Assessing structural change in the Maltese economy via the application of a hypothetical extraction analysis

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Abstract

This paper assesses the extent of change in the production structure of the Maltese Economy on the basis of three symmetric input-output tables, covering the time period from the year 2000 to 2010, via the application of hypothetical extraction analysis. Two methods were applied; the first method allowed for the estimation of the total effects resulting from a sector's hypothetical extraction in terms of the percentage loss in total gross value added, total labour income and total employment. The second hypothetical extraction method was applied to generate backward and forward linkage indicators that were subsequently utilized for the identification of the key sectors. The results obtained indicate that the production structure of the Maltese economy has passed through a number of important structural changes over this period. The manufacturing sector has experienced a decline in its overall relative importance, which is nonetheless still highly significant, whilst a number of service sectors such as the professional, scientific and technical activities and administrative and support service activities sectors as well as the arts, entertainment and recreation activities sector have on the other hand experienced a substantial increase in their overall relative importance. The results generated also illustrate the increased relevance of foreign nationals to the production activities of the Maltese economy. Another key finding of this paper pertains to an increase in the number of sectors which were classified as key sectors, over the specified time period, indicating a higher degree of sectoral interdependence implying greater sectoral diversification.

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1. Introduction

The study aims to assess the extent of change in the production structure of the Maltese economy from the 2000's to date via the application of selected input-output techniques. As discussed in detail within Grech et. al. (2016) over recent decades the Maltese economy has passed through a number of significant structural changes such as the shift from manufacturing to service oriented activities leading to greater diversification, as well as to very rapid changes in the labour market. The application of methods which have their foundation in input-output analysis will enable the assessment of the structural change in the Maltese economy making it possible to obtain a deeper understanding of the importance of each sector, in terms of its inter-linkages with the rest of the economy and how this has changed over time. The study shall make use of two hypothetical extraction methods namely, the hypothetical extraction method originally developed by Strassert (1968) and later developed further in Dietzenbacher and Lahr (2013) and the non-complete hypothetical extraction method proposed by Dietzenbacher and van der Linden (1997).

This study applies the two hypothetical extraction methods to three symmetric input-output tables (SIOTs) for the Maltese economy, the SIOTs for the reference years of 2000, 2008 and 2010, in order to undertake a comparative analysis of how the production structure of the Maltese economy has changed over this time period. Between 2000 and 2008 the Maltese economy passed through a number of significant institutional changes, chief amongst which, becoming a member of the European Union on 1st May 2004 and later joining the Euro zone on the 1st January 2008. Furthermore, between 2008 and 2010, the Maltese economy had to whether the global financial crises, which was to a high degree responsible for the economic recession experienced by the Maltese economy during 2009 and by the Euro Area as whole. Although in 2010 the Maltese economy managed to recover from the recession, this shock together with a more sluggish European and global economic outlook may have also impacted the production structure of the Maltese economy.

The basic premise behind hypothetical extraction methodology is to hypothetically extract a sector from an economic system and to subsequently examine the effect on the other sectors of the economy caused by this hypothetical extraction. The Strassert (1968) hypothetical extraction method, extended in Dietzenbacher and Lahr (2013), shall be utilized in this context to specifically assess the overall effects on total gross value added, total labour income and total employment (which has been disaggregated in terms of loss in employment of Maltese

nationals and loss in employment of foreign nationals), which are caused by the hypothetical extraction of an industry. The magnitude of the resulting extraction effects will therefore depend on both the underlying inter-industry relations but crucially also on the size of the industry itself.

The Dietzenbacher and van der Linden (1997) non-complete hypothetical extraction method is an input-output technique generally utilized within the context of linkages analysis and the identification of key sectors. Contrary to the Strassert (1968) hypothetical extraction method, the Dietzenbacher and van der Linden (1997) non-complete hypothetical extraction method allows for a sectoral linkages analysis which generates separate backward and forward linkage indicators. Sectoral linkages, which denote the interrelations between production sectors, have been defined as in backwards and forwards in the direction of an input output table reflecting the notion that a sector simultaneously purchases inputs from other industries for its production process (the sector's backward linkage) and that the same sector also supplies inputs to other industries thus indicating the forward linkage of the sector with other industries to which it supplies inputs. The analysis of these backward and forward linkages enables researchers to identify the industries that are regarded as key to the economic development strategy of a country (Hirchman, 1958). Hoen (2002) also notes that linkages play a decisive role for the possibility of gaining competitive advantages.

Following a description of the data employed for this study, section 3 presents the methodological framework in which a detailed description of the Strassert (1968) hypothetical extraction method and the Dietzenbacher and van der Linden (1997) non-complete hypothetical extraction methods may be found. Subsequently, section 4 presents the results obtained from the application of the two hypothetical extraction methods and provides a description of the main findings identified from each method. The paper thereafter concludes by discussing the key changes which have occurred in the production structure of the Maltese economy over the period of 2000 to 2010 which were identified from a simultaneous assessment of results obtained from the application of the two hypothetical extraction methods.

2. Description of data

The hypothetical extraction method applied for the analysis of the change in the production structure of the Maltese economy is based on three input output tables for the reference years 2000, 2008 and 2010[2]. The Input-output tables constructed for the Maltese economy prior to the year 2000 do not conform to the European system of accounts guidelines published in 1995.

The 2000 and 2010 tables were highly disaggregated (with 54 and 59 sectors respectively) compared to the 2010 table which was only published by the NSO with a 17-sector disaggregation level. However, the compilation procedure for all three SIOTs is based on the fixed product sales structure assumption which follows Eurostat (2008) methodology. Therefore, for the purposes of this study, the earlier tables were aggregated into a 17 industry-by-industry SIOTs which follow the industry classification of 2010 SIOT as published by the NSO (2016). Furthermore, the industry classification in the 2000 SIOT was brought in line with the European Statistical Classification of Economic Activities (NACE) Rev 2 which superseded the NACE Rev.1.1 classification applicable at the time when the 2000 SIOT was published. Given the underlying limitations of the aggregation exercise, it should be noted for comparative purposes, that in contrast to the SIOTs of 2008 and 2010, within the aggregated 17 industry-by-industry SIOT for 2000, the activities of Postal services were not aggregated with the Transport and Storage activities sector, as indicated in NACE Rev.2, but with the Information and Communication sector. The 59 industry-by-industry SIOT for 2008, which already followed NACE Rev.2, was also aggregated into a 17 sector SIOT for 2008 in line with the NSO (2016) SIOT for 2010. The sectoral aggregation for all three SIOTs follows the specification listed in Table 1 overleaf.

[2] The SIOT for the reference year of 2000, which follows ESA95, was obtained from Cassar (2013) and is a 54 industry-by-industry SIOT. Similarly, the SIOT for the reference year of 2008 was obtained from Cassar (2015), which also follows ESA95, and has a high level of sectoral disaggregation equal to 59 sectors. The SIOT for the year 2010, published by the National Statistics Office of Malta (NSO) conforms to the European system of accounts guidelines published in 2010 (ESA 2010) and was obtained from NSO (2016). It should be noted that in contrast to the SIOTs for 2000 and 2008 the level of sectoral disaggregation of this published SIOT is equal to 17 sectors.

Table 1: Classification of industries utilized for the sectoral aggregation

Sector No	NACE Rev. 2 Code	Sector
1	A	Agriculture, Forestry and Fishing
2	C	Manufacturing
3	D, E	Electricity, Gas, Water supply and Waste Management
4	F, B	Mining, Quarrying and Construction
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles
6	H	Transportation and Storage
7	I	Accommodation and Food service activities
8	J	Information and Communication
9	K	Financial and Insurance Activities
10	L	Real estate activities
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities
12	O	Public Administration and Defence
13	P	Education
14	Q	Human health and Social work activities
15	R	Arts, Entertainment and Recreation
16	S	Other Service activities
17	T,U	Households as employers and activities of extraterritorial organisations

Source: NSO (2016)

Further to the above, the 2010 SIOT follows the national accounting methodology specified in ESA2010, whilst the 2000 and 2008 SIOTs are based on ESA95. As discussed in Sixta et. al. (2014) and Van den Cruyce, B. (2014), this methodological change may impact both the overall supply and use system as well as overall volume of exports and imports, which implies that this change may impact significantly both the backward and forward inter-industry linkages. As noted by NSO (2014), a specific methodological change brought about by the change to ESA2010 is the inclusion of Special Purpose Entities[3] (SPEs) which have been

[3] A special purpose entity may be defined as a limited company or a limited partnership, created to fulfil narrow, specific or temporary objectives and to isolate a financial risk, a specific taxation or a regulatory risk.

classified as activities pertaining to the financial sector and which has resulted in a level increase in output, exports and imports. As shown in Appendix B, this change[4] has significantly impacted the underlying level of output of the Financial and Insurance service sector which rose from a share of total output amounting to the 2.43% in 2008 to an exceptional 31.86% in 2010. The corresponding required adjustment to exports and imports has led to a similar exceptional increase in the sector's respective final demand and primary input use. This methodological change has thus resulted in a significant expansion of the output generated by this sector, without a proportionate increase in use of domestic intermediary inputs. Given the methodology applied in this paper, this would result in an overall dampening of the strength of the derived linkages for this sector. Due to the significant effects that the change from ESA95 to ESA2010 can have on a sector's interindustry linkages, caution must be exercised when evaluating the relative strength of the derived linkage indicators between the SIOTs for 2000 and 2008, and those derived from the SIOT for 2010.

The data required to generate linkages indictors in terms of labour income and gross value added were obtained directly from the three SIOTs employed in the analysis. Within the context of this study, labour income shall follow the national accounting definition of compensation of employees. The data for total employment by sector where provided by the NSO and follow the full-time equivalent (FTE) employment definition. The data pertaining to the employment[5] at the sectoral level of only foreign workers was provided by the central bank of Malta. Appendix A and Appendix B, as well as the four Figures presented in Appendix C describe the relative share of sector output, value added, labour income and employment as a percentage of the total, for each sector, for each of the three 17 industry-by-industry SIOTs. Whilst these estimates provide an assessment of how the relative importance of each sector has changed over the specified time period, these relative sectoral shares only include the sectors' direct effects. Thus, they do not include the impacts relating to the indirect effects on production and do not provide information pertaining to the relative strength of each sectors' inter-industry linkages and on how these linkages have changed over time.

[4] It should be noted that as part of the ESA methodological update the NSO also undertook a benchmark revision in the activities of Insurance service activities (NSO,2014) resulting in overall reduction in intermediate consumption and respective rise in gross value added for the activities of solely the insurance sub-sector. It should however be noted that level terms the impact of this benchmark revision was minor compared the inclusion of SPEs.

[5] The data relating to the employment, at a sectoral level of only foreigner workers had to be converted from full-time and part-time employment into the FTE definition of employment.

To overcome these limitations the analysis of the change in the production structure of the Maltese economy over the time spanning the three SIOTs was undertaken on the basis of the hypothetical extraction method specifications described in section 3.

3. Methodological framework

In order to assess the change in the production structure of the Maltese economy this study employs two alternative hypothetical extraction method specifications. The first specification to be applied is the method developed by Strassert (1968), which Groenewold, Hagger, and Madden (1993) refer to as a scenario of complete shut-down of the industry. This method assesses the relative importance of the sector taking into account both its linkages with the rest of the economy as well as its relative size. Furthermore, following Dietzenbacher and Lahr (2013), this linkage measure, which reflects the output loss resulting from the total extraction of a sector, shall be converted into loss in terms of labour income, employment and gross value added.

The second hypothetical extraction method specification is the Dietzenbacher and van der Linden (1997) non-complete hypothetical extraction method which has been used in numerous studies such as Andreosso-O'Callaghan and Guoqiang (2004), Pfajfar and Dolinar (2000) and Temurshoev (2004) to undertake linkages analysis primarily within the context of the identification of key sectors. The motive for application of this method stems from the observation that there are two significant limitations in the original extraction method put forward by Strassert (1968). The first limitation is that it is not possible to distinguish the derived total linkages into backward and forward linkages (Cella, 1984). The second limitation relates to the hypothesis brought forward by the original complete extraction method; Dietzenbacher and van der Linden (1997, p.236) assert that “the hypothesis of simply scrapping an entire sector from the economy seems to be rather excessive”.

Both hypothetical extraction method specifications utilize as a methodological foundation the Leontief demand driven model and the Ghoshian supply driven model (or the Ghoshian allocation system), an overview of which is provided in Appendix D and Appendix E respectively.

3.1 The hypothetical extraction method put forward by Strassert (1968)

The original hypothetical extraction method was initially developed by Strassert (1968). The basic premise behind this method is to hypothetically extract a sector from an economic system and to subsequently examine the effect on the other sectors of the economy caused by this hypothetical extraction. Following Andreosso-O'Callaghan and Guoqiang (2004), the starting point is the basic balance equation of the Leontief demand driven model[6], ***x = Ax + f*** , where *A* is an (n x n) dimension matrix, *x* and *f* are (n) dimension vectors, such that the solution to the Leontief balance equation yields, in matrix algebra notation, ***x = (I-A)$^{-1}$ f*** . The next step is to assume that the k^{th} sector is extracted by deleting the k^{th} row and k^{th} column of *A* such that a new input coefficient matrix $\tilde{A}$ is formed. Hence the solution to the Leontief basic balance equation can now be re-written as:

$$\tilde{x}\ (k) = (I - \tilde{A}\ (k))^{-1} \tilde{f} \qquad (1)$$

Where $\tilde{A}$ (k) is an (n-1) x (n-1) matrix of technical coefficients, in which the k^{th} sector has been deleted from *A*; $\tilde{x}$(k) and $\tilde{f}$ (k) are (n-1) dimension vectors derived by deleting the k^{th} row corresponding to output vector *x* and final demand vector *f*, respectively. Given the vectors of final demand, *f* and $\tilde{f}$ (k), it follows that the results of $\tilde{x}$(k) from the Leontief Demand Model with the extracted sector are less than the results of x_i , obtained from the Leontief balance equation without the extraction, such that:

$$\tilde{x}_i\ (k) < x_i \quad \text{for i = 1,2, …, k-1, k+1, … n.} \qquad (2)$$

The linkage measure can then be found as the sum of the difference between the output vector *x* excluding the k^{th} element and $\tilde{x}$(k).

$$L\ (k) = \sum_{i=1, j \neq k}^{n} [x_i - \tilde{x}_i\ (k)] \qquad (3)$$

[6] The full derivation of the Leontief demand driven model is provided in Appendix D.

The measure of the linkage effect of the extracted sector k on total output is derived from equation 3, where L(k) denotes the linkage indicator of sector k. In matrix algebra notation this equation may be expressed by equation 4 below:

$$X_k = (\tilde{L}\tilde{f} - Lf) \qquad (4)$$

Where $\tilde{L}$ is an (n-1) x (n-1) Leontief inverse matrix generated after the extraction of the kth sector and $\tilde{f}$ is an (n-1) dimension vector derived by deleting the k^{th} row of final demand vector *f*. It follows that X_k denotes the resulting difference between the total output generated in the economy after the extraction of the sector and the total output generated in the economy prior to the extraction,

Following Dietzenbacher and Lahr (2013) the linkage measure in terms of output loss will be converted to a measure of the impact of hypothetical extraction in terms of value added loss. Let u' denote a row vector of value added multipliers which measure the value added generated by every additional euro increase in final demand for each sector in the economy. As explained in Miller and Blair (2009) value added multipliers are derived via the multiplication of a row vector of value added coefficients[7] denoted by *v'* and the Leontief inverse matrix denoted by *L*.

$$u' = v'L \qquad (5)$$

It follows that the total value added generated in the economy, denoted by *VA*, can be estimated as the multiplication of the row vector of value-added multipliers and the column vector of final demand.

$$VA = u'f \qquad (6)$$

Similarly, the total amount of value added generated in the economy can be estimated following hypothetical extraction of a sector via equation 7.

[7] Value added coefficients are defined as the value added generated in an industry per unit of its gross output.

$$\widetilde{VA} = \tilde{u}'\tilde{f} \qquad (7)$$

Where $\widetilde{VA}$ is the sum of value added in the economy following the hypothetical extraction, $\tilde{u}$ is an (n-1) dimension row vector of value added multipliers following the extraction of the k[th] sector and $\tilde{f}$ is an (n-1) dimension vector derived by deleting the *k*[th] row corresponding of the final demand vector *f*. The linkage indicator in terms of value added is derived as the difference between the total value added generated in the economy after the extraction of the sector and the total value added generated in the economy prior to the extraction.

$$VA_k = (\tilde{u}'\tilde{f} - u'f) \qquad (8)$$

Similarly, a linkage indicator in terms of labour income and physical employment can be derived as the difference between the total labour income/employment generated in the economy after the extraction of the sector and the total labour income/employment generated in the economy prior to the extraction. Let h' denote a row vector of labour income multipliers[8] which measure the labour income (compensation of employees) generated by every additional euro increase in final demand for each sector in the economy and m' denote a row vector of physical employment multipliers[9] which measure the physical employment generated throughout the economy as a result of a marginal increase in final demand for each sector. These two linkage indicators are derived following equations 9 and 10.

$$I_k = (\tilde{h}'\tilde{f} - h'f) \qquad (9)$$

$$E_k = (\tilde{m}'\tilde{f} - m'f) \qquad (10)$$

As stated in the introduction, a goal of this study is to analyse the change in the production structure of the Maltese economy also in the context of the employment of foreign nationals. In order to assess the impact of a sectoral hypothetical extraction in terms of its effect on the employment of solely foreign nationals it was necessary to derive physical employment

[8] Refer to Miller and Blair (2009) for an explanation of how labour income multipliers are derived.

[9] Refer to Miller and Blair (2009) for an explanation of how physical employment multipliers are derived.

multipliers of solely foreign nationals. These multipliers measure the employment of solely foreign nationals generated as a result of a marginal increase in final demand for each sector in the economy. The foreign national physical employment multipliers are derived via the multiplication of a row vector of foreign national physical employment-output ratios denoted by r*'* and the Leontief inverse matrix denoted by *L* and are derived following equation 11.

$$n' = r'L \qquad (11)$$

The derivation of such multipliers therefore assumes that the employment of foreign nationals within an industry is closely linked to the amount of output generated in monetary terms and that the sectoral foreign nationals' employment output ratios are assumed constant irrespective of the level of production undertaken by each sector. The estimated loss in terms of employment of solely foreign nationals due to the hypothetical extraction of a sector, which takes account of both the direct and indirect effects on production, is derived as the difference between the total employment of foreign nationals generated in the economy before and after the extraction of the sector.

$$F_k = (\tilde{n}'\tilde{f} - n'f) \qquad (12)$$

Given that this analysis is also aimed at assessing the change in the relative importance of each sector over time, in order to increase consistency and allow for a greater comparability between the resulting estimates, the result obtained from equations 8, 9 ,10 and 12 shall be expressed in terms of percentage loss of value added/income/employment as a proportion of the total for the given reference year of the SIOT on which they are based.

$$VA = -100 \times \frac{VA_k}{VA} \qquad (13)$$

$$I = -100 \times \frac{I_k}{I} \qquad (14)$$

$$E = -100 \times \frac{E_k}{E} \qquad (15)$$

$$F = -100 \times \frac{F_k}{E} \qquad (16)$$

It should be noted that that the loss in employment of foreign nationals is expressed as a percentage of total employment, such that the loss in employment, due to the hypothetical extraction of a specific sector, of only Maltese nationals can be obtained from the difference between equation 15 and equation 16.

3.2 The non-complete hypothetical extraction method

The Dietzenbacher and van der Linden non-complete hypothetical extraction method (1997) is used to undertake an analysis of both backward and forward linkages and to identify the industries that may be regarded as key to the economic development strategy of a country. Dietzenbacher and van der Linden (1997) suggest that since backward linkages should only reflect a sector's dependence on the inputs produced within the production system, it should then follow that only these inputs should be hypothetically eliminated in order to effectively measure the backward linkages. The method assumes that a sector's input requirements are now delivered from outside the system, e.g. imported, in such a way that the overall technical production process remains unaltered. Therefore, in contrast to the hypothetical extraction method put forward by Strassert (1968), rather than being completely eliminated, a sector is assumed to import all its input requirements and continues to produce output which it subsequently supplies to the other sectors within the system. The backward linkages would then be reflected in the resulting discrepancy obtained by comparing actual total output with the total output generated in the hypothetical situation.

Similarly, since forward linkages should reflect how dependant the sectors within the system are on the output produced by the one sector in consideration, the Dietzenbacher and van der Linden (1997) method assumes a hypothetical situation in which the sector provides no intermediate deliveries within the system. Therefore, rather than being completely eliminated, we assume that the sector in consideration delivers all of its output outside the system, e.g. exports and that the sector still continues to receive its input requirements from the other sectors within the system. The forward linkage would then be obtained as the discrepancy between actual total output and the total output generated in the hypothetical situation. In order to apply the methodology put forward by Dietzenbacher and van der Linden (1997), a framework first introduced in the context of inter-industry linkage measurement by Cella (1984) and later expanded in Miller and Lahr (2001) will be utilised. Let us start by considering the standard representation of an n-sector basic balance equation of Leontief's demand model in matrix representation $\boldsymbol{x = Ax + f.}$

Re-writing the balance equation in a partitioned structure yields:

$$\begin{bmatrix} x_j \\ x_r \end{bmatrix} = \begin{bmatrix} A_{jj} & A_{Jr} \\ A_{rj} & A_{rr} \end{bmatrix} \begin{bmatrix} x_j \\ x_r \end{bmatrix} + \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (17)$$

Such that all the sectors in the economy can be divided into two distinct groups, group j and group r which sell and buy intermediate products to and from each other and also between the individual groups. These two groups also produce their own output as represented by the output vectors x_j and x_r, and have their own final demand shown by vectors f_j , f_r. Where the technical coefficients of matrix A have been partitioned so that k sectors (k < n) are shown in the upper left square sub-matrix identified as A_{jj}. The Leontief inverse of the above partitioned matrix A can be expressed as:

$$L = (I - A)^{-1} = \begin{bmatrix} H & H\,A_{jr}\,G_{rr} \\ G_{rr}A_{rj}H & G_{rr}\,(I + A_{rj}H\,A_{jr}G_{rr}) \end{bmatrix} \qquad (18)$$

Where $H = (I - A_{jj} - A_{jr}G_{rr}A_{rj})$ and $G_{rr} = (I - A_{rr})^{-1}$. Hence the solution to the basic balance equation of Leontief's model ***x = (I-A)$^{-1}$ f*** may thus be written as

$$x = \begin{bmatrix} x_j \\ x_r \end{bmatrix} = \begin{bmatrix} H & H\,A_{jr}\,G_{rr} \\ G_{rr}A_{rj}H & G_{rr}\,(I + A_{rj}H\,A_{jr}G_{rr}) \end{bmatrix} \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (19)$$

The Dietzenbacher and van der Linden non-complete hypothetical extraction method (1997) for calculating backward linkages assumes that a sector's input requirements are now delivered from outside the production system. This implies the assumption that group j will consist of the one sector for which the backward linkages will be calculated whilst group r will consist of (n-1) sectors. From equation 17 illustrating the partitioned matrix of technical coefficients, it then follows that if sector j purchases no inputs from neither of the production sectors including itself, the extracted Leontief basic balance equation can therefore be expressed as:

$$\hat{X}\,(j) = \begin{bmatrix} \hat{x}_j \\ \hat{x}_r \end{bmatrix} = \begin{bmatrix} 0 & A_{Jr} \\ 0 & A_{rr} \end{bmatrix} \begin{bmatrix} \hat{x}_j \\ \hat{x}_r \end{bmatrix} + \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (20)$$

Where $\hat{x}_j$, $\hat{x}_r$ represent sector j's output and the output vector r of the remaining sectors respectively; f_j , f_r represent the final demand of sector j and the final demand vector of the remaining sectors and where $\hat{x}$ (j) denotes the total output vector generated after extracting sector j. The Leontief Inverse with the corresponding extraction conditions $\widehat{L}$, is then given by

$$\hat{L} = (I-\hat{A})^{-1} = \begin{bmatrix} H & H\,A_{jr}\,G_{rr} \\ 0 & G_{rr} \end{bmatrix} \qquad (21)$$

Where H = I and $G_{rr} = (I - A_{rr})^{-1}$. The solution for the extracted output can be obtained directly by solving the Leontief demand driven model for the total output vector $\hat{x}$ (j):

$$\hat{x}\ (j) = \begin{bmatrix} \hat{x}_j \\ \hat{x}_r \end{bmatrix} = \begin{bmatrix} I & A_{jr}\,(I - A_{rr})^{-1} \\ 0 & (I - A_{rr})^{-1} \end{bmatrix} \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (22)$$

Defining the total absolute backward linkage for a sector j (denoted by ABL_j^{DL}) as the sum of output reductions in all sectors due to the extraction of sector j:

$$ABL_j^{DL} = e\,` [x - \hat{x}(j)] \qquad (23)$$

Where e is a column summation vector (that is e_r = 1 for all r). Hence substituting *x* with equation 19 and $\hat{x}$ (j) with equation 22 and solving yields:

$$ABL_j^{DL} = e\,` \begin{bmatrix} x_j - \hat{x}_j \\ x_r - \hat{x}_r \end{bmatrix} = e\,` \begin{bmatrix} H - I & H\,A_{jr}\,G_{rr} - A_{jr}\,G_{rr} \\ G_{rr}A_{rj}H & G_{rr}\left(I + A_{rj}H\,A_{jr}G_{rr}\right) - G_{rr} \end{bmatrix} . \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (24)$$

$$ABL_j^{DL} = e\,` \begin{bmatrix} H - I & (H - I)\,A_{jr}\,G_{rr} \\ G_{rr}A_{rj}H & G_{rr}\,A_{rj}HA_{jr}G_{rr} \end{bmatrix} . \begin{bmatrix} f_j \\ f_r \end{bmatrix} \qquad (25)$$

$$ABL_j^{DL} = [(H\text{-}I) + e_r`\ G_{rr}A_{rj}\ H\ ]\ f_j +$$

$$[\ (H\text{-}I)A_{jr}G_{rr} + e_r`G_{rr}\ A_{rj}\ HA_{jr}G_{rr}\ ]\ f_r \qquad (26)$$

Where $H = (I - A_{jj} - A_{jr}G_{rr}A_{rj})^{-1}$ and $G_{rr} = (I - A_{rr})^{-1}$

Dietzenbacher and van der Linden (1997) note that the magnitude of the resulting absolute backward linkage (ABL_j^{DL}) expressed by equation 26 is determined by the combination of two factors. The first being the size of sector j and the second being its dependence per unit of output (or output multipliers). They note that since the primary concern of linkage analysis is the structure of production, the size effect of sectors should therefore be removed from the absolute linkages measurements. To this end, they suggest to normalize the resulting absolute backward linkage by diving the absolute figures by the value of sector j's output. This results in the backward linkage indicator BL_j^{DL} which reflects the dependence of sector j on all other r sectors.

$$BL_j^{DL} = \frac{(ABL_j^{DL})}{x_j} \quad \mathrm{X} \quad 100 \qquad (27)$$

In the similar manner in which the backward linkage indicators were obtained from the Leontief demand driven system it is possible to derive forward linkage indicators utilizing the Ghoshian supply driven model[10]. The balance equation of the Ghoshian allocation system defined as ***x`* = *x* `*B* + *v`***, can be expressed in partitioned matrix structure as follows:

$$\mathrm{x}\,` = [x_i` \quad x_r`] = [x_i` \quad x_r`] \begin{bmatrix} B_{ii} & B_{ir} \\ B_{ri} & B_{rr} \end{bmatrix} + [v_i` \quad v_r`] \qquad (28)$$

Where *x`*, actual total output, may be obtained by solving the Ghoshian supply driven model for output which is derived following ***x' = v' (I-B)*$^{-1}$,** which in portioned form yields:

$$\mathrm{x'} = [x_i` \quad x_r`] = [v_i` \quad v_r`] \begin{bmatrix} \mathrm{K} & \mathrm{K\,B_{ir}\,Z_{rr}} \\ \mathrm{Z_{rr}B_{ri}K} & \mathrm{Z_{rr}\,(I + B_{ri}K\,B_{ir}Z_{rr})} \end{bmatrix} \quad (29)$$

Where: $\mathrm{K} = (\mathrm{I} - \mathrm{B_{ii}} - \mathrm{B_{ir}Z_{rr}B_{ri}})^{-1}$, $\mathrm{Z_{rr}} = (\mathrm{I} - \mathrm{B_{rr}})^{-1}$

This hypothetical extraction method assumes that sector i delivers all of its output outside the system (exported) rather than being completely eliminated. Therefore, the row i in the output

[10] The full derivation of the Ghoshian supply driven model is provided in Appendix E.

coefficient matrix *B* is set to zero (i.e. sub-matrices B_{ii} and B_{ir} are now set to zero). Hence applying this hypothetical extraction to the output coefficient matrix $\hat{B}$ the following Ghohsian inverse matrix is obtained:

$$\hat{g} = (I-\hat{B})^{-1} = \begin{bmatrix} I & 0 \\ Z_{rr}B_{ri} & Z_{rr} \end{bmatrix} \quad (30)$$

The solution for the extracted output x'(i) may therefore be expressed as:

$$\hat{x}' (i) = [x_i` \quad x_r`] = [v_i` \quad v_r `] \begin{bmatrix} I & 0 \\ Z_{rr}B_{ri} & Z_{rr} \end{bmatrix} \quad (31)$$

The absolute forward linkage for a sector i (denoted by AFL_i^{DL}) are defined in this model as the sum of output reductions in all sectors due to the extraction of sector i:

$$AFL_i^{DL} = [x` - \hat{x}`(i)]\, e \quad (32)$$

Substituting x` with equation 29 and $\hat{x}`$ (i) with equation 31 and solving yields:

$$AFL_i^{DL} = [v_i` \quad v_r `] \begin{bmatrix} K-I & K\,B_{ir}\,Z_{rr} \\ Z_{rr}B_{ri}(K-I) & Z_{rr}\,B_{ri}K\,B_{ir}Z_{rr} \end{bmatrix} e \quad (33)$$

$$AFL_i^{DL} = v_i `[\,(K\text{-}I) + K\,B_{ir}\,Z_{rr}e_r\,] +$$

$$v_r`[\,Z_{rr}B_{ri}(K-I) + Z_{rr}\,B_{ri}K\,B_{ir}Z_{rr}\,]e_r \quad (34)$$

Where $K = (I - B_{ii} - B_{ir}Z_{rr}B_{ri})$, $Z_{rr} = (I - B_{rr})$, $v_i`$ is the total primary inputs of the extracted sector i , $v_r`$ is vector of total primary inputs of the other sectors r. As in the case of the backward linkages indicator the Dietzenbacher and van der Linden (1997) method suggests to normalize the resulting absolute Forward linkage result (AFL_i^{DL}) by diving the absolute figures by the value of sector i's output to remove size effects.

$$FL_i^{DL} = \frac{AFL_i^{DL}}{x_i} \quad X \quad 100 \quad (35)$$

In order to make the backward and forward linkage indicators derived from the non–complete hypothetical extraction method easier to read in terms of their application for the identification and analysis of key sectors both linkage indicators shall be normalized with an average of 1 as follows:

$$BL_{N,j}^{DL} = \frac{\frac{1}{n}.BL_j^{DL}}{\frac{1}{n^2}.\sum_{j=1}^{n} BL_j^{DL}} \quad ; \quad j = 1,\ldots,n \quad (36)$$

$$FL_{N,i}^{DL} = \frac{\frac{1}{n}.FL_i^{DL}}{\frac{1}{n^2}.\sum_{i=1}^{n} FL_i^{DL}} \quad ; \quad i = 1,\ldots,n \quad (37)$$

Where the normalized backward linkage indicator is for sector j and normalized forward linkage indicator for each sector i are derived following, respectively, equations 36 and 37.

4. Results and discussion

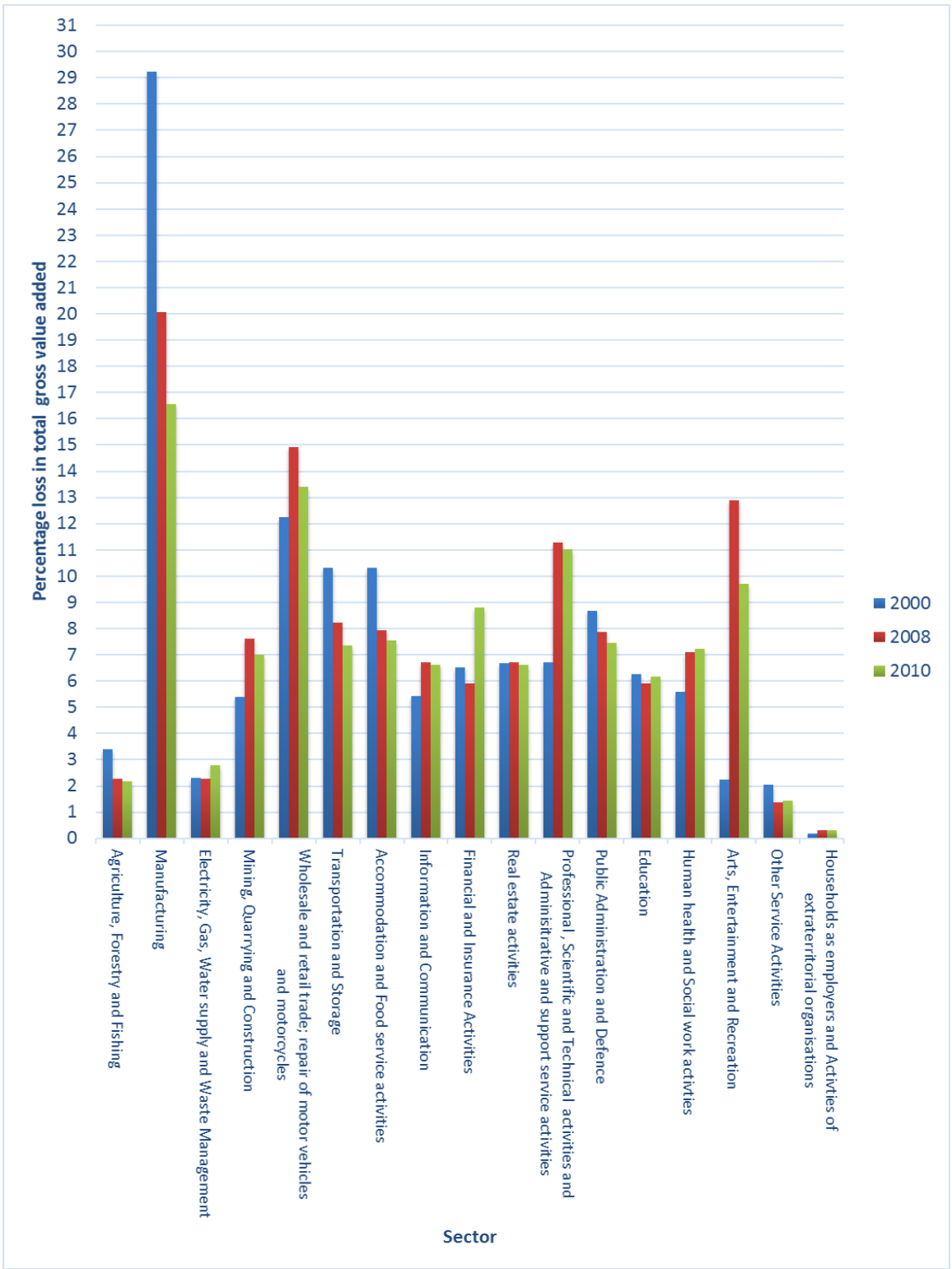
This section presents the results obtained from the application of the two hypothetical extraction methods described in section 3 to the SIOTs for 2000, 2008 and 2010, which were aggregated to a 17 sectoral level of disaggregation, so as to enable a comparative assessment of the relative change in the production structure of the Maltese economy across the specified time period. This section shall first present the results obtained from the Strassert (1968) hypothetical extraction method, which was extended, following Dietzenbacher and Lahr (2013) to also account for the effect of the hypothetical sectoral extraction in terms of the loss in gross value added, labour income and employment. As described in section 3.1 the extraction effects in terms of percentage loss in total employment across all three SIOTs shall furthermore be disaggregated by employee nationality, which in the context of this study is categorized either as a Maltese national or foreign national. The second part of this section presents the results obtained from the non-complete hypothetical extraction method by Dietzenbacher and van der Linden (1997), showing the relative strength of both the backward and forward linkages of each sector in the economy, for each of the three SIOTs. In order to adequately analyze the results obtained from the non-complete hypothetical extraction method it was decided to follow Temurshoev (2004) and assume that according to the magnitude of the various linkage indicators it is possible to classify all the industries (sectors) in the economy as forming part of four distinct categories. If both the normalized values for the backward and forward linkages are greater than 1 the industry will be classified as a key sector

(K). However, if only the normalized backward linkage indicator is greater than 1, then the sector can be classified as strong backward linkages sector (B). Similarly, if only the normalized forward linkage indicator is greater than 1, then the sector can be classified as a strong forward linkages sector (F). If on the other hand neither of the normalized backward and forward linkage indicators are greater than 1, the sector will be classified as having weak linkages (L). Depending on the results obtained every sector will be assigned either a letter K, B, F or L which denote key sector, strong backward linkage, strong forward linkage, and weak linkage categories, respectively.

4.1 Results obtained from the Strassert (1968) hypothetical extraction method

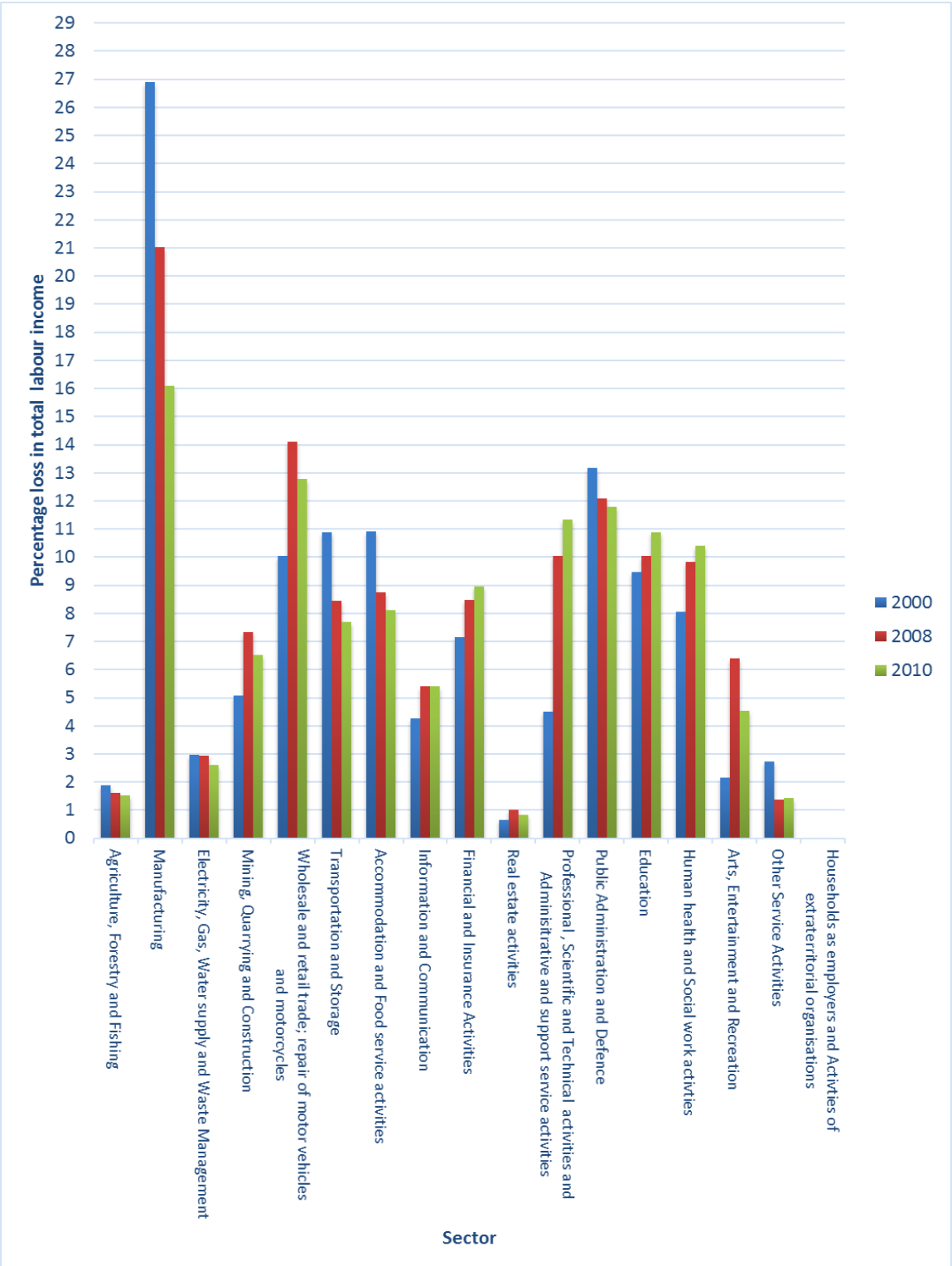
The linkage indicators based on the Strassert (1968) hypothetical extraction method specification were generated in terms of the loss, expressed in percentage, of, total gross value added, total labor income and total employment, disaggregated by Maltese nationals and foreign nationals, resulting from the hypothetical extraction of a sector for each of the three SIOTs. These estimates where derived by applying respectively equations 13, 14, 15, 16 and 17. It should be noted that the factors underpinning the magnitude of the percentage loss of value added, labour income and employment resulting from the hypothetical extraction are the size of sector, its inter-industry dependency as well as the size of the value-added/labour income/employment ratios for the sector and its supplying industries. Furthermore, in contrast to the descriptive statistics presented in Appendix C these extraction effects represent the loss in total gross value added, total labour income and total employment which will implicitly be greater than just the loss associated with the sector's own direct effects. This is because the resulting estimates obtained from this hypothetical extraction method also include the loss in gross value added, labour income and employment which result from loss in economic activity associated with the indirect effects, in terms of both indirect intermediate purchases and sales, of the extracted sector. The results obtained from the Strassert (1968) hypothetical extraction method in terms of percentage loss in total value added, total labour income and total employment are presented respectively in Figure 1, Figure 2 and Figure 3. The full set of results including the relative rankings for each sector, across all three SIOTs are respectively presented in Appendix F, Appendix G and Appendix H.

Figure 1: The percentage loss in total gross value added resulting from the hypothetical extraction of each sector.



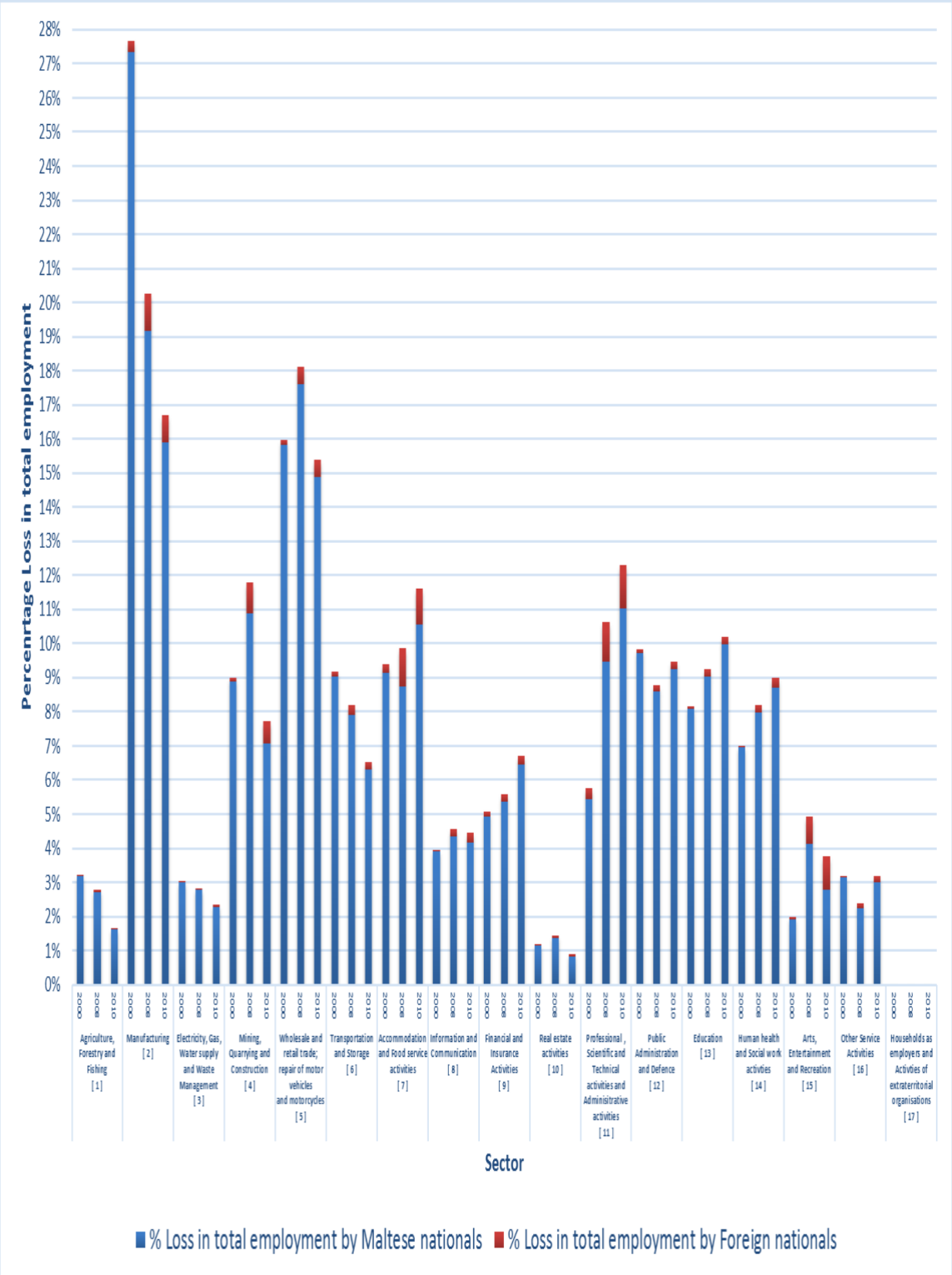
Source: Author's Calculations

Figure 2: The percentage loss in total labour income resulting from the hypothetical extraction of each sector.



Source: Author's Calculations

Figure 3: The percentage loss in total employment resulting from the hypothetical extraction of each sector.



Source: Author's Calculations

From Figure 1, which illustrates the percentage loss in total gross value added as a result of the hypothetical extraction of a sector across each of the three SIOTs, it is possible to observe a number of important changes to the overall structure of the Maltese economy which have occurred over the specified time. The [2] Manufacturing sector is the sector which consistently generates the largest percentage of loss of gross value added over the entire time period. Its relative impact in terms of loss of gross value added has however decreased from a loss of 29.2% in total gross value added in 2000, to 20.0% in 2008 and to 16.6% based on the 2010 SIOT. From Figure 2 and Figure 3 it may be observed that the impact of the hypothetical extraction of the [2] Manufacturing sector in terms of both the percentage loss in total labour income and the percentage loss in total employment is still the largest extraction effect exhibited across all sectors, but these have declined from approximately 27% in 2000 to 16% in 2010. Although the [2] Manufacturing sector is the sector with the largest extraction effect across the specified time period its significance to the overall production structure of the Maltese economy has declined over the decades as a result of the increased diversification which has occurred within the production structure of the Maltese economy over the same period. The [5] Wholesale and retail trade; repair of motor vehicles and motorcycles sector is also another sector which has been consistently ranked amongst the highest in terms of all three extractions across all three SIOTs and should also be viewed as a very important component of the production structure of the Maltese economy.

Two sectors which have seen a considerable increase in their overall extraction effects in terms of the loss of gross value added, labour income and employment are the [15] Arts, Entertainment and Recreation activities sector and the [11] Professional, Scientific and Technical activities and Administrative and support service activities[11]. As illustrated from Figure 1 the [15] Arts, Entertainment and Recreation activities sector has seen the largest increase in its overall extraction effects in terms of the percentage loss in gross value added. Indeed from an extraction effect of approximately 2.3% in 2000 this has risen to 9.7% in 2010. This sector, as may be observed from Figure 2 and Figure 3, has also experienced an increase in its extraction effects in terms of percentage loss of labour income, from 2.2% in 2000 to 4.6% in 2010 as well as in terms of percentage loss in total employment from 2.0% to 3.8%.

[11] This sector covers a wide range of economic activities, namely, Legal and accounting activities, Activities of head offices; management consultancy activities, Architectural and engineering activities; technical testing and analysis, Scientific research and development, Advertising and market research, Other professional, scientific and technical activities, Veterinary activities, Rental and leasing activities Employment activities, Travel agency, tour operator reservation service and related activities, Security and investigation activities Services to buildings and landscape activities, Office administrative, office support and other business support activities.

On the other hand, the [11] Professional, Scientific and Technical activities and Administrative and support service activities has seen the largest increase the extraction effects in terms of the percentage loss of labour income, from 4.5% in 2000 to 11.3% in 2010 as well as in terms of percentage loss in total employment which has seen an increase from 5.8% to 12.3%. This sector has also seen the second largest increase in its overall extraction effects relating to the loss of gross value added which has increased from 6.7% to approximately 11.0%.

From an analysis of the results presented in Appendix F, Appendix G and Appendix H, it may be noted that a number of sectors have experienced a consistent increase in all three of their extraction effects[12] thus also indicating an increase in the overall importance of the sector to the production structure of the Maltese economy over the specified time period. These sectors are the [9] Financial and Insurance activities sector, [14] Human health and Social work activities sector and the [8] Information and Communication activities sector. The [4] Mining, Quarrying and Construction sector experienced an increase in the extraction effects in terms of both value added and labour income. Moreover, [13] Education sector experienced an increase in its extraction effects in terms of both labour income and employment effects.

Although not as significant as the [2] Manufacturing sector, other sectors have also seen a consistent decline in their overall extraction effects. The [1] Agriculture, Forestry and Fishing sector and the [6] Transportation and Storage sector have both experienced a decline in their value added, labour income and employment extraction effect over the specified time period indicating a decline in their relative importance within the context of the production structure of the Maltese economy.

Figure 3 presents the sectoral extraction effects in terms of percentage loss in total employment across all three SIOTs disaggregated by type of employee nationality, which in the context of this study is categorized either as a Maltese national or foreign national. This extraction methodology allows for a separate assessment of the employment extraction effects of a sector disaggregated in terms of the loss in the employment of Maltese nationals as a percentage of total employment and by the loss in the employment of foreign nationals as a percentage of total employment. From Appendix H, it may be observed that the top three

[12] A comparison analysis between the direct contribution in terms of gross value added, income and employment by each sector with the derived sectoral extraction effects are presented respectively in Appendix I, Appendix J and Appendix K.

sectors which have seen the largest increase in their overall extraction effects from 2000 to 2010 of only foreign nationals are also the three sectors which based on the 2010 SIOT generate the largest extraction effects in terms of the loss in employment of foreign nationals as a percentage of total employment. These sectors are the [11] Professional, Scientific and Technical activities and Administrative and support service activities, which generates an extraction effect of 1.25% of total employment originating solely from the loss in employment of foreign nationals, the [7] Accommodation and Food service activities sector with a decline in total employment from solely foreign nationals equal to 1.04% and the [15] Arts, Entertainment and Recreation activities sector with a decline in total employment originating from the loss in employment of only foreign nationals equal to 0.95%. As may be observed from Figure 3, other sectors which also have a significant impact on the employment of solely foreign nationals as a result of their hypothetical extraction, are the [2] Manufacturing sector, the [4] Mining, Quarrying and Construction sector and the [5] Wholesale and retail trade; repair of motor vehicles and motorcycles sector. It should further be noted that most sectors have seen an increase in these extraction effects across the three SIOTs, which indicates the increased importance of foreign nationals to the production activities of the Maltese economy.

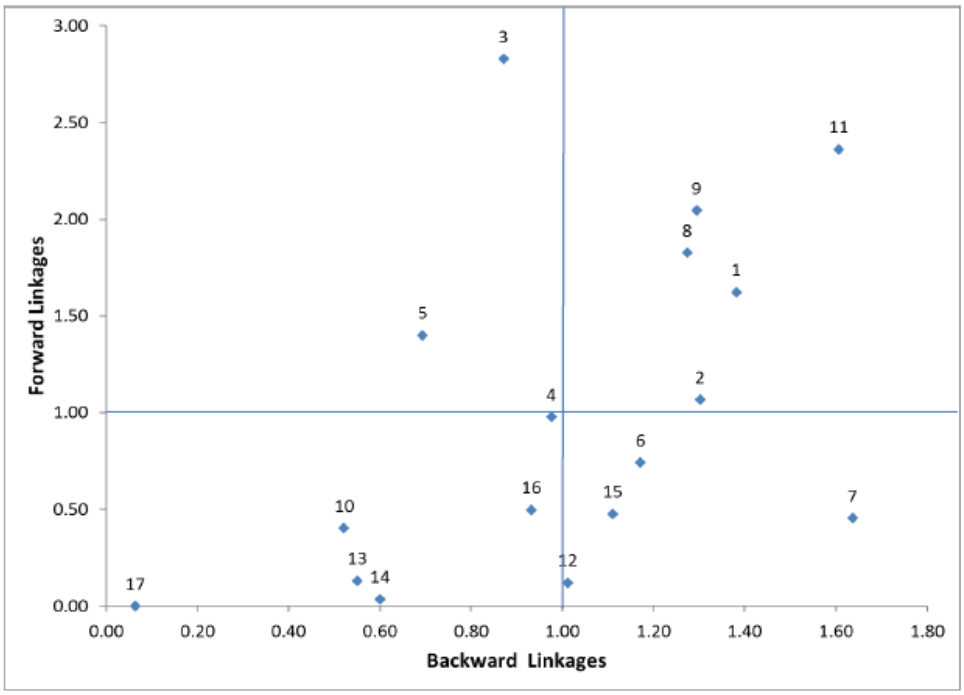
4.2 Linkages analysis based on the non-complete hypothetical extraction method by Dietzenbacher and van der Linden (1997)

The linkage indicators for the non-complete hypothetical extraction method by Dietzenbacher and van der Linden (1997) were found by implementing equations 36 and 37, providing respectively the normalized backward and forward linkages indicators. As described in section 3.2, in order to estimate equations 36 and 37 first the absolute backward and forward linkages estimated from equations 27 and 35 had to be obtained. As described by these two equations, in order to derive the absolute backward and forward linkages for each sector, the output loss per sector due to the hypothetical extraction was weighted by the corresponding output of each sector in order to remove the relative size effects. This implies that in contrast to the results discussed in section 4.1, the primary factor effecting the relative strength of the sector is the sector's overall inter-industry sectoral dependency.

The linkage indicators and their respective classification, for the SIOTs of the year 2000, 2008 and 2010 are provided in Appendix L. The results obtained for each SIOT are respectively presented in Figure 4, Figure 5 and Figure 6. Following Temurshoev (2004) each sector has been categorized into a specific linkage category. Key Sectors (K), have been defined as

those sectors which have both the corresponding normalized backward and forward linkage indicator greater than one, and are depicted within the top right quadrant of the diagram. The sectors with only strong backward linkages (B) are inside the bottom right quadrant, the sectors with only strong forward linkages (F) are inside the top left quadrant and the sectors with weak linkages (L) are inside the bottom left quadrant of each diagram.

Figure 4: Linkages analysis based on the non-complete hypothetical extraction method for the SIOT of the year 2000.



Source: Author's Calculations

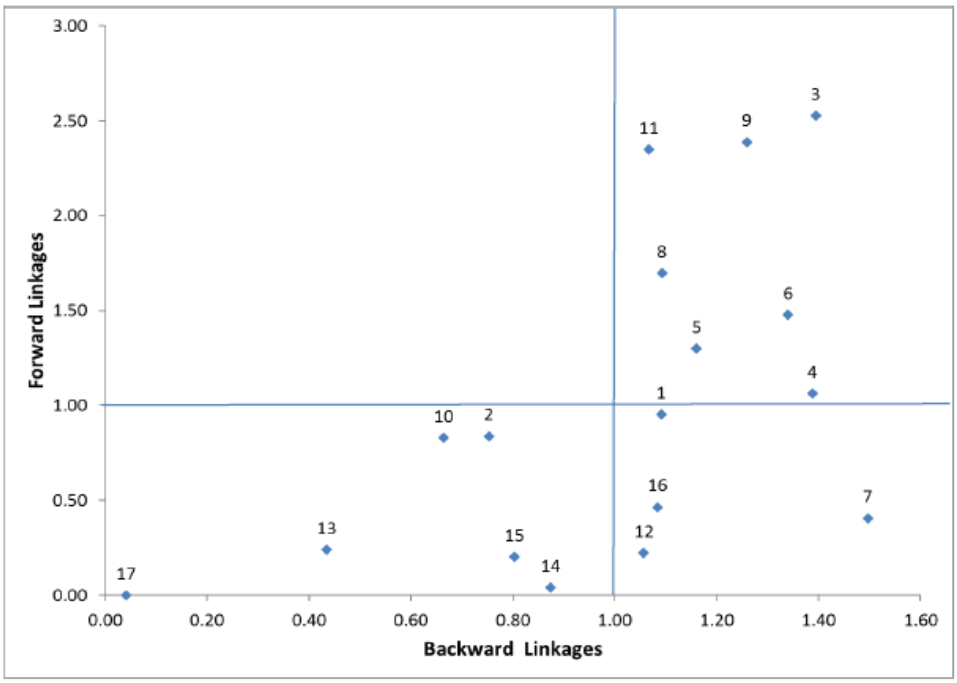
Figure 4 illustrates the linkage indicators obtained from the non-complete hypothetical extraction method applied to the SIOT for the year 2000. Five sectors[13] where identified as key sectors. The [11] Professional, Scientific and Technical activities and Administrative and support service activities sector was the sector with the strongest[14] backward and forward linkages. The other four sectors classified as key sectors are the [9] Financial and Insurance activities sector, the [8] Information and Communication sector, the [1] Agriculture, Forestry

[13] Each number in the table corresponds to a sector. Refer to Table 1 in section 2 to identify the corresponding sector classification for each sector number.

[14] Appendix M illustrates the relative ranking of the sectoral backward and forward linkages obtained from each SIOT.

and Fishing sector and the [2] Manufacturing sector. Two sectors were found to have only strong forward linkages, four sectors were found to have only strong backward linkages and six sectors were found to have weak linkages. The sector with the strongest backward linkage indicator was the [7] Accommodation and Food service activities sector and the sector with the strongest forward linkage indicator is the [3] Electricity, Gas, Water supply and Waste Management sector.

Figure 5: Linkages analysis based on the non-complete hypothetical extraction method for the SIOT of the year 2008.

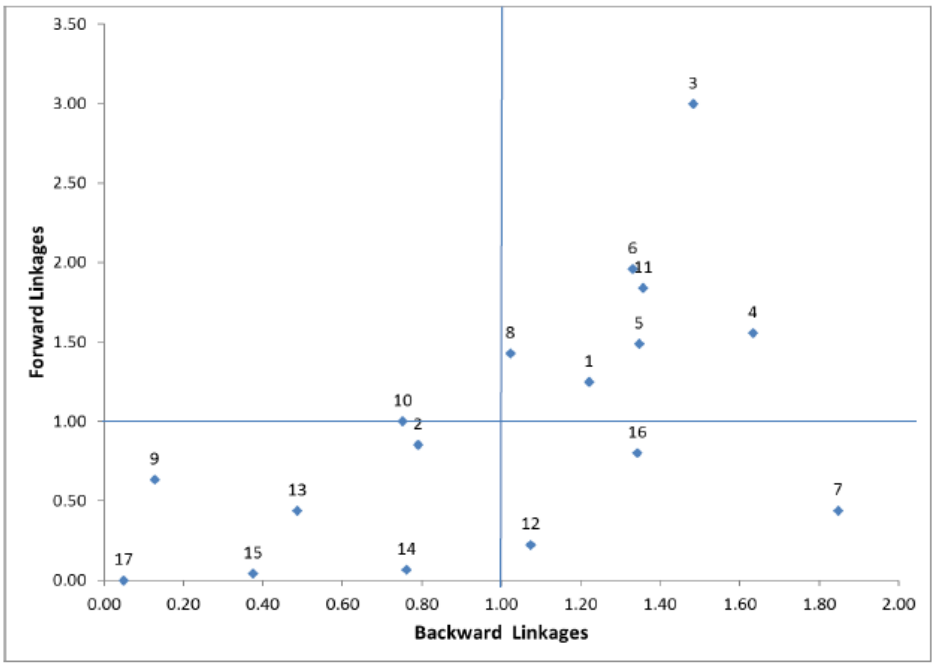


Source: Author's Calculations

Figure 5 portrays the linkage indicators obtained from the application of the non-complete hypothetical extraction method to the SIOT for 2008. As illustrated in Figure 5, seven sectors where identified as key sectors, out of these seven key sectors, the [3] Electricity, Gas, Water supply and Waste Management sector was identified as the sector with the strongest backward and forward linkages. Furthermore, this sector was also the sector with the strongest forward linkage indicator across the entire production structure of the economy. The other six sectors classified as key sectors are the [9] Financial and Insurance activities sector, the [8] Information and Communication services sector, the [11] Professional, Scientific and Technical activities and Administrative and support service activities sector, the [6] Transportation and Storage sector, the [5] Wholesale and retail trade & repair of motor

vehicles and motorcycles sector and the [4] Mining, Quarrying and Construction sector. Four sectors were found to have only strong backward linkages, while no sectors were found to have only strong forward linkages and six sectors were found to have weak linkages. Based on the SIOT for the year 2008 the sector with the strongest backward linkage indicator was the [7] Accommodation and Food service activities sector.

Figure 6: Linkages analysis based on the non-complete hypothetical extraction method for the SIOT of the year 2010.



Source: Author's Calculations

From Figure 6 it may be observed that based on non-complete hypothetical extraction method applied to the SIOT for the year 2010 seven sectors were identified as being key sectors. Out of these seven key sectors, the [3] Electricity, Gas, Water supply and Waste Management sector was identified as the sector with the strongest backward and forward linkages. This sector was also found to be the sector with the strongest forward linkage indicator across the entire the economy. The other sectors which were classified as key sectors are respectively, the [4] Mining, Quarrying and Construction sector, the [6] Transportation and Storage sector, the [11] Professional, Scientific and Technical activities and Administrative and support service activities sector, the [5] Wholesale and retail trade & repair of motor vehicles and motorcycles sector the [8] Information and Communication services sector, and the [1] Agriculture, Forestry and Fishing sector. The [10] Real estate activities sector was found

to be the only sector to have only strong forward linkages and three sectors were found to have only strong backward linkages and six sectors were found to have weak linkages. Based on the SIOT for the year 2010 the sector with the strongest backward linkage indicator was the [7] Accommodation and Food service activities sector and the sector.

An assessment of the variation in the relative strength of both the forward and backward linkages, for each sector, across the three SIOTs, will provide significant insights into the changes which have occurred in the production structure of the Maltese economy between 2000 and 2010. Table 2[15] presents a summary of the resulting sectoral linkage classifications obtained for each of the three SIOTs[16].

Table 2: A summary of the variation in sectoral linkages over the three SIOTs

	Strong backward and forward linkages (Key Sector)	Only strong backward linkages	Only strong forward linkages	Weak linkages
SIOT 2000	1, 2, 8, 9, 11	6, 7, 12, 15	3, 5	4, 10, 13, 14, 16, 17
SIOT 2008	3, 4, 5, 6 ,8, 9, 11	1, 7, 12, 16		2, 10, 13, 14, 15, 17
SIOT 2010	1, 3, 4, 5, 6, 8, 11	7, 12, 16	10	2, 9, 13, 14, 15, 17

Source: Author's Calculations

As illustrated in Table 2 across 2000, 2008 and 2010 significant differences may be observed in the strength of sector specific linkages indicating that the production structure of the Maltese economy has undergone a number of key structural changes. As is observable from Table 2

[15] Each number in the table corresponds to a sector. Refer to Table 1 in section 2 to identify the corresponding sector classification for each sector number.

[16] Refer to Appendix L.

the variation in the sector specific linkages is greater between the 2000 and 2008 SIOTs rather than between the 2008 and 2010 SIOTs. Across the entire time horizon only two sectors have been consistently classified as key sectors, namely, the [11] Professional, Scientific and Technical activities and Administrative and support service activities sector and the [8] Information and Communication services sector. Another sector which may also be considered as very important to the economy is the [1] Agriculture, Forestry and Fishing sector. Although this sector was only classified as a key sector in 2000 and 2010, in 2008 it was identified as having strong backward linkages and was not also classified as having strong forward linkages by a very minor margin. Across the three SIOTs only three sectors have consistently been classified as having weak linkages, these are the [13] Education sector, the [14] Human health and Social work activities sector and the [17] Households as employers and activities of extraterritorial organisations sector.

It is interesting to note[17] that although the [7] Accommodation and Food service activities sector is not classified as a key sector across any of the SIOTs it nonetheless exhibits the strongest backward linkages out of all the sectors in the economy, across the entire time period. Also, the [3] Electricity, Gas, Water supply and Waste Management sector was also found to exhibit the strongest forward linkages across all three SIOTs demonstrating its' significant importance to the supply chain of the Maltese economy.

As may be observed from Table 2 a notable change in the structure of the Maltese economy relates to the classification of the [4] Mining, Quarrying and Construction sector which in 2008 and 2010 was a key sector compared to 2000 when it exhibited only weak linkages in the economy. The [3] Electricity, Gas, Water supply and Waste Management sector and the [5] Wholesale and retail trade; repair of motor vehicles and motorcycles sector, which were both classified as the having only strong forward linkages in 2000, and the [6] Transportation and Storage sector which was classified as having only backward linkages in 2000 were all thereafter classified as key sectors for both 2008 and 2010. Another significant change in the structure of the Maltese economy which may be observed across the specified time period pertains to the fact that the [2] Manufacturing sector which was classified as a key sector in 2000 was then after reclassified as having only weak linkages in both the SIOT for 2008 and 2010. A possible explanation for this reclassification across the 2008 and 2010 SIOTs may

[17] Refer to Appendix L and Appendix M.

pertain to the level of sectoral aggregation within the SIOTs utilized for this study. This study utilizes a highly aggregated SIOT of 17 sectors in which the [2] Manufacturing sector effectively encompasses the transactions of 23 individual NACE sectoral divisions, from division C1O to division C33. This high level of sectoral aggregation has the resulting effect of omitting the various backward and forward linkages which exist amongst those sectoral divisions, which discussed in Cassar (2015), within the context of solely backward linkages, and based on the SIOT for 2008, may be sizeable. This implies that although as a whole the [2] Manufacturing sector has been found to exhibit weak linkages over 2008 and 2010, it does not however mean that the individual industries which are aggregated within that sector also exhibit weak linkages[18].

A number of changes to the structure of the Maltese economy have also occurred between the 2008 and 2010 time periods. Whereas the [9] Financial and Insurance activities sector was classified as a key sector across both 2000 and 2008, in 2010 both the forward and backward linkages exhibited by this sector were however classified as weak (less than 1). A reason which can in great part explain this variation is primarily due to the change in the methodology utilized to compile the SIOTs between 2008 and 2010 from ESA95 to ESA2010. As was explained in section 2, this methodological change resulted in a significant expansion of the output generated by this sector, which without a proportionate increase in the use of intermediary inputs or primary inputs and given the methodology applied to derive the forward and backward linkages indicators, resulted in a dampening of the overall strength of the derived linkages for this sector. Another notable structural change which may be observed between the 2008 and 2010 SIOTs is the change in the classification of the [10] Real estate activities sector. This sector was classified as having weak linkages for both the SIOT of 2000 and of 2008, however the results obtained from the 2010 SIOT indicate that the sector now exhibits strong forward linkages. This reclassification, which highlights the increased importance of the [10] Real estate activities sector to the supply chain of the Maltese economy, together with the reclassification of the [4] Mining, Quarrying and Construction sector, as a key sector, reflect the significant developments experienced within the Maltese housing market between 2000 and 2010[19].

[18] In order to assess the strength of linkages of those industries which are aggregated within the [2] Manufacturing sector the analysis undertaken in this study would have undertaken utilizing a highly disaggregated SIOT.

[19] Refer to Gatt and Grech (2016) for further information on the developments experienced within the Maltese housing market.

5. Concluding remarks

The aim of this paper was to assess the extent of change in the production structure of the Maltese economy on the basis of three SIOTs, covering the time period from the year 2000 to 2010, via the application of two hypothetical extraction methods as discussed in Section 3. The Strassert (1968) hypothetical extraction method, assumed a full hypothetical sectoral extraction and showed the impact such an extraction would have on the Maltese economy in terms of the percentage loss in total gross value added, total labour income and total employment. The non-complete hypothetical extraction method by Dietzenbacher and van der Linden (1997) was applied in order to derive backward and forward linkages indicators (which remove sectoral size effects) for each sector in the economy. These linkages indicators were subsequently utilized for the identification of the key sectors across all three SIOTs.

The results discussed in section 4 indicate that the production structure of the Maltese economy has passed through a number of significant structural changes, which were more pronounced between the 2000 and 2008 SIOTs than between the 2008 and 2010 SIOTs. The analysis presented in section 4.1 indicates that between 2000 and 2010 the [2] Manufacturing sector is the sector which generates the largest extraction effects in terms of total gross value added, total labour income and total employment. These extraction effects, as was noted in section 4.1, have however been declining over the same period reflecting the increased level of sectoral diversification which has occurred in the production structure of the Maltese economy over the same period. Indeed, over the same period, a number of sectors experienced significant increases in all three extraction effects. On the basis of the analysis undertaken, the two sectors with most significant growth in all three extraction effects are the [11] Professional, Scientific and Technical activities and Administrative and support service activities and the [15] Arts, Entertainment and Recreation activities sector. Other sectors which also experienced a sizable increase in all three extraction effects are the [9] Financial and Insurance activities sector, the [14] Human health and Social work activities sector and the [8] Information and Communication activities sector.

In terms of assessing the potential impact that a sectors' hypothetical extraction may have on the employment of solely foreign nationals, it was found that the largest extraction effects were generated by the [11] Professional, Scientific and Technical activities and Administrative and support service activities followed by the [7] Accommodation and Food service activities sector and the [15] Arts, Entertainment and Recreation activities sectors. The growth in these

extraction effects and the impact on foreign nationals observed in nearly all sectors, across all three SIOTs, indicates the increased importance of foreign nationals to the production activities of the Maltese economy.

From the linkages analysis undertaken on the basis of the non-complete hypothetical extraction method it was found that between 2000 and 2010 there was an increase in the number of sectors classified as key sectors, from five to seven sectors, indicating a higher degree of sectoral interdependence implying greater sectoral diversification. Across all three SIOTs, only two sectors were found to be consistently classified as key sectors, the [11] Professional, Scientific and Technical activities and Administrative and support service activities sector and the [8] Information and Communication services sector, highlighting the importance of these two sectors within the context of the economic development strategy of the Maltese economy. Two other sectors which, based on the linkages analysis, should also be regarded as strategically important are the [7] Accommodation and Food service activities sector[20] and the [3] Electricity, Gas, Water supply and Waste Management sector which exhibited respectively, the strongest backward linkages, and, the strongest forward linkages, across all three SIOTs.

Since the input-output tables utilized in this study are measured in monetary terms, the linkages derived represent the strength of the interactions amongst sectors as captured by their underlying monetary transactions. The hypothetical extraction methods applied in this study therefore, to an extent, do not account for the heterogeneity which exists in terms of the relative importance that each specific product or service supplied/produced by a sector may have within the underlying production processes of an economy[21]. Furthermore, Carderente and Sancho (2006) suggests that hypothetical extraction methods based on SIOTs fail to include critical links which go beyond the inter-sectoral ones. They note that a productive sector's role is that of producing but also that of generating and distributing income among primary factors and households as a result of production. The extraction methods applied in this study fail to capture the additional impacts on output production which are produced

[20] This sector is often used as an approximation for the tourism sector. See Fletcher (1989).

[21] Whereas it is reasonable to assume that an economy may to an extent function, if for example a sector such as the [16] Other Service Activities were to be extracted (close down), without other sectors, which serve a more fundamental economic function within production activities, such as the [3] Electricity, Gas, Water supply and Waste Management sector or the [9] Financial and Insurance activities sector, this would however, not be economically feasible.

through the income generating and income redistribution process. A way of accounting for the missing income links would be to apply such methods to a Social Accounting Matrix (SAM) rather than an SIOT. However, at present there is no published fully specified SAM for the Maltese economy for 2010.

A clear scope for further research identified from this study would thus be the construction of a SAM for the Maltese economy and its respective application to hypothetical extraction analysis (and other methods) to shed further light on the true impact of a sector on the economy which would account for both the loss of the productive output, and for the loss of labour payments and factor payments that originate from the productive processes of the sector itself.

Furthermore, as noted in section 4.2 utilizing a highly aggregated SIOT for 2010 omits significant information on the role that numerous sectors, which have been aggregated as one sector within this study, have within the context of the production structure of the economy. For example, in this study the manufacture of food and beverages, the manufacture of electronics and the manufacture of pharmaceuticals, along with many other industries have all been aggregated within the [2] Manufacturing sector. This implies that it was not possible to derive estimates which capture the strength of the sectoral linkages exhibited by those aggregated sectors. Hence, another avenue for further research relates to the identification of key sectors on the basis of a highly disaggregated SIOT for 2010.

Although hypothetical exaction analysis is subject to the limitations of standard input-output methodology[22] and its' results, especially within the context of assessing structural change over time, are to an extent also highly affected by changes in statistical compilation methodologies, the measures obtained from such methods should still be viewed by policy makers as a robust indication of how the production structure of the Maltese economy has evolved over the recent past. These measures, which account for the sectors' degree of sectoral interdependence may thus be utilized to assess the role of each sector in promoting growth and strengthening Malta's overall competitiveness.

[22] Refer to Miller and Blair (2009).

References

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Appendix A: Sectoral descriptive statistics (1)

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010		
			Sector share (%) of total output	Sector share (%) of total final demand	Sector share (%) of total primary inputs		Sector share (%) of total output	Sector share (%) of total final demand	Sector share (%) of total primary inputs		Sector share (%) of total output	Sector share (%) of total final demand	Sector share (%) of total primary inputs
1	A	Agriculture, Forestry and Fishing	2.23	1.94	2.24		2.16	2.04	2.06		1.12	1.24	1.09
2	C	Manufacturing	40.19	36.92	35.45		23.18	20.88	23.59		14.71	14.10	14.41
3	D, E	Electricity, Gas, Water supply and Waste Management	2.23	0.76	2.57		1.81	6.14	4.09		1.28	4.27	2.68
4	F, B	Mining, Quarrying and Construction	3.77	3.97	4.19		6.59	6.63	5.35		3.88	4.80	3.20
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	6.27	6.02	7.80		7.96	8.29	8.40		5.11	5.95	5.04
6	H	Transportation and Storage	8.35	9.72	9.01		6.22	7.50	6.16		3.81	5.57	4.24
7	I	Accommodation and Food service activities	7.66	9.43	6.58		7.02	5.37	4.66		4.70	4.02	2.76
8	J	Information and Communication	3.42	2.93	3.56		3.72	4.91	4.79		3.58	4.19	3.76
9	K	Financial and Insurance Activities	4.02	2.67	4.09		2.43	4.89	4.10		31.86	28.64	35.41
10	L	Real estate activities	3.28	4.25	4.19		3.74	3.29	3.92		2.64	2.62	2.70
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	5.05	2.45	4.18		3.75	7.09	7.02		4.46	6.19	4.67
12	O	Public Administration and Defence	4.77	6.81	5.39		5.75	4.25	4.48		3.89	3.18	3.04
13	P	Education	3.18	4.46	4.05		3.77	2.77	3.54		2.64	2.27	2.56
14	Q	Human health and Social work activities	3.20	4.67	4.07		5.25	3.67	4.11		3.72	2.95	3.10
15	R	Arts, Entertainment and Recreation	1.22	1.54	1.29		15.43	11.31	12.68		11.75	9.25	10.64
16	S	Other Service activities	1.09	1.35	1.25		1.04	0.83	0.86		0.70	0.67	0.57
17	T, U	Households as employers and activities of extraterritorial organisations	0.08	0.11	0.11		0.19	0.13	0.19		0.13	0.10	0.13

Source: Author's Calculations, NSO

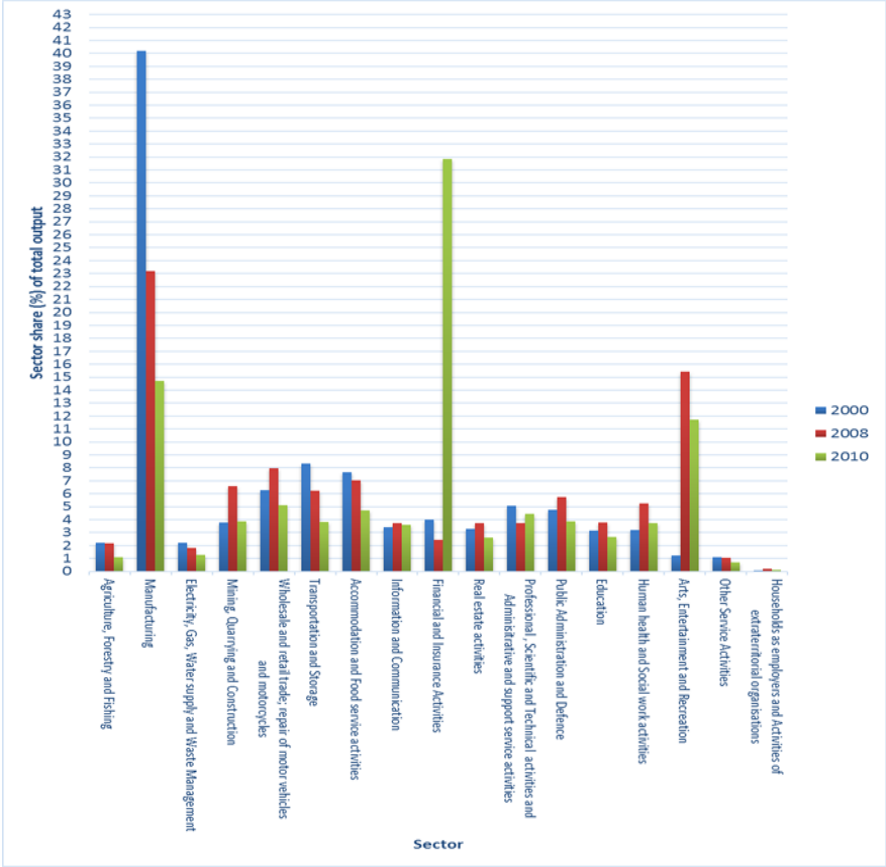
Appendix B: Sectoral descriptive statistics (2)

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010		
			Sector share (%) of gross value added	Sector share (%) of total Labour income	Sector share (%) of total employment		Sector share (%) of gross value added	Sector share (%) of total labour income	Sector share (%) of total employment		Sector share (%) of gross value added	Sector share (%) of total labour income	Sector share (%) of total employment
1	A	Agriculture, Forestry and Fishing	2.54	1.13	2.34		1.47	0.80	1.92		1.66	1.00	1.13
2	C	Manufacturing	23.67	22.25	21.44		15.34	16.44	14.90		12.95	12.68	13.04
3	D, E	Electricity, Gas, Water supply and Waste Management	1.73	2.43	2.40		1.70	2.36	2.24		2.36	2.17	1.90
4	F, B	Mining, Quarrying and Construction	4.59	4.32	8.22		4.91	4.78	9.18		4.79	4.41	5.45
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	10.95	8.83	14.74		11.62	10.89	15.06		10.68	10.35	13.06
6	H	Transportation and Storage	7.23	8.33	6.29		5.86	6.00	5.78		5.98	6.37	5.07
7	I	Accommodation and Food service activities	7.40	8.09	6.53		5.09	6.09	7.00		4.70	5.64	8.86
8	J	Information and Communication	4.27	3.26	2.83		5.30	4.00	3.18		5.52	4.32	3.32
9	K	Financial and Insurance Activities	5.18	6.14	3.81		4.55	7.29	4.34		7.81	7.97	5.68
10	L	Real estate activities	6.18	0.15	0.56		6.01	0.19	0.60		5.99	0.20	0.23
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	4.88	2.82	4.28		9.40	7.97	8.73		9.27	9.64	10.60
12	O	Public Administration and Defence	7.01	11.72	8.19		6.41	10.62	7.23		6.12	10.52	8.17
13	P	Education	5.72	9.01	7.73		5.51	9.63	8.86		5.80	10.55	9.84
14	Q	Human health and Social work activities	4.93	7.42	6.33		6.08	8.75	7.09		6.41	9.62	8.13
15	R	Arts, Entertainment and Recreation	1.82	1.65	1.44		9.41	3.16	1.87		8.57	3.47	2.71
16	S	Other Service activities	1.73	2.44	2.88		1.03	1.05	2.02		1.08	1.10	2.80
17	T, U	Households as employers and activities of extraterritorial organisations	0.17	0.02	0.00		0.30	0.00	0.00		0.31	0.00	0.00

Source: Author's Calculations, NSO

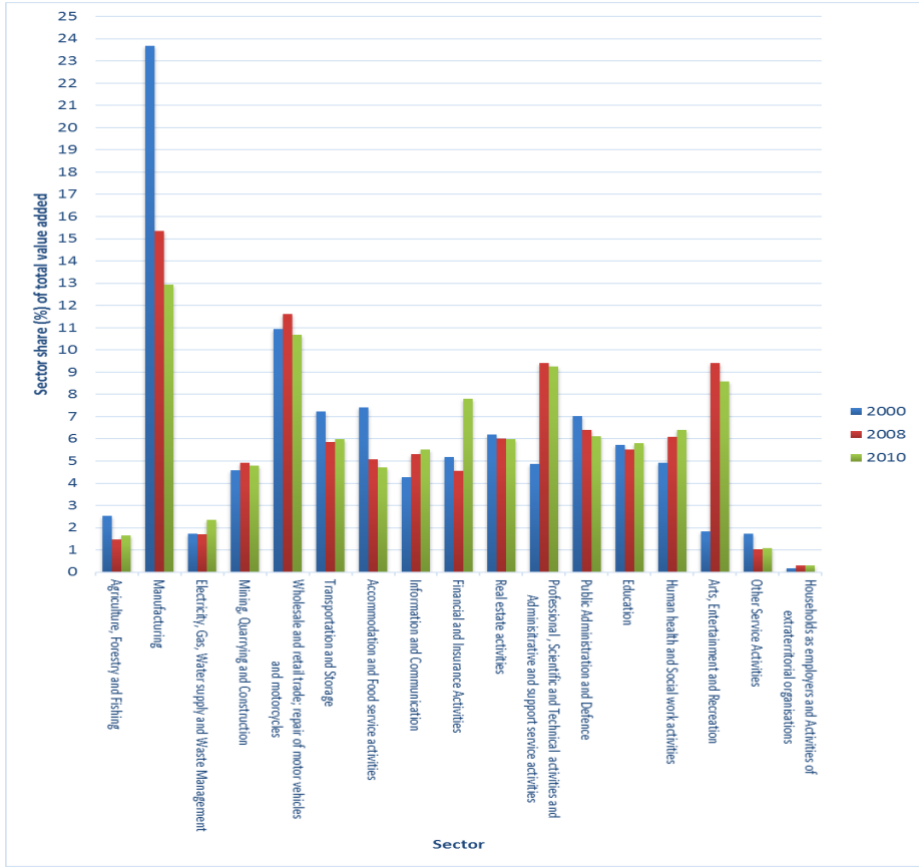
Appendix C: Graphical analysis of selected descriptive statistics

Figure C.1: Sector share of total output in percentage terms



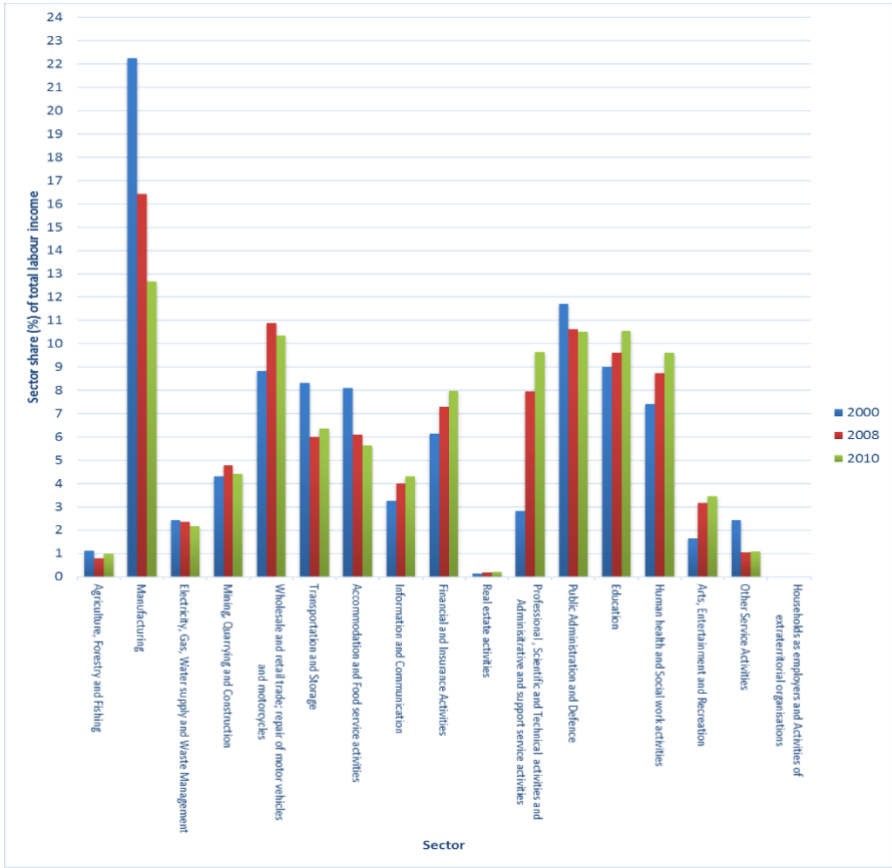
Source: Author's Calculations, NSO

Figure C.2: Sector share of total value added in percentage terms



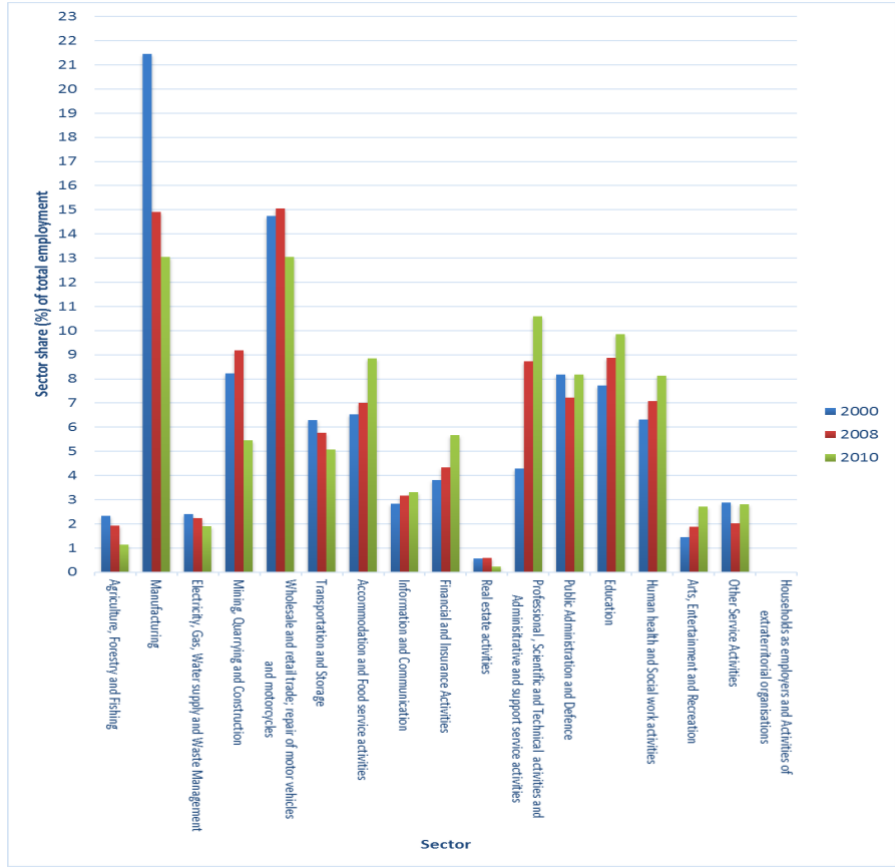
Source: Author's Calculations, NSO

Figure C.3: Sector share of total labour income in percentage terms



Source: Author's Calculations, NSO

Figure C.4: Sector share of total employment in percentage terms



Source: Author's Calculations, NSO

Appendix D: The Leontief demand driven model

The basic Leontief demand driven may be defined as a fixed price general static equilibrium model which describes the interrelations between industries taking into account the 'technical' relations throughout the economy via fixed-coefficient production functions. Under the Leontief demand driven model the economy is divided into *n* sectors such that, utilizing an SIOT, it is possible to formulate a set of general input output equations which reflect the condition of equilibrium between total demand and total supply for each product[23] within the economy (Miller and Blair, 2009):

$$x_i = \sum_{j=1}^{n} z_{ij} + f_i \quad i,j = 1,\ldots,n. \qquad (D.1)$$

Where total production x_i for each sector *i* may be expressed as a function of z_{ij} which denotes the value of sales from sector *i* to sector *j* and f_i which denotes the amount of sales from sector *i* to final demand. Using matrix representation, we can express equation D.1 as:

$$\boldsymbol{x} = \boldsymbol{Ze} + \boldsymbol{f} \qquad (D.2)$$

Where ***x*** denotes an (*n x 1*) column vector of outputs, ***f*** denotes a column vector (*n x1*) of final demand and ***Z*** denotes an (*n x n*) matrix of inter-industry flows and **e** denotes a summation vector. If we let a_{ij} to represent the unit input coefficient which denotes the amount of input i needed to produce a unit of good j then it follows that to produce x_j units of good j, one would require $a_{ij}x_j$ units of input i we may define the matrix of technical coefficients as follows:

$$\boldsymbol{A} = \boldsymbol{Z}\hat{\boldsymbol{x}}^{-1} \qquad (D.3)$$

Equation D.4, which is the balance equation of the Leontief demand driven model, is derived by substituting the relation presented in equation (D.3) into equation (D.2).

[23] It is assumed that each industry is associated with a single characteristic product of output.

$$\boldsymbol{x} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{f} \qquad \text{(D.4)}$$

The solution to the Leontief demand driven model will take a form which allows answering the question of how much output from each sector will vary in response to exogenous increase in the structure of final demand. A unique solution to the n linear equations may be obtained following equation:

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f} = \boldsymbol{L}\boldsymbol{f} \qquad \text{(D.5)}$$

$$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1} \qquad \text{(D.6)}$$

The elements within the Leontief inverse matrix (**L),** derived following equation D.6, incorporate the notion that increases in final demand have a larger impact on the production of output than solely the initial additional output produced (direct effects) required to supply the exogenous increase in final demand. The solution to the Leontief demand driven model represented by equation D.5, implies that, given ***L*** (the Leontief inverse) output is determined solely by the structure of final demand, ***f***.

Appendix E: The Ghoshian supply driven model

The Ghoshian supply driven model was first formulated by Ghosh (1958) and is also referred to as the Ghoshian allocation system. The derivation of the Ghoshian supply driven model starts from the same following set of input-output equations in which the economy is divided into *n* sectors:

$$x_j = \sum_{i=1}^{n} z_{ij} + v_j \quad i,j= 1,\ldots,n \qquad (E.1)$$

The input-output balance equation denoted by equation E.1 asserts that total production x_j, for each sector *j* may be expressed as the summation of z_{ij} which denotes the amount sector *i* supplies to all sectors in the economy as inputs in their production process and the value of expenditure on primary inputs by sector *j* required to undertake the production of output x_j. By expressing E.1 in matrix notation we obtain E.2:

$$\boldsymbol{x}' = \boldsymbol{e}'\boldsymbol{Z} + \boldsymbol{v}' \qquad (E.2)$$

By applying the assumption of fixed output coefficients it is possible to derive the output coefficient matrix which in matrix notation yields:

$$\boldsymbol{B} = \hat{\boldsymbol{x}}^{-1}.\boldsymbol{Z} \qquad (E.3)$$

The elements of the allocation coefficients matrix $\boldsymbol{B}$, b_{ij}, denote the share of output that sector *i* supplies to sector *j* in order for sector *j* to produce its output. These allocation coefficients characterize the distribution of sector *i*'s outputs across the sectors *j* that purchase their inter-industry inputs from *i*. (Temurshoev, 2004). The next step to derive the supply driven model is to substitute equation E.3 into equation E.2 such that:

$$\boldsymbol{x}' = \boldsymbol{e}'\hat{\boldsymbol{x}}\boldsymbol{B} + \boldsymbol{v}' = \boldsymbol{x}'\boldsymbol{B} + \boldsymbol{v}' \qquad (E.4)$$

Equation E.4 is the balance equation of the Ghoshian Supply driven model and it states that total production of output is equal to the sum of all intermediary inputs used for the production of output plus the sum of all primary inputs. The solution to this model is derived following equation E.5:

$$\boldsymbol{x}^{'} = \boldsymbol{v}'(\boldsymbol{I} - \boldsymbol{B})^{-1} = \boldsymbol{v}'\boldsymbol{G} \qquad \text{(E.5)}$$

The solution to the Ghoshian model illustrated within equation E.5 states that changes in total output are caused by shocks or changes to the structure of primary inputs.

$$\boldsymbol{G} = (\boldsymbol{I} - \boldsymbol{B})^{-1} \qquad \text{(E.6)}$$

The inverse $\boldsymbol{(I - B)^{-1}}$ is referred to as the Ghoshian (or output)inverse matrix (***G***) shown in equation E.6. Augustinovics (1970) describes the elements within the Ghosian inverse as measuring the total value of production that is generated in sector *j* per unit of primary input in sector *i*. Ghosh (1964) suggests that the supply driven model is not a substitute for the demand driven model but should rather be used together with Leontief's model as an additional tool for analysis and planning. Criticisms[24] pertaining to the original interpretation and conceptual basis of the Ghoshian supply driven model over the years have been mitigated by an alternative interpretation but forward by Dietzenbacher (1997). Dietzenbacher (1997) asserts that if the model was to be reinterpreted as a Ghosh price model it would yield a far more plausible conceptual interpretation. Although this interpretation is to an extent still criticized[25], this input-output model is still extensively utilized within the context of the inter-industry linkages analysis.

[24] Refer to (Oosterhaven 1981; Oosterhaven 1989).

[25] Refer to Mesnard (2009a) and Mesnard (2009b).

Appendix F: The percentage loss in total gross value added resulting from the hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000		SIOT 2008		SIOT 2010	
			GVA Loss (%)	Rank	GVA Loss (%)	Rank	GVA Loss (%)	Rank
1	A	Agriculture, Forestry and Fishing	3.39	13	2.28	14	2.19	15
2	C	Manufacturing	29.23	1	20.07	1	16.56	1
3	D, E	Electricity, Gas, Water supply and Waste Management	2.31	14	2.26	15	2.80	14
4	F, B	Mining, Quarrying and Construction	5.40	12	7.62	8	7.00	10
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	12.25	2	14.92	2	13.41	2
6	H	Transportation and Storage	10.30	4	8.23	5	7.37	8
7	I	Accommodation and Food service activities	10.31	3	7.93	6	7.56	6
8	J	Information and Communication	5.42	11	6.72	11	6.61	11
9	K	Financial and Insurance Activities	6.52	8	5.90	13	8.81	5
10	L	Real estate activities	6.68	7	6.73	10	6.61	12
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	6.70	6	11.29	4	11.04	3
12	O	Public Administration and Defence	8.68	5	7.88	7	7.44	7
13	P	Education	6.26	9	5.92	12	6.17	13
14	Q	Human health and Social work activities	5.58	10	7.11	9	7.22	9
15	R	Arts, Entertainment and Recreation	2.26	15	12.88	3	9.70	4
16	S	Other Service activities	2.04	16	1.36	16	1.43	16
17	T, U	Households as employers and activities of extraterritorial organisations	0.17	17	0.31	17	0.31	17

Source: Author's Calculations

Appendix G: The percentage loss in total labour income resulting from the hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000		SIOT 2008		SIOT 2010	
			Income Loss (%)	Rank	Income Loss (%)	Rank	Income Loss (%)	Rank
1	A	Agriculture, Forestry and Fishing	1.90	15	1.61	14	1.52	14
2	C	Manufacturing	26.91	1	21.02	1	16.10	1
3	D, E	Electricity, Gas, Water supply and Waste Management	2.96	12	2.93	13	2.60	13
4	F, B	Mining, Quarrying and Construction	5.08	9	7.35	10	6.52	10
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	10.06	5	14.10	2	12.80	2
6	H	Transportation and Storage	10.90	4	8.44	9	7.70	9
7	I	Accommodation and Food service activities	10.90	3	8.75	7	8.13	8
8	J	Information and Communication	4.28	11	5.42	12	5.41	11
9	K	Financial and Insurance Activities	7.16	8	8.47	8	8.97	7
10	L	Real estate activities	0.66	16	1.01	16	0.82	16
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	4.51	10	10.04	4	11.33	4
12	O	Public Administration and Defence	13.17	2	12.08	3	11.79	3
13	P	Education	9.47	6	10.03	5	10.88	5
14	Q	Human health and Social work activities	8.04	7	9.84	6	10.40	6
15	R	Arts, Entertainment and Recreation	2.17	14	6.41	11	4.55	12
16	S	Other Service activities	2.73	13	1.38	15	1.44	15
17	T, U	Households as employers and activities of extraterritorial organisations	0.02	17	0.00	17	0.00	17

Source: Author's Calculations

Appendix H: The percentage loss in total employment resulting from the hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010			
			Total EMP Loss (%)	RANK	Foreign EMP Loss (%)	RANK	Total EMP Loss (%)	RANK	Foreign EMP Loss (%)	RANK	Total EMP Loss (%)	RANK	Foreign EMP Loss (%)	RANK
1	A	Agriculture, Forestry and Fishing	3.21	12	0.02	15	2.80	14	0.08	14	1.67	15	0.05	15
2	C	Manufacturing	27.66	1	0.33	1	20.25	1	1.06	3	16.69	1	0.79	4
3	D, E	Electricity, Gas, Water supply and Waste Management	3.01	14	0.01	16	2.83	13	0.04	16	2.34	14	0.05	16
4	F, B	Mining, Quarrying and Construction	9.01	6	0.12	6	11.79	3	0.92	4	7.71	8	0.63	5
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	15.97	2	0.16	4	18.10	2	0.48	6	15.40	2	0.52	6
6	H	Transportation and Storage	9.19	5	0.15	5	8.19	8	0.29	7	6.52	10	0.22	10
7	I	Accommodation and Food service activities	9.40	4	0.24	3	9.85	5	1.11	2	11.61	4	1.04	2
8	J	Information and Communication	3.97	11	0.07	10	4.58	12	0.23	9	4.45	11	0.30	7
9	K	Financial and Insurance Activities	5.06	10	0.12	7	5.60	10	0.24	8	6.72	9	0.28	8
10	L	Real estate activities	1.16	16	0.02	14	1.43	16	0.08	15	0.90	16	0.07	14
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	5.77	9	0.31	2	10.62	4	1.15	1	12.29	3	1.25	1
12	O	Public Administration and Defence	9.82	3	0.09	9	8.78	7	0.19	12	9.48	6	0.22	11
13	P	Education	8.16	7	0.09	8	9.27	6	0.23	10	10.19	5	0.21	12
14	Q	Human health and Social work activities	7.00	8	0.04	13	8.18	9	0.20	11	8.98	7	0.26	9
15	R	Arts, Entertainment and Recreation	1.99	15	0.07	11	4.93	11	0.82	5	3.75	12	0.95	3
16	S	Other Service activities	3.20	13	0.04	12	2.37	15	0.14	13	3.17	13	0.17	13
17	T, U	Households as employers and activities of extraterritorial organisations	0.00	17	0.00	17	0.00	17	0.00	17	0.00	17	0.00	17

Source: Author's Calculations

Appendix I: Comparing the direct gross value added contribution of a sector with the impact of its hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010			
			Direct GVA (%)	RANK	Total Loss in GVA (%)	RANK	Direct GVA (%)	RANK	Total Loss in GVA (%)	RANK	Direct GVA (%)	RANK	Total Loss in GVA (%)	RANK
1	A	Agriculture, Forestry and Fishing	2.54	13	3.39	13	1.47	15	2.28	14	1.66	15	2.19	15
2	C	Manufacturing	23.67	1	29.23	1	15.34	1	20.07	1	12.95	1	16.56	1
3	D, E	Electricity, Gas, Water supply and Waste Management	1.73	15	2.31	14	1.70	14	2.26	15	2.36	14	2.80	14
4	F, B	Mining, Quarrying and Construction	4.59	11	5.40	12	4.91	12	7.62	8	4.79	12	7.00	10
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	10.95	2	12.25	2	11.62	2	14.92	2	10.68	2	13.41	2
6	H	Transportation and Storage	7.23	4	10.30	4	5.86	8	8.23	5	5.98	9	7.37	8
7	I	Accommodation and Food service activities	7.40	3	10.31	3	5.09	11	7.93	6	4.70	13	7.56	6
8	J	Information and Communication	4.27	12	5.42	11	5.30	10	6.72	11	5.52	11	6.61	11
9	K	Financial and Insurance Activities	5.18	8	6.52	8	4.55	13	5.90	13	7.81	5	8.81	5
10	L	Real estate activities	6.18	6	6.68	7	6.01	7	6.73	10	5.99	8	6.61	12
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	4.88	10	6.70	6	9.40	4	11.29	4	9.27	3	11.04	3
12	O	Public Administration and Defence	7.01	5	8.68	5	6.41	5	7.88	7	6.12	7	7.44	7
13	P	Education	5.72	7	6.26	9	5.51	9	5.92	12	5.80	10	6.17	13
14	Q	Human health and Social work activities	4.93	9	5.58	10	6.08	6	7.11	9	6.41	6	7.22	9
15	R	Arts, Entertainment and Recreation	1.82	14	2.26	15	9.41	3	12.88	3	8.57	4	9.70	4
16	S	Other Service activities	1.73	15	2.04	16	1.03	16	1.36	16	1.08	16	1.43	16
17	T, U	Households as employers and activities of extraterritorial organisations	0.17	17	0.17	17	0.30	17	0.31	17	0.31	17	0.31	17

Source: Author's Calculations

Appendix J: Comparing the direct income generated from a sector with the impact of its hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010			
			Direct Labour income (%)	RANK	Total Loss in Income (%)	RANK	Direct Labour income (%)	RANK	Total Loss in Income (%)	RANK	Direct Labour income (%)	RANK	Total Loss in Income (%)	RANK
1	A	Agriculture, Forestry and Fishing	1.13	15	1.90	15	0.80	15	1.61	14	1.00	15	1.52	14
2	C	Manufacturing	22.25	1	26.91	1	16.44	1	21.02	1	12.68	1	16.10	1
3	D, E	Electricity, Gas, Water supply and Waste Management	2.43	13	2.96	12	2.36	13	2.93	13	2.17	13	2.60	13
4	F, B	Mining, Quarrying and Construction	4.32	9	5.08	9	4.78	10	7.35	10	4.41	10	6.52	10
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	8.83	4	10.06	5	10.89	2	14.10	2	10.35	4	12.80	2
6	H	Transportation and Storage	8.33	5	10.90	4	6.00	9	8.44	9	6.37	8	7.70	9
7	I	Accommodation and Food service activities	8.09	6	10.90	3	6.09	8	8.75	7	5.64	9	8.13	8
8	J	Information and Communication	3.26	10	4.28	11	4.00	11	5.42	12	4.32	11	5.41	11
9	K	Financial and Insurance Activities	6.14	8	7.16	8	7.29	7	8.47	8	7.97	7	8.97	7
10	L	Real estate activities	0.15	16	0.66	16	0.19	16	1.01	16	0.20	16	0.82	16
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	2.82	11	4.51	10	7.97	6	10.04	4	9.64	5	11.33	4
12	O	Public Administration and Defence	11.72	2	13.17	2	10.62	3	12.08	3	10.52	3	11.79	3
13	P	Education	9.01	3	9.47	6	9.63	4	10.03	5	10.55	2	10.88	5
14	Q	Human health and Social work activities	7.42	7	8.04	7	8.75	5	9.84	6	9.62	6	10.40	6
15	R	Arts, Entertainment and Recreation	1.65	14	2.17	14	3.16	12	6.41	11	3.47	12	4.55	12
16	S	Other Service activities	2.44	12	2.73	13	1.05	14	1.38	15	1.10	14	1.44	15
17	T, U	Households as employers and activities of extraterritorial organisations	0.02	17	0.02	17	0.00	17	0.00	17	0.00	17	0.00	17

Source: Author's Calculations

Appendix K: Comparing the direct employment of a sector with the impact of its hypothetical extraction

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010			
			Direct EMP (%)	RANK	Total EMP Loss (%)	RANK	Direct EMP (%)	RANK	Total EMP Loss (%)	RANK	Direct EMP (%)	RANK	Total EMP Loss (%)	RANK
1	A	Agriculture, Forestry and Fishing	2.34	14	3.21	12	1.92	14	2.80	14	1.13	15	1.67	15
2	C	Manufacturing	21.44	1	27.66	1	14.90	2	20.25	1	13.04	2	16.69	1
3	D, E	Electricity, Gas, Water supply and Waste Management	2.40	13	3.01	14	2.24	12	2.83	13	1.90	14	2.34	14
4	F, B	Mining, Quarrying and Construction	8.22	3	9.01	6	9.18	3	11.79	3	5.45	9	7.71	8
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	14.74	2	15.97	2	15.06	1	18.10	2	13.06	1	15.40	2
6	H	Transportation and Storage	6.29	8	9.19	5	5.78	9	8.19	8	5.07	10	6.52	10
7	I	Accommodation and Food service activities	6.53	6	9.40	4	7.00	8	9.85	5	8.86	5	11.61	4
8	J	Information and Communication	2.83	12	3.97	11	3.18	11	4.58	12	3.32	11	4.45	11
9	K	Financial and Insurance Activities	3.81	10	5.06	10	4.34	10	5.60	10	5.68	8	6.72	9
10	L	Real estate activities	0.56	16	1.16	16	0.60	16	1.43	16	0.23	16	0.90	16
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	4.28	9	5.77	9	8.73	5	10.62	4	10.60	3	12.29	3
12	O	Public Administration and Defence	8.19	4	9.82	3	7.23	6	8.78	7	8.17	6	9.48	6
13	P	Education	7.73	5	8.16	7	8.86	4	9.27	6	9.84	4	10.19	5
14	Q	Human health and Social work activities	6.33	7	7.00	8	7.09	7	8.18	9	8.13	7	8.98	7
15	R	Arts, Entertainment and Recreation	1.44	15	1.99	15	1.87	15	4.93	11	2.71	13	3.75	12
16	S	Other Service activities	2.88	11	3.20	13	2.02	13	2.37	15	2.80	12	3.17	13
17	T, U	Households as employers and activities of extraterritorial organisations	0.00	17	0.00	17	0.00	17	0.00	17	0.00	17	0.00	17

Source: Author's Calculations

Appendix L: The backward and forward linkages obtained from non-complete hypothetical extraction method

Sector No	NACE Rev. 2	Sector	SIOT 2000			SIOT 2008			SIOT 2010		
			BL	FL	Linkages	BL	FL	Linkages	BL	FL	Linkages
1	A	Agriculture, Forestry and Fishing	1.38	1.62	K	1.09	0.95	B	1.22	1.25	K
2	C	Manufacturing	1.30	1.07	K	0.75	0.84	L	0.79	0.85	L
3	D, E	Electricity, Gas, Water supply and Waste Management	0.87	2.83	F	1.39	2.53	K	1.48	3.00	K
4	F, B	Mining, Quarrying and Construction	0.98	0.98	L	1.39	1.06	K	1.63	1.56	K
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	0.69	1.40	F	1.16	1.30	K	1.35	1.49	K
6	H	Transportation and Storage	1.17	0.74	B	1.34	1.48	K	1.33	1.96	K
7	I	Accommodation and Food service activities	1.64	0.45	B	1.50	0.41	B	1.85	0.44	B
8	J	Information and Communication	1.27	1.83	K	1.09	1.70	K	1.02	1.43	K
9	K	Financial and Insurance Activities	1.30	2.05	K	1.26	2.39	K	0.13	0.63	L
10	L	Real estate activities	0.52	0.40	L	0.66	0.83	L	0.75	1.00	F
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	1.61	2.36	K	1.07	2.35	K	1.36	1.84	K
12	O	Public Administration and Defence	1.01	0.12	B	1.06	0.22	B	1.07	0.22	B
13	P	Education	0.55	0.13	L	0.43	0.24	L	0.49	0.44	L
14	Q	Human health and Social work activities	0.60	0.04	L	0.87	0.04	L	0.76	0.06	L
15	R	Arts, Entertainment and Recreation	1.11	0.48	B	0.80	0.20	L	0.38	0.04	L
16	S	Other Service Activities	0.93	0.50	L	1.08	0.46	B	1.34	0.80	B
17	T, U	Households as employers and activities of extraterritorial organisations	0.06	0.00	L	0.04	0.00	L	0.05	0.00	L

Source: Author's Calculations

Appendix M: Ranking of the sectoral backward and forward linkages

Sector No	NACE Rev. 2	Sector	SIOT 2000				SIOT 2008				SIOT 2010			
			BL	RANK	FL	RANK	BL	RANK	FL	RANK	BL	RANK	FL	RANK
1	A	Agriculture, Forestry and Fishing	1.38	3	1.62	5	1.09	8	0.95	8	1.22	8	1.25	7
2	C	Manufacturing	1.30	4	1.07	7	0.75	14	0.84	9	0.79	11	0.85	9
3	D, E	Electricity, Gas, Water supply and Waste Management	0.87	12	2.83	1	1.39	2	2.53	1	1.48	3	3.00	1
4	F, B	Mining, Quarrying and Construction	0.98	10	0.98	8	1.39	3	1.06	7	1.63	2	1.56	4
5	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	0.69	13	1.40	6	1.16	6	1.30	6	1.35	5	1.49	5
6	H	Transportation and Storage	1.17	7	0.74	9	1.34	4	1.48	5	1.33	7	1.96	2
7	I	Accommodation and Food service activities	1.64	1	0.45	12	1.50	1	0.41	12	1.85	1	0.44	12
8	J	Information and Communication	1.27	6	1.83	4	1.09	7	1.70	4	1.02	10	1.43	6
9	K	Financial and Insurance Activities	1.30	5	2.05	3	1.26	5	2.39	2	0.13	16	0.63	11
10	L	Real estate activities	0.52	16	0.40	13	0.66	15	0.83	10	0.75	13	1.00	8
11	M, N	Professional, Scientific and Technical activities and Administrative and support service activities	1.61	2	2.36	2	1.07	10	2.35	3	1.36	4	1.84	3
12	O	Public Administration and Defence	1.01	9	0.12	15	1.06	11	0.22	14	1.07	9	0.22	14
13	P	Education	0.55	15	0.13	14	0.43	16	0.24	13	0.49	14	0.44	13
14	Q	Human health and Social work activities	0.60	14	0.04	16	0.87	12	0.04	16	0.76	12	0.06	15
15	R	Arts, Entertainment and Recreation	1.11	8	0.48	11	0.80	13	0.20	15	0.38	15	0.04	16
16	S	Other Service activities	0.93	11	0.50	10	1.08	9	0.46	11	1.34	6	0.80	10
17	T, U	Households as employers and activities of extraterritorial organisations	0.06	17	0.00	17	0.04	17	0.00	17	0.05	17	0.00	17

Source: Author's Calculations