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Blocks and circularity in labour requirements: An interplay between clusters and subsystems in the EU

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ABSTRACT

Clusters and subsystems are two frequently used tools in inter-industry analysis, the former clarifying structure while the latter summarising circularity. Since industry blocks with crucial direct linkages will probably have strong indirect ties as well, localised intra-cluster feedback effects may play a prominent role in explaining total labour requirements. In this paper, we first quantify the labour redistribution taking place between industries and subsystems within and between clusters. Next, we extend the standard notion of vertically integrated labour to account for intra- and extra-cluster circularity, quantifying the extent to which overall productivity growth in every subsystem originates from intra-cluster industries. Both issues are illustrated for the consolidated European Union (EU27) economy between 2000 and 2007.

> Dependence and independence, hierarchy and circularity [...] are the four basic concepts of structural analysis. (Leontief, 1986 [1963], p. 166)

1. Introduction

The extent and pace of economic growth crucially depends on the *structure* of the economic system. In particular, a detailed analysis of inter-sectoral linkages and *industry blocks*[1] – i.e. "the most important chains of sectors in the input–output table, as these denote the most important or *fundamental structure* of an economic system" (Hoen, 2002, p. 134, italics added) – on the one hand, and of the *circularity* of production – i.e. the extent and roundaboutness of linkages between industries within the comprehensive production process of each single item of final demand – on the other, are of utmost importance for the definition of effective industrial policies. While the former task may be achieved through cluster analysis, the latter relies on reduction procedures.

The *reduction* of an input–output (IO, hereinafter) model was formally introduced by Leontief (1967)[2]; it consists in choosing a group of commodities in terms of which all others have to be expressed, their output thus being

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[1] In what follows the terms 'cluster', 'industry block' and 'community' will be interchangeably used to indicate a subset of industries sharing strong connections.

[2] See also Guccione and Gillen (1995).

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eliminated.[3] By doing so, the unit of analysis switches from the industry to the corresponding final demand subsystem (in the sense of Sraffa, 1960), and the reduced commodities participate into vertically integrated productive capacity and labour (Pasinetti, 1973).[4]

Instead, the focus of *cluster* analysis in an IO context has been mainly twofold: mapping the fundamental structure of an economic system via graphic techniques, and looking for consistent aggregation criteria (Ghosh, 1960). In both cases, the starting point has been that of scaling down the degree of complexity of the information provided by IO tables, through the identification of industry groups connected by above-average linkages.

Even though IO literature is rich of attempts in both directions, to our knowledge few attention has been devoted to the fact that clusters' identification provides a *partition* of the inter-industry network, which can be treated in a similar fashion (from a purely formal point of view) as the partition into regions of a multi-regional IO table.

In particular, by exploiting block partitioning of matrices, it is possible to quantify backward and forward linkages between clusters along the same lines as has been done for the case of different regions by, e.g. Miyazawa (1966) and Miller (1969). Such extension was already envisaged by Miyazawa (1966), and further developed in Miyazawa (1971), who studied "the interdependence between service and goods-producing sectors", partitioning the IO matrix according to this criterion. A similar idea was also put forward by Milana (1985), who posed the question of how to build subsystems for gross, rather than net, output, exploiting Miyazawa's internal and external matrix multipliers.[5]

A key point of computing internal and external multipliers is that of measuring feedback and spillover effects. In particular, if we consider two industry clusters (A and B), final demand directed towards group A might induce demand for group B intermediates which, to be produced, require further inputs from group A, generating a feedback effect. Instead, demand for intermediates by group A, produced by industries in group B, to satisfy final demand of group A products, gives rise to spillovers.

The aim of the present paper is that of further developing the analysis of internal and external matrix multipliers, by rendering endogenous the partition of the IO table into industry blocks via cluster analysis. Moreover, by deriving vertically integrated sectors at the cluster level we identify *blocks of circularity*. In so doing, linkage measures between each *cluster* and the rest of the economy are introduced. A hierarchy of such clusters according to their closeness to final demand is further obtained on the basis of the difference between vertically integrated and direct labour.

Linkage indicators usually refer to the systemic effects induced by a single sector, or to the effect of all other activities on a given specific industry. The main original feature of the present contribution with respect to traditional analyses is that of singling out linkages between industries conforming structural paths, by grouping activities whose interactions have an above-average weight in determining systemic effects.

More specifically, the two research questions faced by the present contribution are the following:

- what is the labour redistribution between intra-cluster and extra-cluster industries and subsystems?
- what is the proportion of total (direct and indirect) labour requirements of each subsystem which is due to: (a) self-contained intra-cluster circularity, or (b) induced inter-cluster feedback and spillover effects?

The first question aims at identifying net backward linkages at the cluster level, which could be exploited by properly coordinated final demand expansions in order to stimulate employment. Additionally, it may render explicit the extent of phenomena such as tertiarisation. The answer to the second question provides a separate assessment of internal synergies within a cluster, on the one hand, and of feedback and spillover effects between clusters, on the other, which may be of importance in the design of performance indicators for industrial and innovation policies.

In fact, motivating the distinction between reduction and clustering, emphasized throughout the paper, within the context of industrial and innovation policy design is highly relevant. A 'wide' taxonomy of industrial policy includes (Pelkmans, 2006, p. 47): (i) framework aspects (e.g. competition policy, quality standards), (ii) horizontal interventions (e.g. labour force training, public procurement, R&D stimuli) and (iii) sectoral/specific interventions (e.g. *filières*, trade policy, specialised technology policy).

On the one hand, reduction procedures, focusing on direct and indirect content of a common element (labour, energy inputs, R&D expenditure) per unit of final demand, might be a valuable tool for assessing the systemic effects of *horizontal* industrial policy. For example, R&D stimuli or labour training programmes imply changes in industry-specific intensities, whose propagation through the IO network may be quantified. Subsystems are particularly useful for this task.

On the other hand, clustering leads precisely to the identification of linkage-based *filières*, providing a basic input to *sectoral* industrial policies. State aid targeted towards strategic industries might benefit from a 'graph' of strongly connected sectors, which renders clear, for example, to what extent there are synergies between health services, pharmaceutical and medical equipment industries, or if the construction industry depends more on its forward suppliers (real estate and financial services) rather than on its input providers (sand, cement, wood and metal products).

[3] A concept that can be traced back to the origins of economic analysis: "Adam Smith discussed at length the question of whether corn should be measured in labor units required to grow it, or, on the contrary, labor measured in terms of corn that a worker needs to live" (Leontief, 1967, p. 419).

[4] In what follows, the terms 'subsystem' and 'vertically integrated sector' will be interchangeably used.

[5] Building on Milana (1985), Heimler (1991) computed what he called the industries' *degree of vertical integration*, i.e. the ratio of value added directly or indirectly due to each industry's *gross output* to total value added.