Physica A 479 (2017) 236–248

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

The topology of inter-industry relations from the Portuguese national accounts

Tanya Araújo [*,1], Rui Faustino

ISEG (School of Economics and Management), University of Lisbon, Miguel Lupi 20, 1248-079 Lisbon, Portugal

HIGHLIGHTS

- From the Portuguese Industry/Product Output tables, networks of inter-industry relations are defined.
- Topological analysis characterizes the structure of these networks from 2000 to 2014.
- Industrial networks are complemented with the construction of their corresponding MSTs.
- Two topological coefficients (Redundancy and Residuality) allow for capturing important structural changes after 2011.
- These changes result from the implementation of the recent Portuguese economic adjustment program.

ARTICLE INFO

Article history:
Received 19 December 2016
Received in revised form 19 January 2017
Available online 9 March 2017

Keywords:
Industry/product output table
Network analysis
Minimal spanning trees
Industrial clusters
National accounting systems
Proximity networks

ABSTRACT

In last years, the Portuguese economy has gone through a severe adjustment process, affecting almost all industrial sectors, the building blocks of economic structures. Research on economic structural changes has made use of input/output tables to define networks of industrial relations. Here, these networks are induced from output tables of the Portuguese national accounting system, being each inter-industry relation defined by the output made by any two industries for the products that they both produce. The topological analysis of these networks allows to uncover a particular structure that comes out during the Portuguese adjustment program. The evolution of the industrial networks shows an important structural change in 2011–2014, confirming the usefulness of inducting similarity networks from output tables and the consequent promising power of the graph formulation for the analysis of inter-industry relations.

1. Introduction

As most complex systems, economic structures may be described in many different ways. The simplest descriptions are usually built on top-down decompositions, where aggregation of economic concerns can be either driven by institutional sectors: households, firms and government or by economic outputs as in the three approaches of GDP measurement: the production, expenditure and income approaches.

The economic outputs used in the calculation of GDP by the production approach are collected, validated and reported by national statistical systems. In so doing, these systems organize production by products (goods and services) which are produced by industries. Because each industry is able to produce several goods and since a given good can be the output of various industries, the top-down decomposing chain (sector → industry → product) may be conveniently replaced by a

* Corresponding author.
E-mail address: tanya@iseg.ulisboa.pt (T. Araújo).
[1] UECE - Research Unit on Complexity and Economics.

http://dx.doi.org/10.1016/j.physa.2017.03.018
0378-4371/

bottom-up description, where economic structures are built on inter-industry relations. In this setting, it is possible to define each inter-industry relation as the output made by any two industries for the products that they both produce. In so doing, the strength of an inter-industry relation – between any two industries – depends on the number of common products that they share.

The adoption of a bottom-up perspective and the availability of year-based data allows for analyzing the time evolution of inter-industry relations from a network approach. Moreover, such a relational setting provides the basis for evaluating the degree of specialization of the economy from the distribution of its industrial production.

Network approaches are the natural setting for representing and analyzing relational linkages. There has been an increasing interest in applying network approaches to economic problems, from the reconstruction of artificial financial markets to the analysis of international trade, there is a great number of successful and inspiring applications ([1–9]). The first step in the adoption of a network approach concerns the definition of the network nodes and links. As there are many ways to relate the elementary units of a system, the choices may depend strongly on the questions that a network analysis aims to address [10].

The main objective of this paper is to investigate the extent to which the Portuguese economic performance from 2000 to 2014 had some bearing on the Portuguese inter-industry relations. Given the recent process of strong economic adjustment suffered by the Portuguese economy from 2011 to 2014, we focus on the impact of this process on the Portuguese economic structure which is herein represented by bipartite networks of inter-industry relations.

In many economic networks – and specially in those induced from empirical data – the adoption of a network representation intuitively emerge. It happens because these systems are characterized by a low abstraction level, being the network representation the most obvious solution, as in the case of air-traffic, power-grid, and trade networks.

It also happens with the specific field of input/output (I/O) tables, an important part of the national accounting systems. Because I/O tables are quite similar to adjacency matrices there has been an increased interest in applying network theory to represent money flows between industrial sectors [11–17].

In the pioneering work of Slater [12], 75 industries are clustered according to the USA inter-industry flow table of 1967. Later, Schnabl [13] applies Minimal Flow Analysis to induce networks from the German I/O tables reporting data in between 1978 and 1988. There, centrality measures allow for classifying industries into three different sectors (source, sink and center). More recently, Blöchl and co-authors [11], using I/O tables of 37 OECD countries, induce networks of industries to which measures of random walk centrality and counting betweenness are applied. Their results have shown the suitability of those measures in the identification of groups of countries according to their development status.

The present study also falls into the broad category of data-driven investigation on industrial relations using a network approach. Nevertheless, we follow a different perspective. Instead of considering I/O tables, we take the output of each industry distributed by the set of products that this industry produces. Inter-industry relations are then defined by the production of common products. Industries are linked whenever they share at least one mutual product, being the strength of each inter-industry link defined by the output made by the involved industries for the products that they both produce. In so doing, the intensity of a link between any two industries depends on the number of mutual products weighted by their relative (output) values in each linked industry.

The networks we work with are proximity (and bipartite) networks. In proximity networks, the links are defined from shared features, correlation coefficients or other well-defined similarity measures. Like in many other economic networks, the elementary units do not have to be explicitly linked by any concrete relation existing in the real world except for a well-defined measure of distance in between them. Although the induction of proximity networks is less intuitive than those obtained from the air-traffic, power-grid or I/O table examples, they provide useful analytical settings, being found in a multitude of applications. Examples of proximity networks in Economics can be found in references [18–20]. A detailed discussion on proximity networks is presented in reference [10].

The paper is organized as follows. Section two presents the data we work with. Section three is targeted at presenting the methodological aspects and a brief discussion on the first results. Section four discuss the evolution of the Portuguese industrial networks, focusing on the topological analysis of different time periods . Finally, Section five presents the concluding remarks.

2. The data

Our data source is the year-based Industry/Product output tables ($OT^t t = 2000, 2001, \ldots, 2014$) compiled by the Portuguese national accounting agency (INE [21]). The output tables consist of data on production values (at market prices) organized by industry and related products. In this context, industries (I) refer to firms and other business, and the products (P) refer to goods and services. Moreover, while the classification of a given business into a specific industrial category (I) is determined by its economic activity classification (NACE code) by taking into account the main activity of the firm; products (P) are classified by activity according to a statistical coding (CPA code).

There are international standards for the industry (and product) classification sets provided by the United Nations (UN) and adopted by most of countries. The UN System of National Accounts (SNA) provides the basis for uniformity among the various data sets, while the OECD industry classifying into 10, 21 and 38 industries makes the international comparisons possible [22].