Dynamics in Keysector-Analysis

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Abstract

The Hirschmanian-Rassmussen key-sector analysis is a static photo of the potential total impacts of the sectors of an economy in a specific moment of time. However, dynamics are important to realise the trends of an economy and observing successive photos may be useful. Trendalyzer is an information visualization software for animation of statistics, initially developed by Gapminder Foundation, included for free in Google Docs gadgets. This paper aims to show a new way to analyze and present input-output data taking advantage of free, ready and easy-to-use tools, in order to gain deeper insights in a collaborative environment.

Keywords: Input-output, Keysector analysis, dynamics, GoogleDocs, Interactive Charts.

Topic: 25.

1. Introduction

2. Key sector analysis

2.1 What is a key sector? Why is it useful?

Hirschman (1958) introduced the concept of the key sector for the very first time. This is a transposition of the logic of Schumpeter's (1912) concept of economic evolution to the sectoral level. It has been shown that economies are driven by innovative and adaptable firms, whose interaction explains the process of entry and exit of firms. This has been a source of long-term increases of productivity (Eliasson, 1991). At the sectorial level, such a scheme is represented by 'propulsive', 'leading' or 'key' sectors driving the economy to increases in interdependence and income levels (Cuello and Mansouri, 1992).

Obviously, the essence of the key sector concept relates itself to the concept of unbalanced development. Hirschman (1958) argues that the unbalanced development of main final demand sectors will drive the entire economy on the path of efficient growth like that of a competitive economy. The countries that have followed Hirschman's strategy have been the most successful in their development policies (these include Japan, Taiwan, and South Korea). Unfortunately, the countries for which the approach was first proposed (Latin American economies) enacted plans based on other concepts, such as the import substitution of basic industries and infrastructure projects.

However, the key sectors are an issue not only for developing countries. At a time of crisis, budgeting for regional development may also play an increasingly important role. During a crisis, efficient budgeting for Keynesian policies may benefit from input-output information through the identification of narrow key sectors. Moreover, EU regional development plans, essential for territorial cohesion policies, may be more efficient if the concept of key sectors is taken into account. Even Porter's (1990) concept of competitive advantage is closely related to the strategy of unbalanced development. Essential concepts for industrial policy, such as the cluster or value chain, are also closely related to the ideas of key sectors and linkages.

2.2 Multiplier Analysis

The so-called central input-output equation system offers multiple approaches for analysis (Eurostat, 2008):

$$b = c(I - A)^{-1}. \tag{1}$$

where A is the technological matrix, the row vector $\boldsymbol{c}$ includes the input coefficients (per unit of output) of the selected variables for the analysis (*e.g.*, intermediates, labor, capital, energy, emissions) and vector b (backward linkages) shows the direct and indirect requirements (*e.g.*, energy, labor, capital) or joint products (emissions) needed (or generated) to produce goods and services (Eurostat, 2008) that would satisfy one unit increase in final demand of commodities or industry outputs. Within this framework, the use of input-output systems is generally and often applied in the literature to evaluate environmental and employment policies, to productivity analysis, to energy issues, and so on. Notice also that when $c = e$, where e is a unitary vector of suitable dimension, b refers to output multipliers. Eventually, we will denote $L = (I–A)^{-1}$. As noted before, output b may be computed by summing over the rows of L.

Contrary to backward multipliers, the row sums of the Leontief inverse are a traditional but somewhat controversial forward linkage (FL) measure. They are interpreted as the impact on sector *i*'s output of simultaneous unit changes in each and every sector's final demands. This is objected by Jones (1976) for the unrealistic 'simultaneous unit changes' assumption and by Beyers (1976, p. 231) for having 'calculated FL on the basis of the strength of backward linkages'. Despite the controversies, this FL measure is widely supported by many authors (Haji, 1987; Hewings *et al.* 1989; Sonis *et al.* 2000, etc.). On the contrary, the row sums of the Ghosh inverse (Ghosh, 1958) are suggested to replace the Leontief's approach in estimating FL (Beyers, 1976 and Jones, 1976). Despite being endorsed by many authors either conceptually or empirically (Bulmer-Thomas, 1982; Dhawan and Saxena, 1992; Dietzenbacher, 2002; Miller and Blair, 2009; Oosterhaven, 1988; Poot, 1991; among others), the Ghosh inverse row sums (as a FL measure) are criticized by a few hard to neglect authors (e.g. Cella, 1984), who are mainly concerned about the 'implausibility' of the Ghosh model (Oosterhaven, 1988 and Mesnard, 2009).

Nevertheless, the row sums of the Ghosh inverse are widely used as a standard FL measure to capture both direct and indirect effects and this paper will not address this issue.

Although we are aware that the Ghosh inverse is not free of controversy, it is perhaps the least controversial FL measure. In an experimental work (Iráizoz, 2006), the Ghoshian measures have proven to provide similar results to those obtained by hypothetical extraction methods or Cai and Leung (2004). Therefore, we will use in this paper the Rasmussen (1956)'s coefficients under a Ghoshian transformation.

Similarly, we will define another input-output equation system for addressing forward multipliers (see the Ghosh price model), i.e.:

$$f = (I–B)^{-1}c^{T}. \qquad \mathbf{(2)}$$

That is, an increase in the value added coefficients coming from unitary changes in factor input prices will generate f amounts of e.g., energy, labor, capital, output or emissions. This model is mostly known as the "supply-driven" model since the initial shock is located on the value added component of industries (see a more detailed description in Dietzenbacher, 1997). In Equation (8), B is the Ghosh matrix, the column vector c^T denotes the input coefficients (per unit of output) of the selected variables for the analysis (*e.g.*, intermediates, labour, capital, energy, emissions), and the vector f (forward linkages) shows the direct and indirect supply-driven effects (*e.g.* energy, labour, capital) or joint products (emissions) for the newly produced goods and services. Within this framework, the use of input-output systems is generally applied to evaluate several kinds of policy impacts due to changes in factor prices of inputs and/or taxes (*e.g.*, environmental taxes). Notice also that when $c = e$, then, f refers to output multipliers. We will denote $G = (I–B)^{-1}$. Similarly, output f may be calculated by summing over the columns of G.

Sectors "above average" will have stronger total backward and/or forward linkages while sectors "below average" will have exactly the opposite meaning. These indices are known as the "powers of dispersion" according to Rasmussen's (1956) terminology. Table 1 schematically shows the method proposed by Rasmussen (1956).

Table 1. Traditional Multiplier-Based Key Sector Analysis

$b_j > \bar{b}$	Backward-oriented sector	Key sector
$b_j < \bar{b}$	Weakly-linked sector	Forward-oriented sector
	$f_i < \bar{f}$	$f_i > \bar{f}$

Notwithstanding the simplicity and intuitive approach of the Rasmussen's methodology, we are fully aware that this is not free of criticism. To mention two examples, the multiplier/linkage-based key sector analysis provides a rigid classification under which only a small distance would separate some sectors (*e.g.*, key sectors) from others (not close enough to the threshold) and the final identification of key sectors may even be very sensitive to the selected threshold (*e.g.*, simple mean, corrected mean, median, etc.). Further discussion of this would be addressed in the results section.

2.3 Shortcomings of Static Keysector Analysis

Two main issues concerns about static analysis: first, it avoids the underlying trends and second, it is impossible to know if the period analysed is an outlier one for any of the sectors. These problems cannot be even guessed by comparing the Figures 1 and 2.

Figure 1: Static Keysector Analysis for EU 2000 (Employment)

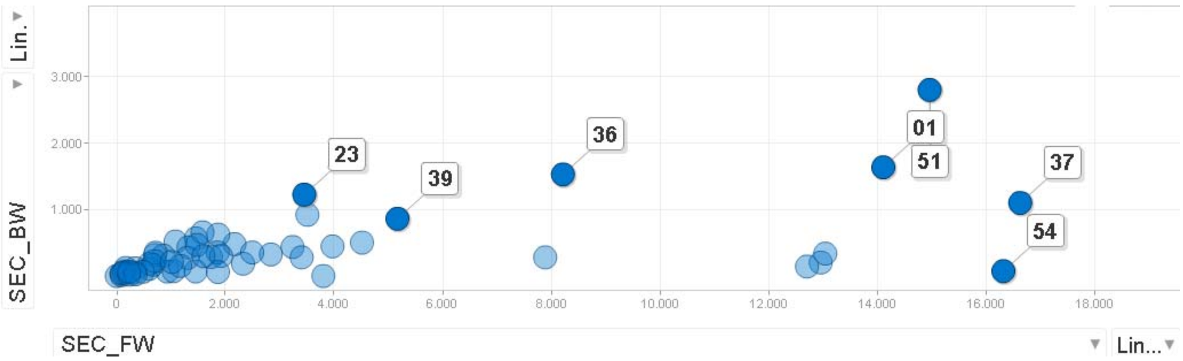
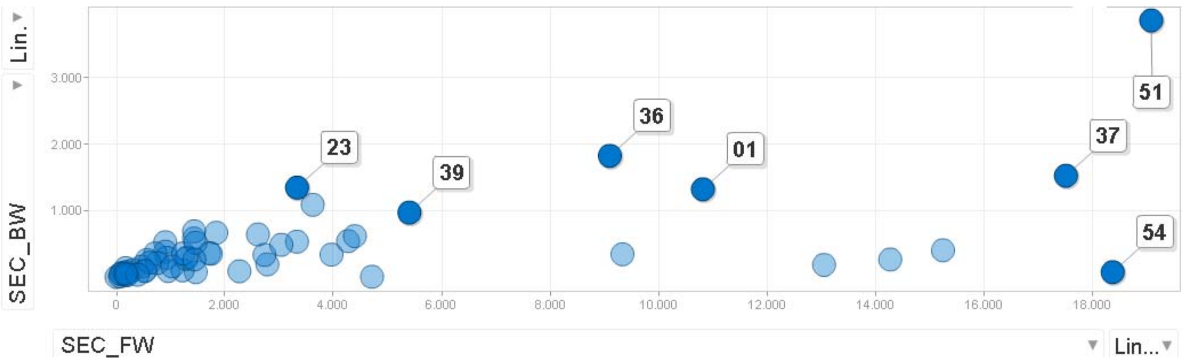


Figure 2: Static Keysector Analysis for EU 2007 (Employment)



Regarding the first problem (trends), only the (in)existence of differences not can be highlighted, i.e.: Industry 51 has increased its employment multipliers from 2000 to 2007. Industry 01 has reduced them. Industries 23 and 39 has not changed noteworthy. But what has happened in the meanwhile? Has the increase/decrease been a continuous process or has there been comings and goings?

Regarding the second problem (outlier?), looking at only one of the figures, 1 or 2, it is impossible to realise if the year considered is an outlier period. Even if that period is not an outlier for the whole economy, it can be an outlier for specific sectors. Making impact analysis with outlier multipliers can result in biased estimations.

3. Dynamic Key sector Analysis

3.1 Trendanalyzer, Gapminder and GoogleDocs

Trendalyzer is an information visualization software for animation of statistics. It was initially developed by Gapminder Foundation (www.gapminder.org), a non-profit established by the Swedish specialist in public health and development issues, Häns Rosling. Memorable presentations of him are available in the TED (Technology, Entertainment and Design) Talks repository (www.ted.org), another non-profit which slogan is “Ideas worth spreading”. The inspirational idea under Trendalyzer by its creator was: “break myths”. He referred to the problem that summarizing data usually hide interesting patterns or even worse, give the false impression that there is a unique patter (the “average”) that fits for the whole dataset forgetting the spread of data. Trendalyzer was lately bought by Google Inc. and included for free among the gadgets in the spreadsheets of GoogleDocs (an online office software). It is an easy and ready-to-use tool that do not need any programming knowledge.

3.2 Advantages

First, this tool lets to represent 4 variables and the time evolution in a single shot. Apart from the multipliers shown in the X and Y-axes, other two variables can be represented as the bubbles size and colors. This may be useful, for example, to represent the relevance of each industry/commodity as the output, value added or final demand to focus on the most important industries/commodities. It is very easy to change from one variable to others, just by using the drop-down lists (grey triangles). In the Figure 3, the standard static key sector analysis has been enlarged to account for the size of the sector (output) and its value added.

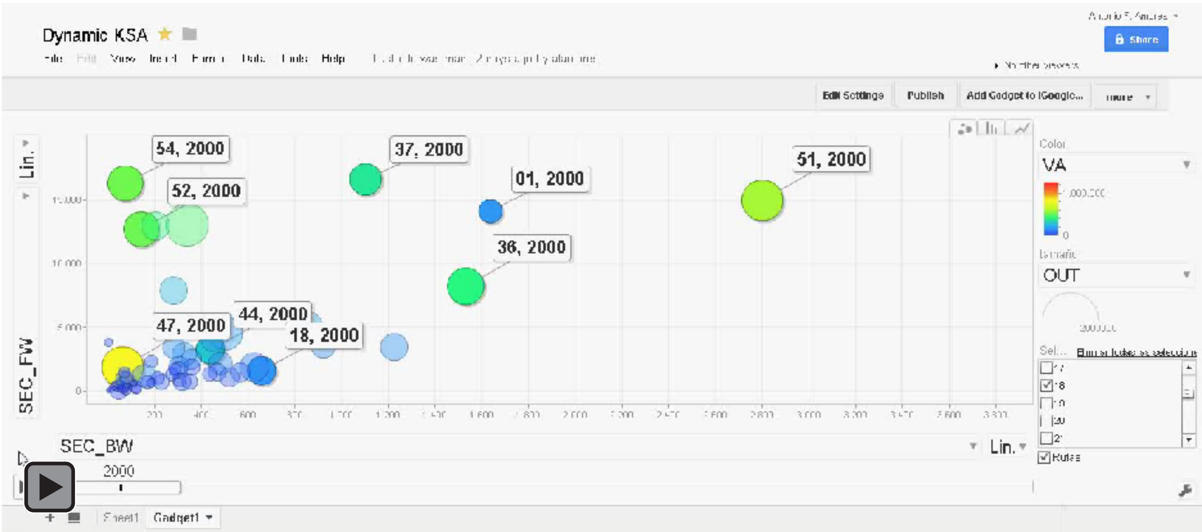
Figure 3: 4-variables Keysector Analysis for EU 2000 (Employment)

Video 1: Example of how charts can be modified

Specific industries/commodities can be selected by clicking over them or selecting from them from the list on the right (see the Video 1). Selected units are marked with a label with the name of column A and the date of column B. Selecting a unit makes that the non-selected ones appear in a semi-transparent colour. Besides, ticking the “Rutas” option, the path followed by each of the selected industries/commodities along the animation are shown. The speed of the animation can be adjusted with the selector next to the “play” button.

The trends of multipliers are easily observed with the temporal animations (see Video 2). At the same time this evolution can be useful to realize if/what multipliers are stable or not, and if from/up some period there is any change in the stability or evolution of multipliers. That clears any doubt on outliers. I.e.: Industries 01 and 51 present large movements, but the first decreases quickly in the first part of the analyzed period. The latter does it the other way round: it increases very quickly in the second part of the period. It is worthwhile to mention that Industries 01, 36, 37 and 51 do not present a continuous evolution, their multipliers were decreasing till 2004, and after that they grew up with a large speed. On the other hand the evolution of industries 54 and 52 was continuous. Industries 44 and 18 started and ended in the same point but some goings and comings happened in the meanwhile. Industry 47 remains more or less the same but its relevance in terms of value added increased dramatically, as well as industry 51.

Video 2: Dynamic Key Sector Analysis of EU 2000-2007 (Employment)

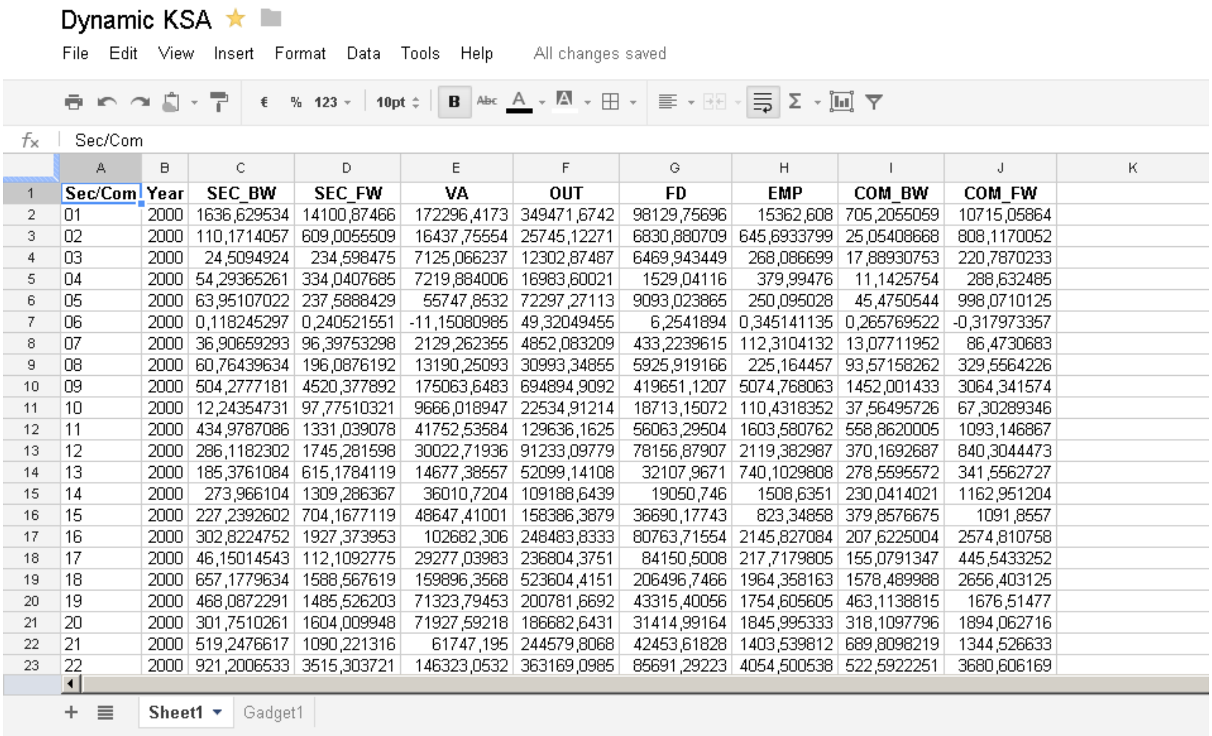


The animations can be shared with collaborators among Google registered users (using the blue “Share” button on the top-right corner) and easily published in any web or htm-stand-alone file (using the html code provided by the “Publish” button). Animations in html files can be performed offline after loading data. Although, the animation can be also recorded with any screencast software to include it in a text file or in slides, the usage of the animated tool is much richer. It is only the last aspect which may push to rethink the publishing standards. Despite the move to online publishing, the layout and presentation of scientific articles has altered little since the 17th Century. Maybe it is time to try html files and their multimedia capacities. I keeps the most important advantage of traditional publishing (content cannot be altered after publishing), but enriches the content and its communication, with state of the art tools.

3.3 How to do it:

Upload your dataset to a GoogleDocs spreadsheet and follow the instructions shown in http://www.gapminder.org/upload-data/motion-chart/

Figure 3: Dataset layout of the Keysector Analysis for EU 2000-2007 (Employment)



	A	B	C	D	E	F	G	H	I	J
1	Sec/Com	Year	SEC_BW	SEC_FW	VA	OUT	FD	EMP	COM_BW	COM_FW
2	01	2000	1636,629534	14100,87466	172296,4173	349471,6742	98129,75696	15362,608	705,2055059	10715,05864
3	02	2000	110,1714057	609,0055509	16437,75554	25745,12271	6830,880709	645,6933799	25,05408668	808,1170052
4	03	2000	24,5094924	234,598475	7125,066237	12302,87487	6469,943449	268,086699	17,88930753	220,7870233
5	04	2000	54,29365261	334,0407685	7219,884006	16983,60021	1529,04116	379,99476	11,1425754	288,632485
6	05	2000	63,95107022	237,5888429	55747,8532	72297,27113	9093,023865	250,095028	45,4750544	998,0710125
7	06	2000	0,118245297	0,240521551	-11,15080985	49,32049455	6,2541894	0,345141135	0,265769522	-0,317973357
8	07	2000	36,90659293	96,39753298	2129,262355	4852,083209	433,2239615	112,3104132	13,07711952	86,4730683
9	08	2000	60,76439634	196,0876192	13190,25093	30993,34855	5925,919166	225,164457	93,57158262	329,5564226
10	09	2000	504,2777181	4520,377892	175063,6483	694894,9092	419651,1207	5074,768063	1452,001433	3064,341574
11	10	2000	12,24354731	97,77510321	9666,018947	22534,91214	18713,15072	110,4318352	37,56495726	67,30289346
12	11	2000	434,9787086	1331,039078	41752,53584	129636,1625	56063,29504	1603,580762	558,8620005	1093,146867
13	12	2000	286,1182302	1745,281598	30022,71936	91233,09779	78156,87907	2119,382987	370,1692687	840,3044473
14	13	2000	185,3761084	615,1784119	14677,38557	52099,14108	32107,9671	740,1029808	278,5595572	341,5562727
15	14	2000	273,966104	1309,286367	36010,7204	109188,6439	19050,746	1508,6351	230,0414021	1162,951204
16	15	2000	227,2392602	704,1677119	48647,41001	158386,3879	36690,17743	823,34858	379,8576675	1091,8557
17	16	2000	302,8224752	1927,373953	102682,306	248483,8333	80763,71554	2145,827084	207,6225004	2574,810758
18	17	2000	46,15014543	112,1092775	29277,03983	236804,3751	84150,5008	217,7179805	155,0791347	445,5433252
19	18	2000	657,1779634	1588,567619	159896,3568	523604,4151	206496,7466	1964,358163	1578,489988	2656,403125
20	19	2000	468,0872291	1485,526203	71323,79453	200781,6692	43315,40056	1754,605605	463,1138815	1676,51477
21	20	2000	301,7510261	1604,009948	71927,59218	186682,6431	31414,99164	1845,995333	318,1097796	1894,062716
22	21	2000	519,2476617	1090,221316	61747,195	244579,8068	42453,61828	1403,539812	689,8098219	1344,526633
23	22	2000	921,2006533	3515,303721	146323,0532	363169,0985	85691,29223	4054,500538	522,5922251	3680,606169

In our case, data in each column are:

Column in Spreadsheet	Default meaning in Motion Chart (Bubbles)	Variable in our example
A	Entities	Sectors/commodities
B	Time values	Years
C	Y-axis	Sectoral backward multipliers
D	X-axis	Sectoral forward multipliers
E	colour of the bubbles[1]	Value added
F	size of the bubbles	output
G and following	drop down lists	Final demand, Employment, Commodity backward/forward multipliers

The videos contained in this paper, have been screencast using Camstudio-Recorder (freeware). This is fine for presentation purposes, but for research (pure research, before results communication) the GoogleDocs spreadsheet or an html file with the code generated by the tool is much more useful because of its interactivity.

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[1] If the variable is quantitative, the reddish, the larger the represented figure is; the bluer the smaller the represented figure is.

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