

# CLUSTERIZATION: EFFECTS ON SOME INDUSTRY SECTORS OF LITHUANIA

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**Abstract.** *In this paper we focus on clusterization in Lithuanian wood products manufacturing and in computer, electronic and optical products manufacturing industries. These sectors were chosen upon analyzing Jucevičius (2003) and Jucevičius (2009) who describe them as having undergone a clusterization process. We use graphical and statistical analysis to find that clusterization has had a positive effect on the mentioned industries. Our analysis also covers a brief review of clusterization theory, development and current state. We also note that clusterization is supported in the European Union, which might be one of the major reasons why it has been accepted in Lithuania. Finally, we argue that competent practitioners who focus on clusterization professionally are scarcely available in the labour market, and clusterization theory is far from mature and requires a lot of academic input.*

**Key words:** *cluster as an economic policy measure, cluster, clusterization, economic clusterization effect, structural break test*

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## Introduction

There are a lot of reasons that make clusterization relevant to both business and research. This phenomenon, being a pool of all the necessary resources, creates all the required preconditions for the commercialization of inventions. However, the theoretical background is still not mature enough to ensure the creation of clusters in different areas and to make government policies more efficient. Despite the fact that clusters (as a form of running one's business) have been existing and helping to create a greater added value for a rather long time now, they had little success in attracting adequate academic attention.

This leads to a need of more research effort in the field. Further studies should try to describe the effects of clusterization with empirical data and explore the phenomenon

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not only in a qualitative but also in a quantitative direction, especially on the macrolevel. The economic consequences of clusterization are widely acknowledged, but there is a lot of room for research extension and theory improvement because the existing literature on the phenomenon is rather recent.

Therefore, we have set ourselves the objective to analyze the existing literature on clusterization theory. We aim to systemically discuss clusterization as a macroeconomic policy measure in European Union and to test some of Lithuanian manufacturing industries for possible changes in production output because of clusterization.

To achieve the mentioned goals, we use have systemic and logical analysis of academic literature. We also applied analogies, complex generalizations and comparisons as well as document analysis and an econometric Perron structural break test.

When business structures concentrate into clusters, a new range of opportunities becomes available, such as gain in competitiveness, reduction in costs, or a decrease of business organization risks. Moreover, creating innovative, new or improving old products becomes easier. Consequently, new export markets open up and business entities receive more room for expansion.

Although performing in a cluster provides undisputed economic benefits, they are not attainable if the members of a cluster do not perceive them in advance. This has some practical consequences in the first phases of clusterization as firms may see their goals as incompatible. The essence of a cluster is the creation of a multidimensional link system for joint activity, and this requires defining common goals in the first place. Governments are also interested in successful clusterization processes, therefore, they engage in various policy actions that favour the phenomenon. Detailed studies on the matter are needed to enable the government to create effective measures for stimulating clusterization.

The rest of this paper is structured as follows. In the first section, we analyze the literature on the definition and classification of clusters. Then clusters are characterized as macroeconomic policy measures, mainly focusing on the policy of the European Union, and different views on the matter. The third section contains a comparative analysis of studies carried out in Lithuania regarding the clusterization phenomenon. In the next section, we perform the Perron structural break tests on a time series of wood products and computer, electronic and optical equipment industries. The final part of this paper presents the conclusions of this research.

## **1. The definition of cluster**

The author classical cluster theories is Porter (1998), and his definition of cluster is the basis for the other authors' research on the phenomenon of clustering. In fact, in the scientific literature, in the studies initiated by the European Union and the government, the assumptions of clusterization and effective incentives for cluster formation are usually

analyzed. However, at this stage, most often scientific analysis is concluded. Clusters as an academic subject are very new, and the analysis of the cluster subjects is only in its initial stage.

As already mentioned, the most commonly used definition of a cluster belongs to Porter (1998). A business cluster is a geographic concentration of interconnected businesses, suppliers, and associated institutions in a particular field. Clusters are considered to increase the productivity with which companies can compete both nationally and globally (Porter, 2000). This definition refers to the main reason for grouping into clusters, which are international competition and its changes. Changes in the international market create a need to support economic development in Lithuania by increasing business efficiency, understanding the efficiency as an integral part of innovation.

Most of the cluster's benefit is achieved due to the integration of different competencies of human resources. It should be noted, that a cluster embraces not only the co-operating companies; it is a synergy of a dynamic relationship and network between the cluster members (business, government, education institutions, and support organizations).

According to the scientific literature, clusters appear in different ways:

- companies often need specialized labour force;
- the business is dependent on the geographical location where natural resources are concentrated;
- business is dependent on infrastructure;
- there is a need for research.

For these reasons, companies determine to concentrate into a cluster and grow in the region. Of course, in some cases it is possible to start a cluster if there is the business leaders' consensus on cooperation as a consequence of communication. Despite these considerations, the supporting infrastructure is vital for cluster development, and the absence of infrastructure may be the major cause of a slow progress of clusterization.

Each cluster in different regions have different strengths. Overall, the region where the cluster is based has reached a significant competitive advantage. According to Porter (1998), clusters have the ability to offer local benefits, such as the pooling of expertise, developed relationships, and motivation to work together. Cluster creates jobs, encourages innovation.

Cluster entities are related by manifold connections, so it is worth noting that a cluster is an integral part of the clustering phenomenon; its theory is based on the sociology of science, specifically on social structure theory describing the relationship between a set of nodes. According to Vilkas and Bučaitė-Vilkė (2009), network theory can be studied at different levels, such as interpersonal, organizational, inter-organizational. According to these authors, the interpersonal level is associated with the provision that

an individual behavior depends not on personal qualities but only on the involvement into social networks. The organizations that are interrelated by manifold connections consist of numerous components (individuals, groups, organizational units). All the components' behaviour varies depending on the changing relations among them, which means that even the economic behaviour is embodied in the interpersonal networks. Another important phenomenon described by scientists is the result of networking, where individuals can reach each other in a very small number of intermediaries; it is the so-called small-world effect. A deep analysis always enables researchers to make the same conclusion: clusterization allows achieving a greater efficiency and a new quality.

Recently, the often discussed concept of cluster has been included in the cluster theory. The concept of clustering amplitude predetermines the clusterization analysis of multiple incisions, discovering many new approaches. In principle, the cluster is a network-type organization. It is a network type business formation and organization that preconditions the development of the new value-added to all management processes.

The comprehensive availability of a new quality implies the necessity of developing a cluster theory. The usefulness of the clustering phenomenon has already been proven by numerous scientific researches. However, as mentioned before, the issue of scarce scientific theory of clustering is still actual.

According to Ministry of Economy of the Republic of Lithuania (2012), knowledge required for innovations cannot be accumulated in state institutions or individual companies. It is scattered across many players of the system: companies, universities, government structure, and most probably the only way companies can use this knowledge for the development of innovation is cooperation with the neighbouring businesses, organizations or institutions while combining the existing competencies of unique services and products.

The search for competitive advantage stimulates the search for new business models. In principle, clusters are not a new phenomenon, but their theory is very new. It is recognized that regional clusters are a phenomenon of developed and rapidly expanding economies. New processes and information sources create a need to change the perception of business. The conception of competition is changing: classical competition (individual and business arrangement) is being changed with internal competition. Consequently, there opens a possibility for a shift to a new qualitative level as clusterization allows for synergy effects by integrating subjects of different competences. According to Porter (1998) and Krugman (1994), competitiveness is perceived as a broad concept which comprises a low resource cost, the quality of public administration at a national level, including geographical and cultural factors.

The definition of a cluster is provided by a number of authors. Typically, these definitions are only Porter's (1990; 2000) definition's modifications, just focusing on some elements to describe the cluster, on the grounds that the latter is most important. It

can be argued that the definition of cluster is receptive to the addition which arises from the need to create effective cluster-describing criteria for granting support to businesses if they are creating a cluster.

Cluster theory is still being developed; each case it is possible to find different criteria that describe the cluster formation process.

Nevertheless, the definitions of cluster in the literature are rather similar, and it is possible to identify the key elements as the main components combined in different ways by different authors in their definitions.

Different definitions of cluster can be characterized by the main cluster elements that describe the entity. The main aspect in the definition of cluster is geographical concentration, say Porter (1990), Porter (2000), Marshall (1890), Silvestre and Dalcol (2010), Felzensztein (2008), Pearl (2010), Williams and Claiborne (2009), Callarisa Fiol (2009), Jucevičius (2009). As a very important aspect of identifying the cluster, Brito and Costa (2009), Felzensztein (2008), Chong Ju Choi et al. (1999), Pearl (2010), Xiaoqiang (2009), Jucevičius and Puidokas (2007) distinguish multiple connections between the cluster members. The end product and the role of scientific institutions as an integral part of cluster in order to identify the formation are stressed by Porter (1990), Porter (2000), Schumpeter (1930), Romer (1998), Montresor and Marzetti (2008), Brito and Costa (2009), Felzensztein (2008), Hatani (2009), Williams and Claiborne (2009), Jucevičius and Puidokas (2007).

Generally, in the literature, the definition of cluster stresses either the perception of the value chain or the sector arrangement. The first approach has been developed by Porter (1990), Porter (2000), Romer (1998), Silvestre and Dalcol (2010), Brito and Costa (2009), Hatani (2009), Pearl (2010), Xiaoqiang (2009), Williams and Claiborne (2009), Callarisa Fiol (2009), Jucevičius (2009). The sector approach is followed by Montresor and Marzetti (2008), Silvestre and Dalcol (2010), Felzensztein (2008), Xiaoqiang (2009). Some authors suggest that geography is losing its relevance in the current conditions of information technologies and telecommunications (ITT). Melnikas (2009), Montresor and Marzetti (2008), Hatani (2009), Jucevičius and Puidokas (2007) say that that geography is absolutely not necessary for establishing a network-type organization. The only necessary elements for a cluster are the exclusive possession of skills and the implementation of value chain activities by specialization. The authors ask whether all this can be achieved with geographic distance, which can be overcome by the information technologies and telecommunications. Another trend is that not all the authors emphasize the importance of clusters in cooperation with scientific institutions. Most important is the ability to share risk and to develop a greater economic power and a significant competitive advantage which occur due to special skills, but the need of educational institutions is not always emphasized. It should be noted that the importance of educational institutions is indicated by the authors focusing on the clusters that are implementing innovations.

A rarely encountered criterion is the industry cluster version. In essence, this criterion loses importance of natural cluster's practices: it is practically impossible to achieve that the cluster does not exceed one sector boundaries.

As mentioned above, clusters are analyzed on different layers. Although the topic of academic clustering approach is new, there are many different approaches. It is worth noting that a cluster may be considered as a form of business organization. As an organization, a cluster can be analyzed in its life cycle perspective. Most clusters are able to renew themselves through innovation, because the nature of a cluster ensures its internal dynamics. A cluster exists both in local and in global spaces. There are two opinions: some scientists say that geographic proximity allows acquiring collaborative skills through innovation, while others argue that the relationships that are expressed on a global scale are the key element in assuring technological advantage. The geographical aspect in the age of information and telecommunications is a subject of discussion. On the other hand, this discussion cannot be limited by the unique properties of clusters. Each case is different and unique and cannot be cloned.

## **2. The classification of clusters**

Each cluster is quite unique, but to form a sustainable theoretical basis, the definitions of clusters' are justified. The mostly of sort clusters into classes.

Clusters are usually classified according to several criteria. Xiaoqiang (2009) classifies them according to the degree of specialization and by the size; Jucevičius (2008) provides a broad classification of clusters by their specialization, goals, life cycle or scale. Malakauskaitė and Navickas (2010), Huggins (2008) classify clusters according to life cycle. In the literature, the classification of clusters is based either on their scope (by analyzing a number of different classification criteria) or on their depth (by analyzing the classification system or a cluster's life cycle).

There are many different kinds of clusters. There also exist quite different ways of classifying clusters based on the cluster definition. Jucevičius (2008) provides a classification, which is very comprehensive and focused on the scope. The author argues that clusters can be classified into:

1. Very small clusters, or horizontal networks (cluster entities cooperate in certain areas of the initiatives).
2. Value chain clusters (a classic example of the cluster members specializing in the value chain).
3. Supply chain clusters (cluster entities supplying components for a large manufacturer or a group of manufacturers).
4. Industry clusters (cluster entities are companies that produce similar goods or offering similar services, i.e. operate in one sector and form a network of competencies).

5. Geographical; clusters this classification describes the geographical distribution of subjects, ranging from the city, county clusters, local clusters, regional clusters, to the national or international clusters.

According to Huggins (2008), the main characteristic in cluster classification is the life-cycle stage. According to this author, the key indicator of a cluster is its maturity: it allows grasping the properties that are characterizing clusters. This classification focuses on the depth.

According to Xiaoqiang (2009), the main differences between clusters are their value chain and sector characteristics. This classification is oriented to the scope. According to the author, the classification of these two potential cuts is very different in nature: industry clusters are the subject of economics, and the value-chain clusters are closer to business organization, clusterization sciences. The value chain model by this author is recognized as classical, but as the basis for a possible cluster analysis it is currently too narrow.

The sector cluster, called industrial in the above mentioned source, is reported as an economic phenomenon. It must be emphasized that regional businesses that belong to the same industry are not considered a cluster. Whether there is a cluster or not depends on the characteristics of the relationships among the businesses under review: in order to have a cluster, links between subjects must be network-like.

In the value chain case, clusters are supraregional or even global, while sector clusters are quite limited geographically. Returning to the cluster's principle, it should be noted that sector clusters are a precondition for the successful operation of value chain clusters as these clusters complement each other.

Malakauskaitė and Navickas (2010) offer to base cluster classification on their level of development. This approach is very close to Huggins' (2008) theory. The latter author distinguishes the following stages: establishment of a cluster, its development stage, maturity, decline, and transformation.

In principle, cluster classification reveals all the possible clustering techniques and the value that can be achieved in the future. In practice, there is always a need of creating detailed cluster recognition criteria because of government policies to support clusters and because of new different ways of making a cluster.

It is likely that the future classification of clusters can be expanded. Currently, the scientific literature is more oriented towards the interpretation of the formation depth than scope. This can be interpreted in all aspects of the issue in a cluster in order to achieve a substantial progress in understanding clusterization.

### **3. Cluster as a leverage of macroeconomic policy**

Because of the high economic benefit that clusters are able to accumulate, the European Union and the governments of member states are interested in their development. The European Cluster Memorandum was signed in 2008 in Stockholm, and clusters were

approved as a cornerstone of the European economic and innovation engine in this document. Cluster development is a priority, especially in Lithuania where an embryonic stage of networking is only found (it should be borne in mind that networking is a very long process, so the situation in Lithuania can be called natural, but, as already mentioned, to encourage the networking is often effective, and speeds up the process). In the EU industrial policy, as strategic directions, orientation to a knowledge economy (creation of high value added products and services through innovation) and networking are distinguished (Jucevičius, 2009). In the Lithuanian economic development strategy, it is noted that networking is one of the priorities of the strategy, largely for export promotion.

When the country's business can be directed to export, the country can produce more, i.e. to create a higher added value. This stimulates economic growth, as well as wage growth, the implementation of more ambitious projects which are undertaken on a larger scale satisfying the demand for investment.

The economic effect of clusters is recognized, but because the novelty of the cluster theories can be studied at different levels, thus forming the basis for high-quality cluster theory and supplementing cluster research.

Historically, economists and geographers were the first to take interest in cluster analysis. It was noted that such geographic entities brought economic benefits. The first analysis of the process was done by Marshall (1890) who observed a tendency of specialized companies to concentrate into clusters according to their geographical distribution. Marshall (1890) wrote about the achieved benefits of specialized businesses when they were in the neighborhood of similar businesses. Later, Schumpeter (1930) examined the networking process, noticing that everything in such economic activity was encouraged only by new technologies. Continuing cluster research, Romer (1998) has developed a knowledge-based growth theory which states that technological progress is going on because of new ideas only, i.e. because of innovations. Romer (1998) argues that there is no direct and obvious link between innovation and entrepreneurship, and growth must be understood as a process which carries out research work in half and other interested parties are developing new products to the market.

Later cluster investigations have been carried out by Porter (1990) who is the creator of the classical cluster theory. Porter's works show that the same business when operating in the geographical proximity can achieve an extremely high competitive success.

Although the government encouraged-cluster support programs are specifically designed to stimulate economic benefits, the role of government in networking is a subject of discussion for both scientists and those who believe that government policy can promote the efficiency of networking, and those who state that the government cannot have a significant impact on the networking, and the main driving force of clusterization is economic benefit.



Despite the existing debate, the recognition of the positive effect of clusterization at the level of government confirms the importance of supporting clusters.

Although there are a lot of motivation and positive examples of cluster implementation, clusterization is not a mass phenomenon for a number of key internal and external reasons. External factors hindering it are often government macroeconomic policy consistency and lack of efficiency. Internal factors comprise the inability of cluster members to agree on economic goals, the lack of cooperation culture, inability to resolve partnership problems, the lack mutual confidence. Studies on these problems are still scarce.

Overall clusterization is a natural process, which means that the promotion of government is possible, but it is limited by competition legislation. Government intervention in order to catalyze the emergence of clusters may be measured in two ways. It is worth noting that government interference is not a completely destructive act as indicated by the different cluster masses; the government can be an effective catalyst of the clustering process. The key features of the ongoing organizational changes in society are increasingly dominating the clusterization process, as well as business and the public sectors, various areas of these sectors, convergence and integration of these areas (Melnikas, 2009). Vilkas and Bučaitė-Vilkė (2009) offer clusterization to be seen as targeted networking activities. The definition of clustering gives the awareness of the present-day realities, and the clustering process in Lithuania is actively promoted.

According to Choi (1999), in Europe there exist both types of clusters: those formed naturally and those formed with government support (by subsidies to high-technology companies), and both can successfully exist and expand; however, with government support, according to the author, the clustering process is much faster in its beginning (bearing in mind that a naturally evolving cluster takes to create about fifty years, while with government support this period may be shortened by a decade). It is worth noting that the largest clusters are formed without government support, so the government policy efficiency for clusters cannot be confirmed or denied. The scientists that do not accept the positive role of government claim that the assumption that the government can lead the region's economic power is fundamentally flawed. According to skeptics, the government's role should be limited to tax incentives but not deal with entrepreneurship education.

Cluster supporting initiatives tend to focus on small to medium businesses, because these businesses themselves have no resources and opportunities to create competitive advantage throughout their whole value chain. Clusterization enables such businesses to reach new levels of performance and quality. According to Statistics Lithuania (2012), 99.3 percent of Lithuanian companies have less than 250 employees. So, obviously Government's interest in clusters is justified. Lithuania is currently developing a favourable environment to innovative clusters driven by the influx into the international clusters.

In particular, it should be noted that throughout the EU the cluster policy is not equally intensive. The different mechanisms of the policy for supporting clusters ensure flexibility in each region. The European Cluster Observatory at present, according to the publication of the Innovation Strategy (2011), charges about 2000 clusters in the EU, which employ about 38 percent of the EU labour force, so we can see that the cluster policy is quite effective.

In general, the EU policy on clusters is based on supporting strong clusters as an important economic reform tool. There is the transnational network that takes care of its innovative systems. It should be noted that the network of a variety of initiatives has been created, including regional economic change initiative, knowledge-based regional initiative, the European Research Area policy, the *Innova* initiative. This infrastructure creates a cluster support through research and innovation, including cluster development.

There is a tendency that different EU regions with different cluster policies are becoming increasingly intertwined and close at all levels. Successful cluster projects create a chain reaction and support for new initiatives; such projects are likely to cooperate and communicate their experience. Cluster support policy mostly deals with too little cooperation, weak industrial research and market fragmentation. Some clusters are fictitious, with no economic benefit, and created only for getting subsidies. Cluster policy should move toward the elimination of such structures. This requires a very precise cluster policy: it should be very attentive to the clarity of a cluster, the cluster actors' motivation.

According to Ministry of Economy (2012) of the Republic of Lithuania, Member States have to step up their efforts to integrate the cluster policies into their national initiatives; there is a need for tracking annually results of their policies, and they should be used for future cluster motivation.

According to Journal of the European Commission on Innovation Strategy (2011), clusters are usually administered by specialized institutions which are aware of the issue. Cluster operators need professional help because only then we can expect to achieve the maximum benefits of clusterization. However, cluster theories have not been formed and have not gained enough experience and knowledge; especially the scientific basis of cluster formation has not yet been established.

Cluster is a business model that guarantees a significant competitive advantage in a cluster entity operating simultaneously, by extending the concept of competition from the outside only to the outer and the inner cluster competition, and each cluster subject competes with each other.

Cluster added value is the result of synergy effect, because the sum of all cluster members' created added value is greater than the amount that each entity would be getting just by itself. This performance model has a significant effect on the economy.

#### **4. Clusterization process in selected Lithuanian industry sectors**

Effects of clusterization on the Lithuanian industry performance have not been studied in academic literature so far. That does not mean that there is no demand for such researches (e. g. evaluation of clusterization effects and testing of theory). Following Jucevičius (2003) and Jucevičius (2009), choosing only the sectors that have displayed an evidence of clusterization is a good starting point for the research. This eliminates the need to test for clusterization existence in the first place and allows to jump straight to testing structural changes in the sectors. Moreover, the European Union has been running policies that suppose to clusterize the Union's industry. It is driven by the goal to improve the competitiveness of European manufacturers. Consequently, Lithuania, being an integral part of the European Union, through its Ministry of Economy prepared a study on clusterization, in which such important aspects of the field as identifying sectors with the largest clusterization potential and determining industries with signs of the ongoing clusterization are analyzed.

Jucevičius (2009) shows that in not a distant past some of Lithuania's industry sectors have indeed undergone the process of clusterization. The author used his own previous paper (Jucevičius, 2003) as a starting point. Also, he shows that several more sectors have a potential for clusterization and benefits that come with it.

Jucevičius (2003) formulates the definition of different levels of clusterization in different industry sectors. He starts with the statistical analysis of clusterization by taking into account the economic data which he uses to identify concentration development in different industries. Such concentration creates prerequisites required for clusters. Therefore, we based our choice of industry sectors for this study by following Jucevičius (2003) and Jucevičius (2009). We take one more step forward by analyzing the output data of the selected industries and searching for the evidence of structural breaks in the time series. Then, we analyze what effects such clusterization might have on the macroeconomic level.

Just as in the mentioned papers, we have gather our data from Statistics Lithuania. The time series are structured according to NACE rev. 2; therefore our results can be easily replicated and compared with those of Jucevičius (2003) and Jucevičius (2009).

Jucevičius (2003) and Jucevičius (2009) argue that in the recent decade, while having a potential, clusterization did not occur in food, chemistry and biotechnology as well as in printing, machinery and textile manufacturing industries. However, wood and wood products manufacturers are rather mature in Lithuania, and the sector accommodates the oldest cluster in the country. The latter sector is identified as clusterized from 2002. In 2003, according to Jucevičius (2009), the IT manufacturing sector had shown signs of clusterization; however, it was still being developed. From today's perspective, we can see that the cluster has not broken and continues to function. According to the data acquired from Statistics Lithuania (2012), the manufacture of laser products and

their components industry was very small, accounting only for 0.062 percent of GDP (Jucevičius, 2003). Despite the fact that the sector does not have a significant economic power in terms of output or social importance, Jucevičius (2009) shows that it has undergone the clusterization process.

For our analysis of structural breaks in selected industries we chose data on the real output of the sectors. Such a time series represents real improvements or deteriorations in industries' performance and eliminates the impact of inflation. We assume that most of Lithuanian industry expansion can be attributed to exports as the Lithuanian domestic market is of limited size. This also means that goods of Lithuanian origin must become more competitive than their foreign counterparts in order to penetrate markets beyond Lithuania. We believe that most gains in competitiveness in the period under review in the selected industries come from clusterization. This being said, an analysis of the mentioned time series can be used to test for the positive effects of clusterization on the Lithuanian economy.

Because obtaining data on a detailed breakdown of Lithuanian industry into small sectors is rather complicated, we chose to analyze the real output of the manufacture of computer, electronic and optical equipment products. We acknowledge it cannot fully represent the dynamics of laser equipment manufacturing; however, quarterly data are not available in more detail. Annual data to the date of writing this paper were still too scarce for a reasonable statistical analysis.

## **5. Tests for structural changes in selected industry sectors**

By analyzing quarterly time series data on the manufacturing of wood products and computer, electronic and optical equipment, we seek to elucidate any structural changes that might have been caused by clusterization. All the data used in our research, as mentioned earlier, are publicly available from the Statistics Lithuania online database. We believe that the industries' output data represent best the processes going on in these sectors.

For our task, we chose to perform a graphical and formal econometric analysis of the time series. To be more precise, we searched for any structural changes in the data dynamics by employing structural change tests proposed by Perron (1989). In his seminal paper, he argued that most of the economic data are in fact trend-stationary but look the other way because of constant structural (endogenous or exogenous) shocks in the economy. These shocks generate time series dynamics that greatly reduces the power of unit root tests (such as Augmented Dickey–Fuller test). We have a prior belief based on the theory and literature analysis (see previous section of this paper) that clusterization should generate a positive shock to the sector in which it occurs, with possible positive spillover effects. This means that forming a cluster should shift the industry's time series trend upwards. We tried to test whether the latter supposition can be supported by empirical data.

The Perron test could be of the following three types:

$$z_t = \alpha_1 + \delta t + dD(T_B)_t + e_t, \quad (1)$$

$$z_t = \alpha_1 + \delta t + (\alpha_2 - \alpha_1)DU_t + e_t, \quad (2)$$

$$z_t = \alpha_1 + \delta t + (\alpha_2 - \alpha_1)DU_t + e_t. \quad (3)$$

In the above equations,  $z_t$  is the time series that is being tested,  $\alpha_1$  is an intercept,  $\delta t$  is the time trend (not necessarily linear),  $D(T_B)_t = 1$  if  $t > T_B$  and 0 otherwise.  $DU_t = 1$  when  $t > T_B$  and 0 otherwise. In other words, (1) tests for exogenous time series level shift, (2) tests for time series slope change, and (3) tests for both of the changes. The Perron tests rest on the intuition about the residuals of the above equations ( $e_t$ ). If the time series, presented in deterministic terms with exogenous shocks, generates stationary residuals, it can be concluded that the data are trend-stationary.

## 6. Graphical and statistical analysis of selected industries' data

Our chosen data cover the period from the first quarter of 1998 to the last quarter of 2011. This means we have a sample of 60 data points. To avoid the influence of change in prices, we use only the real gross value added (chain-linked volumes) data. To represent wood products industry we chose data on the manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, while to represent laser industry we choose data on manufacturing computer, electronic and optical products. In the first case, empirical data reflect our research object rather well; however, in the second case, as mentioned in the previous sections of the paper, the time series covers more industrial dynamics than we would like as the data also include the manufacture of computer and electronic products.

Jucevičius (2003) and Jucevičius (2009) argue that the wood products industry has undergone the process of clusterization before 2003, while in the manufacturing of laser equipment it happened in the period from 2003 to 2008. We present the mentioned time series in Fig. 1. As we can see, the time series have experienced apparent level shifts in their samples. The wood products sector has an evident shift in its added value somewhere between the first and second quarters of 2002; this is in line with the findings of Jucevičius (2009), and we can suspect the shift to be caused by the formation of a cluster. Another apparent shift in the wood products industry occurred in the second half of 2008. It was undoubtedly caused by the Great Recession which started after the Lehman Brothers bankruptcy in September 2008 and which caused a lot of harm to all parts of Lithuanian economy. This negative shock is in no way related to the clusterization phenomenon; therefore, we will not analyze it.

In Fig. 1, the dynamics of manufacturing computer, electronic and optical products is also portrayed. As mentioned before, such data cover more industrial sub-sectors and not only the performance of laser equipment manufacturing. These specific features constrain us from drawing robust conclusions, and we take this into consideration while

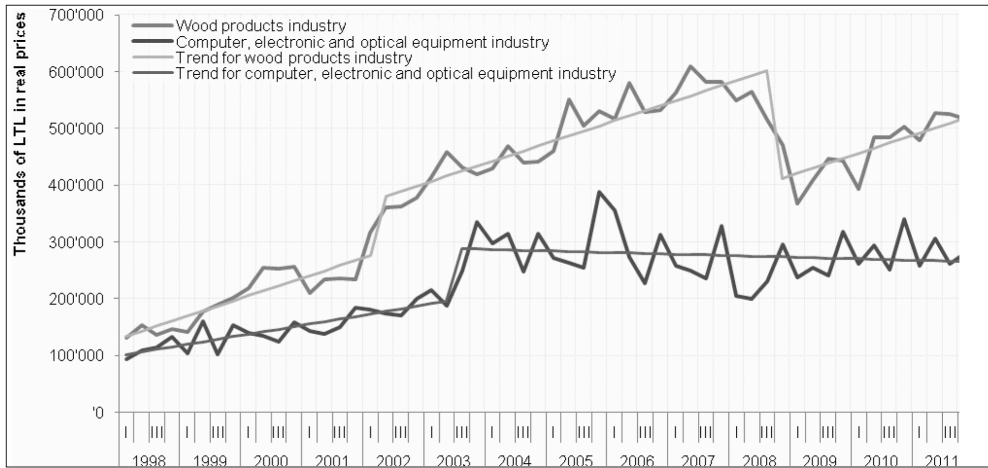


FIG. 1. Time series of manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials and of computer, electronic and optical products and their linear trends

Source: composed by authors from Statistics Lithuania data and authors' calculations.

interpreting the results. Nevertheless, the manufacturing of laser equipment is an integral part of the selected time series and, therefore, it shows at least some of the movements in the sector that interests us. So, as we can see from the graph, the laser, computer and electronic products manufacturing sector has an apparent structural break in the time series in the first half of 2003. We can see the shock that caused it not only shifted the series to a new level, it also altered the slope of the trend. Furthermore, in the end of 2008 the sector did not experience negative shocks, despite the fact that the Lithuanian economy was experiencing the deepest recession in its modern history.

Before moving to performing the Perron structural change test, we would like to note that the ADF test could not reject the non-stationarity hypothesis for both time series under consideration. Because the results of the formal test are supported by visual analysis of Fig. 1 and the ADF procedure is rather trivial, we do not discuss it here<sup>1</sup>.

We presume that the time series under review are governed by linear trends. We acknowledge that this is not necessarily the case; however, it is a handy computational simplification while retaining reasonable results. The latter argument is supported by Fig. 1, as we can see that the trends follow the time series dynamics rather well. Taking the visual information from the graph into account, we estimate the following equations:

$$z_t = \alpha_1 + \delta t + d1_t + d2_t + e_t, \quad (4)$$

$$z_t = \alpha_1 + \delta_1 t1 + \alpha_2 + d2_t + \delta_2 t2 + e_t, \quad (5)$$

<sup>1</sup> Interested reader, however, can easily verify our statements with any modern statistical or econometric software.

Equation (4) represents the wood products industry,  $d_1$  is a dummy variable, which is equal to 0 until the second quarter of 2002 and equal to 1 between the third quarter of 2002 and the third quarter of 2008. To account for the effects of the Great Recession, we include  $d_2$  as another dummy variable which is equal to 1 from the fourth quarter of 2008 to the end of the series and equal to 0 otherwise Equation. (5) represents the laser products manufacturing (with computer and electronic products). Because of different dynamics, it is specified in a different way as compared with equation (4): the  $\alpha_1$  and  $\delta_1$  components describe the period until the second quarter of 2003, while  $\alpha_2$  and  $\delta_2$  cover the third quarter of 2003 and afterwards.

We estimate the above equations by OLS and test their residuals ( $e_t$ ) for stationarity. In order to make residuals of equation (4) a white noise process, we did not have to add any new elements. Therefore, the mentioned process is described by the following equation (standard error in parentheses):

$$e_t = 0.385e_{t-1} + \gamma_t \quad (6)$$

(0.120)

The Perron statistics calculated from (6) are equal to 5.12 and are more negative than the critical value<sup>2</sup>. Based on the test, we can accept the hypothesis that the data generating process is trend-stationary. In other words the Perron test concludes that treating the time series with a deterministic trend is correct, if we account for its structural shift in the level with dummy variables. Because the structural change (the shift in the level of the time series) for the wood products industry was found in the exact period described by Jucevičius (2009), describes, we may conclude that the clusterization of the sector had a significant impact on its performance in the period under review. Indeed, it is rather difficult to come up with another than clusterization argument to explain the structural shift in the data: the Lithuanian economy was not booming at the time, and its accession to the European Union was still more than a year away.

To make the (5) residuals white noise, we had to include three more lags of the first differences to the equation. We estimated the following equation to perform the Perron test (standard errors in parentheses):

$$e_t = 0.4452e_{t-1} - 0.4038\Delta e_{t-1} - 0.4025e_{t-2} - 0.5509e_{t-3} + \gamma_t \quad (7)$$

(0.2613)      (0.2163)      (0.1753)      (0.1222)

The Perron test statistics calculated from (7) are equal to 2.12. This is not more negative than any of the critical values with conventional confidence levels<sup>3</sup>. This means that, econometrically, we cannot draw the same conclusions for the laser sector as in the case of the wood products industry. However, this might only mean that the time series

<sup>2</sup> Critical Perron statistics with 0.01 significance level for the first type of structural breaks when the break occurs after 30% of the sample is equal to 4.39 (Zemčík, 2012).

<sup>3</sup> Critical Perron statistics with the 0.1 confidence level for the third type of structural break when it occurs after 40% of the sample is equal to 3.95 (Zemčík, 2012).

is indeed not stationary, but it does not negate the fact that a structural break did occur. Moreover, the results we got might be disrupted by including data on manufacturing computer and electronic products. In any case, a positive shock is visually apparent in Fig. 1. As in the wood products industry, it is hard to explain the shift without attributing most of the causes to clusterization.

## **Conclusions**

A cluster is defined in a rather similar way across different sources of academic literature. The main difference between the definitions is mostly the variation of the focus on different features. The main elements used in defining a cluster are the following: common end product, network-like links among cluster participants, internal dynamics and competition of the cluster, geographical proximity of cluster subjects, common technology and know-how, and partnership between academic institutions and businesses. The main benefits of clusterization that were often mentioned in the literature are the integration of competences, better possibilities to improve products, cost reduction, diminishing risks by sharing them, and increase in competitiveness. The mentioned elements form the basis for cluster theory, which was analyzed from various perspectives. Academic literature tends to classify clusters according to the integral parts of the definition of a cluster.

There is no common and undisputed view on the role of government in the clusterization processes. Two different views prevail in the literature: one side tends to favour government intervention in order to stimulate creation of clusters, while the other argues that the government can only disrupt the free market forces that drive businesses into clusters. A certain compromise between these extremes should be reached as there are evidences of successful clusters that have emerged both spontaneously and with government stimuli.

The graphical analysis of data on wood products industry gives a clear support to positive structural shifts after the sector formed a cluster. We argue that the process of clusterization must have taken place somewhere in transition from the first quarter of 2002 to the second quarter of the same year. Similar conclusions could be drawn concerning the laser equipment industry; however, the conclusion is not as clear as in the previous case, because the data include the manufacturing of computer and electronic products. In this case, clusterization must have taken place in transition from the first quarter of 2003 to the second quarter of the same year. It is hard to explain the shifts in the levels of the time series of the selected industries without attributing the majority of the positive shocks to clusterization. Our analysis supports the view that clusterization creates positive economic effects. Our conclusion is supported by Jucevičius (2009), because the our structural changes identified by us, i.e. breaks in the time series, occur in the periods identified by the mentioned researcher.



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