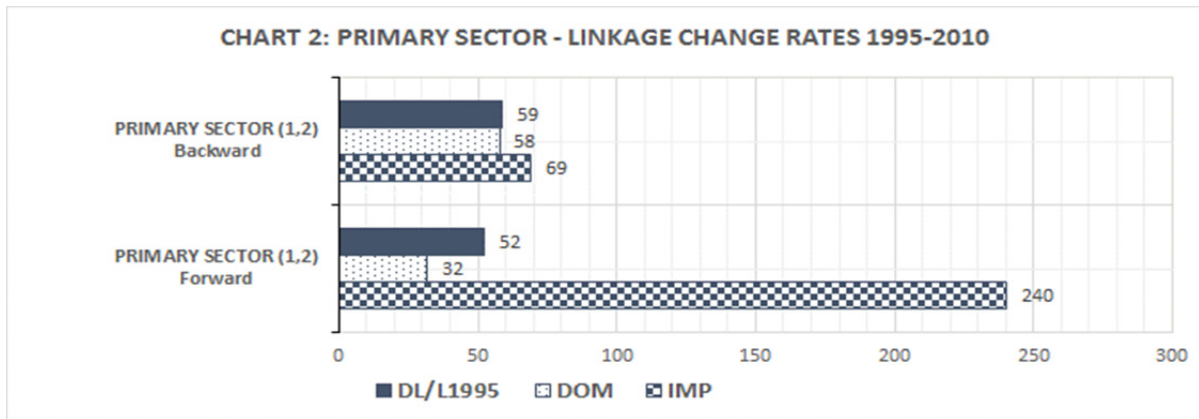
change interpretation, in terms of import substitution or import penetration, that derives from the relationship between the domestic (DOM) and imported (IMP) change rate contributions, which are behind the rate of change of backward or forward linkages over the period.

TABLE No.3: Structural Trade Change Interpretation of DOM-IMP Relationship

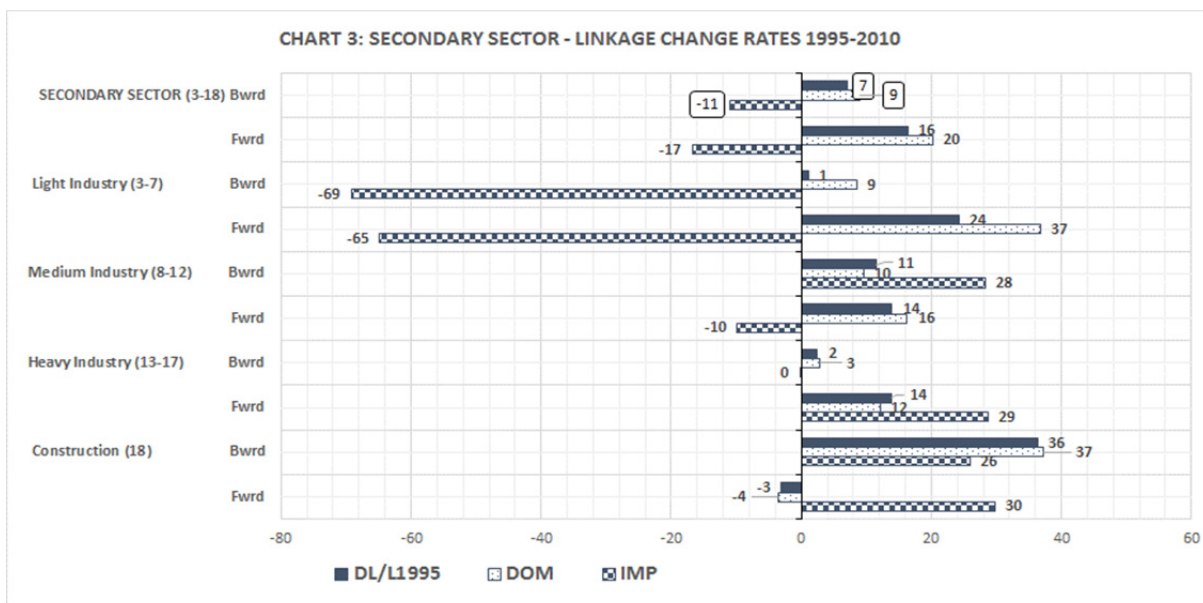
COMPARISON	SIGNS	STRUCTURAL CHANGE TYPE
DOM = IMP	if both positive or negative	No Change
DOM > IMP	if both positive or negative	Relative Import Substitution
DOM > IMP	if DOM positive and IMP negative	Absolute Import Substitution
DOM < IMP	if both positive or negative	Relative Import penetration
DOM < IMP	if DOM negative and IMP positive	Absolute Import Penetration

3.1.2 Sectoral Analysis

First, the primary sector has the largest BL increase (59%), notably mining and quarrying (industry 2), but with a slight decrease in its domestic pull (as $IMP > DOM$). This shows a sector that while becoming relatively less important, and so with less pull over the whole economy, it also shows some relative import penetration, as its positive and large increase in domestic BL is lower than that of imported origin. But it started with a high domestic share in total BL and FL, so this can actually be welcome if these imported intermediates are necessary and currently not produced home or are more efficiently imported. Chart 2 below visually summarize this for both backward and forward linkages.



The large increase in forward imported inputs (240%) is simply due to the very small imported content in the base year. It can be shown that such an increase contributed with less than half of the increase in total forward linkages of 52%. In the forward linkage panel especially, every time that Table No.1 shows a very large IMP it should be interpreted as an imported contribution that starts from a very low imported base (e.g. notably industry 28: Real estate activities with a 1758% increase). As a conclusion, the primary sector shows a slight relative import penetration in its BL pull and a more significant one in the FL push, but the latter is still at a very low import content base. And given that its output share has become significantly smaller, it has a significant lower relative influence in the economy. Chart 3 shows the case for the secondary sector over the period.

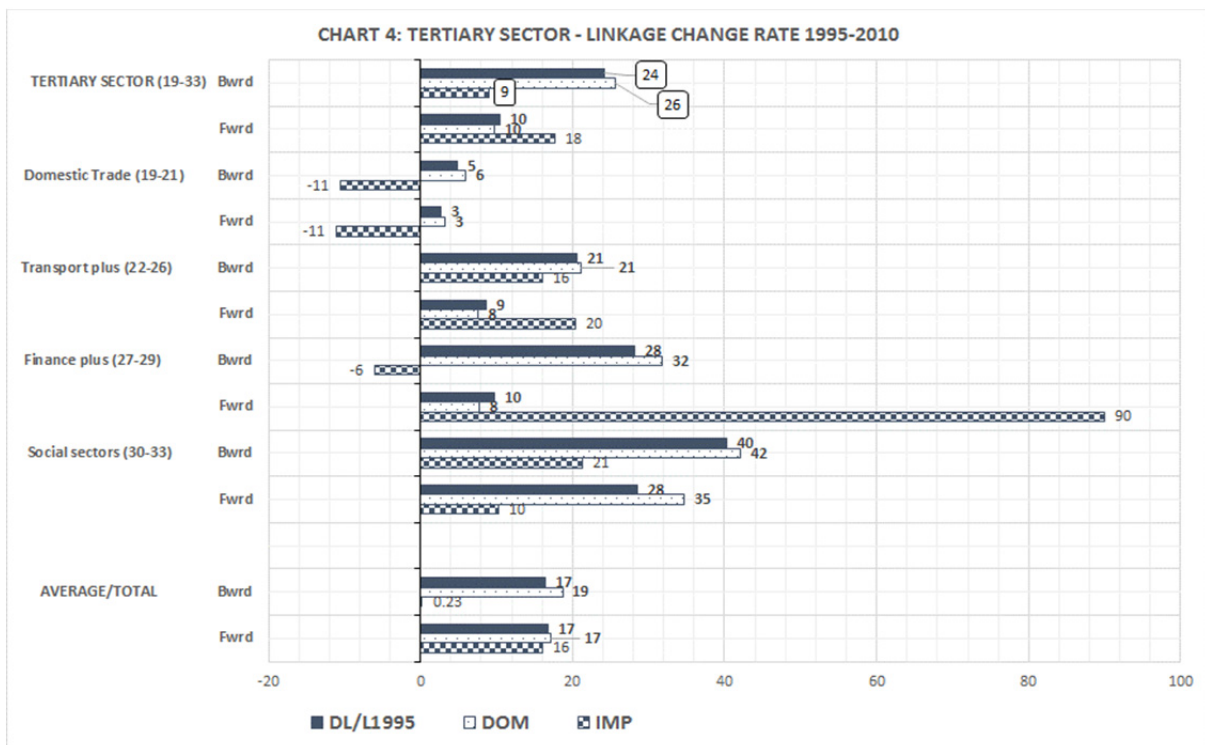


In contrast to the previous case, the secondary sector shows a clear case of absolute import substitution over the period ($DOM > 0$ and $IMP < 0$), both for backward (BL) and forward linkages (FL). But this is almost fully concentrated in the light industry for both BL and FL. This is especially the case for industries 4 (textiles plus), 5 (leather plus) and 6 (wood plus). Other things being equal, this means that this subsector has become less dependent on imports both upstream (BL) and downstream (FL) over the period, so it exerts a greater domestic pull and push over the economy. Medium industry, on the other hand, shows a mixed case of relative import penetration for BL and absolute import substitution for FL. For the former, this is especially the case for industries 8 (coke, petroleum refineries and nuclear fuel) and 9 (chemicals plus). But industry 10 (rubber and plastics) shows an absolute import substitution, notably for industries 9 and 10. So it is mixed here too. For FL there is a more clear case of absolute import substitution. There appears to be a tendency towards the use of domestic intermediates in general at the expense of imported ones, but key industries for energy sources and chemicals appear as a relative counter trend. Of course, an increase in the relative use of imported intermediates is not a problem in itself, as this may be more efficient. The issue however is about useful domestic linkages. A relative increase in imported inputs also represents a relative weakening of domestic integration (especially the BL pull of the economy), which may have consequences for a more balanced growth if these are large (Stiglitz 1996).

Heavy industry, in turn, which is the one that has grown significantly faster than the rest of the economy, exhibits a pretty mixed case. There is a small relative import substitution for BL, mostly on account of industries 15 (transport plus) and 16 (manufacturing plus), but at the same time an absolute import penetration in industries 13 (machinery) and 14 (electrical

plus). As shown in Table No.1, the latter is the industry that shows the fastest growth in gross output share over the period, but also the one that exerts the largest domestic pull weight. But for FL its domestic linkage significantly increased while its import linkage significantly decreased ($IMP < 0$), so there is here a clear case of import substitution. This means, others things being equal, that while the pull of this industry has weakened, its push has increased⁽⁸⁾. There is also some relative import penetration in the production of electricity, water and gas (industry 17).

For FL there is a relative import penetration in general on account of all of its industries, except 14 (electricals plus), as indicated above. But also an absolute import penetration in the case of industry 16 (non-electrical manufacturing). Finally, construction shows a mixed of relative import substitution for BL and absolute import penetration for FL. Given that the latter shows that $DOM < 0$, then it can be interpreted as a general fall in domestic provision of intermediates to using industries over the period. Chart 4 shows the change rates of backward and forward linkages for the tertiary sector.



The tertiary sector also increased its BL (24%), with an increase in its relative domestic pull or relative import substitution (DOM>IMP), and an increase in its relative import supply push or relative import penetration, but with a decreased share in gross output. So again, this is a sector that becomes better domestically integrated, especially in BL, but with a smaller but significant relative influence pull on the whole economy.

The meagre BL rate of change increase in the domestic trade subsector (5%) is fully due to industry 21 (hotels and restaurants); and that of the finance plus subsector (28%) is due to real estate activities (industry 28) and renting machinery and equipment plus other business activities (industry 29). Transport, especially air one (industry 24), and social sectors, notably education, health and other services (industries 31-33), show both a strong BL increase and domestic pull. All this contributes to a more mutually dependent and integrated social economy. As a general summary of section 3.1, we can conclude as follows:

- (a) Over the period, the rates of growth of output of sectors/industries were systematically positive, but at differential speeds, creating large disparities in their shares of the economy. The secondary sector, especially heavy industry, increased massively its share in total gross output, at the expense of notably the primary sector, but also the tertiary one.
- (b) The primary sector has the largest increase in domestic BL and FL, but the largest loss in output share, so while it becomes better integrated into the domestic economy has a relatively less influence in it. There has also been some import penetration, especially in FL, which is due to mining and quarrying, but from a low import base.

(c) The secondary sector has a small increase in especially domestic BL, but the largest gain in its share of output. So it has both become better integrated into the economy and has by far the largest influence in it. This sector also shows an absolute import substitution over the period, but almost fully concentrated in the light industry for both BL and FL. Heavy industry shows on average a relative import substitution in BL, with small import penetration in its two largest industries (nos.13 and 14 in Table No.1). The other subsectors are on average mixed in this respect.

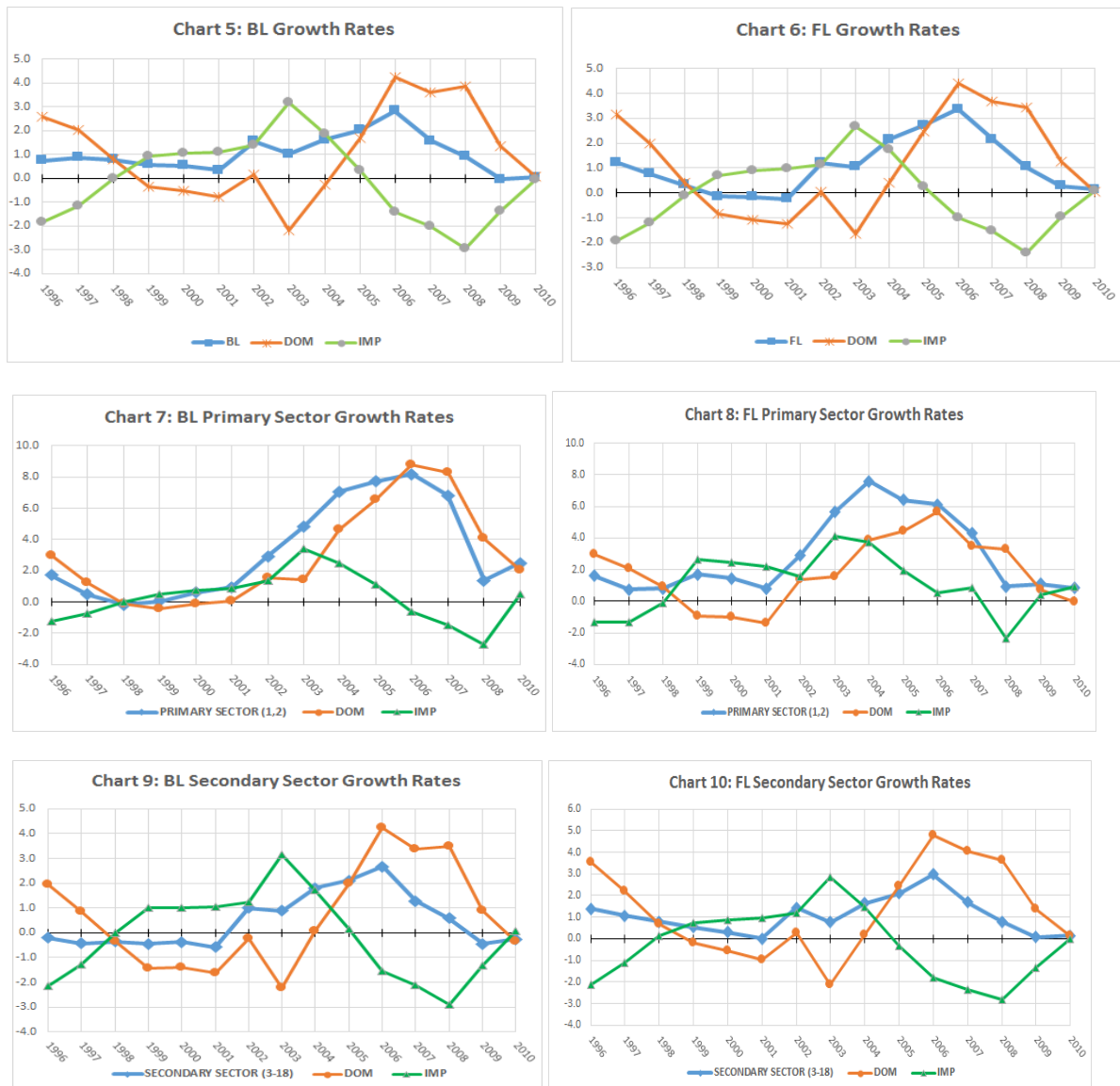
(d) The tertiary sector shows an increase in both domestic BL and FL and a secondary loss in its share of output over the period. So it has become better integrated and has an important but lower relative influence in the economy than in 1995. This sector shows both absolute and relative import substitution for all its constituent subsectors on average. At the same time there is clear indication of import penetration in FL for all constituent subsectors and industries, except social sectors. So while the domestic BL pull has increased its traction, the domestic FL push has lost some of its strength. The latter means that in general the economy depends on more imported input supply coming from this sector than before. Still this represents a small imported FL proportion.

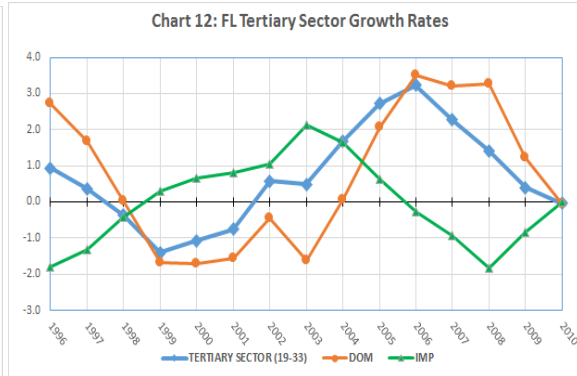
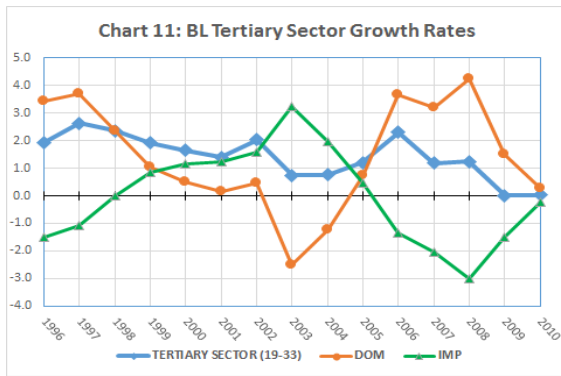
It is also useful to complement the above story about import changes in BL and FL over the period, with the changes in the direct import content of total intermediate inputs demanded by industries and sectors as well as the change of imported intermediates inputs in total intermediates according to the type of intermediate, e.g. agricultural intermediates, construction intermediates and so on. We do this in our Appendix II below.

3.1.3 Growth Rates Trajectory over 1995-2010

We now look at the trajectory of backward and forward linkage growth rates over the period in question, at the level of each sector and accounting for the domestic and imported growth rate changes via a collection of charts grouped in Charts 2-12. These show the evolution of the growth rates that made up the total growth rate changes over the period as shown in Table No.1.

Charts 5-12: BL and FL - Total and Sectoral Growth Rates 2006-2010.





Charts 5 and 6, which present this for the economy as a whole, show a similar pattern for both total backward (BL) and forward (FL) linkages and their domestic (DOM) and imported (IMP) components. There are three distinctive crossing points between the domestic and the imported growth rates. First, there is a notable crossing where import rates grow faster than declining domestic ones, the latter becoming negative, which seems to correspond to the East-Asian crisis of 1997-98. There is here a significant decrease of both total backward and forward linkages, dragged down by linkages of domestic origin, which only start to recover by 2001. Second, from 2003, there is a sustained increase in BL and FL, producing an opposite crossing by 2004 that reaches its maximum by 2006, almost fully on account of domestic linkages, as imported ones have now become negative. And there is a third crossing, where BL and FL rapidly decrease, reaching about zero by 2008-09, with imported linkages moving towards positive values while domestic ones towards negative ones, which seems to correspond to the onset of the 2008 world crisis.

Following the categorization of our Table No.3, this shows that between 1995 and 1998 there mostly seems to be an absolute import substitution, then between 1998 and 2005 there appears to be both an absolute and relative import penetration, and from 2005 until 2010 it shows an absolute import substitution. The latter seems to be due to both policies towards the

domestic market and the shock from the 2007-08 international credit crunch, as further illustrated below.

In general, the pattern for the whole is pretty similar to that for the three economic sectors, for both backward and forward linkages, and their domestic and foreign components, especially for the secondary sector given its large output share. There are some minor differences in the timing of the crossings and in their levels, as can be seen in the sectoral charts above. That is, from 2004, domestic backward and forward linkages take the largest contribution to total linkages, meaning that the use of domestically produced intermediates, which otherwise would have been imported, significantly increased, making the economy better domestically integrated over this last tract of our period.

We know that the secondary sector underwent a massive growth over the period, increasing its share of gross output to over 75%, especially for heavy and medium industries (Table No.1). And also that the contribution of export demand to the total growth of secondary sector gross output was by far the most important demand source between 1997 and 2005. From about then, domestic demand became more prominent, replacing eventually export demand as the most important growth source of the period. This is seen to be related to important domestic policies and the credit crunch. This tallies with the above observation that the growth rates of domestic BL became positive and significant after 2004⁽⁹⁾.

3.1.4 Some Policies behind the above Patterns

Over the period 1994-96 some deep reforms were introduced with the aim at both developing private domestic business and attracting foreign direct investment via among others policies a

widespread liberalization of capital flows (Prasad and Wei 2005). The 1997 East Asian crisis plus other accumulated domestic economic problems, like sluggish rural income growth and general industrial inefficiency, impinged on both a slowdown of positive growth rates and a significant fall in the total factor productivity of the economy (Albala-Bertrand 2013, Yueh 2013, Zhen, Bigsten and Hu 2009). Apart from some short-term crisis-induced counteracting policies, which aimed at stimulating domestic demand, especially in the areas of construction and services over 1997-2001, some deeper reforms were introduced and implemented. Notably, a law that let the markets to guide prices with outside intervention by the government. In addition, in 2001 China became a member of the WTO, which eliminated direct price controls and export subsidies on agricultural products (Yueh 2010, 2013; Zhang and Tan 2007, OECD 2002). On top of this, open market agreements with the US and Southeast Asian countries, set a strong foundation on which total factor productivity and capital intensity 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), which accumulated some large imbalances in the economy to the point that by 2007 China officially acknowledged that its economic growth was “unsteady, unbalanced, uncoordinated and unsustainable” (Wen Jiabao-Annual Meeting of China’s legislature, 2007). This reality check referred to the situation of the whole economy: imbalance between domestic and foreign demand, imbalance between the secondary and the other economic sectors, disparities between regions, increasing 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 2008 international financial crisis, which brought new policies to counteract it. A major stimulus package for agriculture, construction and services came about. There was here, sets of policies that focused on particular areas, like housing and rural infrastructure, education and health, environment and disaster reconstruction, industry and transportation, tax cuts and finance, and so on (Wong 2011). All this, appeared to have produced a strong structural change reversal, especially from 2007, between the contribution of final domestic demand and that of foreign demand to total gross output (Albala-Bertrand, 2016). This was also reflected in an important domestic substitution of previously imported intermediaries and in an increase of domestic backward and forward linkages, as shown in the charts above.

It seems then that over the period 1995-2010, world external shocks together with counter and strategic policy packages as well as the overall structural change of economy and society, can be partly illustrated with the help of the above type of analysis, which can complement and serve as the basis for other approaches and aims (e.g. Albala-Bertrand, 2013, 2016; He and Zhang 2010, Cai and Wang 2010, Zheng, Wang and Shi 2008).

3. Conclusions

We started by setting up the input-output model and its derivation for total backward and forward linkages the economy. We then produced a decomposition of both type of linkages into domestic and imported ones. This was essential for our aims, which where to learn about the changes of domestic industrial/sectoral backward and forward linkages (i.e. the pull and push of the economy) as well as the changes in their domestic and imported linkages (i.e. via import substitution- import penetration) over the 1995-2010 period. To such aims we

produced a disaggregation of 33 industries and a re-aggregation of the standard three economic sectors and their main subsectors of grouped industries, as presented in Table No.1. Then with the help of a couple of additional tables and a series of charts we presented the results in terms of rates of change for the period as a whole and for their yearly evolution or trajectories over such a period.

(a) Whole period changes

The first conclusion is that over the period, the secondary sector massively grew its share in total (gross) output via heavy industry (especially its electrical and optical equipment component) at the expense of notably the primary sector, but also the tertiary one. This is the result of different speeds of positive growth rates of sectors and industries, given that as a rule none of them exhibited yearly negative growth rates of output over the period.

Total backward (BL) and forward linkages (FL) significantly increased for all sectors, with its highest increase in the primary and tertiary sectors. This should have made the primary sector as having the strongest pull and push over the economy, but this is a case of a sector that while becoming better domestically integrated, it shows also a significant share loss in gross output and a slight relative import penetration, making it a sector with significant less relative weight in the economy (Table No.2). Still this sector started with a pretty high share of domestic linkages, so this can actually be welcome if these imported intermediates are currently not produced home or are more efficiently imported. The tertiary sector is more mixed. Its domestic linkage pull has become significantly more important (notably for trade and finance with an absolute import substitution), but with a lower share on total output, with the two factors partly compensating with each other, so this sector seems to have slightly

reduced its relative domestic pull weight over the period. Its domestic forward push FL shows a similar picture.

The secondary sector shows a small positive increase in both backward and forward linkages, but it also shows on the whole an absolute import substitution. This is especially the case for the pull of light and heavy industry on the economy. In other words, these industries exert a demand pull on the whole economy that requires less imported intermediates to satisfy it. Given the huge increase in output share, this sector on the whole has significantly increased its domestic weight on the economy. However, the electrical and optical equipment, which also have the largest share in output, show a small absolute import penetration in backward linkages and an important import substitution in forward one. This can be interpreted as follows. Any time that this industry (no. 14) initiates an increase in its domestic final output, all industries upstream (pull) will slightly increase their share of imported intermediates on average to satisfy the input requirement of this initial industry. And any time this industry (no. 14) increases its total supply of intermediates (domestic plus imported), all industries downstream (push) will be on average acquiring a lower share of imported intermediates to satisfy their own outputs (and not only that of the industry 14 alone).

(b) Trajectories of changes over period

Both for the total economy and for its constituent sectors the pattern of the trajectories are similar, although the levels and timing may slightly differ. There appear to be three distinctive period, which correspond to the crossing points between the domestic and the imported growth rates in the charts (Charts 5-15). First, around 1997-98 there appears to be a significant decrease of both backward (BL) and forward linkages (FL), dragged by a fall of linkages of domestic origin, which start to recover by 2001. For both BL and FL, import

growth rates grow faster than declining domestic ones, the latter becoming negative. This seems to correspond to the East-Asian crisis of 1997-98 and policies that gave privilege to exports of especially heavy industry and market deregulation. Second, from 2003, there appears to be a sustained increase in both BL and FL, producing the opposite picture, where domestic linkages grow faster than imported ones, with the latter now becoming negative, producing a crossing by 2004. This departure reaches its maximum by 2006, and then this gap rapidly decreases. By 2007 China officially acknowledged that its economic growth was “unsteady, unbalanced, uncoordinated and unsustainable”, coinciding with the onset of the 2007-8 world financial crisis, which brought major short term stimulus package and longer-term reforms giving more importance to the domestic market. Third, by 2008-09 the growth of BL and FL move towards zero, with the gap between the two then closing around it, where it seems that again imported linkages moves towards positive territory while domestic ones seem to go the other way round. Following the categorization of our Table No.3, between 1995 and 1998 the trajectories show an absolute import substitution, between 1998 and 2005 there appears to be both an absolute and relative import penetration, and from 2005 until 2010, there seems to be an absolute import substitution. The latter seems to be due to both policies towards the domestic market and the shock from the 2007-08 international credit crunch.

APPENDIXES

Appendix I: Backward and Forward Linkages

1. Backward Linkages (economic pull)

Using equation (3) and recalling that A is a matrix of input demand coefficients, then solving for X :

$$X = (I - A)^{-1}(F + E - M) \quad (\text{gross output: demand viewpoint}) \quad (5)$$

Let $C = (I - A)^{-1}$ be the Leontief inverse. Each element of this matrix contains the total (direct and indirect) input demand per unit of final net demand ($F + E - M$) of a particular industry with respect to any other industry (including itself). The column sum of C represents the total intermediate demand for domestic and imported inputs in all the economy, derived from the

increase of one unit of output for net final demand by a particular industry. This coefficient will be larger than or equal to one, as for each unit of final demand, an addition of intermediate inputs is required, which is why sometimes the Leontief matrix is called a matrix of multipliers, i.e. multiplies each unit of final demand into a larger number of gross output units. The larger this is, the stronger the total upstream backward linkage between a particular industry and the overall economy, i.e. the stronger the overall input-demand effects of a particular industry's final production decisions, and *vice versa*. This represents the total industrial/sectoral pull of the economy. In matrix notation, backward linkages (*BL*) are expressed as follows:

$$BL = i'C \text{ (backward linkage, row vector)} \quad (6)$$

This vector correspond to the vertical sum of the C matrix. In addition, these sectoral BL values should be weighted by the sectoral gross output shares in total gross output to assess their pull influence in the economy, as shown in Tables No. 1 and No. 2.

2. Forward Linkages (economic push)

The procedure we adopt here to calculate *FL* is fully analogous to that for *BL*, but instead of using a matrix of *input-demand* coefficients (A), we use a matrix of *input-supply* coefficients (A^*)⁽¹⁰⁾. That is, letting $i'W = X'A^*$, substituting this in (4), and solving for X' we get:

$$X' = (V' - M^{W'}) (I - A^*)^{-1} \quad \text{(gross output: production cost viewpoint)} \quad (7)$$

Let us define the Leontief inverse as: $C^* = (I - A^*)^{-1}$, where each cell in this matrix contains the total (direct and indirect) intermediate supply per unit of net value added ($V' - M^{W'}$). Hence, a row sum of C^* accounts for the overall intermediate supply in the economy derived from the increase of one unit of value added by a particular industry. This represents the total downstream industrial/sectoral push of the economy. Then, in matrix notation, forward linkages (*FL*) are expressed as follows:

$$FL = C^*i \quad (\text{forward linkage column vector}) \quad (8)$$

This vector corresponds to the horizontal sum of the C^* matrix. In addition, these sectoral FL values should be weighted by the sectoral gross output shares in total gross output to assess their push influence in the economy, as shown in Tables No. 1 and No. 2.

Appendix II: A Word about the Import Content of Output and its Measurement.

There are no input-output tables that directly include the import content of exports at sectoral/industrial level, so in our paper this is treated by means of imported input substitution of the whole economy, which does not allow to distinguish between intermediate imports used for domestic demand (consumption and investment) and those for export demand, let alone processed exports and non-processed ones. Given the highly globalized fragmentation of some industrial structures, the import content of exports and their supply chains, which relates to vertical specialization and derived value chains, are important research efforts, which have so far shown only relative success. Given the insufficiency of direct information from the standard tables, this issue has been tried indirectly either via the use of some strong assumptions (e.g. Hummels et al. 2001), which produce some significant biases, or by means of focussing on a couple of years using complementary data that comes from custom and tax rules, which are peculiar to China alone (Yang, Dietzenbacher et al. 2015)⁽¹¹⁾. This also require some convenient assumptions on these data, so the results may not be devoid enough of biases. The research attention paid to this issue is an important endeavour, which will surely see more robust results in due course.

In this paper, apart from what has been presented above, some additional information can be construed from the basic input-output table and some studies on the area. From the basic table, which is only an account that registers the value of the direct transactions of each

classified industry, via its purchases from other industries (along the columns) and supplies to other industries (along the rows), we can learn both (i) the import *content* of total intermediaries for each classified industry/sector and (ii) the general *types* of imported intermediates (which would correspond to the industry/sector where they are classified). The former corresponds to the percentage of imports of the column-wise sum of matrix W (which includes domestic and imported intermediaries), and the latter corresponds to the percentage of imports of the row-wise sum of the same matrix W . In addition, we obtain an idea from some studies (with the provisos mentioned above) about the shares of vertical specialization of Chinese exports by industry (i.e. especially processing exports that require some imported input for their production). Notice that this is not equivalent to the matrix obtained via the Leontief inverse, which records the direct and indirect transactions upstream and downstream, derived from the increase of one unit of final demand (upstream or backward) or derived from one unit of value added (downstream or forward), so they don't have to coincide in terms of import penetration-import substitution. Table No.4 shows the initial level of imports in total inputs in 1995, both according to content (MC) and type (MT), as well as their variation in percentage points over the 1995-2010 period.

TABLE No.4: Change in Imported Input Content and Type over 1995-2010.

No	INDUSTRY	MC 1995 (%)	MT1995 (%)	ΔMC (pp)	ΔMT (pp)
1	Agriculture, hunting, forestry and fishing	4.4	6.3	-0.5	2.1
2	Mining and quarrying	11.3	7.3	1.8	19.9
3	Food , beverages and tobacco	3.5	4.1	0.5	-0.6
4	Textiles and textile	17.3	12.2	-8.1	-15.0
5	Leather, leather and footwear	17.6	13.0	-7.9	-12.8
6	Wood and of wood and cork	13.0	11.9	-6.6	-10.6
7	Pulp, paper, paper , printing and publishing	10.9	9.3	-1.4	-6.0
8	Coke, refined petroleum and nuclear fuel	8.0	8)	17.1	1.2
9	Chemicals and chemical	16.9	10.0	0.6	-4.2
10	Rubber and plastics	7.8	11.5	-3.2	-3.0
11	Other non-metallic mineral	0.1	4.8	0.9	1.5
12	Basic metals and fabricated metal	9.3	8.1	2.7	-3.0
13	Machinery, nec	7.4	8.7	0.7	3.4
14	Electrical and optical equipment	32.1	16.8	2.1	-8.9
15	Transport equipment	10.1	8.7	-0.3	-1.8
16	Manufacturing nec; recycling	5.6	10.4	-3.6	22.6
17	Electricity, gas and water supply	0.2	6.1	2.1	0.1
18	Construction	1.5	5.5	-0.5	4.6
19	Wholesale trade and commission trade, ex motor vehicles	0.5	6.2	-0.1	1.9
20	Retail trade, ex motor vehicles; repair of household goods	0.7	6.2	-0.1	0.4
21	Hotels and restaurants	11.8	3.7	-0.2	-8.3
22	Inland transport	1.2	7.5	-2.3	3.3
23	Water transport	3.2	8.5	-2.7	-2.3
24	Air transport	17.4	8.5	-0.3	14.9
25	Other Supporting and auxiliary transport activities; travel agencies	19.9	8.0	-2.2	-18.1
26	Post and telecommunications	4.3	11.4	0.0	1.0
27	Financial intermediation	0.8	6.3	-0.9	-0.1
28	Real estate activities	0.0	3.9	3.9	0.1
29	Renting of m&eq and other business activities	7.0	17.7	-8.7	3.4
30	Public admin and defence; compulsory social security	ncd	7.4	ncd	-27.0
31	Education	0.3	7.8	1.9	3.2
32	Health and social work	13.9	11.6	-2.6	-13.2
33	Other community, social and personal services	7.4	8.3	-0.5	-3.0
I PRIMARY SECTOR (1,2)		6.5	6.5	0.7	10.5
II SECONDARY SECTOR (3-18)		11.0	9.1	1.1	-1.2
	Light Industry (3-7)	11.7	8.8	-3.9	-8.6
	Medium Industry (8-12)	9.0	9.1	2.1	-2.1
	Heavy Industry (13-17)	15.0	11.5	2.3	1.1
	Construction (18)	1.5	5.5	-0.5	4.6
III TERTIARY SECTOR (19-33)		3.3	7.8	-0.6	1.4
	Domestic Trade (19-21)	2.4	5.5	-0.5	0.2
	Transport plus (22-26)	5.5	8.2	8.2	0.0
	Finance plus (27-29)	2.2	10.0	-2.0	2.8
	Social sectors (30-33)	8.9	8.6	-0.7	-0.8
Average/Total		8.6	8.6	0.9	0.9

MC1995: Import content of total inputs 1995 (%)

MT1995: Import Type of total inputs 1995 (%)

ΔMC: Variation of Imported Input Content 1995-2010 (percentage points)

ΔMT: Variation of Imported Input Type 1995-2010 (percentage points)

ncd: no consistent data

From the table we can derive the following observations:

- (i) As of 1995, the sector with the most import content in total intermediate inputs was the secondary sector, especially associated with light and heavy industries. That is, textiles (no.4), leather (no.5) and notably electrical and optical equipment (no.14). There were also some important import content in the tertiary sector, especially associated with social sector industries, like health and social work (no.32). Other industries of the tertiary sector had a high import content, but as they had a small share of output, this does not reflect in its subsectors, e.g. air transport (no.24) and other transport (no.25).

- (ii) For the most part, in percentage, the *type* of imported inputs generally coincide with the industrial/sectoral imported *content*. But there are some notable differences. For example, the import content required by construction (no.18) is 1.5%, but the construction type of imported inputs that is required by the whole economy is 5.5%. Even more notable, financial industries (nos. 27-29) required only 2.2% imported content, but the whole economy required 10% of financial type of imported inputs. Contrariwise, mining and quarrying required 11.3% of imported inputs as content for its production, but the economy required only 7.3% of these type of inputs.
- (iii) Taking into account the significant shift in output shares over 1995-2010 (Table No.1), these two categories of imported input dependency (i.e. content and input type) underwent some important variations over this period. On the whole, there was an increase in import content (and import type, which coincides at this aggregate level) of 0.9pp for the whole economy, but this is not homogeneous across sectors and industries. The primary sector import content grew by less than 1pp, while primary type imported inputs grew by over 10pp, notably for mines and quarrying (no.2). The secondary sector shows an increase in content by just over 1pp, but a decrease in these type of imported inputs for the economy of around the same magnitude. Light industry and construction show falls in imported content, but with a significant increase in the case of fuels (no.8), while medium and heavy industry show some increases, but with falls in key industries like transport and manufacturing. However, electrical and optical equipment (no.14), which had the highest import content in 1995, still shows an increase in

import content of 2.2pp over the period considered, and given that this is also the sector with the highest share in gross output in 2010 (see Table No.1), then this is highly significant in terms of import penetration, as was also indicated after Chart 3 above. As regards import type, the light industry type of imports for the whole economy shows a significant fall (8.6pp), and secondarily the medium industry. Heavy industry and especially construction show increases in their import types for the economy. Finally, the tertiary sector content fell by less than 1pp, especially in finance and general business activities (nos.27 and 29, respectively), but increased in type by over 1pp, except in social sectors, notably in health and social work (no.32).

From a study by Yang et al (2015), we learn that as most imports go to feed production for domestic use, the import content of exports is underestimated by using standard input-output tables, as industries involved in especially processing exports represent a small proportion of total production of around 5%. Although this study uses only two years 2002 and 2007, there appears to be a tendency for processing exports to become more input supplied from domestic sources than foreign ones (i.e. import substitution), while domestic production generally seem to move slightly in the opposite direction (i.e. import penetration). Also another study by Dean et al (2011) shows that most industries associated with processing exports generally correspond to medium and heavy industry (industries 8-17), i.e. including computers, telecom equipment, and the like. As expected this tallies only generally with our Tables No.1 and No.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 (or firm), it represents the actual productive effort to supply both intermediate inputs to other industries (or firms) and goods/services for final demands. So what the input-output model does is to show the total productive effort made, directly and indirectly, by all sectors of the economy.
- (2)
$$\Delta BL = i'[\Delta B^{-1}] = i'[B_1^{-1}B_0^{-1}B_0 - B_0^{-1}B_1^{-1}B_1] = i'[B_0^{-1}(B_0 - B_1)B_1^{-1}]$$

$$= i'B_0^{-1}\{[I - (A^d + A^m)_0] - [I - (A^d + A^m)_1]\}B_1^{-1} = i'[B_0^{-1}\Delta A^d B_1^{-1}] + i'[B_0^{-1}\Delta A^m B_1^{-1}].$$
- (3)
$$\Delta FL = [\Delta B^{*-1}]i = [B_1^{*-1}B_0^{*-1}B_0 - B_0^{*-1}B_1^{*-1}B_1]i = [B_0^{*-1}(B_0^* - B_1^*)B_1^{*-1}]i$$

$$= B_0^{*-1}\{[I - (A^{*d} + A^{*m})_0] - [I - (A^{*d} + A^{*m})_1]\}B_1^{*-1}i$$

$$= [B_0^{*-1}\Delta A^{*d} B_1^{*-1}]i + [B_0^{*-1}\Delta A^{*m} B_1^{*-1}]i$$
- (4) 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.
- (5) It is to be noticed that over this period the growth rate of gross output ($\Delta X/X_{1995}$) was around 385%. For an input-output analysis of structural change in industrial output over this period, see Albala-Bertrand (2016), which is a good complement to this paper.
- (6) Other things being equal, the backward-pull demand contribution (BL) is normally the most important *ex-ante*, as it represents a direct demand stimulus to supplying firms to increase their output to satisfy such a new market demand, while the forward-push supply contribution (FL) represents only an opportunity for purchasing firms to increase their output, as more inputs are now available from their suppliers, but that does not guarantee its market sale. However, *ex post*, FL reflects what actually happened by giving an indication of the importance of the input supply of a particular sector/industry on all sectors/industries of the economy, which is what we do in this paper.
- (7) Other things being equal, if newly available imports are taken up by firms to increase their output (whether for an expected demand or for inventories), this will necessarily increase the demand for domestic and other imported intermediates to satisfy such a new output, so there will be an indirect backward pull effect, which was originated by an imported forward push effect. However, *ex post*, this effect is already counted when measuring backward linkages, which is what we do in this paper.
- (8) A simple visualization would be to imagine that this industry makes the economy to require (directly and indirectly) relatively more imports to satisfy its output, but the increased availability of domestic intermediate supply from this industry to the

rest of the economic sectors seems to require less imported inputs for their own productions.

- (9) Had we kept adding charts, we would see that the pattern for domestic BL and FL for the three main components of the secondary sector is similar to that for the whole (Charts 9 and 10 above), which would confirm the prominence of heavy and medium industry after 2004. But enough of charts, as the point has already been made.
- (10) The standard procedure to calculate FL is based in the matrix A, rather than A*, but this has serious shortcomings (Bulmer-Thomas, 1982). This still has shortcomings, but they are less relevant for our *ex-post* or actual linkage analysis.
- (11) There is here some rather unpersuasive distinction between processing exports and domestic production for some industries, especially associated with multinationals, as the same product is sold home and abroad.

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