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**Dear Readers,**

In our publishing policy to date, *Argumenta Oeconomica Cracoviensia* has invited contributions from authors of original texts in the economic sciences, i.e. economics, finance, and management. In previous issues of the journal, economics has been dominant, although the proportion of articles in the field of finance has been noticeable.

In light of the new classification of academic fields, areas and disciplines adopted in Poland in 2018, as a consequence of which the discipline of economics has been merged with that of finance, our journal will remain primarily interested in publishing articles on economics and finance. Without attaching too much weight to the formal criteria, we do not, of course, exclude the possibility of accepting interdisciplinary works in the social sciences – to which the economic sciences belong – such as in the fields of sociology, law and mathematics, provided that economic and financial aspects are predominant in such works and that the methods and tools borrowed from other disciplines serve to better explain economic and financial phenomena and processes. A more explicit orientation towards economics and finance should also help the authors of texts published in our journal to categorise those texts when their academic ouput is assessed, which is important as regards their own advancement and the parametrisation of the academic institutions to which they are affiliated.

The present issue of the journal has a special character, which is reflected in its contents; the inspiration for it was the career of Professor Andrzej Malawski, who died in October 2016. There are two principal reasons for bringing our readers' attention to this fact: one academic and one organisational. Professor Malawski's academic achievements are appreciated both nationally and internationally. Particularly noteworthy are his works devoted to the theoretical foundations of economics. Professor Malawski also had a passionate interest in critical analysis of the theory of general equilibrium, especially from the Arrow-Debreu perspective. His studies in this area resulted in a dynamic understanding of general equilibrium in relation to economic transformation processes. This approach is an

original contribution to the theoretical foundations of transformation, an issue rarely addressed not only in domestic but also in world literature. Professor Malawski's contribution to the axiomatic analysis of economic transformation processes is confirmed by an entry in the monograph entitled *Current Trends in Economics: Theory and Applications*, edited by Ahmet Alkan, Charalambos D. Aliprantis, and Nicholas C. Yannelis. The second – organisational – reason for dedicating the current issue to the memory of Professor Malawski is his contribution to the development of our journal. As Vice-Rector for Research at the Cracow University of Economics – which publishes *Argumenta Oeconomica Cracoviensia* – Professor Malawski showed extraordinary commitment in helping us to reactivate our publishing activity and to develop our journal.

In recognition of Professor Malawski's contribution to the development of economic theory, methodology and the philosophy of economics, authors who were either former students of his or for whom he was a recognised authority have submitted their contributions. The current issue includes articles by well-known economists from various institutions. These works have, of course, been subject to the standard review procedure for texts published in our journal.

The present issue opens with a work that refers directly to Professor Malawski's academic achievements. It is by Łukasz Hardt and is entitled *Some Reflections on Professor Malawski's Ideas Concerning Economics, Mathematics, and Philosophy*. As the title suggests, the article offers the reader a deeper insight into Professor Malawski's views and academic profile. It is all the more valuable on account of being written by someone from a younger generation of economists.

Professor Malawski obtained his Master's degree in economics and philosophy, and the achievements underlying his academic advancement were closely related to the possibility of applying quantitative tools in economics and finance. Therefore, the subsequent articles in this issue present various tools useful for the study of economic phenomena. They include an article entitled *When Do Optima Converge to Optimum?* by Marta Kornafel, whose academic development took place under the guidance of Professor Malawski. In her article, the author presents the problem of optimisation in economic modelling using a formalised approach. She analyses the possibilities of applying the Ramsey model with an approximation of parameters in the direction of maximising the CRRA utility functional.

Katarzyna Ostasiewicz's article, *Income and Expenditure Inequalities among Households in Poland*, is an example of the search for, and interpretation of, objective measurement of empirical data distribution. The author addresses the important problem of income inequalities and how to measure them. Although the practical importance of this issue is highlighted by economists, the continued growth of income inequalities in many countries – and in the world in general – remains barely noticed by politicians. It is for this reason that Katarzyna Ostasiewicz's article, which is devoted to inequalities in Poland, deserves attention.

Another example of applying quantitative methods to research that is important not only from the economic but also from the social point of view is Agata Girul and Edyta Mazurek's article, *Structural Similarities between Populations of Persons with and without Disabilities by Selected Social and Economic Factors*. Using statistical methods based on indexes of structural similarity, the Gini coefficient, and chi-squared statistic, the authors compared the living conditions of people with and without disabilities on the basis of empirical data. This article, aside from its methodological and cognitive value, should stimulate reflection among decision-makers responsible for social policy.

The revolution in information technology is not just a fact. There has been uninterrupted development in this field, one example of which is the development of the e-economy in the broadest sense and also the dynamic development of the financial and technological sector (FinTech). We are witnessing the emergence of various inventions that have implications for economics and finance, such as cryptocurrencies. For these reasons, one can confidently recommend the article by Justyna Brzezińska entitled *A Multivariate Statistical Analysis of the Information Society in Poland*. The author presents the current state, vision and mission of the information society on the example of Poland. Her analysis of the information society and its prospects is carried out using multivariate statistical methods.

Financial crises, different state approaches to them in different countries, and their economic and social consequences, have led to greater interest in political economy and the evolution of economic and social doctrines. Kalim Siddiqui's article, *The Political Economy of India's Economic Changes since the Last Century*, deserves attention in this regard. The author presents, in a long-term perspective, both the characteristics and a critical assessment of the economic doctrines underlying the functioning of the Indian economy. The example of India is interesting in that the country is still classified as

a developing country and as such has been susceptible to various trends developed within the framework of political economy.

Space plays an important role in research on economic phenomena. Research on the distribution of economic phenomena in space has historically been a challenge for economists. This is in part due to the limited possibilities for comparing these phenomena, especially across countries. In her article entitled *The Socio-economic Dimension of Industry in Subregions*, Beata Bal-Domańska investigates the impact of the level of industrialisation on the situation of subregions (NUTS-3) in Poland. The author's study applied the Ward classification method and SDM linear ordering with a common development model. Aside from their cognitive character, the findings are important for industrial policy conducted in the spatial aspect.

Countries that have transformed their economic system remain of interest due to the still-existing ballast of the previous system's economic structure. In this respect, Alicja Kasperowicz-Stępień's article, *The Impact of the Macroeconomic Situation on the Labour Market in the Baltic States in 2000–2016*, should be of interest. Indeed, this interest is fully justified if one takes into account the fact that the Baltic countries analysed in the article not only underwent systemic transformation but also entered the eurozone relatively recently. Another positive aspect of the article is the author's attempt to capture the impact of the financial crisis on basic macroeconomic figures and their consequences for the labour market in these countries.

While commending the present issue to our readers, we would also like to invite contributions in the form of original texts, information about important academic events, and reviews of outstanding books. Texts in the field of economics and finance will be treated as most relevant to the journal's profile.

*Prof. Stanisław Owsiak*
Editor-in-chief

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Łukasz Hardt

# SOME REFLECTIONS ON PROFESSOR MALAWSKI'S IDEAS CONCERNING ECONOMICS, MATHEMATICS, AND PHILOSOPHY

**Abstract**

This paper explores the ways Prof. A. Malawski understood the various kinds of interplay between economics, mathematics, and philosophy. In particular, it addresses the issue of the mathematicity of the economy and what it means for economics to be a mathematical science. Next, it focuses on the nature of economic laws. It concludes by claiming that the interpretative key to Prof. Malawski's research lies in his deep humility.

**Keywords:** A. Malawski, philosophy of economics, mathematisation of economics, laws and models in economics.
**JEL Classification:** B40, C18.

## 1. Introduction

I had the privilege of knowing Professor Andrzej Malawski, whom I greatly admired not only for his intellectual capacity but also for his humility and wisdom. He was a truly virtuous man. In his writings he was ambitious and thus conscious that economics as such was not enough to understand the socio-economic world and that researchers should analyse the world in much greater depth; hence his interest in philosophy and the foundations of mathematics. I would say that Prof. Malawski went even further – he not only explored the socio-economic realm but also contemplated it. Consequently, he was well aware that one cannot resolve

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the mystery of the world, although one can still progress towards a better understanding of it. This explains his commitment to philosophical realism. In one of his last texts, he wrote: "I accept what philosophers call ontological and epistemological realism and accordingly that there is an objective reality independent from the researcher that analyses it (…). Our world is characterized by ontological depth" (Malawski 2016, pp. 132–33). Such an attitude probably contributed to his endorsement of Jevons's idea that "(…) economics, if it is to be a science at all, must be a mathematical science" (Jevons 1879, p. 3). Prof. Malawski spent years investigating what precisely being a mathematical science means for economics.

In this article I will not attempt to reconstruct all of Prof. Malawski's ideas in detail, but will rather reflect on some of them. As a philosopher of economics I am particularly interested in Prof. Malawski's work at the intersection of economics, mathematics, and philosophy. Therefore, I am interested in the following issues: (1) to what extent the economic realm can be studied using only mathematical techniques and to what extent socio-economic worlds are ontologically mathematical; or, in other words, are economies mathematical or are they only mathematicised? (2) can mathematics alone, without making any reference to laws, causes etc., explain economic phenomena? (3) the proper understanding of the nature of laws in economics. In analysing these issues I shall refer in particular to Prof. Malawski's inspiring 1999 book entitled *The Axiomatic Method in Economics*[1] (Malawski 1999).

## 2. Is the Economic World Mathematical or Only Mathematicised?

As Prof. Malawski was both a mathematician and economist, the question of whether the economic realm was mathematical preoccupied him for years. In his 1999 book, he stated:

> Therefore, it is difficult to find arguments for treating the mathematical character of economic reality similarly to the way we conceptualise the mathematical nature of material world (…). Thus, it seems impossible to broaden the hypothesis of the so-called field of rationality from natural world structures towards social ones (…). Consequently, the very fact that economics can be mathematicised does not necessarily mean that economic systems are mathematical (Malawski 1999, p. 166)[2].

[1] For this book, Prof. Malawski was awarded the Bank Handlowy Prize for Particular Achievements in Economics in 2000.

[2] The field of rationality idea was put forward by Józef Życiński. It may be described as "a kind of a formal field constituted by a net of mathematical structures and abstract relations. This

In one of his last texts he still argued against the mathematicity of economic realm:

> (...) the extraordinary efficacy of mathematics in explaining the physical world does not translate into an understanding of social life and its economic dimension (...); however, attempts to mathematize economics are not fruitless. They give better insight into the nature of research problems in economics and thus can lead to enhanced prediction of economic phenomena (Malawski 2016, p. 132).

The issue of whether economies are inherently mathematical was raised by some nineteenth century economists. However, since neoclassical economics was conflated relatively soon with mathematical economics, this issue ceased to catch the attention of economic thinkers. Indeed, as P. Mirowski (2012) explains, for decades now, there has been no real debate or contact between the philosophy of mathematics and the philosophy of economics. Nevertheless, we can point to some lines of thought which suggest, on the one hand, that economies are naturally quantitative and, on the other, that mathematics should be treated only as a language in which economics can be rewritten. Those ascribing a mathematical character to the economic realm usually refer in some way to the Putnam-Quine thesis concerning the indispensability of mathematics for the empirical sciences. Let me therefore recall H. Putnam's words:

> So far I have been developing an argument for realism along roughly the following lines: quantification over mathematical entities is indispensable for science, both formal and physical; therefore we should accept such quantification; but this commits us to accepting the existence of the mathematical entities in question. This type of argument stems, of course, from Quine, who has for years stressed both the indispensability of quantification over mathematical entities and the intellectual dishonesty of denying the existence of what one daily presupposes (Putnam 1979, p. 347).

However, as recent studies in the philosophy of science show, one can distinguish between the weak and strong indispensability argument (Decock 2002). The former refers to W. V. Quine's thesis that "to be is to be the value of a variable"; thus it only postulates that mathematical variables exist in our theories and that mathematical statements (theorems) are true, yet it says nothing about the realities beyond our theories. The latter, on the other hand, makes a stronger ontological claim and states that only really

hypothesis explains the so called mathematicity and rationality of nature by assuming that formal structures are ontologically prior to physical phenomena" (Pabjan 2011, p. 7).

indispensable mathematical objects in our theories are allowed to function as the values of variables. How do such arguments refer to Platonism about mathematics, namely, to the view – put very simply – that mathematical objects are discovered rather than created in theory-making? And here many philosophers treat the Putnam-Quine indispensability argument as the best way of defending Platonism (or mathematical realism). But important problems still remain, for instance, the very meaning of indispensability. I offer some comments on this issue below.

Firstly, what does it mean to be indispensable? If a given entity, say a mathematical one, is dispensable, then after eliminating it our theory should be still acceptable, e.g. it may still provide explanations. In such a case, if what is eliminated is a mathematical entity, then this very entity cannot be characterised as being indispensable. Therefore, one should ask how much mathematics is indispensable (Colyvan 2015). According to Putnam and Quine, the indispensability of mathematics is defined by its ability to have physical designates. In other words, according to Quine, if we do not find physical application of a given mathematical theory, then our mathematics is just "(…) recreation (…) without ontological rights" (Quine 1986, p. 400). But one can claim here that the very fact that one cannot find any physical picture of a given mathematical fact cannot alone support the thesis that this fact is dispensable, since one may be able to find such a physical realm in the future. The history of non-Euclidean geometry and Hilbert's axioms can be illuminative in this context.

Secondly, what would be Prof. Malawski's standpoint in this debate? It is definitely hard to say. However, what I would claim is that he might follow P. Kitcher's (1984) criticism of the indispensability thesis by insisting that the Putnam-Quine argument does not explain why mathematics is indispensable for science and for economics in particular. Hence Prof. Malawski's question of whether the economic realm is ontologically mathematical. As we know, he claimed that economies are not mathematical to the extent that physical worlds are. Also, for both Malawski and Kitcher, questions about the indispensability and ontological status of mathematics are relatively separate. But what about another critique raised against Putnam and Quine, namely, from H. H. Field (1980), who argued that mathematics is not indispensable for science. I think Prof. Malawski would disagree. He put forward a lot of arguments for the efficacy of the axiomatic method in economics. In his 1999 book, he wrote: "It leads to the final conclusion that the axiomatic method in economics is legitimate and that its popularization, being a part of a broader phenomenon in science as such, can be treated as a wide-ranging

tendency in science, namely, its euclidization" (Malawski 1999, p. 160). However, here we touch upon a very serious problem: is it possible to remove all mathematics from economic theory and still have successful economics? Most probably Prof. Malawski would claim the following: it is possible, but at the price of lowering the accuracy, precision, and range of economic insights. He would probably say this because in his view the axiomatisation of economics contributed greatly to its development.

Malawski's insights in support of the idea that economics can be axiomatised are somehow in line with various developments in twentieth--century economics. Take, for instance, the epigraph to P. Samuelson's *Foundations of Economic Analysis*: "Mathematics is a language". Or G. Debreu's claim that "in its mathematical form, economic theory is open to efficient scrutiny for logical errors" (Debreu 1991, p. 3). Not to mention R. Lucas's manifesto: "(...) mathematical analysis is not one of many ways of doing economic theory. It is the only way" (Warsh 2006, p. 168). Some readers may simply ask why there is such strong emphasis on the use of mathematics. Here we should refer to the philosophy that inspired people like Samuelson and Debreu. As far as Samuelson is concerned, one should note his links to key logical positivist philosophers such as R. Carnap. It was Carnap, together with H. Hahn and O. Neurath, who famously proclaimed in their manifesto:

> In science there are no "depths"; there is surface everywhere: all experience forms a complex network, which cannot always be surveyed and can often be grasped only in parts. Everything is accessible to man; and man is the measure of all things. Here is an affinity with the Sophists, not with the Platonists; with the Epicureans, not with the Pythagoreans; with all those who stand for earthly being and the here and now. The scientific world--conception knows no unsolvable riddle (Carnap, Hahn & Neurath 1929, p. 306).

If there are no "depths", and if mathematics only can serve as something relatively unchangeable, then paradoxically we have metaphysics in economics; however, it is mathematics that plays this role. As A. Weil put it: "Metaphysics has become mathematics, and is ready to form the topic of a treatise whose cold beauty would be incapable of moving us" (Dalmedico 2001, p. 236)[3]. Nevertheless, Samuelsonian economics treats mathematics as a very special tool and is therefore similar to the Marshallian treatment of mathematics famously summarised in his maxim that "[Economists should]

[3] André Weil was a very influential French mathematician and a member of the so-called Bourbaki group.

use mathematics as a shorthand language, rather than an engine of inquiry" (Marshall 1906)[4]. His scepticism was shared by Vilfredo Pareto (1911), who claimed that many economists wrongly imagined mathematical economics to be something capable of solving the problems of practical economics. Knowing Prof. Malawski's work, I am convinced that he would agree with this statement.

But let me now offer a different way of analysing the issue of whether the economic realm is deeply mathematical. Imagine, contrary to Prof. Malawski, that economies are mathematical like many domains analysed by physicists, and thus one can legitimately claim that in such a case mathematics alone should be able to explain economic phenomena. Is this possible? I shall attempt to answer this question below.

## 3. Can Mathematics Alone Explain Economic Phenomena?

Mathematics is widely present in economics. It is used in many kinds of explanations. However, some philosophers of science argue that mathematics alone can explain phenomena without making any references to laws, causes, etc. Thus, for instance, M. Lange (2013) claims that distinctively mathematical explanations (DME) are possible. He gives the following example:

> The fact that twenty-three cannot be divided evenly by three explains why it is that mother fails every time she tries to distribute exactly twenty--three strawberries evenly among her three children without cutting any (strawberries!) (Lange 2013, p. 488).

P. Lipton (2004), on the other hand, offers the following illustration:

> There also appear to be physical explanations that are non-causal. Suppose that a bunch of sticks are thrown into the air with a lot of spin so that they twirl and tumble as they fall. We freeze the scene as the sticks are in free fall and find that appreciably more of them are near the horizontal than near the vertical orientation. Why is this? The reason is that there are more ways for a stick to be the horizontal than near the vertical. To see this, consider a single stick with a fixed midpoint position. There are many ways this stick could be horizontal (spin it around in the horizontal plane), but only two

[4] Here is the full quotation from A. Marshall (1906, pp. 427–428): "[I had] a growing feeling in the later years of my work at the subject that a good mathematical theorem dealing with economic hypotheses was very unlikely to be good economics: and I went more and more on the rules – (1) Use mathematics as a shorthand language, rather than an engine of inquiry. (2) Keep to them till you have done. (3) Translate into English. (4) Then illustrate by examples that are important in real life. (5) Burn the mathematics. (6) If you can't succeed in (4), burn (3). This last I did often".

> ways it could be vertical (up or down). This asymmetry remains for positions near horizontal and vertical, as you can see if you think about the full shell traced out by the stick as it takes all possible orientations. This is a beautiful explanation for the physical distribution of the sticks, but what is doing the explaining are broadly geometrical facts that cannot be causes (Lipton 2004, pp. 9–10).

So, we have DME in a given science, say economics, once mathematics alone explains phenomena. Or, in other words, once we delete economics (e.g. references to economic laws, causes, etc.) from economic explanations and what remains is just mathematics that still explains economic phenomena, then what we have is DME in economics. Now, if one understands the above mother-strawberries example as an instance of the classic economic problem of the optimal allocation of scarce resources, then this very illustration may be treated as DME in economics. But what about cases of explanations in economics where mathematics is in place but which cannot be understood as DME? Let me give the following example. Suppose that we have a typically defined average variable cost of production, namely $AVC(y)=\frac{c_v(y)}{y}$ and hence the question is what is the value of $AVC(0)$? If $y = 0$, then this expression (0/0) is indeterminate. However, the value of the limit of $\frac{c_v(y)}{y}$ can be calculated using L'Hôpital's rule: $\lim_{y\to 0}\frac{c_v(y)}{y}=\frac{c'_v(0)}{1}$. It follows that the average variable cost of production at zero output is just marginal cost (see, for instance, Varian 1992, p. 69). If we agree that L'Hôpital's rule constitutes a mathematical fact, we can assess whether this is a distinctively mathematical explanation and, bearing in mind that we are referring to economic ideas of various cost categories, my answer is that it is not.

In my 2017 book, *Economics without Laws* (Hardt 2017), I show that cases of DME are relatively rare in economics. In other words, mathematics alone does not offer economists much in accounting for economic phenomena. This is also true in the case of the Arrow-Debreu world where we do not have only mathematics but also references to laws, concepts, causes, etc. If instances of DME are hardly present in economics, does this prove that the economic realm is not mathematical? Well, to be honest, more research is needed to answer this question. However, one may suppose that the more mathematical a given realm, the more frequent the use of DME to account for its functioning. So, we should have more DME in physics than in economics. Prof. Malawski would probably agree, although he might

humbly add that one may only potentially have more DME in physics. Why? Simply because one needs to have *a proper* mathematics in order to correctly explain various phenomena. At the very end of his 2016 paper on whether the economic world is mathematical, he cites the following paragraph from Whitehead (1964):

> Having regard to the immensity of its subject-matter mathematics, even modern mathematics, is a science in its babyhood. If civilisation continues to advance, in the next two thousand years the overwhelming novelty in human thought will be the dominance of mathematical understanding" (Whitehead 1964, p. 117).

Therefore, we may have more DME in economics in the future once we achieve more advanced mathematics, but since the economic realm is not totally mathematical, it is hardly possible that mathematics alone will be able to explain economic phenomena[5]. But still another important issue requires our attention, namely, the issue of the nature of laws in economics. Here one may suppose that although economies are not inherently mathematical, economics is so mathematicised that it should have rather strict and strong laws. Is this right? The following section addresses this very issue.

## 4. Are There Laws in Economics?

Let us give the floor to Prof. Malawski with regard to his opinion on the nature of economic laws. In his 1999 book, he wrote:

> The laws of nature are spatiotemporally universal whereas the laws of economics are historical and local. This difference is due to the fact that real systems investigated by economists are far more complex and internally integrated as well as less stable than the ones analysed in physics. Therefore, economists have problems with *ceteris paribus* clauses (…). At the same time, the historical variability of economic systems causes permanent lags in the formulation of economic laws (…) and hence they are of little use in

[5] I am aware that there are many purely philosophical problems regarding the status of DME. Let me highlight the following one, for instance. Some philosophers claim that the ontic form of the counterfactual theory of explanation cannot accommodate DME. This is so because, in *ontic* theories, dependencies hold between things in the world rather than between representations (see, for instance, Kuorikoski 2017). M. Lange (2013) is well aware of this problem and thus opts for more modal conceptions that show the necessity of the explanandum. I think that one can have abstract dependencies in ontic theories based on counterfactuals (cf. Reutlinger 2016). Let us, then, reformulate the mother-strawberries example in the following way: "if mother had had a number of apples evenly divisible by four, then she would not have failed to distribute her apples among her four children". Further in-depth study of these issues is definitely beyond the scope of this paper, but I would like my readers to be aware of these philosophical problems.

> the formulation of economic policies and their predicative power is less than limited (...) (Malawski 1999, pp. 165–66).

Clearly, therefore, for Prof. Malawski the laws of economics are not the same as the laws of physics. It is interesting that this view is shared by the founding fathers of modern economics. For instance, A. Marshall wrote that "the laws of economics are to be compared with the laws of the tides, rather than with the simple and exact law of gravitation" (Marshall 1920, p. 32). And commenting on the historical character of such laws he stated the following: "If the subject matter of a science passes through different phases of development, the laws of the science must have a development corresponding to the things of which they treat" (Marshall 1890, p. 65). Similarly, J. S. Mill emphasised the inexactness of economic laws; hence his well-known definition of such law-statements: "All laws of causation, in consequence of their liability to be counteracted, require to be stated in words affirmative of tendencies only, and not of actual results" (Mill 1843, p. 523). In Hardt (2017) I summarise in the following words the way classical economists understood laws of economics:

> Classical economists were conscious that the laws they formulate definitely do not hold in every circumstance. Moreover, they seem to agree that the only place in which a given law is always true is in the model used to produce that very law (Hardt 2017, p. 195).

I do not claim that Smith, Ricardo, Mill, and Marshall used models as contemporary economists do. However, they had their model words. Smith talked about little imaginary machines that thinkers use while investigating the way the world works. Ricardo is famous for the models employed in his theories of comparative advantage and rent. Mill offered economics notions of abstract truth and truth in the concrete; he thus wrote: "the conclusions correctly deduced from these assumptions, would be as true in the abstract as those of mathematics; and would be as near an approximation as abstract truth can ever be, to truth in the concrete" (Mill 1836, p. 49). And what about Marshall? He was very mechanistic in his world view, at least at the beginning of his research career, and for him economies resembled machines. One could therefore investigate them by building mechanistic pictures of them, namely, models. In Marshall's words: "(...) it is worthwhile to reduce the processes to system and to erect the machinery of science in order to deal with them" (Marshall 1890, p. 88). So, the modelling method is at the very heart of economics, and from the outset classical economists did not believe in the pure universality of economic laws.

But what if economic phenomena are not reducible to their parts and are just the emergent effects of underlying processes? Or, to put it another way, what if economic causes react chemically rather than mechanically? Both Marshall and Mill were conscious of this very fact. And thus Marshall had a dream to write the second part of his *Principles* offering a vision of economics based on biology. Consequently, he famously claimed that "the Mecca of the economist is economic biology rather than economic dynamics" (Marshall 1898, p. 43). And similarly Mill stated that when economic causes interact chemically one cannot use the method of isolation, and thus formulating laws of economics with the same lawhood as Newtonian laws of physics would be simply impossible. Interestingly, we find similar insights in Prof. Malawski's attempts to unify (and axiomatise) Schumpeterian evolutionary theory. For him, evolution is possible only when one subscribes to a very special kind of world ontology, precisely one which treats the world as always being dynamically *in statu nascandi*. In such a world, any spatiotemporally universal constant conjunctions are simply impossible. Therefore, Prof. Malawski's work on the mathematisation of various aspects of evolutionary economics resembles, at least to some extent, the research done by his great predecessors.

Let me return, however, to the mechanistic models economics uses and ask what is the nature of the knowledge they produce, or, to put it differently, how one should understand relations in the triad: models–theories–empirical phenomena? Firstly, models may be conceptualised as entities producing theories. Take, for instance, the celebrated checkerboard model by Schelling and its product, namely, the insightful claim that even without a strong preference for segregation people will strongly self-segregate. Secondly, these models' claims are statements of tendencies only. So, in the context of Schelling's model, one should only say that people will tend to self--segregate. Thirdly, as far as empirical phenomena are concerned, one does not test the validity of a given model as such, but rather the claims produced by the model in question. As F. Guala rightly points out: "The fact that a model turns out not to work under certain circumstances does not count as a refutation of the model but only as a failed test of its applicability in a given domain" (Guala 2005, p. 220). Models should resemble the realities they refer to. Next, tendency laws produced by models may be understood in an ontologically rich manner, namely, as sentences describing what is in the nature of a given entity to produce. Now, for instance, rather than claiming that lower interest rates will produce a tendency for investments to rise, one should just say that it is in the nature of lower interest rates to

stimulate investments[6]. Similarly, a typical *ceteris paribus* clause should be supplemented by a *ceteris normalibus* reservation. Hence we are in a very Aristotelian world.

To conclude, let us once again return to Prof. Malawski's words from the final chapter of his 1999 book:

> Differential equations constitute the language in which the laws of physics are formulated. Similar attempts were undertaken in the social sciences and in economics, such as in the works of A. Cournot and L. Walras and in the contemporary works of P. Samuelson and R. Lucas. However, one cannot assess them as satisfactory – differential equations failed to form the language of the social sciences and economics; and, even more so, a strict and general language for formulating such laws does not exist. The reason for this lies in the great complexity of social and economic systems as compared with natural ones (Malawski 1999, p. 178).

Most probably, the postulated nonexistence of strict language may be understood as Prof. Malawski's refusal to view the socio-economic world through mechanistic ontology. Nevertheless, his conviction that universal laws are not possible in economics is beyond doubt.

## 5. Conclusions

After the above short reflection on Prof. Malawski's thinking on economics, mathematics, and philosophy, one might ask where lies the key to interpreting his way of analysing the world. What I believe is that this key may be found in Prof. Malawski's humility: he was not only a humble person, but his science was a humble science – we are able to know much, but our knowledge will never be free of doubt. He was well aware that there is mystery in the world. As L. Kołakowski wisely put it many years ago: "But although we cannot pierce the mystery and convert it into knowledge, our awareness that there is mystery is in itself important; although we cannot tear the veil from ultimate reality, we should know that such a veil exists" (Kołakowski 2001, p. 10). And for Prof. Malawski the very existence of this mystery is somehow connected to ontological uncertainty about the foundations of the socio-economic realm. Why uncertainty? Simply because the old Newtonian mechanistic ontology is no longer valid, and Prof. Malawski, as an economist interested in evolutionary economics, was deeply conscious of this fact. In a sense, his work may be treated as a search for a "post-mechanistic" and metaphysically rich paradigm. Prof. Malawski

[6] I develop such a vision of economic laws in Hardt (2017).

surely belonged to that very special group of scientists described by P. Davies and J. Gribbin as follows:

> In all these areas scientists have found it fruitful, or even essential, to regard the portion of the universe they are studying in entirely new terms, terms that bear little relation to the old ideas of materialism and the cosmic machine. This monumental paradigm shift is bringing with it a new perspective on human beings and their role in the great drama of nature (Davies & Gribbin 1992, p. 8).

Thus, Prof. Malawski's work was at once intellectually elegant, philosophically rich, and revealed not only his sound knowledge of economics but also his desire to influence economic theory. Last but not least, he tried to persuade to do economics in a humble way; hence his denial of the existence of universal laws of economics combined with his refutation of the possibility that the depths of the economic realm can be purely mathematical. I hope that this special issue of *Argumenta Oeconomica Cracoviensia* will help the Polish community of economists to rediscover Prof. Malawski's works and in particular his 1999 book – *The Axiomatic Method in Economics*.

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## Abstract

### Refleksje na temat poglądów prof. A. Malawskiego na związki między ekonomią, matematyką i filozofią

W artykule podjęto rozważania na temat sposobu rozumienia przez prof. A. Malawskiego związków pomiędzy ekonomią, matematyką i filozofią. W szczególności analizie poddano kwestię matematyczności gospodarki, a także tego, jak należy rozumieć ekonomię traktowaną jako naukę matematyczną. Podjęto także problematykę natury praw ekonomicznych. Artykuł kończy się stwierdzeniem, że kluczem interpretacyjnym do badań prof. A. Malawskiego jest jego wyjątkowa pokora.

**Słowa kluczowe:** A. Malawski, filozofia ekonomii, matematyczność ekonomii, prawa i modele w ekonomii.

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Marta Kornafel

# WHEN DO OPTIMA CONVERGE TO OPTIMUM?*

**Abstract**

In this paper we consider the problem of the convergence of optima in approximated problems to the optimum of limiting problem. We recall the concept of Γ-convergence, which is crucial in optimisation problems. We show its importance and provide a list of theorems describing its properties. Using described tools we derive the conditions under which an approximation of the parameters of the Ramsey model with vanishing absolute error of approximation gives the *explicite* formula for the time-varying consumption per capita, which leads to "almost"-maximisation of the CRRA utility functional.

**Keywords:** Gamma-convergence, Ramsey model, convergence of optima, stability of optimal paths.
**JEL Classification:** C02, C62.

## 1. Introduction

There are several types of convergence of sequences of functions. The usual and well-known types are pointwise and uniform convergence. In this paper we present the basis of the theory of Γ-convergence of sequence of functions. This kind of convergence can be expressed also in terms of Kuratowski convergence of epigraphs of those functions (limit of sequence of closed sets).

Γ-convergence is a crucial concept in optimisation problems. It is worth emphasising that it is not obvious that if we have a sequence of functions

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– or functionals (Attouch 1984), possibly profit, cost or utility functionals – each of which possesses an extremum at some point, then the limit of functions has an extremum in the limiting point of the optima sequence. We start our analysis in the second section with an elementary example that shows the opposite effect for a pointwise limit of sequence of functions. In the next part of the paper we formulate a formal definition of the Γ-limit and discuss the theorems linking it to other types of limits of sequence of functions.

The paper closes with an analysis of the standard Ramsey model, in which we consider a disturbance of coefficients. We provide an answer to the natural question: in what circumstances does the optimal consumption path in a "disturbed" problem approximate the optimal consumption path from the "ideal" model and under what conditions does blanking the coefficients disturbance lead to the non-disturbed optimum.

## 2. The Idea of Γ-convergence – an Example

Γ-convergence is one of the most important tools of optimisation theory, which assures the convergence of both minima and minimisers to, respectively, the minimum and minimiser of the limiting functional. The problem of convergence of optima was first considered by E. De Giorgi (1984), who introduced and developed the concept of Γ-convergence. In parallel, mathematicians studied the problem of convergence of sets, also in optimisation problems. There was the question of how to extend the Hausdorff metric, defined for nonempty and compact (therefore, in $\mathbb{R}^n$: closed and bounded) sets, to the case of closed sets. Kazimierz Kuratowski was the first to prepare a fundamental description of this convergence and showed the equivalence between Γ-convergence of functionals and the Kuratowski convergence of their epigraphs (Kuratowski 1961).

We are now going to present a brief outline of both approaches. First, we give a definition of epigraph and – using this intuitive geometric approach – discuss an example illustrating the fundamental role of Γ-convergence.

*Definition 1.* Let function $f: X \to \mathbb{R}$ be given, where $X$ is a topological space. The epigraph of function $f$ is the set:

$$epi(f) := \{(x, v) \in X \times \mathbb{R} : v \geq f(x)\}.$$

Geometrically, epigraph of function is the part of Cartesian product $X \times \mathbb{R}$ above the graph of $f$. For a lower semicontinuous function $f$ its graph is a closed subset of the Cartesian product $X \times \mathbb{R}$.

*Example 1.* The epigraph of function $f(x)=x^4-3x^3+x-4$ is presented in Figure 1.

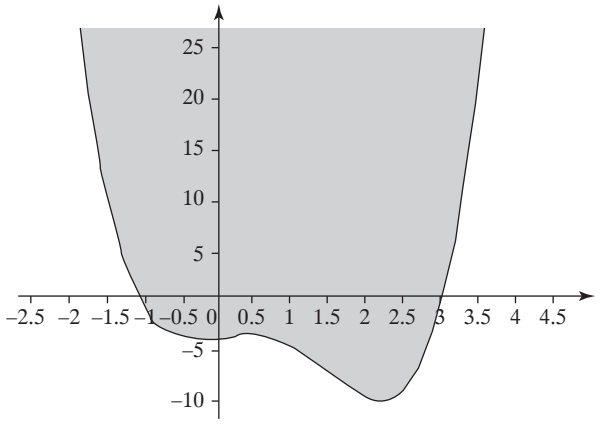


Fig. 1. The Epigraph of Function *f*
Source: author's own elaboration.

*Example 2.* Consider the following sequence of functions ($n\in\mathbb{N}$):

$$f_n(x)=\begin{cases} 1, & -2\le x<-\frac{2}{n},\\ (1-2n)x+\frac{2-3n}{n}, & -\frac{2}{n}<x\le-\frac{1}{n},\\ (2n-1)x+1, & -\frac{1}{n}<x\le 0,\\ -x+1, & 0<x\le 1. \end{cases}$$

Their graphs (for exemplary values of parameter *n*) are presented in Figure 2.

It is easy to observe that each function $f_n$ possess the minimum at point $x_n=-\frac{1}{n}$, and the minimal value is $y_n=f_n(x_n)=-1+\frac{1}{n}$. Therefore, calculating trivial limits one obtains that $\overline{x}=\lim_{n\to+\infty}x_n=0$ and $\overline{y}=\lim_{n\to+\infty}y_n=-1$, being respectively the limits of minimisers and of minima.

Consider now the limit of sequence $(f_n)$, in two approaches. The pointwise limit is obviously the function:

$$f_p(x)=\begin{cases} 1, & -1\le x<0,\\ -x+1, & 0\le x\le 1.\end{cases}$$

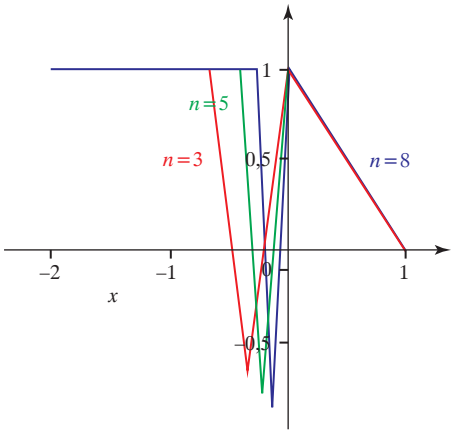


Fig. 2. Graphs of Functions $f_n$

Source: author's own elaboration.

However, if we consider the epigraphs of functions $f_n$, it is easy to observe that they converge to the set in Figure 3.

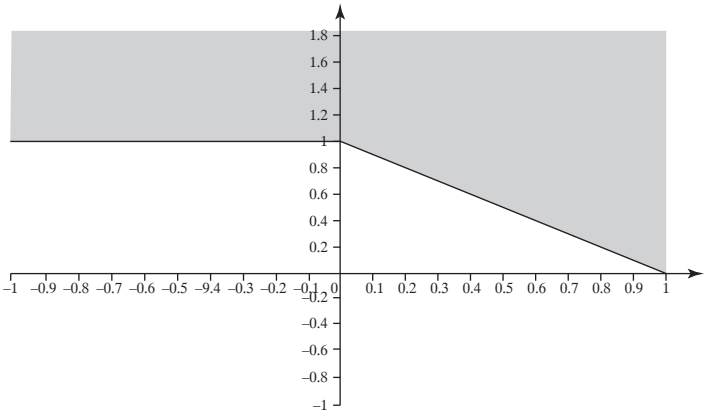


Fig. 3. The Kuratowski Limit of Sequence $(epi(f_n))_{n\in\mathbb{N}}$

Source: author's own elaboration.

Therefore, the function whose epigraph is represented by this limiting set is:

$$f_{epi}(x)=\begin{cases} 1, & x\in[-1,0), \\ -1 & x=0, \\ -x+1, & x\in(0,1]. \end{cases}$$

Since $f_{epi}(0)\neq f_p(0)$, we have that $f_{epi}\neq f_p$.

Let us have a look at the variational properties of both limit functions, $f_p$ and $f_{epi}$. The minimal value of $f_p$ is attained at $x_p = 1$ and $y_p=\min_{x\in[-1,1]} f_p(x)=0$, while the minimiser and minimal value for $f_{epi}$ are $x_{epi} = 0$ and $y_{epi}=\min_{x\in[-1,1]} f_{epi}(x)=-1$. Notice that the last two coincide with the limits $\overline{x}$ and $\overline{y}$. Therefore, function $f_{epi}$ has good variational properties: it is the limit of our sequence $(f_n)$ – more precisely: the Γ-limit of this sequence; the limit of minimisers $(x_n)$ is a minimiser of the limit $f_{epi}$ and finally the limit of minima $(y_n)$ is in fact the minimum of the limit $f_{epi}$.

The observed phenomenon is not incidental. In fact, it was the reason to define Γ-convergence. Those properties are crucial in optimisation problems. They assure the stability of optima and justify the usage of numerical methods, which – by their nature – deal with approximate problems and face the issue of propagation of computational errors.

While studying the last example, the natural question arises: how can the Γ-limit of sequence of functions be formally defined and how is it related to the pointwise and uniform limit of sequence of functions (which are not sufficient in those kinds of problems)? Also, when discussing example 1, we used the intuitive concept of the epigraphical limit of the sequence $(f_n)$ and only mentioned its relation to the Γ-limit. In the next section, all those concepts are formalised.

## 3. Γ-limit and Links to Other Types of Limits

In this section, we formulate the necessary definitions and theorems on epigraphical convergence. They are cited from G. Dal Maso (1993).

In what follows, we are going to denote by $X$ a topological space[1] and $f_n: X\to\overline{\mathbb{R}}$ (where $\overline{\mathbb{R}}=\mathbb{R}\cup\{\pm\infty\}$ is the extended real line) a sequence of

[1] In the definitions and theorems, we consider $X$ to be a topological space, metric space or topological vector space. These are mathematical structures, allowing usage of different operations on the elements of set $X$, like measuring the distance or operating on vectors, respectively. For

functions defined in it, while $N(x)$ denotes the family of open neighbourhoods of the point $x$.

*Definition 2* (Dal Maso 1993, p. 38). The lower and upper Γ-limits of the sequence $(f_n)$ are defined as follows:

$$f_{low-\Gamma} := \Gamma - \liminf_{n\to\infty} f_n(x) := \sup_{U\in N(x)} \liminf_{n\to\infty} \inf_{y\in U} f_n(y),$$

$$f_{upp-\Gamma} := \Gamma - \limsup_{n\to\infty} f_n(x) := \sup_{U\in N(x)} \limsup_{n\to\infty} \inf_{y\in U} f_n(y).$$

If $f_{low-\Gamma} = f_{upp-\Gamma} := f_\Gamma$, then sequence $(f_n)$ is said to be Γ-convergent to $f_\Gamma$ and function $f_\Gamma$ is Γ-limit of it.

We define now the lower and upper Kuratowski limits of the family of sets (net), $(E_n) \subset X$, when $n \to \infty$.

*Definition 3* (Dal Maso 1993, p. 41). The lower and upper Kuratowski limits of a sequence of sets are, respectively:

$$x \in K - \liminf_{n\to\infty} E_n \Leftrightarrow \forall U \in N(x) \;\; \exists k \in \mathbb{N} \; \forall h \geq k: \;\; U \cap E_h \neq \varnothing$$

$$x \in K - \limsup_{n\to\infty} E_n \Leftrightarrow \forall U \in N(x) \;\; \forall k \in \mathbb{N} \; \exists h \geq k: \;\; U \cap E_h \neq \varnothing.$$

Clearly, $K - \liminf_{n\to\infty} E_n \subset K - \limsup_{n\to\infty} E_n$. If the converse inclusion holds as well, we denote the resulting set by $E := K - \lim_{n\to\infty} E_n$ and call it the Kuratowski limit of $(E_n)$ when $n \to \infty$. Therefore, $(E_n)$ converges to some set $E$ as $n \to \infty$, iff:

$$K - \limsup_{n\to\infty} E_n \subset E \subset K - \liminf_{n\to\infty} E_n.$$

The next theorem establishes the relation between Γ-convergence of sequence of functions and the Kuratowski convergence of their epigraphs.

*Theorem 1* (Dal Maso 1993, p. 44). Let $f_{low-\Gamma}$ and $f_{upp-\Gamma}$ be respectively the lower and upper limits of a sequence of functions $(f_n)$. Then:

$$epi(f_{low-\Gamma}) = K - \limsup_{n\to\infty} epi(f_n),$$

$$epi(f_{upp-\Gamma}) = K - \liminf_{n\to\infty} epi(f_n).$$

Therefore, $(f_n)$ Γ-converges to $f_\Gamma$ if and only if $epi(f_\Gamma) = K - \lim_{n\to\infty} epi(f_n)$.

the sake of our further applications, the reader may consider $X = \mathbb{R}^n$ with standard metric, which satisfies all the necessary requirements of each case.

We are ready to formulate the theorem which describes the fundamental role of Γ-convergence in optimisation theory. This is particular case of the more general theorem 7.12 in Dal Maso (1993, p. 73).

For a function $f: X \to \overline{\mathbb{R}}$ denote by $M(f)$ the set of its minimisers (possibly empty), i.e.:

$$M(f) := \left\{ x \in X : f(x) = \inf_{y \in X} f(y) \right\}.$$

*Theorem 2.* Assume that sequence $(f_n)$ is Γ-convergent to $f_\Gamma$. Then:

a) $K - \lim\inf_{n\to\infty} M(f_n) \subset M(f_\Gamma)$,

i.e. any limit of a sequence of minima $y_n$ is a minimiser of $f_\Gamma$;

b) if $K - \lim_{n\to\infty} M(f_n) \neq \emptyset$, then $M(f_\Gamma) \neq \emptyset$ and $\min_{x\in X} f_\Gamma(x) = \lim_{n\to\infty}(\inf_{x\in X} f_n(x))$,

i.e. if there exists a limit of a sequence of minima $y_n$, then function $f_\Gamma$ has at least one minimiser (this limit itself, maybe also some other) and the minimum of $f_\Gamma$ is approximated by minima $y_n$;

c) if $f_\Gamma$ is a proper function (not identically $+\infty$), then:

$$M(f_\Gamma) \subset K - \limsup_{n\to\infty} M(f_n),$$

i.e. if $f_\Gamma$ has at least one finite value, then any minimiser of this function is the limit of a sequence of minimisers $y_n$.

As we observed in example 1, both pointwise and Γ-limits of the considered sequence of functions existed. In general, these are independent concepts and it may happen that one of those limits exists while the other does not. However, there are some situations when they both do exist and coincide. Below we cite the theorems from Dal Maso (1993) describing most important cases, usual in economic modelling.

The subscript "p" is related to pointwise limit.

*Theorem 3*

a) $f_{low-\Gamma} \leq f_{low-p}$ and $f_{upp-\Gamma} \leq f_{upp-p}$.

In particular, if both the Γ-limit $f_\Gamma$ and pointwise limit $f_p$ exist, then $f_\Gamma \leq f_p$.

b) If each function $f_n$ is continuous and sequence $(f_n)$ converges uniformly[2] to a function $f$, then $f$ is continuous and $f = f_\Gamma$.

c) If $(f_n)$ is an increasing sequence of continuous functions, then $f_\Gamma = \sup_{n\in\mathbb{N}} f_n$.

[2] Having $(X, d)$ a metric space with distance function $d$, sequence of functions $f_n: X \to \overline{\mathbb{R}}$ is uniformly convergent to function $f: X \to \overline{\mathbb{R}}$ iff $\lim_{n\to\infty} \sup_{x\in X} d(f_n(x), f(x)) = 0$.

d) Let $X$ be normed vector space. If $(f_n)$ is a sequence of equi-bounded[3] in a neighbourhood of a point $x \in X$ and convex functions, then – provided the sequence $(f_n)$ is convergent – $f_\Gamma = f_p$.

The next theorem determines when the properties of convexity and homogeneity are inherited by Γ-limits.

*Theorem 4.* Let $X$ be a topological vector space over the real numbers. Then:

a) if $(f_n)$ is a sequence of convex functions, then $f_{upp-\Gamma}$ is a convex function. In particular, for Γ-convergent sequence the Γ-limit $f_\Gamma$ is convex;

b) if $(f_n)$ is a sequence of positively homogeneous of degree $p$ functions[4], then both $f_{low-\Gamma}$ and $f_{upp-\Gamma}$ are positively homogeneous of degree $p$. In particular, if the sequence $(f_n)$ Γ-converges to $f_\Gamma$, then $f_\Gamma$ is positively homogeneous of degree $p$.

Notice that due to the obvious facts:

1) if function $f$ attains minimum at a point $x_0$, then function $-f$ attains maximum at this point;

2) if function $f$ is increasing in a set $A$, then function $-f$ is decreasing in this set;

3) if function $f$ is convex in a set $X$, then function $-f$ is concave in the same set;

4) $\limsup_{n\to\infty}(-f_n(x)) = -\liminf_{n\to\infty} f_n(x)$ and $\liminf_{n\to\infty}(-f_n(x)) = -\limsup_{n\to\infty} f_n(x)$;

all the presented theorems have their corresponding formulations for functions possessing symmetric properties.

## 4. Household's Utility Optimisation

We consider now the household optimisation problem of the Ramsey model (Barro & Sala-i-Martin 2004), in which the parameters are given with some approximation. In what follows, all the introduced functions are smooth.

The households are assumed to be identical, so they are characterised by the same preferences, the wage rate ω, the rate of returns $r$ (for simplicity

[3] A family (or sequence) of functions $(f_n)$, $f_n : X \to \mathbb{R}$, is equi-bounded iff there exists a constant $M > 0$, which bounds any function, i.e. for any $x \in X : \left| f_n(x) \right| < M$.

[4] Having $X$ a vector topological space, function $f : X \to \overline{\mathbb{R}}$ is positively homogeneous of degree $p$ iff for any $t > 0$ and any $x \in X$ it holds that $f(tx) = t^p f(x)$.

assumed to be constant, may be understood as the average) and the same assets per person. The population grows at the rate $n > 0$, so $L(t) = L(0) \cdot e^{nt}$. In further calculations, the initial size of population $L(0)$ is normalised to 1. $C(t)$ denotes the total consumption at time $t$ and $c(t) := \frac{C(t)}{L(t)}$ consumption per capita. We consider CRRA utility, i.e.:

$$u(c) = \frac{c^{1-\theta} - 1}{1-\theta}, \qquad \theta \in (0,1) \tag{1}$$

so it satisfies the usual monotonicity and concavity assumptions and meets Inada conditions. Therefore, the households face the problem of choosing such a consumption path $c(t)$ to maximise the intertemporal utility functional (with discount rate $\rho > n$):

$$U[c] = \int_0^\infty u(c(t)) e^{-(n-\rho)t} dt, \tag{2}$$

taking into account the budget constraints and $c(t) \geq 0$. The budget constraints are expressed by the dynamics of a household's assets per person $a(t)$:

$$\frac{da}{dt} = (r-n)a(t) + \omega(t) - c(t). \tag{3}$$

Ruling out the chain-letters possibilities we do require that the present value of assets is asymptotically nonnegative:

$$\lim_{t \to \infty} a(t) \cdot e^{-(r-n)} \geq 0. \tag{4}$$

Thanks to transversality conditions and the Pontryagin Maximum Principle we can derive the optimal consumption path:

$$c^*(t) = c(0) \exp\left(\frac{1}{\theta}(r-\rho)t\right). \tag{5}$$

For the derivation of the constraints and a detailed solution of the model, see R. J. Barro and X. Sala-i-Martin (2004, pp. 88–93).

Consider now the Ramsey model with "disturbed" parameters. The rates $r$, $n$, $\rho$ and parameter $\theta$ are given with some approximation, which may depend on measurement rules. Denote those approximate values by $r_\varepsilon$, $n_\varepsilon$, $\rho_\varepsilon$ and $\theta_\varepsilon$, respectively. Assume that for any $\varepsilon$, $\rho_\varepsilon > n_\varepsilon$, and $\theta_\varepsilon \in (0,1)$. Increasing the accuracy of measurement, the approximate values $b_\varepsilon$ tend to actual value $b$ for $b \in \{r, n, \rho, \theta\}$. Having those approximate values $b_\varepsilon$

the household's maximisation problem is now to maximise the functional $U_\varepsilon[c]=\int_0^\infty u_\varepsilon(c(t))e^{-(n_\varepsilon-\rho_\varepsilon)t}dt$, where $u_\varepsilon(c)=\frac{c^{1-\theta_\varepsilon}-1}{1-\theta_\varepsilon}$ subject to the analogous constraints to (3) and (4). Repeating the reasoning for each $\varepsilon > 0$, we obtain the optimal solution: the function $c_\varepsilon^*(t)=c(0)\exp\left(\frac{1}{\theta_\varepsilon}(r_\varepsilon-\rho_\varepsilon)t\right)$. The natural questions now are whether or not $c_\varepsilon^*$ converges to $c^*$ and $U_\varepsilon[c_\varepsilon^*]$ converges to $U[c^*]$, i.e. whether or not the optimal path $c_\varepsilon^*$ approximates the actual optimal path $c^*$ and $U_\varepsilon[c_\varepsilon^*]\approx U[c^*]$. To give the answer, we prove the following theorem:

*Theorem 5.* If $\lim_{\varepsilon\to 0}r_\varepsilon=r, \lim_{\varepsilon\to 0}n_\varepsilon=n, \lim_{\varepsilon\to 0}\rho_\varepsilon=\rho$ and $\lim_{\varepsilon\to 0}\theta_e=\theta$, then $U_\varepsilon$ converges to $U$ uniformly.

*Proof.* We will show first that the uniform limit of $(u_\varepsilon)$ is function $u$. Estimating the distance between $u_\varepsilon$ and $u$, we get:

$$\left|u_\varepsilon(c)-u(c)\right|=\left|\frac{c^{1-\theta_\varepsilon}-1}{1-\theta_\varepsilon}-\frac{c^{1-\theta}-1}{1-\theta}\right|=$$

$$=\left|\frac{(c^{1-\theta_\varepsilon}-c^{1-\theta})+(\theta_\varepsilon\cdot c^{1-\theta}-\theta\cdot c^{1-\theta_\varepsilon})+(\theta-\theta_\varepsilon)}{(1-\theta_\varepsilon)(1-\theta)}\right|\leq$$

$$\leq\frac{\left|c^{1-\theta_\varepsilon}-c^{1-\theta}\right|+\left|\theta_\varepsilon\cdot c^{1-\theta}\pm\theta_\varepsilon\cdot c^{1-\theta_\varepsilon}-\theta\cdot c^{1-\theta_\varepsilon}\right|+\left|\theta-\theta_\varepsilon\right|}{(1-\theta_\varepsilon)(1-\theta)}\leq$$

$$\leq\frac{(1+\theta_\varepsilon)\left|c^{1-\theta_\varepsilon}-c^{1-\theta}\right|+(c^{1-\theta_\varepsilon}+1)\left|\theta-\theta_\varepsilon\right|}{(1-\theta_\varepsilon)(1-\theta)}.$$

Notice that if $\theta_\varepsilon\to\theta$, then both terms in the numerator tend to zero, so $u_\varepsilon\rightrightarrows u$. We are ready to prove the uniform convergence of operators $U_\varepsilon$ to $U$:

$$\left|U_\varepsilon[c]-U[c]\right|=\left|\int_0^\infty u_\varepsilon(c(t))e^{-(n_\varepsilon-\rho_\varepsilon)t}dt-\int_0^\infty u(c(t))e^{-(n-\rho)t}dt\right|\leq$$

$$\leq\int_0^\infty\left|u_\varepsilon(c(t))e^{-(n_\varepsilon-\rho_\varepsilon)t}\pm u(c(t))e^{-(n_\varepsilon-\rho_\varepsilon)t}-u(c(t))e^{-(n-\rho)t}\right|dt\leq$$

$$\leq\int_0^\infty\left[\left|u_\varepsilon(c(t))-u(c(t))\right|\cdot e^{-((n_\varepsilon-n)-(\rho_\varepsilon-\rho))t}+u(c(t))\cdot e^{-((n_\varepsilon-n)-(\rho_\varepsilon-\rho))t}-1\right]\cdot e^{-(n-\rho)t}dt.$$

Due to the uniform convergence of $(u_\varepsilon)$ and convergence of sequences $(n_\varepsilon)$ and $(\rho_\varepsilon)$, the integrand tends to zero function, so $U_\varepsilon \rightrightarrows U$, which proves the theorem.

*Theorem 6.* The functional $U$ is the Γ-limit of the sequence $U_\varepsilon$ when $\varepsilon \to 0$. Theorem 6 is the immediate consequence of theorems 5 and 3b.

*Corollary.* If parameters $r$, $n$, $\rho$ and $\theta$ are given with an approximation whose absolute error tends to zero, then the corresponding consumption path approximates the optimal "theoretical" consumption path and the obtained value of utility is close to the actual maximum.

## 5. Conclusions and Further Research

The aim of the study reported in this paper is two-fold. Firstly, we want to emphasise the role of Γ-convergence in optimisation problems, and in particular in economic modelling. Secondly, we show that using an approximation of the parameters of the Ramsey model with vanishing absolute error of approximation it is possible to give the explicite formula for the time-varying consumption per capita, which leads to "almost"--maximisation of the CRRA utility functional.

In the author's opinion it would be interesting to consider a similar problem of convergence of optimal path in the more general Ramsey model, where the rates are functions of time. Then we would enquire what kind of time-dependence of rate of returns, wages, discount rate or preference parameter still allows for the maximum of the utility functional and what kind approximation of them gives an approximation of optimal paths.

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## Abstract

### Kiedy optima są zbieżne do optimum?

W artykule podjęto zagadnienie zbieżności ciągu optimów zagadnień przybliżonych do optimum zagadnienia granicznego. Oparto się na Γ-zbieżności – kluczowym pojęciu w teorii optymalizacji. Wykazano istotność jej stosowania i podano twierdzenia opisujące jej najważniejsze własności. Wykorzystując wprowadzone narzędzia, wyprowadzono warunki, przy których przybliżenie parametrów modelu Ramseya (przy wygaszanym błędzie bezwzględnym aproksymacji) pozwala na podanie explicite przepisu na zmienną w czasie ścieżkę konsumpcji per capita, które prowadzi do bliskich maksimum wartości funkcjonału użyteczności typu CRRA.

**Słowa kluczowe:** Gamma-zbieżność, model Ramseya, zbieżność optimów, stabilność ścieżek optymalnych.

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# INCOME AND EXPENDITURE INEQUALITIES AMONG HOUSEHOLDS IN POLAND

**Abstract**

Stratification and its inverse concept, overlapping, are strictly connected with inequality, playing an essential role in one kind of decomposition of the Gini index. Properties of overlapping indexes are investigated in this paper. Decomposition of inequalities in Poland (of incomes, expenditures, and their difference), which includes the overlapping-due term, is performed and analysed.

**Keywords:** stratification, overlapping, Gini, decomposition, between-group inequality.
**JEL Classification:** D14, D63, I32.

## 1. Introduction

Inequalities of wealth, or, in general, in quality of life and standards of living, are an urgent problem nowadays, gaining much attention among the public and policy-makers alike. To better understand the situation, it is frequently useful to know how overall inequality is distributed among various geographical regions and/or social groups. Thus, the question arises of the proper decomposition of inequality measures.

As for the Gini index, the most popular and most frequently used measure of inequality, its decomposition with respect both to different groups and to different sources of the total quantity in question (e.g. different sources of income), is known and used. Within the standard approach to decomposition of the Gini index with respect to different groups, three components are identified (see, for instance, Bhattacharya & Mahalanobis 1967; Pyatt 1976; and Dagum 1997). First, it is the within-group component that is a weighted

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sum of the Gini indexes for each of the subgroups, while the weighting factor is the share of the group in the total population times the share of the total good belonging to the particular group. The second component is the between-group one, which is calculated as the Gini index while neglecting all diversity within groups – that is, treating all individuals within a particular group as if they possessed an amount of good equal to the average for this group. These two components in general do not constitute the overall Gini index, and there remains the so-called residual term, which results from the overlapping of the distributions of different groups. This means that if the group with the lower average did not involve any individual which had more than any individual from the group with the higher average value, the overlap component would be equal to zero. However, this is rarely the case for any set of natural groups. Of course, if one defined groups as quintile groups, for instance, they would not overlap by their very definition. However, once we are willing to investigate any geographical or socio-economic groups, the overlapping will occur and thus the third term of decomposition will have non-zero value. This residual term takes into account all pairs of individuals from the whole populations whose order (with respect to the investigated quantity, e.g. income) is inverse to the order of the averages of the groups the individuals belong to.

Another approach to decomposition of the Gini index has been proposed by Yitzhaki (1994), who focussed on the concept of stratification.

Stratification is in fact one of the many faces of inequality, along with others such as segregation and polarisation. Under the name of stratification, four types of strata are considered: caste, class, estate, and slavery. An example of perfect caste stratification is the caste system in India. In the case of class stratification, the essential problem concerns the determination of the three "basic" classes: working class, middle class, and upper, or capitalist class. Problems concerning economic polarisation, which means polarisation according to economic status, are investigated at length in M. Kot's monograph (2008). The scope of this paper is rather to shed some light on the problem of stratification of inequalities when strata are overlapping.

Assuming that definitions of social classes are dependent not merely on income but on the type of occupation, lifestyle, social capital, etc., some members of the middle class may be richer than some members of the aristocracy. Thus, stratification of social classes is not perfect. Again, the groups or classes might be defined in such a way as to ensure perfect stratification. However, when dealing with natural socio-economic groups or

geographical subpopulations, one may expect no stratification will be perfect and that some overlapping will occur between each pair of groups.

Within the scope of Yitzhaki and Lerman's decomposition (1991), the within-group part is identical as in the standard decomposition. The between-group part is expressed in terms of stratification and assumes, in general, a different value from the standard between-group Gini. The residual term in the latter decomposition differs from the standard one with respect to establishing the position of the particular group within the whole population. While in the standard method it is taken as the rank of the average of the group in the set of the groups' averages, the latter decomposition makes use of more information. The rank of the group is the average rank of all individuals' ranks (all individuals belonging to the group). Thus, it may be different from the former. For example, if only one individual makes the average of his group very high (and accordingly gives it a high rank), while all of the remaining individuals are placed very low in the whole population, the average of individuals' ranks may be much lower than the rank of the overall average for this group.

The concept of stratification, and its inverse – overlapping, allows us to present the mutual relationship between each pair of groups, not only the overall picture, which might be advantageous in many situations. Moreover, the overlapping index, as will be shown in later sections of this paper, is standardised as it does not exceed the value of 2 (and cannot be negative). This is an advantage in the presence of negative values. It is known that the Gini index is not normalised in the presence of negatives, that is, it is not bounded from above by 1 and it is difficult to compare two different Ginis in such a situation. Of course, the method of decomposition does not overcome the problem for the final Gini result, however: it postpones the moment of incomparability of values until the final step of composing the overall Gini from the group and between group-values.

The problem of stratification of Polish households based on data from the Household Budget Survey has been investigated recently by A. Jędrzejczak (2014). The essential difference of the approach presented in this paper is that it focusses on overlapping rather than on stratification and uses a different definition of the within-group term. Jędrzejczak (2014) adopted the within-group term as defined in the work of Yitzhaki and Lerman (1991), which is thus different from the within-group term as defined in the "standard" decomposition used by, for instance, C. Dagum (1997), G. Pyatt (1976) or A. F. Shorrocks (1984). Using the overlapping index rather than the stratification index enables us to represent the within-group term

in a way consistent with the standard way of decomposition and to compare the remaining parts of inequality. Moreover, while the stratification index describes the degree of stratification of a given group with respect to the whole population, the overlapping index is in a natural way a weighted sum of overlapping indexes between each pair of groups – thus, it is easy to see the mutual relationship of any pair of groups, which may be useful in identifying some social groups.

The aim of this paper is to present the Yitzhaki-Lerman methodology for calculating overlapping between different groups and to use it for Polish households of different types. Before presenting the results for empirical data, some simple theoretical examples are used to support the intuition of circumstances in which the overlapping index is low/high and symmetrical/unsymmetrical. Readers who are not interested in the mathematical details of how the formulae are obtained can go straight to Section 3 for these illustrations.

The paper is organised as follows: in the next section the notation and basic formulae are introduced. In the third section, three simple examples of distributions with a detailed presentation of stratification and overlapping indexes, along with the Gini values, are presented. The following section presents some results for Poland, and the presence of stratification with respect to types of households is examined. The final section offers a summary and conclusions.

## 2. Basic Formulae and Notation

In what follows, the population consisting of $N$ members is divided into $g$ groups, each of them having $n_i$ members, $\sum_{i=1}^{g} n_i = N$. The share of the population of group $i$ in the whole population is denoted by $p_i : p_i = \frac{n_i}{N}$, $\sum_{i=1}^{g} p_i = 1$.

Let us consider some quantity $X$, e.g. income, which is considered to be a random variable, distributed according to $F_X$ (which will simply be denoted also as $F$). The probability distribution $F$ is considered to be a mixture of $g$ distributions characterising each of the $g$ groups:

$$F = \sum_{i=1}^{g} \frac{n_i}{N} F_i. \tag{1}$$

Denoting by $\mu$ the overall mean value and by $\mu_i$ the mean value of $X_i$, the share of group $i$ in the whole amount of investigated good is denoted by $s_i : s_i = \frac{n_i \mu_i}{N\mu} = p_i \frac{\mu_i}{\mu}, \sum_{i=1}^{g} s_i = 1$.

The index of overlapping, $O_{ji}$, measuring the degree to which distribution $j$ is included in the range of distribution $i$, is defined as (Yitzhaki & Lerman 1991):

$$O_{ji} = \frac{\mathrm{COV}_i(F_j(X), X)}{\mathrm{COV}_i(F_i(X), X)}, \tag{2}$$

where $\mathrm{COV}_i(Y, X)$ denotes the covariance between random variables $Y$ and $X$ with respect to distribution $F_i$, i.e.

$$\mathrm{COV}_i(Y, X) = \int (Y - \mu_Y)(X - \mu_X) dF_i. \tag{3}$$

From the definition (2), it follows that $O_{ii} = 1$. Also, when the distributions $F_i$ and $F_j$ are identical, $F_i \equiv F_j$, it holds: $O_{ji} = 1$.

The lowest value of $O_{ji}$ is zero (as the cumulative distribution is always a non-decreasing function of $X$) and it is equal to zero if no part of distribution $F_j$ lies within the range of distribution $F_i$.

The other limiting case is reached for the distribution of $F_i$ being divided into two parts: all values greater than the expected value should lie beyond the range of distribution $F_j$, while all values smaller than the expected value should lie beneath the range of distribution $F_j$. That may be seen as the expression:

$$\mathrm{COV}_i(F_j(X), X) = \int F_j \cdot (X - \mu_X) dF_i \tag{4}$$

assumes maximum value if for positive differences $X - \mu_X > 0$ the value of $F_j$ will be as high as possible (that is, equal to 1), while for negative differences $X - \mu_X < 0$ the value of $F_j$ will be as small as possible (that is, equal to 0).

In each case the maximum value of $O_{ji}$ is at most 2, as (cf. Yitzhaki 1994):

$$\mathrm{COV}_i(F_j(X), X) \leq \frac{1}{2} E\left(\left| X - \mu_X \right|\right),$$

$$\mathrm{COV}_i(F_i(X), X) = \frac{1}{4} E\left(\left| X_i - Z_i \right|\right),$$

thus

$$O_{ji} \leq \frac{\frac{1}{2} E\left(\left| X - \mu_X \right|\right)}{\frac{1}{4} E\left(\left| X_i - Z_i \right|\right)},$$

and what follows from Jensen's inequality:

$$O_{ji} \leq \frac{2E\left(\left| X - \mu_X \right|\right)}{E\left(\left| X_i - Z_i \right|\right)} \leq 2. \tag{5}$$

However, for the case of particular distributions the maximum value might be smaller than 2. As the overlapping index $O_{ji}$ is maximum for the distribution $F_j$ concentrated at the mean value of distribution $F_i$, this maximum will depend rather on the shape of $F_i$ than $F_j$ (the density of the latter tending to the shape of the Dirac delta located at the mean value of distribution $F_i$). These more precise restrictions for the overlapping index will be presented for three particular distributions in what follows.

The overall overlap for group $i$ is a sum of all indexes $O_{ji}$, that is:

$$O_i = \sum_{j=1}^{g} p_j O_{ji} = p_i + \sum_{\substack{j=1 \\ j \neq i}}^{g} p_j O_{ji}, \tag{6}$$

as $O_{ii} = 1$.

The concept related to the overlapping index is the index of stratification of group $i$, denoted by $Q_i$. It is defined as:

$$Q_i = \frac{\mathrm{COV}_i(F_i(X) - F_{ni}(X), X)}{\mathrm{COV}_i(F_i(X), X)} = 1 - \frac{\mathrm{COV}_i(F_{ni}(X), X)}{\mathrm{COV}_i(F_i(X), X)}, \tag{7}$$

where $F_{ni}$ denotes the cumulative distribution function of the whole population apart from group $i$, that is:

$$(1 - p_i) F_{ni} = F - p_i F_i, \tag{8}$$

(which follows from $F = p_i F_i + F = (1 - p_i) F_{ni}$).

Comparing (2), (6) and (7) it is easy to express the overlapping index in terms of the stratification index and vice versa. As:

$$\begin{aligned} O_i &= \frac{\sum_{j=1}^{g} \mathrm{COV}_i(F_j(X), X)}{\mathrm{COV}_i(F_i(X), X)} = \frac{\mathrm{COV}_i(F(X), X)}{\mathrm{COV}_i(F_i(X), X)} = \\ &= p_i + \frac{(1 - p_i)\mathrm{COV}_i(F_{ni}(X), X)}{\mathrm{COV}_i(F_i(X), X)}, \end{aligned} \tag{9}$$

using (8) one obtains:

$$O_i = p_i + (1 - p_i)(1 - Q_i) = 1 - Q_i(1 - p_i). \tag{10}$$

Now we may proceed to decompose the overall Gini index for the whole population with respect to the Gini indexes for particular groups and two other terms.

The Gini index for the whole population reads:

$$G = \frac{2}{\mu}\mathrm{COV}(F, X) \tag{11}$$

while for the *i*-th group:

$$G_i = \frac{2}{\mu_i}\mathrm{COV}_i(F_i, X). \tag{12}$$

Using (1), covariance in (11) may be re-expressed as follows:

$$\mathrm{COV}(F, X) = \int (x - \mu)F(x)dF = \sum_{i=1}^{g} p_i \int (x - \mu)F(x)dF_i. \tag{13}$$

Subtracting and adding $\mu_i$ one gets:

$$\mathrm{COV}(F, X) = \sum_{i=1}^{g}\left[p_i \int (x - \mu_i)F(x)dF_i + \int (\mu_i - \mu)F(x)dF_i\right]. \tag{14}$$

The first term is a sum of within-group covariances:

$$\sum_{i=1}^{g} p_i \int (x - \mu_i)F(x)dF_i = \sum_{i=1}^{g} p_i \mathrm{COV}_i(F, X). \tag{15}$$

The second term is the covariance between the *g*-tuple of groups' means and the *g*-tuple of average values of cumulative distribution for particular groups:

$$\begin{aligned}\sum_{i=1}^{g} \int (\mu_i - \mu)F(x)dF_i &= \sum_{i=1}^{g} (\mu_i - \mu)\int F(x)dF_i \equiv \\ &\equiv \sum_{i=1}^{g} (\mu_i - \mu)\overline{F}_i = \mathrm{COV}(\mu_i, \overline{F}_i).\end{aligned} \tag{16}$$

Altogether, the Gini index (11) may be rewritten as:

$$G = \frac{2}{\mu}\sum_{i=1}^{g} p_i \mathrm{COV}_i(F, X) + \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i). \tag{17}$$

Notice that $\mathrm{COV}_i(F, X)$ is not the one that would appear in the formula for $G_i$, as cumulative distribution here is measured in the general population, not within the group. To reach the within-groups cumulative distribution, one can use (8) and re-express:

$$\mathrm{COV}_i(F, X) = p_i \mathrm{COV}_i(F_i, X) + (1 - p_i)\mathrm{COV}_i(F_{ni}, X). \tag{18}$$

Expression $\mathrm{COV}_i(F_i, X)$ is related to $G_i$ by:

$$G_i = \frac{2}{\mu_i}\mathrm{COV}_i(F_i, X). \tag{19}$$

On the other hand, $\mathrm{COV}_i(F_{ni}, X)$ may be expressed in terms of either the stratification index or the overlapping index, as:

$$\mathrm{COV}_i(F_{ni}, X) = (1-Q_i)\mathrm{COV}_i(F_i, X) = \frac{\mu_i}{2}(1-Q_i)G_i, \tag{20}$$

or:

$$\mathrm{COV}_i(F_{ni}, X) = \frac{\mu_i}{2}\left(\frac{O_i - p_i}{1-p_i}\right)G_i. \tag{21}$$

Thus:

$$G = \frac{1}{\mu}\sum_{i=1}^{g} p_i^2 \mu_i G_i + \frac{1}{\mu}\sum_{i=1}^{g} p_i \mu_i (1-Q_i)(1-p_i)G_i + \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i), \tag{22}$$

or, after rearranging,

$$G = \sum_{i=1}^{g} s_i G_i + \sum_{i=1}^{g} s_i G_i Q_i (p_i - 1) + \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i), \tag{23}$$

and

$$G = \sum_{i=1}^{g} p_i^2 \frac{\mu_i}{\mu} G_i + \sum_{i=1}^{g} p_i \frac{\mu_i}{\mu}(O_i - p_i)G_i + \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i), \tag{24}$$

or:

$$G = \sum_{i=1}^{g} p_i s_i G_i + \sum_{i=1}^{g} s_i (O_i - p_i)G_i + \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i). \tag{25}$$

The three terms are correspondingly within-group Gini, overlap-due Gini, and between-group Gini indexes:

$$G_W \equiv \sum_{i=1}^{g} p_i s_i G_i, \tag{26}$$

$$G_O \equiv \sum_{i=1}^{g} s_i (O_i - p_i)G_i, \tag{27}$$

$$G_B \equiv \frac{2}{\mu}\mathrm{COV}(\mu_i, \overline{F}_i). \tag{28}$$

For the discrete case, the counterpart of the cumulative distribution function are the normalised ranks.

## 3. Three Simple Illustrative Examples

### 3.1. Preliminary Remarks

The relationship between $O_{ij}$ and $O_{ji}$ is far from obvious. $O_{ji}$ measures the degree to which the distribution $j$ is included within the range of the

distribution *i*. $O_{ij}$ measures the degree to which the distribution *i* is included within the range of the distribution *j*. Thus, it might be suspected that the greater one of them is, the smaller is the other one. This would be indeed the case in some circumstances, e.g. the fixed central tendencies of both distributions and changing dispersions. However, under other circumstances, e.g. fixed dispersions and changing central tendencies, both $O_{ij}$ and $O_{ji}$ will change accordingly, simultaneously increasing or decreasing. Let us visualise these possible effects with simple examples of two distributions of the same kind.

In the three following examples it will be assumed that we are dealing with two subpopulations with equal numbers of members, that is, the share of each of these subpopulations is equal to 0.5.

For the case of two subpopulations with equal numbers of members, formula (25) becomes:

$$\begin{aligned} G = & \frac{1}{(n_1+n_2)(n_1\mu_1+n_2\mu_2)}\left[n_1^2\mu_1 G_1 + n_2^2\mu_2 G_2\right] + \\ & + \frac{n_1 n_2}{(n_1+n_2)(n_1\mu_1+n_2\mu_2)}\left[\mu_1 G_1 O_{21} + \mu_2 G_2 O_{12}\right] + \\ & + \frac{2}{(n_1\mu_1+n_2\mu_2)}\frac{n_2 n_1 (\mu_1-\mu_2)}{(n_1+n_2)}(\overline{F}_1 - \overline{F}_2), \end{aligned} \tag{29}$$

which for an equal number of individuals in both subpopulations, $n_1 = n_2 = n, N = 2n$, reduces further:

$$\begin{aligned} G = & \frac{1}{2(\mu_1+\mu_2)}\left[\mu_1 G_1 + \mu_2 G_2\right] + \frac{1}{2(\mu_1+\mu_2)}\left[\mu_1 G_1 O_{21} + \mu_2 G_2 O_{12}\right] + \\ & + \frac{\mu_1-\mu_2}{\mu_1+\mu_2}(\overline{F}_1 - \overline{F}_2). \end{aligned} \tag{30}$$

In what follows, three simple examples will be examined: uniform distribution, normal distribution, and Weibull distribution. Although the main subject of interest in the context of inequality and stratification is income and related quantities which are known to be far from symmetrically distributed, investigating uniform and normal distributions enables us to gain some intuition of overlapping and stratifications, which are concepts not as familiar as inequality and the Gini index itself.

### 3.2. Uniform Distribution

Let us start with the simplest example: two uniform distributions with the same median value, *m*. One of the distributions ranges over a constant

interval, $\langle a_1, b_1\rangle\left(\frac{a_1+b_1}{2}=m\right)$, while the other one starts from the wider interval $\langle a_2, b_2\rangle$ with $a_2 < a_1$, $b_2 > b_1$ (and $\frac{a_2+b_2}{2}=m$, $a_1 - a_2 = b_2 - b_1$), gradually increasing $a_2$ through $a_2 = a_1$ and $a_2 > a_1$ while simultaneously decreasing $b_2$ in a symmetrical way, through $b_2 = b_1$ and $b_2 < b_1$. Symmetry in the change of the second uniform distribution means that $a_2 = a_1 + x$ and $b_2 = b_1 - x$. For illustration, three graphs are presented in Figure 1, one for a basic distribution defined on the interval $\langle 1000, 3000\rangle$ (corresponding to the case when $x = 0$), and two additional graphs for $x = 500$ and $x = -500$.

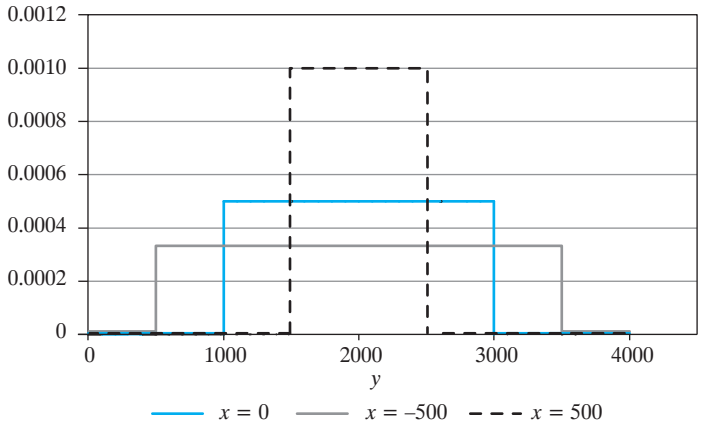


Fig. 1. Uniform Distributions on the Interval $\langle 1000 + x; 3000 - x\rangle$

Source: elaborated by the author.

The relationship between $O_{12}$ and $O_{21}$ is in this case intuitively predictable: the wider the interval $\langle a_2, b_2\rangle$ as compared to the interval $\langle a_1, b_1\rangle$ (and thus the smaller fraction of its range is included within the range of the latter) the smaller is $O_{21}$. Thus, $O_{21}$ is an increasing function of $x$, increasing linearly with respect to $y=\frac{(b_1-a_1)}{(b_2-a_2)}$ up to $y = 1$, then still increasing but in a nonlinear way. On the other hand, $O_{12}$ decreases with $y$, and from $y = 1$ it is equal to $1/y$ (as it is equal to the fraction of the range of $\langle a_2, b_2\rangle$ included within $\langle a_1, b_1\rangle$ – that is, equal to $\frac{(b_2-a_2)}{(b_1-a_1)}$). The explicit analytical form of $O_{21}$ is as follows:

$$O_{21}^{U}=\begin{cases}\dfrac{b_1-a_1}{b_1-a_1-2x} & \text{for } x<0\\ 1+\dfrac{2x(b_1-a_1-x)}{(b_1-a_1)^2} & \text{for } x\geq 0\end{cases}. \tag{31}$$

These are presented in Figure 2 (as function of $x$).

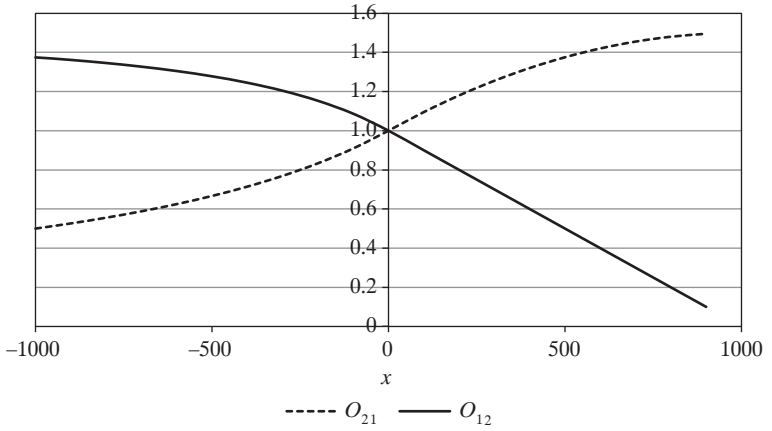


Fig. 2. Graphs of $O_{12}$ and $O_{21}$

Source: author's own calculations.

As mentioned before, $O_{ji}$ is bounded from above by 2; however, in particular cases yet more precise limitations may be fixed. For the uniform distribution case, even if the other distribution assumed the form of the Dirac delta centred in the expected value of the uniform distribution, it may be easily shown that the overlapping index will not exceed:

$$O_{U,21}^{\max}=1.5, \tag{32}$$

as for $x$ approaching $\frac{b_1-a_1}{2}$ (second distribution concentrated at the average value of the first one), (31) assumes the value 1.5. This may be also noticed in Figure 2.

As the dispersion of one of the distributions lowers, the Gini index for the sum of the distributions also decreases with increasing $y$. Simultaneously, the share of within Gini in the overall inequality increases (although the absolute value of the within Gini index decreases), while – what follows – the

share of the overlap part of the Gini index increases (as the average ranks of both distributions are equal to 0.5, the between Gini is equal to zero here) – cf. Figure 3.

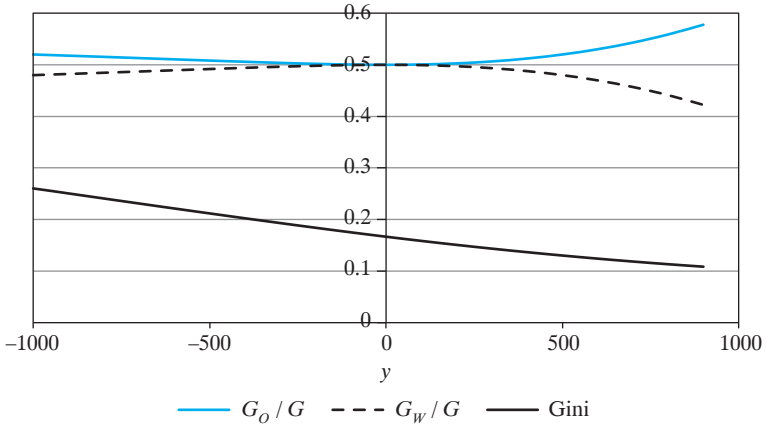


Fig. 3. Graphs of $G$, $G_W/G$, and $G_O/G$

Source: author's own calculations.

One may also consider two uniform distributions over the intervals of identical width, shifted one with respect to the other: $\langle a_1, b_1 \rangle$ and $\langle a_2, b_2 \rangle$, $a_2 = a_1 + x, b_2 = b_1 + x$ (see Figure 4, with $a_1 = 1000, b_1 = 3000$).

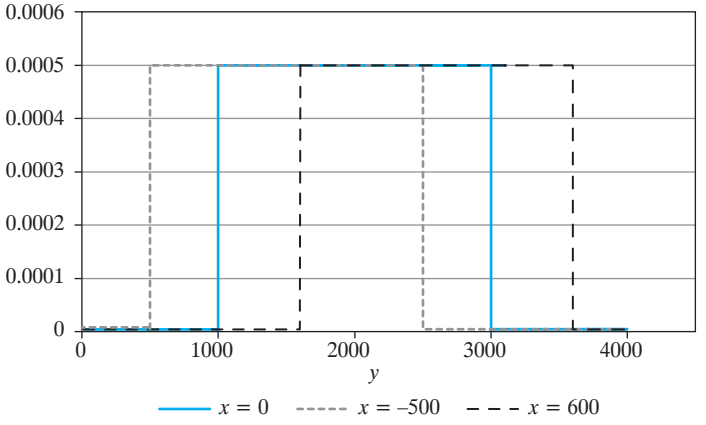


Fig. 4. Uniform Distributions on the Interval $\langle 1000 + x; 3000 + x \rangle$

Source: elaborated by the author.

In this case the overlap indexes will be obviously symmetrical, that is, $O_{12} = O_{21}$, and have the following analytical form:

$$O_{U,21} = \begin{cases} \dfrac{a_1^3 - 3a_1(b_1^2 + x^2) + 2(b_1^3 - x^3)}{(b_1 - a_1)^2 (a_1 + 2b_1)} & \text{for } |x| < b_1 - a_1 \\ 0 & \text{otherwise} \end{cases}. \tag{33}$$

If one fixes one of the distributions, shifting the other one towards higher averages, $O_{12} = O_{21}$ will reach the maximum value of 1 for $x = 0$ (see Figure 5).

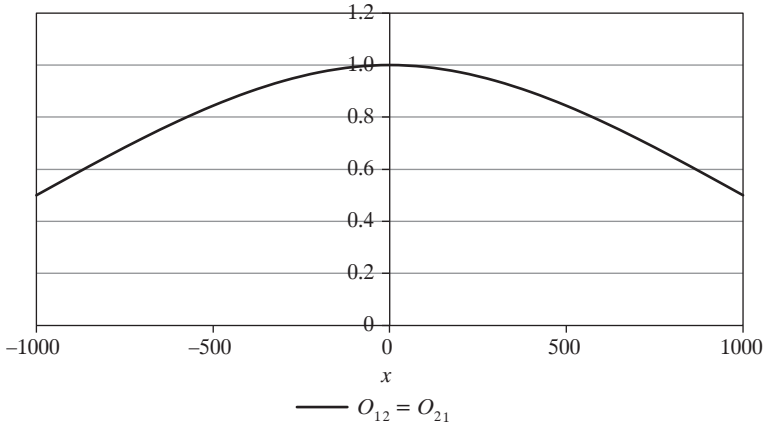


Fig. 5. Graphs of $O_{12} = O_{21}$ for Two Uniform Distributions for $x \in \langle -1000; 1000 \rangle$.
Source: author's own calculations.

The Gini index for the first distribution will be fixed and for the other one will decrease (as the mean value increases). Thus, the within Gini will decrease. The overlap Gini will reach its maximum for $x = 0$, and the between Gini its minimum for the same value. In Figure 6, the functions of $x$: $G_W$, $G_O$, $G_B$ are presented for $x \in \langle -1000; 1000 \rangle$.

To conclude this simplest example: $Q_{12}$ may change inversely or accordingly to $O_{21}$ depending on whether the change in the relative positions of the probability density functions of two distributions results from the change of dispersion of distributions (or one of them) or rather from the relation between their central tendencies. On the other hand,

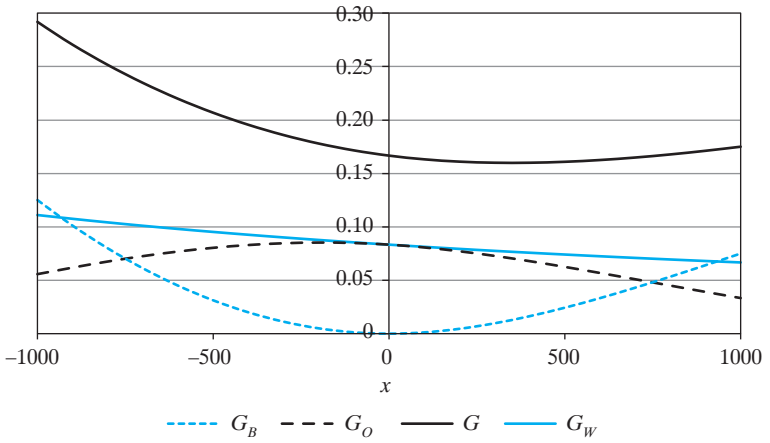


Fig. 6. Graphs of $G$, $G_W$, $G_O$ and $G_B$ for $x \in \langle -1000; 1000 \rangle$.
Source: author's own calculations.

the relationship between the overlapping and the share of Gini due to overlapping is not straightforward, as the overlapping indexes are weighted by the group becoming a part of the overall Gini index.

### 3.3. Normal Distribution

Let us say we have two normally distributed populations with an equal number of members. The distribution of the first population is $N(\mu_1, \sigma_1)$ with the within-group Gini index $G_1$, while the second one is distributed according to $N(\mu_2, \sigma_2)$ with the within-group Gini index $G_2$. Starting from the case of $\mu_1 = \mu_2$ and $\sigma_1 = \sigma_2$ we have two identical populations, and, of course, $G_1 = G_2$. Then we change the standard deviation of the second group, keeping its mean value constant.

For $\mu_1 = \mu_2$ formula (23) reduces to the simple form:

$$G = \frac{1}{4}[G_1 + G_2] + \frac{1}{4}[G_1 O_{21} + G_2 O_{12}]. \tag{34}$$

It may be shown, moreover (Schechtman 2005), that for two normal distributions $N(\mu_1, \sigma_1)$ and $N(\mu_2, \sigma_2)$ the overlapping index is equal to:

$$O_{N,21} = \frac{\sqrt{2}\,\sigma_1}{\sqrt{\sigma_1^2 + \sigma_2^2}} \exp\left[\frac{-(\mu_2 - \mu_1)^2}{2(\sigma_1^2 + \sigma_2^2)}\right], \tag{35}$$

with the maximum possible value again lower than 2, namely:

$$O_{N,21}^{\max} = \sqrt{2} \approx 1.414. \tag{36}$$

Figure 7 illustrates Gini indexes and overlapping indexes for the exemplary distributions, for which calculations have been performed. $\mu_1 = \mu_2 = 4000$, $\sigma_1 = 1000$ while $\sigma_2$ changes from $\sigma_2 = 100$ to $\sigma_2 = 5000$. Figure 7 presents $O_{21}$ (the degree to which distribution 2 is included in distribution 1) and $O_{12}$ (the degree to which distribution 1 is included in distribution 2).

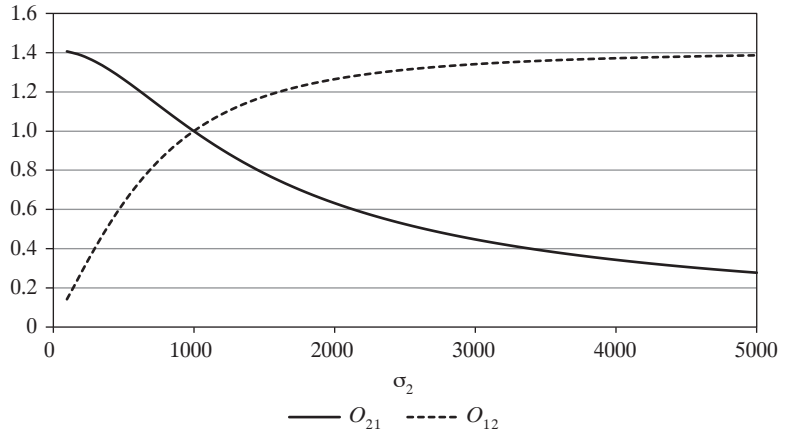


Fig. 7. Graphs of $O_{12}$ and $O_{21}$ for Two Normal Distributions, $\mu_1 = \mu_2 = 4000$, $\sigma_1 = 1000$ while $\sigma_2$ Changes from $\sigma_2 = 100$ to $\sigma_2 = 5000$

Source: author's own calculations.

Figure 8 presents the shares of within-group inequality and the overlapping-due term together with the overall Gini index, $G$. As $\mu_1 = \mu_2$, the between-group term is of course zero.

For this example $O_{21}$ and $O_{12}$ are inversely related, as the greater part of distribution 2 is included inside distribution 1, and the smaller part of distribution 1 is included inside distribution 2.

On the other hand, if we change the mean value of distribution 2 (from $\mu_2 = 5000$ to 20,000, while $\mu_1 = 10{,}000$) keeping the standard deviations constant (and equal, $\sigma_1 = \sigma_2 = 1000$), $O_{21}$ and $O_{12}$ will be equal (as the overlapping is symmetrical). $G_1$ is constant, while $G_2$ monotonously

decreases with increasing mean value (the Gini index decreases if a positive constant is added to each value of the distribution).

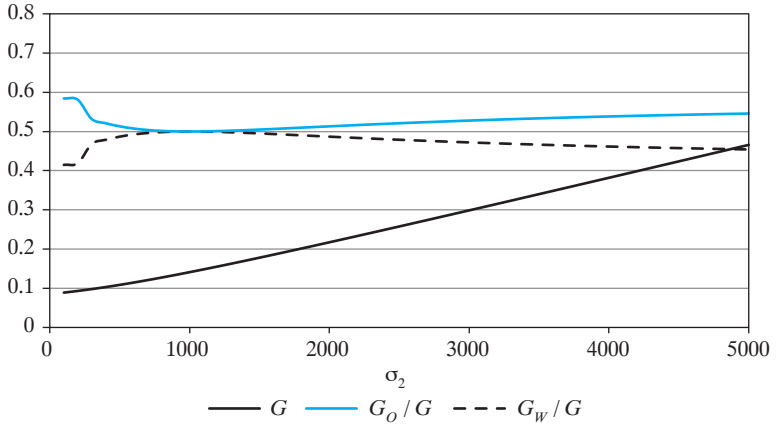


Fig. 8. Graphs of $G$, $G_W/G$, and $G_O/G$
Source: author's own calculations.

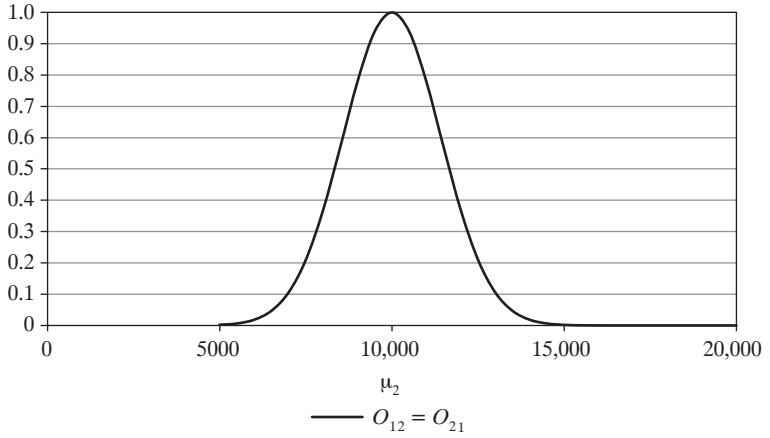


Fig. 9. Graphs of $O_{12} = O_{21}$ for Two Normal Distributions, $\sigma_1 = \sigma_2 = 1000$, $\mu_1 = 10{,}000$, while $\mu_2$ changes from $\mu_2 = 5000$ to $\mu_2 = 20{,}000$
Source: author's own calculations.

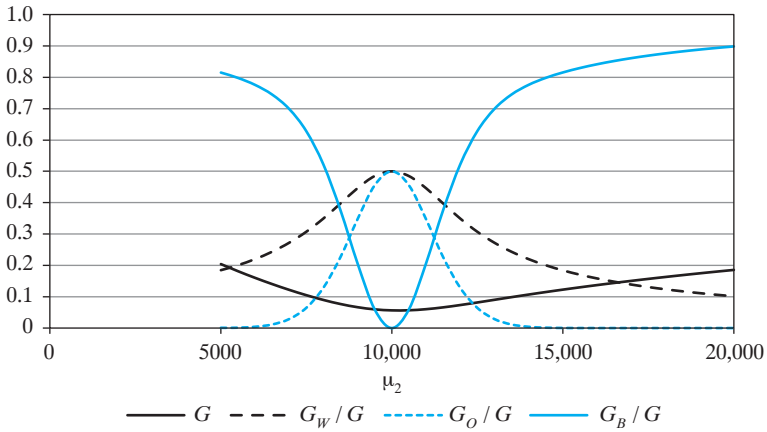


Fig. 10. Graphs of $G$, $G_W(x)/G$, $G_O(x)/G$ and $G_B(x)/G$

Source: author's own calculations.

Again, it may be concluded that the relationship between $O_{12}$ and $O_{21}$ may be either inverse or strict. While in the former case the share of the overlapping term within the overall Gini is not in a straightforward dependence on the overlapping indexes, in the latter, while they are the same, the behaviour of the overlapping share in overall inequality is qualitatively in accordance with the behaviour of the overlapping indexes.

### 3.4. Weibull Distribution

Let us now consider two Weibull distributions describing two populations consisting of the same number of individuals. Let us further fix the parameters of one of the distributions as $k_1 = 5$, $\lambda_1 = 5000$ (and thus $\mu_1 = 4590.84$). The behaviour of overlapping indexes is investigated in two cases: 1) if one requires the overall mean to be fixed while changing the inequality of the second distribution 2) keeping the inequalities of both distributions fixed while changing their relative positioning.

Although it is not possible to obtain a simple analytical expression for the overlapping index for the case of the Weibull distribution, one may obtain the maximum value of it. Let us recall that for any case this index cannot exceed the value of 2. However, for particular distributions there might be further restrictions, lowering this maximum. For the case of the Weibull distribution the maximum value of the overlapping index is equal to:

$$O_W^{\max} = \frac{4\exp[-\Gamma^k((k+1)/k)][-\Gamma((k+1)/k) + \exp[\Gamma^k((k+1)/k)]\Gamma((k+1)/k, \Gamma^k((k+1)/k))]}{(2-2^{(k-1)/k})\Gamma((k+1)/k)}, \quad (36)$$

which depends on the shape parameter of the Weibull distribution. It starts from 2 for $k \to 0$, assumes a minimum value of 1.41823 near $k = 49$, tending to 1.41827 with $k \to \infty$. For $1.5 < k < 2.5$ (ranges of values for fitting the considered data) the maximum of overlapping assumes values between 1.43 and 1.44 (which is close to the maximum overlapping for the normal distribution, $\sqrt{2}$).

Figure 11 presents overlapping terms for the changing shape of one of the Weibull distributions, $k_1 = 5$, $\lambda_1 = 5000$ while $k_2$ from 2 to 8 (adjusting $\lambda_2$ as to keep $\mu_2 = 4590{,}84$).

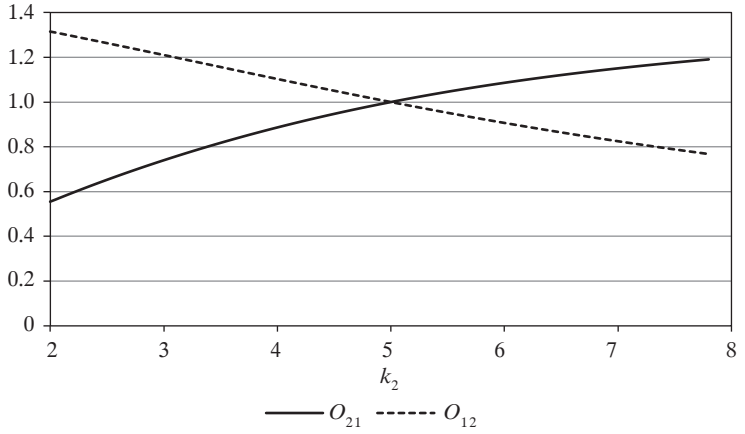


Fig. 11. Graphs of $O_{12}$ and $O_{21}$ for Weibull Distributions: $k_1 = 5$, $\lambda_1 = 5000$ while $k_2$ changes from $k_2 = 2$ to $k_2 = 8$ (Adjusting $\lambda_2$ as to Keep $\mu_2 = 4590.84$)

Source: author's own calculations.

Figure 12 presents the share of within group inequality and the share of the overlapping-due term together with the overall Gini index, *G*.

On the other hand, if we keep the shapes (i.e. Gini indexes) of both of distributions unchanged, changing only their relative positions, the overlapping indexes change, roughly speaking, in the same direction – as the Weibull distribution is not symmetrical, they are not the same (see Figure 13).

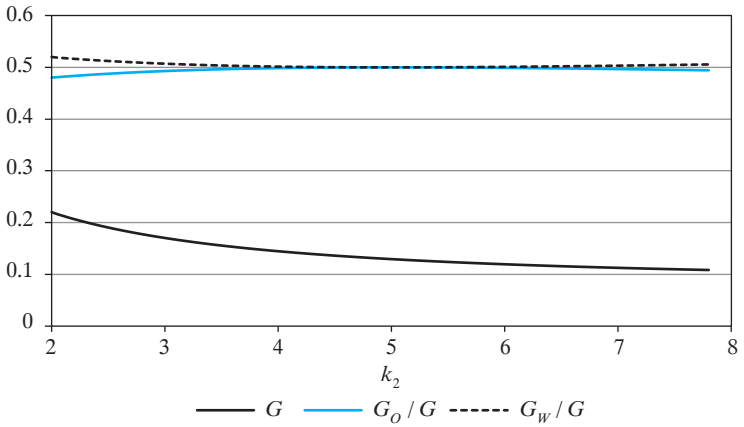


Fig. 12. Graphs of $G$, $G_W/G$, and $G_O/G$

Source: author's own calculations.

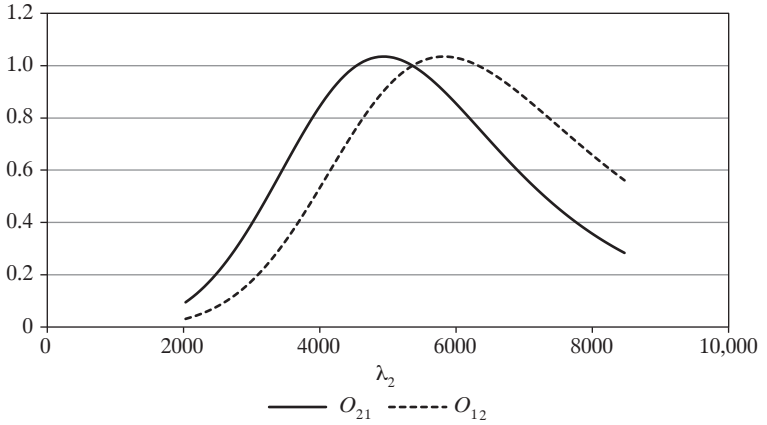


Fig. 13. Graphs of $O_{12}$ and $O_{21}$ for Weibull distributions: $k_1 = 5$, $\lambda_1 = 5000$ while $\lambda_2$ Changing from 2000 to 8000 (Adjusting $k_2$ as to Keep $G_2 = G_1 = 0.1295$)

Source: author's own calculations.

Still, the qualitative changes in the share of overlap-due input to inequality behaves in accordance with the behaviour of overlapping indexes (see Figure 14).

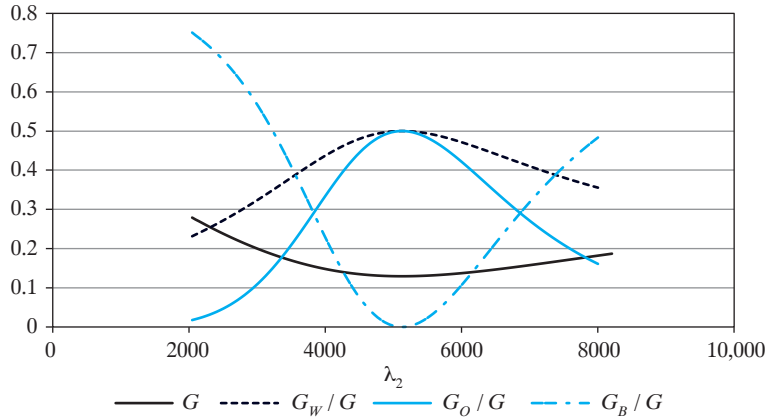


Fig. 14. Graphs of $G$, $G_W(x)/G$, $G_O(x)/G$ and $G_B(x)/G$

Source: author's own calculations.

## 4. Results for Poland

The data investigated in this section comes from the Household Budget Survey for 2011 (HBS 2011) and consists of 37,167 households of different (and specified below) types from all Polish regions.

Although it is known that some areas of Poland are richer than others, one would not expect provinces to be overly stratified. Moreover, it would be more interesting to look at the potential stratification of different types of households as this would throw light on the situation of different parts of Polish society and their input into overall inequality in Poland.

To this end, all households were divided into 22 groups. Of these, 21 consisted of households of the same type, while the final 22nd group was composed of all the remaining households, which in total comprises 1.1% of households. The OECD equivalence scale has been adopted, i.e. the first adult person is the reference point and is equal to 1, all other adults (that is, over 14 years of age) are counted as 0.7, while each child below 24 is equivalent to 0.5 of a single adult. Table 1 presents the number of adults and number of children within each type of household, its equivalence scale, and the number of households of that type, together with the average equivalent value for the equivalent adult person in the household. The quantities that will be considered here are: incomes, expenditures, and the difference between incomes and expenditures, i.e. the "money balance" (which may also assume negative values).

Table 1. Summary Statistics

| Adults | Children | Households | Equivalence Scale | $\bar{x}_{in}$ | $\bar{x}_{sp}$ | $\bar{x}_{b}$ | $G_{in}$ | $G_{ex}$ | $G_{b}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 6619 | 1.0 | 1804.70 | 1633.33 | 171.37 | 0.32 | 0.32 | 2.51 |
| 1 | 1 | 314 | 1.5 | 1741.60 | 1610.15 | 131.45 | 0.34 | 0.33 | 2.89 |
| 2 | 0 | 10,841 | 1.7 | 1924.86 | 1592.74 | 332.12 | 0.30 | 0.31 | 1.35 |
| 1 | 2 | 126 | 2.0 | 1329.76 | 1371.48 | –41.71 | 0.32 | 0.35 | –8.01 |
| 2 | 1 | 3007 | 2.2 | 1941.33 | 1558.29 | 383.04 | 0.32 | 0.30 | 1.22 |
| 3 | 0 | 4779 | 2.4 | 1635.16 | 1309.12 | 326.04 | 0.29 | 0.29 | 1.12 |
| 2 | 2 | 2601 | 2.7 | 1624.2 | 1334.48 | 289.72 | 0.33 | 0.31 | 1.39 |
| 3 | 1 | 1649 | 2.9 | 1427.37 | 1169.52 | 257.85 | 0.30 | 0.29 | 1.25 |
| 4 | 0 | 2458 | 3.1 | 1442.24 | 1138.32 | 303.92 | 0.28 | 0.28 | 1.09 |
| 2 | 3 | 553 | 3.2 | 1200.85 | 1034.8 | 166.06 | 0.33 | 0.30 | 1.94 |
| 3 | 2 | 641 | 3.4 | 1267.72 | 973.81 | 293.90 | 0.32 | 0.26 | 1.19 |
| 4 | 1 | 928 | 3.6 | 1287.04 | 1006.33 | 280.71 | 0.29 | 0.27 | 1.15 |
| 2 | 4 | 107 | 3.7 | 935.479 | 844.75 | 90.73 | 0.27 | 0.28 | 1.93 |
| 5 | 0 | 713 | 3.8 | 1283.85 | 1008.99 | 274.86 | 0.28 | 0.28 | 1.17 |
| 3 | 3 | 132 | 3.9 | 1047.26 | 864.00 | 183.26 | 0.27 | 0.29 | 1.28 |
| 4 | 2 | 410 | 4.1 | 1229.31 | 897.25 | 332.05 | 0.34 | 0.26 | 1.15 |
| 5 | 1 | 327 | 4.3 | 1140.65 | 897.60 | 243.06 | 0.27 | 0.24 | 1.09 |
| 6 | 0 | 197 | 4.5 | 1203.67 | 873.79 | 329.88 | 0.30 | 0.27 | 1.09 |
| 4 | 3 | 99 | 4.6 | 1165.07 | 755.12 | 409.95 | 0.38 | 0.26 | 0.99 |
| 5 | 2 | 137 | 4.8 | 1058.21 | 813.39 | 244.82 | 0.27 | 0.25 | 1.01 |
| 6 | 1 | 112 | 5.0 | 1041.5 | 862.32 | 179.18 | 0.26 | 0.29 | 1.48 |
| Remaining | | 417 | | 941.69 | 745.13 | 196.56 | 0.30 | 0.26 | 1.18 |

Source: author's own calculations based on (Central Statistical Office 2011).

The overall Gini index for incomes equals 0.321, for expenditures – 0.320, and for the money balance – 1.321.

It is known that while negative values are present, the Gini index is no longer restricted to the range $\langle 0,1 \rangle$ but may exceed 1 as well as being negative. There are some methods to deal with this problem, e.g. to standardise this value in a proper way (see, for instance, Raffinetti, Siletti & Vernizzi 2015; Ostasiewicz & Vernizzi 2017). Here, however, as the decomposition is what is being investigated, there will simply be presented the shares of each of the terms of the decomposition within the overall inequality, and with respect to the shares the non-standardised character of inequality does not matter.

Although it is slightly outside the scope of this paper, let us briefly comment on a discrepancy between the inequality of these particular components (incomes and expenditure) and the inequality of the money balance. According to the standard decomposition of inequality with respect to different sources, overall inequality can be composed of inequalities from these two sources according to:

$$G = \frac{1}{\bar{x}}(\bar{x}_{in} R_{in} G_{in} + \bar{x}_{ex} R_{ex} G_{ex}),$$

where $\bar{x}, \bar{x}_{in}$ and $\bar{x}_{ex}$ are the average values of the money balance, incomes, and expenditures respectively, and $R_{in}$ and $R_{ex}$ are Gini correlations of incomes and expenditures, defined as:

$$R_q = \frac{\mathrm{COV}(x_q, F_b(x_q))}{\mathrm{COV}(x_q, F_q(x_q))},$$

where $q$ stands for a quantity being either incomes or expenditures, $x_q$ denotes its value, $F_b(x_q)$ – the value of the cumulative distribution of the "money balance" for the value of the balance corresponding to a particular value of quantity $q$ and $F_q(x_q)$ – the cumulative distribution of quantity $q$.

Gini correlations, like conventional correlation coefficients, range between –1 and 1 and measure the degree to which the order of incomes/expenditures is in accordance with the order of the money balance. To estimate very roughly the order of values which overall inequality may acquire, let us assume that the inequalities of both incomes and expenditures are the same (which is lightly deviated in the real data), $G_{in} \approx \left| G_{ex} \right|$. Denoting by $\eta$ the average fraction of incomes that are spent, $\bar{x}_{ex} = -\eta \bar{x}_{in}$ (as expenditures are taken as negative values), one gets:

$$G = \frac{\overline{x}_{in} G_{in}}{\overline{x}_{in}(1-\eta)}(R_{in} - \eta R_{ex}),$$

where the sign between the terms in the bracket is "minus" as $G_{ex}$ has a negative sign.

The above expression will assume the maximum value for $R_{in} = 1$ and $R_{ex} = -1$, and this maximum value will be:

$$G_{\max} = \frac{G_{in}(1+\eta)}{(1-\eta)},$$

which can take arbitrarily large values, depending on $\eta$.

As for the Polish data considered here $\eta \approx 0.8$, $G$ could almost assume the value of 3 – thus the value of 1.32 does not seem high.

On the other hand, if both components were positive and both component Gini indexes were positive, the maximum possible value would be $G = \frac{\overline{x}_{in} G_{in}}{\overline{x}_{in}(1+\eta)}(R_{in} + \eta R_{ex}) = G_{in}$ (which would be a result for $R_{in} = R_{ex} = 1$), thus, for positive components the overall Gini index cannot exceed the larger of the two Gini indexes from which the overall value is composed.

For the data examined here one has: $R_{in} = 0.585324$, $R_{ex} = -0.201955$, and what follows:

$$G = \frac{1}{292.343}(1603.97 \cdot 0.585324 \cdot 0.321125 - (1311.63) \cdot (-0.201955) \cdot 0.319525) =$$
$$= 1.03127 + 0.289518 = 1.32079,$$

thus, it is far from being maximum.

Each of the Gini indexes, $G_{in}$, $G_{ex}$ and $G$, may be decomposed into a within-groups part, between-groups part, and the term resulting from overlapping. The results are presented in Table 2.

While the share of within-groups inequality in overall inequality is more or less the same for all three quantities (incomes, expenditures, and balance) and is about 11%, there is a huge difference in the share of between-group inequalities between incomes and expenditures on the one hand and the money balance on the other – of magnitude 10.

The component due to overlapping may be represented as the weighted sum of overlapping indexes between each pair of groups. These overlapping indexes between particular pairs, $O_{ij}$ and $O_{ji}$ are presented in Tables A1–A3 in the Appendix.

Table 2. Results of the Gini Index and Its Component for Incomes, Expenditures and Money Balance

| Gini | Incomes | | Expenditures | | Money balance | |
|---|---|---|---|---|---|---|
| | 0.321158 | | 0.319525 | | 1.320791 | |
| | Value | Share | Value | Share | Value | Share |
| Within-group | 0.035715 | 0.111218 | 0.036328 | 0.113692 | 0.151776 | 0.114913 |
| Between-group | 0.035741 | 0.111298 | 0.042892 | 0.134237 | 0.013563 | 0.010269 |
| Overlapping | 0.249703 | 0.777506 | 0.240305 | 0.752071 | 1.155452 | 0.874818 |

Source: author's own calculations.

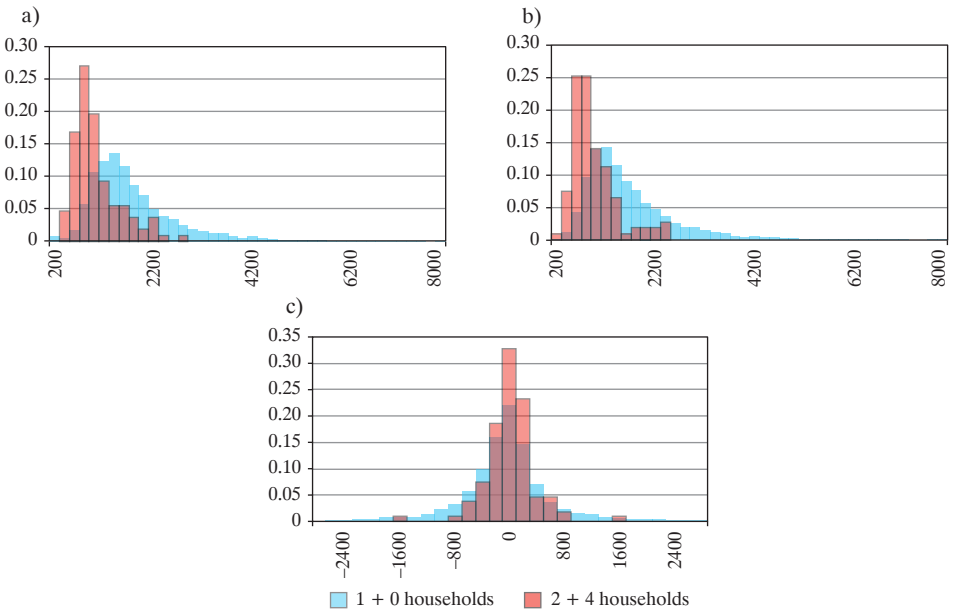


Fig. 15. Histograms for 1 + 0 and 2 + 4 Households for a) Incomes, b) Expenditures, c) Money Balance.

Source: elaborated by the author.

The values of $O_{ij}$ and $O_{ji}$ summarise numerically what might be visualised in the form of histograms. Let us picture the distributions of incomes, expenditures and balance for 1 + 0 and 2 + 4 households. As $O_{21} = 0.56$, one may expect that two histograms will be to a visible degree separated one from another, which can indeed be noticed in Figure 15a. Likewise for expenditures: $O_{21} = 0.57$ and that is again justified by the visualisation (see Figure 15b). Proceeding to the result for the overlapping of the

money balance, it changes significantly to $O_{21} = 1.12$, which may again be corroborated by the visual estimation, cf. Figure 15c.

A similar effect might be observed for many pairs of distributions for the investigated data, hence the noticeable change in the share of the overlapping-due term in overall inequality when passing from incomes/expenditures to the money balance.

## 5. Discussion and Conclusions

What may be observed, for most types of households, is that the inequalities of incomes are higher than those of expenditures. This seems intuitive as some basic needs have to be satisfied regardless of whether this leads to debt. One of the few exceptions is the 1 + 2 type of household. It is also the one with the worst balance (negative) and huge inequality of this balance (with respect to the absolute value, but with a negative sign). The negative sign of the Gini index is of course the result of the negative average value (as the sum of absolute differences is always positive). Although the sample size is not very large (126 households), the situation of single parents with two children is obviously worth further investigation.

The merit of calculating overlapping indexes for particular pairs of groups and for the overlapping of a single group by all the others, is the simplicity of such a presentation as compared with the (imprecise, in addition) visual estimation of the overlapping of two distributions, which is far more advanced information than merely comparing the average values for two groups. Comparing the situations of different types of households in Poland is beyond the scope of this paper and rather a task for sociologists. However, the tool of the set of overlapping indexes seems to be very helpful.

The between-group term within the Yitzhaki-Lerman decomposition has a share about ten times less for the money balance than for incomes and expenditures. On the other hand, within the Dagum decomposition, the corresponding between-group term for balance has a share of 9%, *versus* 32% and 36% for incomes and expenditures, respectively. Thus, the difference is not so huge, less than four times. It is known that the between-group term for the Dagum decomposition in the presence of non-zero overlapping is always greater than the between-group term within the scope of the Yitzhaki-Lerman method. Thus, one may ask what the "real" between-group inequality is, or rather, how to make the best use of both pieces of information available, in which situations they differ the most, and in which situations it is more illustrative to use one rather than the other, if it is not possible to complement both. This will be the subject of a future study.

## Appendix

Table A1. Overlapping Indexes $O_{ji}$ for Incomes for Households of Different Equivalence Scales

| $j$ \ $i$ | 1.00 | 1.50 | 1.70 | 2.00 | 2.20 | 2.40 | 2.70 | 2.90 | 3.10 | 3.20 | 3.40 | 3.60 | 3.70 | 3.80 | 3.90 | 4.10 | 4.30 | 4.50 | 4.60 | 4.80 | 5.00 | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 1.00 | 1.05 | 0.94 | 1.10 | 0.98 | 1.00 | 1.07 | 1.02 | 1.01 | 1.07 | 1.05 | 1.01 | 0.83 | 0.98 | 0.91 | 1.09 | 0.91 | 1.01 | 1.14 | 0.92 | 0.82 | 0.91 |
| 1.50 | 0.94 | 1.00 | 0.89 | 1.05 | 0.93 | 0.95 | 1.02 | 0.97 | 0.96 | 1.03 | 1.01 | 0.96 | 0.82 | 0.94 | 0.89 | 1.05 | 0.89 | 0.97 | 1.10 | 0.89 | 0.81 | 0.90 |
| 1.70 | 1.05 | 1.09 | 1.00 | 1.08 | 1.04 | 1.02 | 1.09 | 1.02 | 1.00 | 1.03 | 1.02 | 0.98 | 0.73 | 0.94 | 0.83 | 1.07 | 0.85 | 0.97 | 1.12 | 0.85 | 0.74 | 0.84 |
| 2.00 | 0.77 | 0.87 | 0.72 | 1.00 | 0.77 | 0.84 | 0.91 | 0.91 | 0.90 | 1.03 | 0.97 | 0.93 | 0.97 | 0.93 | 0.98 | 1.01 | 0.95 | 0.98 | 1.10 | 0.95 | 0.91 | 1.01 |
| 2.20 | 1.01 | 1.05 | 0.96 | 1.05 | 1.00 | 0.97 | 1.05 | 0.98 | 0.96 | 1.01 | 1.00 | 0.95 | 0.73 | 0.91 | 0.81 | 1.04 | 0.83 | 0.94 | 1.10 | 0.84 | 0.73 | 0.83 |
| 2.40 | 1.00 | 1.05 | 0.94 | 1.10 | 0.98 | 1.00 | 1.07 | 1.02 | 1.01 | 1.07 | 1.04 | 1.00 | 0.84 | 0.98 | 0.92 | 1.08 | 0.91 | 1.01 | 1.13 | 0.92 | 0.83 | 0.92 |
| 2.70 | 0.92 | 0.98 | 0.86 | 1.04 | 0.90 | 0.93 | 1.00 | 0.96 | 0.95 | 1.03 | 1.00 | 0.96 | 0.84 | 0.94 | 0.90 | 1.04 | 0.90 | 0.97 | 1.11 | 0.90 | 0.82 | 0.91 |
| 2.90 | 0.90 | 0.97 | 0.84 | 1.09 | 0.88 | 0.94 | 1.02 | 1.00 | 0.99 | 1.09 | 1.04 | 1.00 | 0.95 | 1.00 | 0.99 | 1.08 | 0.98 | 1.03 | 1.14 | 0.98 | 0.92 | 0.99 |
| 3.10 | 0.92 | 0.99 | 0.86 | 1.09 | 0.91 | 0.96 | 1.03 | 1.01 | 1.00 | 1.08 | 1.04 | 1.00 | 0.92 | 1.00 | 0.97 | 1.08 | 0.97 | 1.02 | 1.14 | 0.97 | 0.90 | 0.97 |
| 3.20 | 0.70 | 0.80 | 0.65 | 0.95 | 0.70 | 0.78 | 0.85 | 0.86 | 0.86 | 1.00 | 0.93 | 0.89 | 0.98 | 0.90 | 0.97 | 0.97 | 0.94 | 0.95 | 1.06 | 0.94 | 0.93 | 1.01 |
| 3.40 | 0.77 | 0.87 | 0.71 | 1.03 | 0.76 | 0.85 | 0.92 | 0.93 | 0.93 | 1.06 | 1.00 | 0.96 | 1.01 | 0.97 | 1.02 | 1.04 | 1.00 | 1.01 | 1.11 | 0.99 | 0.96 | 1.04 |
| 3.60 | 0.82 | 0.91 | 0.76 | 1.08 | 0.81 | 0.90 | 0.97 | 0.98 | 0.98 | 1.10 | 1.04 | 1.00 | 1.03 | 1.01 | 1.05 | 1.08 | 1.03 | 1.05 | 1.14 | 1.02 | 0.98 | 1.05 |
| 3.70 | 0.56 | 0.68 | 0.52 | 0.85 | 0.56 | 0.67 | 0.74 | 0.76 | 0.76 | 0.94 | 0.85 | 0.80 | 1.00 | 0.84 | 0.96 | 0.89 | 0.91 | 0.89 | 1.00 | 0.93 | 0.95 | 1.03 |
| 3.80 | 0.85 | 0.93 | 0.78 | 1.07 | 0.83 | 0.91 | 0.98 | 0.98 | 0.98 | 1.08 | 1.03 | 0.99 | 0.98 | 1.00 | 1.01 | 1.07 | 1.00 | 1.03 | 1.13 | 0.99 | 0.95 | 1.02 |
| 3.90 | 0.66 | 0.77 | 0.61 | 0.94 | 0.65 | 0.75 | 0.83 | 0.85 | 0.85 | 1.01 | 0.93 | 0.89 | 1.02 | 0.91 | 1.00 | 0.97 | 0.97 | 0.96 | 1.06 | 0.97 | 0.97 | 1.05 |
| 4.10 | 0.70 | 0.81 | 0.65 | 0.98 | 0.70 | 0.79 | 0.87 | 0.88 | 0.88 | 1.03 | 0.96 | 0.92 | 1.01 | 0.94 | 1.00 | 1.00 | 0.98 | 0.98 | 1.08 | 0.98 | 0.97 | 1.04 |
| 4.30 | 0.76 | 0.85 | 0.70 | 1.03 | 0.75 | 0.85 | 0.92 | 0.93 | 0.93 | 1.06 | 1.00 | 0.95 | 1.02 | 0.97 | 1.02 | 1.03 | 1.00 | 1.01 | 1.10 | 0.99 | 0.97 | 1.04 |
| 4.50 | 0.75 | 0.85 | 0.69 | 1.02 | 0.74 | 0.83 | 0.91 | 0.92 | 0.92 | 1.05 | 0.99 | 0.95 | 1.01 | 0.96 | 1.01 | 1.03 | 0.99 | 1.00 | 1.10 | 0.98 | 0.96 | 1.04 |
| 4.60 | 0.61 | 0.71 | 0.56 | 0.87 | 0.60 | 0.70 | 0.76 | 0.79 | 0.79 | 0.95 | 0.87 | 0.83 | 0.97 | 0.85 | 0.94 | 0.91 | 0.91 | 0.90 | 1.00 | 0.91 | 0.92 | 0.99 |
| 4.80 | 0.66 | 0.77 | 0.60 | 0.97 | 0.65 | 0.76 | 0.84 | 0.86 | 0.86 | 1.03 | 0.96 | 0.91 | 1.05 | 0.94 | 1.03 | 1.00 | 1.00 | 0.99 | 1.09 | 1.00 | 1.00 | 1.07 |
| 5.00 | 0.70 | 0.80 | 0.63 | 1.01 | 0.68 | 0.80 | 0.87 | 0.90 | 0.90 | 1.05 | 0.98 | 0.94 | 1.05 | 0.96 | 1.04 | 1.02 | 1.02 | 1.01 | 1.09 | 1.01 | 1.00 | 1.06 |
| R | 0.53 | 0.64 | 0.49 | 0.83 | 0.53 | 0.63 | 0.71 | 0.73 | 0.74 | 0.91 | 0.83 | 0.78 | 0.97 | 0.81 | 0.93 | 0.87 | 0.89 | 0.87 | 0.97 | 0.90 | 0.93 | 1.00 |

Note: "R" stands for "remaining part".

Source: author's own calculations.

Table A2. Overlapping Indexes $O_{ji}$ for Expenditures for Households of Different Equivalence Scales

| $j$ \ $i$ | 1.00 | 1.50 | 1.70 | 2.00 | 2.20 | 2.40 | 2.70 | 2.90 | 3.10 | 3.20 | 3.40 | 3.60 | 3.70 | 3.80 | 3.90 | 4.10 | 4.30 | 4.50 | 4.60 | 4.80 | 5.00 | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 1.00 | 1.01 | 0.99 | 1.09 | 0.98 | 1.00 | 1.04 | 1.01 | 0.98 | 1.01 | 0.90 | 0.92 | 0.87 | 0.95 | 0.93 | 0.86 | 0.81 | 0.89 | 0.72 | 0.75 | 0.92 | 0.69 |
| 1.50 | 0.99 | 1.00 | 0.99 | 1.07 | 0.98 | 0.99 | 1.03 | 0.99 | 0.96 | 0.98 | 0.87 | 0.89 | 0.85 | 0.92 | 0.90 | 0.83 | 0.78 | 0.86 | 0.70 | 0.73 | 0.90 | 0.67 |
| 1.70 | 1.01 | 1.01 | 1.00 | 1.09 | 0.99 | 1.01 | 1.05 | 1.01 | 0.99 | 1.01 | 0.90 | 0.92 | 0.87 | 0.95 | 0.93 | 0.86 | 0.81 | 0.89 | 0.72 | 0.75 | 0.92 | 0.69 |
| 2.00 | 0.86 | 0.89 | 0.87 | 1.00 | 0.86 | 0.93 | 0.97 | 0.97 | 0.97 | 1.01 | 0.95 | 0.94 | 0.95 | 0.96 | 0.99 | 0.93 | 0.87 | 0.95 | 0.85 | 0.86 | 0.99 | 0.83 |
| 2.20 | 1.01 | 1.02 | 1.01 | 1.11 | 1.00 | 1.02 | 1.06 | 1.03 | 1.00 | 1.02 | 0.92 | 0.93 | 0.89 | 0.97 | 0.94 | 0.87 | 0.82 | 0.90 | 0.73 | 0.76 | 0.94 | 0.70 |
| 2.40 | 0.93 | 0.95 | 0.94 | 1.06 | 0.93 | 1.00 | 1.03 | 1.03 | 1.03 | 1.06 | 0.98 | 0.98 | 0.98 | 1.01 | 1.02 | 0.95 | 0.90 | 0.96 | 0.85 | 0.87 | 1.01 | 0.82 |
| 2.70 | 0.90 | 0.92 | 0.91 | 1.04 | 0.90 | 0.97 | 1.00 | 1.00 | 1.00 | 1.04 | 0.96 | 0.96 | 0.97 | 0.99 | 1.01 | 0.94 | 0.89 | 0.96 | 0.85 | 0.86 | 1.00 | 0.82 |
| 2.90 | 0.84 | 0.87 | 0.85 | 1.00 | 0.84 | 0.95 | 0.97 | 1.00 | 1.01 | 1.06 | 1.00 | 1.00 | 1.03 | 1.02 | 1.06 | 1.00 | 0.95 | 1.01 | 0.93 | 0.94 | 1.05 | 0.91 |
| 3.10 | 0.83 | 0.87 | 0.84 | 0.99 | 0.84 | 0.94 | 0.96 | 0.99 | 1.00 | 1.04 | 0.99 | 0.98 | 1.03 | 1.00 | 1.04 | 0.99 | 0.94 | 0.99 | 0.92 | 0.93 | 1.05 | 0.90 |
| 3.20 | 0.71 | 0.76 | 0.73 | 0.89 | 0.73 | 0.85 | 0.87 | 0.92 | 0.94 | 1.00 | 0.96 | 0.95 | 1.04 | 0.97 | 1.05 | 0.99 | 0.94 | 1.00 | 0.97 | 0.97 | 1.05 | 0.96 |
| 3.40 | 0.71 | 0.76 | 0.73 | 0.90 | 0.73 | 0.87 | 0.88 | 0.94 | 0.97 | 1.03 | 1.00 | 0.98 | 1.08 | 1.00 | 1.08 | 1.03 | 0.98 | 1.03 | 1.01 | 1.01 | 1.09 | 1.00 |
| 3.60 | 0.74 | 0.79 | 0.76 | 0.93 | 0.76 | 0.90 | 0.91 | 0.96 | 0.99 | 1.05 | 1.02 | 1.00 | 1.09 | 1.02 | 1.09 | 1.04 | 0.99 | 1.04 | 1.01 | 1.01 | 1.09 | 0.99 |
| 3.70 | 0.57 | 0.62 | 0.58 | 0.75 | 0.58 | 0.71 | 0.73 | 0.79 | 0.82 | 0.89 | 0.87 | 0.86 | 1.00 | 0.87 | 0.98 | 0.92 | 0.88 | 0.94 | 0.97 | 0.95 | 1.00 | 0.98 |
| 3.80 | 0.72 | 0.77 | 0.74 | 0.91 | 0.74 | 0.87 | 0.89 | 0.94 | 0.97 | 1.03 | 1.00 | 0.98 | 1.07 | 1.00 | 1.07 | 1.02 | 0.97 | 1.02 | 0.99 | 0.99 | 1.08 | 0.98 |
| 3.90 | 0.56 | 0.62 | 0.58 | 0.75 | 0.58 | 0.71 | 0.73 | 0.80 | 0.83 | 0.90 | 0.89 | 0.87 | 1.02 | 0.88 | 1.00 | 0.94 | 0.90 | 0.96 | 1.00 | 0.98 | 1.02 | 1.00 |
| 4.10 | 0.64 | 0.69 | 0.65 | 0.83 | 0.65 | 0.80 | 0.81 | 0.88 | 0.91 | 0.98 | 0.96 | 0.94 | 1.07 | 0.96 | 1.06 | 1.00 | 0.95 | 1.01 | 1.02 | 1.01 | 1.07 | 1.02 |
| 4.30 | 0.65 | 0.71 | 0.67 | 0.87 | 0.68 | 0.83 | 0.85 | 0.92 | 0.95 | 1.02 | 1.01 | 0.98 | 1.11 | 1.00 | 1.10 | 1.05 | 1.00 | 1.05 | 1.05 | 1.04 | 1.11 | 1.05 |
| 4.50 | 0.59 | 0.65 | 0.61 | 0.79 | 0.61 | 0.76 | 0.77 | 0.85 | 0.89 | 0.96 | 0.95 | 0.92 | 1.07 | 0.94 | 1.05 | 0.99 | 0.95 | 1.00 | 1.03 | 1.02 | 1.06 | 1.03 |
| 4.60 | 0.48 | 0.54 | 0.50 | 0.68 | 0.50 | 0.65 | 0.66 | 0.74 | 0.78 | 0.86 | 0.86 | 0.83 | 1.02 | 0.85 | 0.98 | 0.92 | 0.88 | 0.93 | 1.00 | 0.98 | 1.00 | 1.02 |
| 4.80 | 0.56 | 0.62 | 0.58 | 0.77 | 0.58 | 0.73 | 0.75 | 0.82 | 0.86 | 0.94 | 0.92 | 0.90 | 1.05 | 0.92 | 1.03 | 0.97 | 0.94 | 0.98 | 1.01 | 1.00 | 1.04 | 1.02 |
| 5.00 | 0.56 | 0.62 | 0.58 | 0.75 | 0.58 | 0.71 | 0.73 | 0.79 | 0.83 | 0.90 | 0.88 | 0.86 | 1.00 | 0.88 | 0.99 | 0.92 | 0.88 | 0.94 | 0.98 | 0.96 | 1.00 | 0.98 |
| R | 0.48 | 0.54 | 0.50 | 0.68 | 0.50 | 0.65 | 0.66 | 0.74 | 0.78 | 0.85 | 0.85 | 0.82 | 1.00 | 0.84 | 0.97 | 0.91 | 0.87 | 0.92 | 0.99 | 0.96 | 0.99 | 1.00 |

Note: "R" stands for "remaining part".

Source: author's own calculations.

Table A3. Overlapping Indexes $O_{ji}$ for Money Balance for Households of Different Equivalence Scales

| $j$ \ $i$ | 1.00 | 1.50 | 1.70 | 2.00 | 2.20 | 2.40 | 2.70 | 2.90 | 3.10 | 3.20 | 3.40 | 3.60 | 3.70 | 3.80 | 3.90 | 4.10 | 4.30 | 4.50 | 4.60 | 4.80 | 5.00 | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 1.00 | 0.99 | 1.00 | 0.90 | 0.99 | 0.95 | 0.99 | 0.94 | 0.94 | 0.94 | 0.93 | 0.91 | 0.78 | 0.93 | 0.87 | 0.93 | 0.89 | 0.92 | 0.91 | 0.87 | 0.91 | 0.85 |
| 1.50 | 1.01 | 1.00 | 0.98 | 0.95 | 0.96 | 0.93 | 0.97 | 0.93 | 0.92 | 0.94 | 0.91 | 0.89 | 0.82 | 0.91 | 0.86 | 0.89 | 0.87 | 0.89 | 0.86 | 0.85 | 0.92 | 0.83 |
| 1.70 | 0.98 | 0.97 | 1.00 | 0.84 | 1.00 | 0.96 | 0.99 | 0.93 | 0.94 | 0.92 | 0.95 | 0.92 | 0.70 | 0.93 | 0.83 | 0.96 | 0.89 | 0.94 | 0.96 | 0.86 | 0.86 | 0.85 |
| 2.00 | 1.02 | 1.01 | 0.96 | 1.00 | 0.93 | 0.90 | 0.95 | 0.90 | 0.89 | 0.93 | 0.87 | 0.85 | 0.86 | 0.88 | 0.87 | 0.83 | 0.84 | 0.84 | 0.78 | 0.82 | 0.92 | 0.80 |
| 2.20 | 0.97 | 0.96 | 0.99 | 0.83 | 1.00 | 0.96 | 0.98 | 0.93 | 0.94 | 0.92 | 0.95 | 0.92 | 0.69 | 0.92 | 0.82 | 0.97 | 0.89 | 0.94 | 0.97 | 0.86 | 0.86 | 0.85 |
| 2.40 | 1.01 | 1.01 | 1.03 | 0.88 | 1.03 | 1.00 | 1.02 | 0.97 | 0.98 | 0.96 | 0.98 | 0.95 | 0.76 | 0.97 | 0.88 | 0.99 | 0.93 | 0.98 | 0.98 | 0.91 | 0.91 | 0.89 |
| 2.70 | 1.00 | 0.99 | 1.01 | 0.88 | 1.01 | 0.97 | 1.00 | 0.95 | 0.95 | 0.94 | 0.96 | 0.93 | 0.76 | 0.94 | 0.86 | 0.96 | 0.90 | 0.95 | 0.95 | 0.88 | 0.90 | 0.87 |
| 2.90 | 1.04 | 1.04 | 1.05 | 0.92 | 1.04 | 1.02 | 1.04 | 1.00 | 1.00 | 0.99 | 1.00 | 0.97 | 0.82 | 0.99 | 0.92 | 0.99 | 0.96 | 0.99 | 0.98 | 0.94 | 0.96 | 0.91 |
| 3.10 | 1.03 | 1.02 | 1.05 | 0.89 | 1.05 | 1.02 | 1.04 | 0.99 | 1.00 | 0.98 | 1.00 | 0.97 | 0.78 | 0.98 | 0.90 | 1.00 | 0.95 | 0.99 | 1.00 | 0.93 | 0.94 | 0.91 |
| 3.20 | 1.06 | 1.06 | 1.04 | 0.99 | 1.02 | 1.00 | 1.04 | 1.00 | 0.99 | 1.00 | 0.98 | 0.95 | 0.89 | 0.98 | 0.94 | 0.95 | 0.95 | 0.95 | 0.92 | 0.93 | 0.99 | 0.91 |
| 3.40 | 1.05 | 1.04 | 1.06 | 0.93 | 1.05 | 1.02 | 1.05 | 1.01 | 1.01 | 0.99 | 1.00 | 0.97 | 0.83 | 0.99 | 0.93 | 1.00 | 0.96 | 0.99 | 0.97 | 0.94 | 0.97 | 0.92 |
| 3.60 | 1.06 | 1.06 | 1.07 | 0.94 | 1.06 | 1.05 | 1.07 | 1.03 | 1.03 | 1.02 | 1.03 | 1.00 | 0.86 | 1.02 | 0.95 | 1.02 | 0.99 | 1.01 | 1.00 | 0.98 | 1.00 | 0.95 |
| 3.70 | 1.12 | 1.12 | 1.09 | 1.04 | 1.06 | 1.06 | 1.09 | 1.07 | 1.06 | 1.07 | 1.04 | 1.01 | 1.00 | 1.04 | 1.03 | 1.00 | 1.02 | 1.00 | 0.95 | 1.01 | 1.09 | 0.99 |
| 3.80 | 1.04 | 1.04 | 1.06 | 0.91 | 1.05 | 1.03 | 1.05 | 1.01 | 1.02 | 1.00 | 1.01 | 0.99 | 0.83 | 1.00 | 0.93 | 1.01 | 0.97 | 1.00 | 1.00 | 0.96 | 0.97 | 0.93 |
| 3.90 | 1.09 | 1.10 | 1.10 | 0.98 | 1.08 | 1.07 | 1.09 | 1.07 | 1.06 | 1.05 | 1.05 | 1.03 | 0.93 | 1.05 | 1.00 | 1.04 | 1.03 | 1.03 | 1.01 | 1.02 | 1.05 | 0.99 |
| 4.10 | 1.05 | 1.05 | 1.06 | 0.94 | 1.04 | 1.03 | 1.05 | 1.01 | 1.01 | 1.01 | 1.01 | 0.98 | 0.86 | 1.00 | 0.94 | 1.00 | 0.98 | 0.99 | 0.98 | 0.96 | 0.98 | 0.94 |
| 4.30 | 1.07 | 1.07 | 1.08 | 0.96 | 1.07 | 1.05 | 1.08 | 1.04 | 1.04 | 1.03 | 1.03 | 1.01 | 0.89 | 1.03 | 0.97 | 1.02 | 1.00 | 1.01 | 1.00 | 0.99 | 1.02 | 0.96 |
| 4.50 | 1.04 | 1.04 | 1.06 | 0.91 | 1.05 | 1.03 | 1.05 | 1.01 | 1.01 | 1.00 | 1.02 | 0.99 | 0.83 | 1.00 | 0.93 | 1.02 | 0.97 | 1.00 | 1.00 | 0.96 | 0.97 | 0.94 |
| 4.60 | 1.05 | 1.05 | 1.06 | 0.92 | 1.06 | 1.04 | 1.06 | 1.02 | 1.02 | 1.01 | 1.03 | 0.99 | 0.85 | 1.01 | 0.94 | 1.02 | 0.98 | 1.01 | 1.00 | 0.97 | 0.98 | 0.95 |
| 4.80 | 1.08 | 1.08 | 1.09 | 0.96 | 1.08 | 1.06 | 1.09 | 1.05 | 1.05 | 1.04 | 1.05 | 1.02 | 0.89 | 1.04 | 0.98 | 1.04 | 1.01 | 1.03 | 1.01 | 1.00 | 1.03 | 0.98 |
| 5.00 | 1.07 | 1.07 | 1.07 | 0.96 | 1.06 | 1.04 | 1.07 | 1.03 | 1.03 | 1.02 | 1.02 | 0.99 | 0.87 | 1.01 | 0.95 | 1.00 | 0.98 | 1.00 | 0.98 | 0.96 | 1.00 | 0.94 |
| R | 1.11 | 1.11 | 1.10 | 1.02 | 1.08 | 1.07 | 1.10 | 1.07 | 1.07 | 1.07 | 1.06 | 1.03 | 0.98 | 1.05 | 1.02 | 1.03 | 1.03 | 1.02 | 0.99 | 1.02 | 1.08 | 1.00 |

Note: "R" stands for "remaining part".

Source: author's own calculations.

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## Abstract

### Nierówności przychodów i wydatków wśród polskich gospodarstw domowych

Stratyfikacja oraz pojęcie do niej odwrotne, przekrywanie, są ściśle powiązane z miarami nierówności i odgrywają kluczową rolę w jednym ze sposobów dekompozycji współczynnika Giniego. W niniejszej pracy badane są własności współczynników przekrywania. Analizowana jest dekompozycja nierówności w Polsce (przychodów, rozchodów oraz różnic pomiędzy przychodami i rozchodami gospodarstw domowych), w której pojawia się człon zależny od przekrywania się rozkładów dla poszczególnych grup.

**Słowa kluczowe:** stratyfikacja, przekrywanie, współczynnik Giniego, dekompozycja, nierówności międzygrupowe.

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# STRUCTURAL SIMILARITIES BETWEEN POPULATIONS OF PERSONS WITH AND WITHOUT DISABILITIES BY SELECTED SOCIAL AND ECONOMIC FACTORS

**Abstract**

Cohesion policy pursued by the EU addresses the important issue of improving the quality of life of persons with disabilities and, above all, preventing their social exclusion and discrimination. Measures in support of these aims are included in many strategic documents, among others, Europe 2020 and Strategy for Accountable Development until 2020. This paper aims to assess the situation of persons with disabilities compared to persons without disabilities by selected socio-economic variables and on the basis of real data from the 2011 General Population and Housing Census. The population structure of persons with and without disabilities was compared using statistical methods based on indexes of structural similarity, the Gini coefficient, and chi-squared statistic.

The structures of the examined groups of persons with and without disabilities turned out to be similar with respect to education and civil status, but significantly dissimilar with respect to age, economic activity, and source of income. Compared to persons without disabilities, among disabled persons there are considerably more persons who are professionally inactive and hence non-wage earners, living on retirement or disability pensions. Persons without disabilities begin living on their own sooner than persons with disabilities. Today, the lower level of education and

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professional activity among persons with disabilities compared to persons without disabilities is the most fundamental and difficult challenge for government policy towards persons with disabilities.

**Keywords:** persons with disabilities, discrimination, index of structural similarity, Gini coefficient, labour market.
**JEL Classification:** J15, J18, J71.

## 1. Introduction

The structure of states and regions in the European Union is remarkably diversified with respect to economic and demographic resources, which is why Member States pursue an integration policy known as cohesion policy. One of the main objectives of cohesion policy is to correct imbalances between EU regions as regards economic level, and business and social conditions. Cohesion policy has set eleven thematic objectives for 2014–2020. One of these is about promoting social inclusion and combating poverty and discrimination, while another concerns support for labour mobility (EU 2013).

One of the social groups most exposed to social exclusion and discrimination is persons with disabilities. Employment is an area where discrimination can be observed (Grabowska 2016, Bennett, Ray & Wilson 2016). Other researchers also mention the built environment and social barriers to people with disabilities (Sendi & Kerbler-Kefo 2009). There are almost 50 million citizens with disabilities in EU countries. Measures aimed at equal opportunities are therefore pursued, and measures designed to improve the quality of life of people with disabilities are provided in many strategic documents. The Europe 2020 strategy identifies sustainable development as the main priority in favour of social inclusion that aims to support the economy with high employment, ensuring social and territorial cohesion, activities promoting social innovation for the benefit of persons in difficult social circumstances (including persons with disabilities), and enhancing awareness and recognition of the basic rights of the socially excluded poor by giving them the opportunity to participate in social life (EU 2010).

Another important document as regards improving the quality of life of persons with disabilities is Strategy for Accountable Development until 2020. One of its particular objectives is socially sensitive and territorially sustainable development which encompasses activities aimed at inclusive development rather than exclusion and which seeks solutions that will allow all social groups (including persons with disabilities) to actively participate

in development processes, thus allowing them to benefit from economic growth. Achieving the targets of cohesion policy and fulfilling the tasks required by the above-mentioned strategies as regards counteracting social exclusion and discrimination, as well as enhancing the quality of life of persons with disabilities, require the situation of this social group to be systematically monitored. This paper seeks to evaluate the situation of persons with disabilities in contrast to those without disabilities by selected social and economic attributes based on real data sourced from the 2011 Population and Housing Census. The structures of social and economic variables characterising populations of people with disabilities and without disabilities in the Dolnośląskie Province are compared by means of statistical methods based on indexes of structural similarity, the Gini coefficient, and chi-squared statistic.

## 2. Data Sources

The structures of populations of persons with and without disabilities with respect to selected social and economic variables, i.e. age, education, economic activity and sources of income, have been compared using data from the 2011 Population and Housing Census published by the Central Statistical Office in Poland. The data is not up-to-date, so the actual condition of persons with disabilities cannot be evaluated, but it provides a valuable basis upon which to analyse the structural similarity of populations of persons with and without disabilities using the proposed methodology. The obtained results can support the debate conducted in the context of cohesion policy.

Censuses are generally considered one of the most important sources of statistical information because they transmit fundamental and complete knowledge about society and its demographic as well as social and economic properties.

Questions about disabilities broadly understood were introduced into census questionnaires in the 1978 census. The main objective of that census and of subsequent censuses conducted in 1988, 2002 and 2011 was to recognise and to obtain the demographic, social, economic and housing characteristics of this population, whose significance is socially so important.

The data on persons with disabilities gained as a result of the 2011 Population and Housing Census, which was carried out in compliance with the General Census Act of 2011 (The Act 2010, No 47, item 277), was collected in a representative survey for the first time, and the acquisition

of data was not mandatory due to the specific nature and sensitivity of the issue. The available responses included an optional refusal for respondents to answer specific questions concerning the area of disabilities. One may therefore suppose that data on the proportion of persons with disabilities in the total population collected in the 2011 census is underestimated (Central Statistical Office 2013).

According to the 2011 census methodology, disabled persons, in legal terms, are those who have been awarded relevant judgements issued by an approved authority. Biologically disabled persons, in turn, are those who have not been awarded such judgements but who feel constrained in their ability to perform basic activities of daily living typical for their age. Basic activities typical for infants are, for instance, correct reactions to external stimuli (crying, gestures, reflex actions), while for elderly persons they are daily self-care activities such as grooming, shopping, and cooking. Consequently, a disabled person as defined in the 2011 census is either a person with disabilities in the legal sense (i.e. only legally, or both legally and biologically) or a person who is not officially disabled but who feels constrained when performing basic activities of daily living typical for their age (working, studying, leisure, self-care).

The population and housing census is a valuable source of data input to analyses of social and economic conditions of disabled persons and their households. It is also the only source of data used to perform a wide--reaching analysis in this field at the regional level.

## 3. Methodology

### 3.1. General Remarks

In this paper we measure the similarity of structures using the Bray--Curtis and Canberra metrics as well as concentration ratios graphically illustrated by concentration curves. The analysis is focused on visualisation so as to better understand and recognise the data structure in its entirety and the underlying interrelationships. Pearson's $\chi^2$ test (Agresti 2002) was used to evaluate the relationship between two populations under study in regard to selected social and economic variables:

$$\chi_2 = \sum_{i=1}^{I} \sum_{j=1}^{J} \frac{(n_{ij} - e_{ij})^2}{e_{ij}}, \tag{1}$$

where $n_{ij}$ are frequencies in the contingency table $(I \times J), e_{ij} = \frac{n_{i.} n_{.j}}{n}$ – are theoretical, expected frequencies if we assume the independence of variables. The test statistic (1) is asymptotically distributed as chi-squared with $(I - 1)$ $(J - 1)$ degrees of freedom, if $n$ is sufficiently large. When expected frequencies are small, then the type II error probability increases. Therefore, the above tests were conducted with a large sample of 75,257 observations, and the expected frequencies were always greater than 10.

In order to indicate variables such as age, education, marital status, economic activity and source of income, which are significant for a person with or without disabilities, the following null hypotheses claiming the independence between two variables were tested:

$$H_0: \forall\, i = 1,2,...,I \quad \forall\, j = 1,2,...,J \; p_{ij} = p_{i.} p_{.j},$$

i.e. the variables under study are independent, with the alternative hypothesis:

$$H_1: \exists\, i = 1,2,...,I \quad \exists\, j = 1,2,...,J \; p_{ij} \neq p_{i.} p_{.j},$$

i.e. the variables under study are dependent, where $I$ and $J$ denote the numbers of rows and columns in a contingency table created for the two variables under study.

### 3.2. Similarity Index

There are a number of structural similarity (comparison) measures in the literature using distance (unlikeness) measures (*Taksonomia*… 1998). The choice of specific measures is a debatable issue, and their application depends on a given case, whereas no measure can outperform other measures (Ostasiewicz 2011).

Let $p = (p_1, p_2, \ldots, p_r)$ and $q = (q_1, q_2, \ldots, q_r)$ denote structures of populations of persons without disabilities and with disabilities, respectively, as regards the selected social and economic variables for $r$ elements of the structure, where:

$$\sum_{i=1}^{r} p_i = 1, \sum_{i=1}^{r} q_i = 1, i = 1, 2, \ldots, r.$$

The measure of similarity of two structures, based on the Bray-Curtis metric, belonging to the interval [0, 1], is then defined by the following formula:

$$s_{BC} = \sum_{i=1}^{r} \min(p_i, q_i). \tag{2}$$

This index can also be written using the Czekanowski's metric, normed on the interval [0, 1], which is based on the city block (taxicab) metric (Młodak 2006):

$$s_{Cz} = 1 - \frac{1}{2}\sum_{i=1}^{r} \left| p_i - q_i \right|. \tag{3}$$

Another popular measure of similarity of structures is also the measure based on the Canberra distance, which is normed on the interval [0, 1] and defined as:

$$s_C = 1 - \frac{1}{r}\sum_{i=1}^{r} \frac{\left| p_i - q_i \right|}{p_i + q_i}. \tag{4}$$

The similarity coefficient based on the Canberra metric, in contrast to that based on the Bray-Curtis metric, is sensitive to the type of dissimilarity that is typical in the case of differences between structures of entities in populations. A good measure should indicate such sensitivity, even if it is not always necessary (Młodak 2006).

If the examined structures are totally different (dissimilar), then structural similarity measures normed on the interval [0, 1] are equal to zero, and if they are identical, the index is equal to one.

### 3.3. Concentration Curve

The concentration (dispersion) curve of distribution $q$ with respect to distribution $p$ has been applied in a non-standard way in this research to compare the populations of persons with and without disabilities concerning a given attribute.

A diversity of two structures $p$ and $q$ can be represented graphically by a broken line connecting in a plane, in a unit square, the points with following coordinates:

$$(0, 0), (p_1, q_1), (p_1 + p_2, p_1 + q_2), \ldots,$$
$$(p_1 + p_2 + \cdots + p_{r-1} + p_r, q_1 + q_2 + \cdots + q_{r-1} + q_r), (1, 1).$$

The number of segments of the concentration curve is equal to the number of values taken by variables characterising the populations examined with regard to the given variable. When the points in the curve concerning one variable are naturally ordered, then the curve can be situated over the diagonal of the unit square or under the diagonal as well. However, if the points belonging to the concentration curve are in a non-decreasing order

according to the angle of inclination with respect to the horizontal axis, calculated from the formula $q_i/p_i$, then the curve obtained by joining the points will always be situated under the diagonal (the curve will be convex). The curve formed according to the ordered non-decreasing quotients is called the curve of maximal concentration (dispersion), and the diagonal of the square is called the line of uniform division (Borowski & Szczęsny 2005, Wyżnikiewicz 1987).

If the structures of populations of persons with and without disabilities were identical with regard to some social and economic variables, then the concentration curve would be equal to the line of uniform division. In practice, such a situation does not ever occur, or it occurs extremely rarely. The opposite situation occurs in the case of a total concentration, when both populations are described by a single, yet different, value taken by the variable. In such a case the concentration curve has the form of two perpendicular segments – the horizontal axis and the right-hand side segment of the plot.

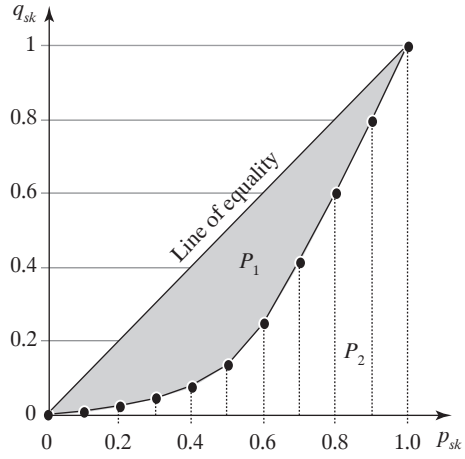


Fig. 1. Concentration Curve

Source: authors' own elaboration.

The higher the degree of concentration or the more diversified the structures of the populations under study, the more distant the concentration curve is from the line of uniform division. The concentration curve represents the application of the Lorenz curve, well-known in statistics and econometrics as a measure of inequality of distribution of income or

another good. The concentration curve allows an analysis of the character of concentration based on its shape, and also determines the degree of concentration by means of the Gini coefficient. The numerical value of concentration is given as the ratio of the area between the concentration curve and the line of uniform division to the half area of the unit square. With respect to the above definition, the coefficient of concentration is calculated from the following formula:

$$G = \frac{P_1}{P_1 + P_2} = 2P_1 = 1 - 2P_2 . \tag{5}$$

The coefficient of concentration defined in this way belongs to the interval [0, 1]. It is equal to zero in the case of a total absence of concentration (the curve is equal to the line of uniform distribution), and to one in the case of full concentration. The greater the value of the coefficient, the more dissimilar the structures of the examined populations. Using area formulas for a trapezium and triangle (Fig. 1), the coefficient of concentration can be written in the form:

$$G = 1 - 2\sum_{i=1}^{r} \frac{q_{sk_i} + q_{sk_{i-1}}}{2} p_i, \tag{6}$$

where: $p_{sk_i}$, $q_{sk_i}$ denote the cumulative frequencies for a population of persons with and without disabilities, respectively.

With its graphical interpretation, the Gini coefficient outperforms other indexes used to study the similarity of structures that are measures of similarity only.

## 4. Results of the Analysis

Information at the regional level about persons with disabilities may only be gained from General Censuses of Population and Housing. With no other source of information available, the 2011 census data was used to compare the structures of populations of persons with and without disabilities by selected social and economic variables in the Dolnośląskie Province.

According to the 2011 census, Dolny Śląsk (Lower Silesia) had a population of 2.915 million, which comprised 13% of persons with disabilities and 87% of persons without disabilities. In other words, there are 15 persons with disabilities per 100 persons without disabilities. Among the approximately 384,000 persons with disabilities, 253,000 were officially disabled (66% of the total number of those with disabilities), and the

remaining approximately 130,000 persons were biologically disabled only (34%).

Women outnumbered men among persons both with and without disabilities (Fig. 2). This is primarily because on average women live longer than men. In 2016, average life expectancy for women in Lower Silesia was 81.4 years, while for men it was 73.5 years. Average life expectancy in Poland has been systematically increasing due to advanced medical technology, diagnostics, as well as the general promotion of proactive and healthy lifestyles (Central Statistical Office 2017).

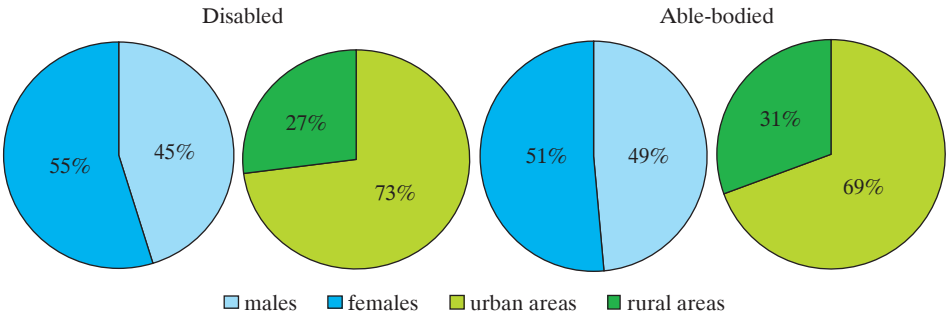


Fig. 2. Structure of Disabled and Able-bodied People by Sex and Place of Residence

Source: authors' own elaboration.

The structure of populations of persons with and without disabilities was quite similar with respect to place of residence, as it was with respect to gender. In both populations of persons with and without disabilities, approximately 30% lived in villages. In 2011, nearly 12% of village dwellers were persons with disabilities, whereas almost 14% of urban dwellers were persons with disabilities. Both shares were quite similar.

Various demographic and socio-economic variables are important determinants of civilised communities. Therefore, the present similarity analysis of distributions in the populations under study was conducted by such variables as: age, education, marital status, economic activity, and source of income. The chi-squared test applied to test for independence of the aforementioned demographic variables of being a person with or without disabilities in each case rejected a null hypothesis claiming that disability is independent of given variables ($p_{value} = 0.00$). Hence, it is justified to analyse the quality of life and symptoms of social exclusion of persons with

disabilities regarding those demographic and socio-economic variables. To determine the similarity of distributions, the presented method was applied based on similarity measures constructed in relation to the Bray--Curtis and Canberra distance measures. The structure of the population of persons without disabilities was compared to the population of persons with disabilities, and to subpopulations of legally disabled persons and of biologically disabled persons.

The conducted analyses of population structures by age, source of income, and economic activity demonstrate major differences between the populations under study. The similarity indexes (cf. Table 1) for those variables ranged from 0.42 to 0.64. Groups of persons with and without disabilities were more similar regarding marital status and education – the similarity measures ranged from 0.66 to 0.84. This result may indicate that disabilities do not always have to be a hindrance to achieving the life goals of raising a family or pursuing a professional career, where knowledge and proficiency associated with adequate education are the strongest factors.

Table 1. Similarity Measures of Structures

| Statistical Variable | Persons without Disabilities *versus* | | |
|---|---|---|---|
| | All Persons with Disabilities | Persons with Disabilities, Legally | Persons with Disabilities, Biologically |
| Index Based on the Bray-Curtis Distance | | | |
| Age | 0.53 | 0.55 | 0.47 |
| Marital status[a] | 0.81 | 0.84 | 0.74 |
| Education level[b] | 0.77 | 0.78 | 0.74 |
| Source of income | 0.44 | 0.42 | 0.48 |
| Economic activity[a] | 0.59 | 0.59 | 0.59 |
| Index Based on the Canberra Distance | | | |
| Age | 0.52 | 0.54 | 0.47 |
| Marital status[a] | 0.73 | 0.76 | 0.69 |
| Education level[b] | 0.69 | 0.71 | 0.66 |
| Source of maintenance | 0.52 | 0.49 | 0.59 |
| Economic activity[a] | 0.62 | 0.61 | 0.64 |

[a] – persons aged 15 years and over, [b] – persons aged 13 years and over.

Source: authors' own elaboration.

In the population of persons without disabilities 54% were married *versus* 52% among those with disabilities. The biggest difference with respect to civil status involved widows and widowers (7% of those without disabilities and 25% of those with disabilities, respectively), while more than 90% of them were aged 60 or over. This is partly because disabilities become more acute with age (Fig. 3).

Education is distributed similarly to civil status in the populations under study. The similarity is weaker than in the case of civil status, but it is quite noticeable. Persons with disabilities are less educated than persons without disabilities, but at most levels of education the share of persons with disabilities differs from that of persons without disabilities by 3 percentage points on average. The biggest difference concerned higher education. Only 7% of persons with disabilities (or perhaps as much as 7%, because generally the organisms of disabled people are less efficient) have higher education *versus* 20% of persons without disabilities (Fig. 3).

As for the other analysed variables, the structures of the examined populations are dissimilar. Especially different are distributions of economic activity and related sources of maintenance. The population of persons with disabilities contains markedly more persons who are professionally inactive, and thus their sources of income are non-wage related such as retirement and disability pensions. Hence, there are fewer professionally active persons with disabilities who are wage-earners compared to persons without disabilities.

It is also interesting that the share of dependent persons in the population of persons without disabilities is three times bigger than the share of dependent persons in the population of persons with disabilities. This is because young people are dominant in the group of persons without disabilities. Among dependent persons without disabilities, 78% were persons aged 24 or under *versus* 46% of dependent persons under 25 among disabled persons. Hence, persons without disabilities become independent and live on their own sooner than persons with disabilities.

Today, the lower level of education and professional activity among persons with disabilities compared to persons without disabilities is undoubtedly the most fundamental and difficult challenge for government policy towards persons with disabilities.

Both measures of similarity of structures – the one based on the Bray-Curtis metric and the one based on the Canberra distance – produced similar results.

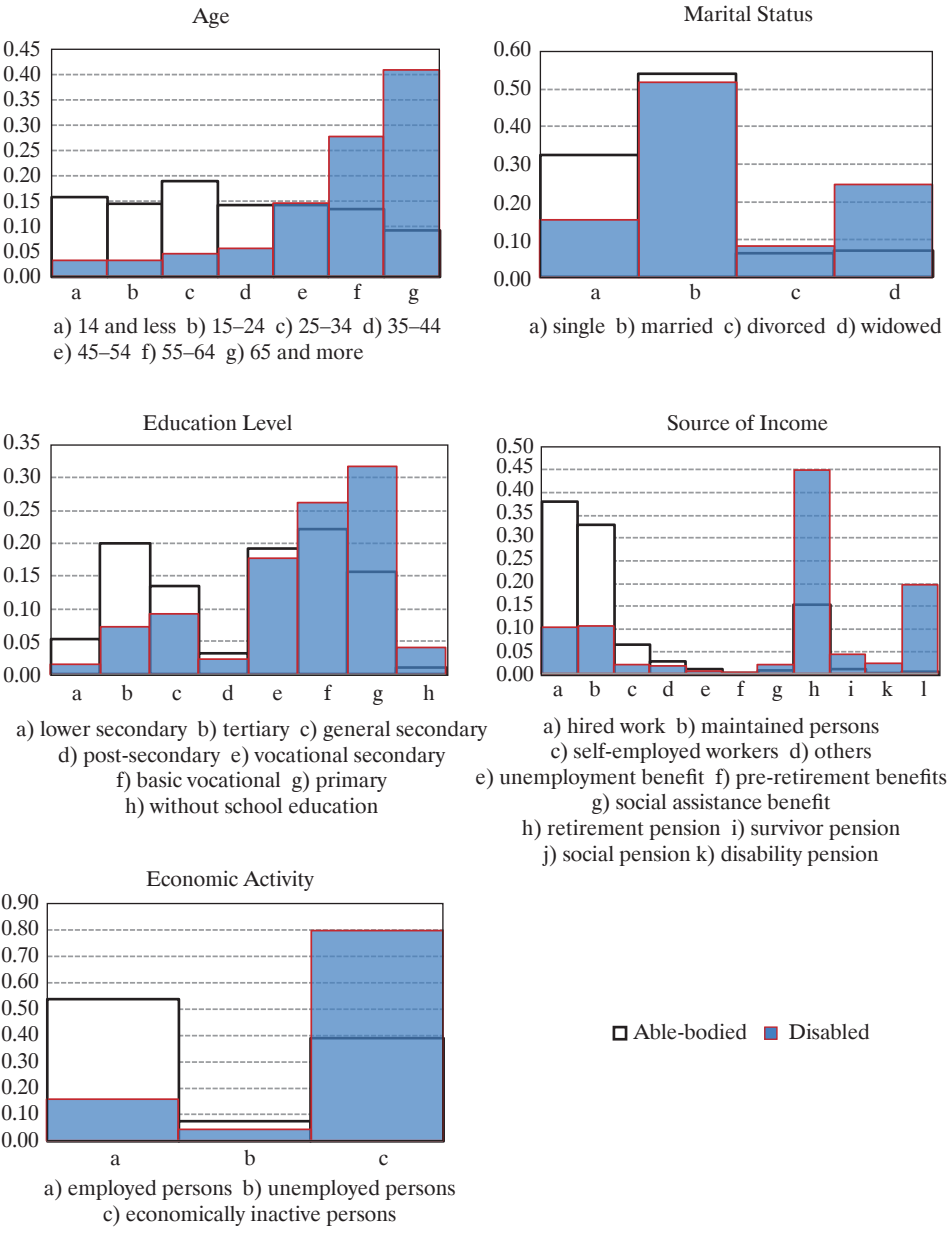


Fig. 3. Similarity in the Structure Due to Selected Features

Source: authors' own elaboration.

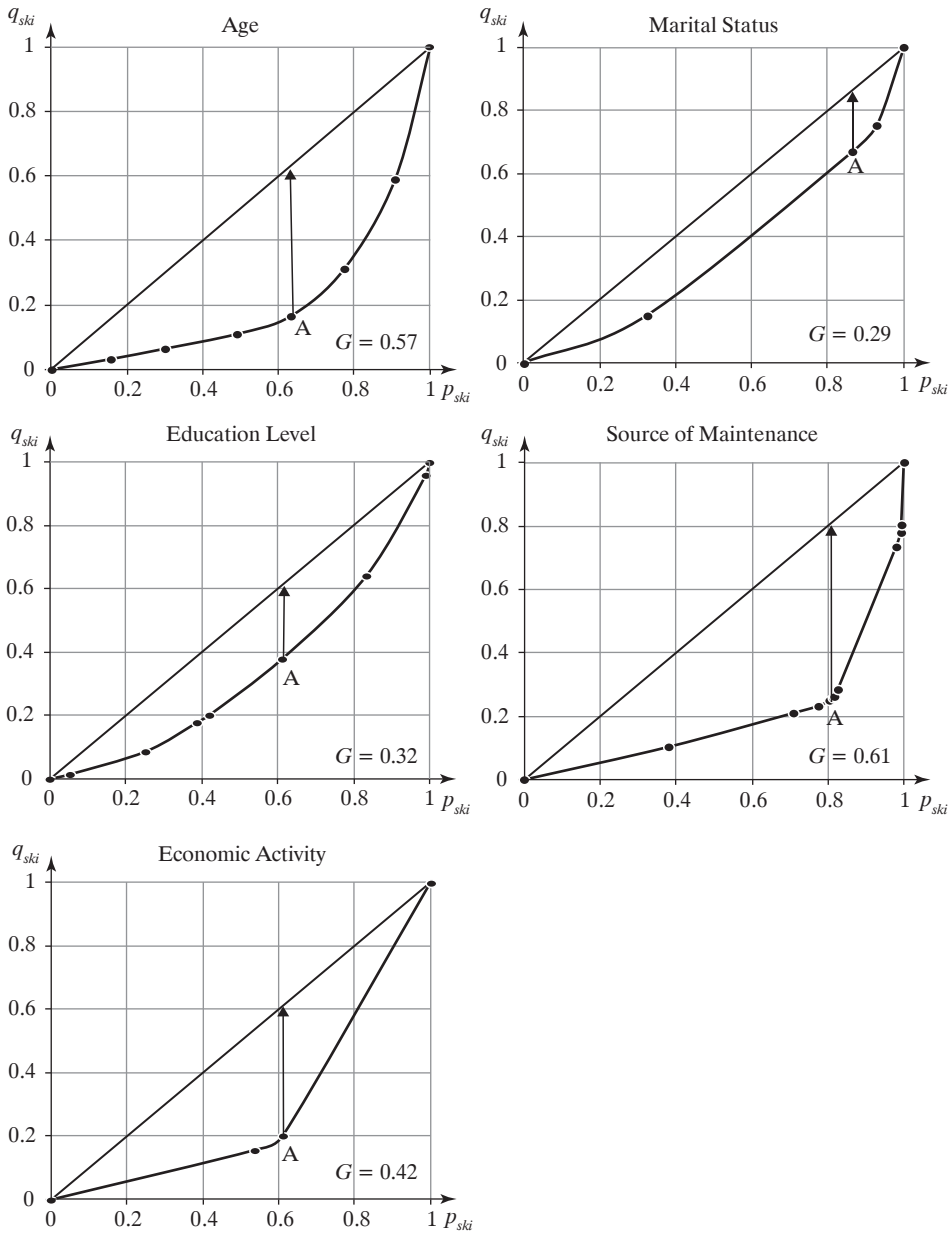


Fig. 4. Maximum Concentration Curve

Source: authors' own elaboration.

The similarity of structures measured by indexes based on the Bray--Curtis and Canberra metrics was found to be comparable, both in the case of all persons with disabilities and in the case of subpopulations of legally disabled and biologically disabled persons. Therefore, the analysis based on concentration curves and coefficients will now consider all persons with disabilities and compare them to persons without disabilities.

The concentration coefficients calculated according to formula (6) take on analogous values as metrics based on the Bray-Curtis and Canberra distances to show the dissimilarity of structures. When analysing their values, one may conclude, as above, that the structures of the populations of persons with and without disabilities resemble one another more as regards civil status and education, and less in the case of the remaining variables. This approach is better because the measure is graphically interpreted by the curve of maximal concentration.

The concentration curve (cf. Fig. 4) demonstrates the level of disparity between the structures of the populations under study. The closer to the line of uniform division the concentration curve, the lower the level of concentration. The line of uniform division represents the case where the cumulative frequency of persons without disabilities, given the values of the categorical variable from the first to the $r$th item, is identical to the cumulative frequency of persons with disabilities.

Looking at the concentration curves in Figure 4, we notice that in each case the curves first diverge from the diagonal and then come closer to it again. This is because the cumulative frequencies of persons with disabilities first diverge from the cumulated frequencies of persons without disabilities for the respective categorical data, but after reaching a certain "critical" point ($A$ in Fig. 4), the differences between them start to decrease.

The distance between the concentration curve and the uniform division line is biggest at point $A$, and equals for the respective variables: age – 0.47, civil status – 0.19, education – 0.23, source of income – 0.56, economic activity – 0.42.

In the case of age, the result indicates that approximately 47% of persons should be shifted from one age bracket to another in order to obtain an identical structure of persons with and without disabilities among all age groups. In addition, the maximal concentration curve implies that in the four age groups jointly (i.e. persons aged 14 years and under, from 15 to 24 years, from 25 to 34 years, and from 35 to 44 years) the percentage of persons without disabilities who are aged 45 years or less is bigger by 0.47 percentage points than the percentage of persons with disabilities in this age bracket.

In turn, persons with disabilities dominate those without disabilities in the case of three age groups, i.e. 45 to 54 years, 55 to 64 years, and 65 years and older, which are located above the critical point A, while the difference between the percentages is biggest for the oldest group (9% for the population of persons without disabilities *versus* 41% for the population of persons with disabilities).

Looking at the concentration curve describing economic activity, one notices that in the case of two categories, i.e. employed and unemployed, in other words professionally active or inactive persons, the structure exhibits an excess of persons without disabilities over persons with disabilities. On the other hand, professionally inactive persons dominate in the population of persons with disabilities, as demonstrated by the third segment of the cumulative maximal concentration curve. If 41% of professionally inactive persons with disabilities were shifted to the professionally active group, i.e. to employed persons, then the curve of maximal concentration would be almost identical with the line of uniform division, and the coefficient of concentration would equal zero. Similar analysis can be conducted for the remaining statistical variables.

The conducted research demonstrated the considerable usefulness of methods based on concentration curves for analysing the structural similarity of two populations, especially as regards delivering quick information using graphical visualisation.

## 5. Conclusions and Further Research

The European Union's strategy is primarily aimed at creating a society that is friendly and accessible to all. Messages, guidelines, and even directives are regularly issued that oblige EU Member States to work against the social exclusion of persons with disabilities. Nevertheless, it is mainly the Member States who bear responsibility for the policy towards persons with disabilities. Each government should regulate the issue through its internal cohesion policy towards disabled persons. This policy should be supported by statistical analyses aimed at evaluating the social and economic conditions facing persons with disabilities.

Even though the data provided by the General Population and Housing Census is underestimated, it relates to a large group of people with disabilities and hence allows their demographic and socio-economic situation to be assessed quite well at both the country and regional level. Therefore, it is necessary to continue research in this area and to extend its range, so

that the results obtained by researchers may contribute to the undertaking of proper measures aimed at improving the situation of disabled persons.

The presented facts, which are expressed in numbers, provide the material for sociological and demographic analyses of disabled persons and for the accomplishment of basic needs-oriented activities. The analysis emphasises the significant differences in the structure of populations of persons with and without disabilities. It also tries to demonstrate that in some areas the structure of persons with disabilities does not deviate from that of persons without disabilities, and that disabilities do not always have to be a hindrance to achieving life goals or pursuing a professional career.

Today, the lower level of education and professional activity among persons with disabilities compared to persons without disabilities is undoubtedly the most fundamental and difficult challenge for government policy towards persons with disabilities. The low level of involvement of persons with disabilities in labour markets represents a major policy problem not only in Poland, but also in many EU countries. The employment rate for persons with disabilities aged 20–64 in the EU in 2009 was 45.7%, whereas in Poland it was as low as 33.3% – one of the lowest rates recorded in the EU (Kukulak-Dolata & Sobocka-Szczapa 2013). This index was only lower in Romania, Hungary, and Greece. The situation of persons with disabilities primarily depends on economic development in their home countries and on policies pursued by governments. Further research is needed to examine how efficiently persons with disabilities are supported. Actual improvement in the well-being of disabled persons also depends on whether they can make determined efforts to take advantage of the help provided by policymakers.

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## Abstract

### Analiza podobieństwa struktur zbiorowości osób niepełnosprawnych i pełnosprawnych według wybranych cech społeczno-ekonomicznych

W ramach polityki spójności prowadzonej w Unii Europejskiej ważnym problemem jest poprawa jakości życia osób niepełnosprawnych, a przede wszystkim zapobieganie ich wykluczeniu społecznemu i dyskryminacji. Działania wspierające ten kierunek wymieniane są w wielu dokumentach strategicznych, m.in. Europa 2020 czy Strategia na rzecz odpowiedzialnego rozwoju do 2020 r. Celem artykułu jest ocena sytuacji osób niepełnosprawnych w porównaniu z osobami sprawnymi według wybranych cech społeczno-ekonomicznych na podstawie rzeczywistych danych pochodzących z Narodowego Spisu Powszechnego Ludności i Mieszkań z 2011 r. Analiza porównawcza struktury cech społeczno-ekonomicznych ludności sprawnej i niepełnosprawnej w województwie dolnośląskim została przeprowadzona z wykorzystaniem metod statystycznych opartych na wskaźniku podobieństwa struktur, współczynniku Giniego oraz statystyce chi-kwadrat.

Badane grupy osób pełnosprawnych i niepełnosprawnych okazały się podobne pod względem struktury wykształcenia i stanu cywilnego, natomiast istotnie zróżnicowane pod względem wieku, aktywności ekonomicznej oraz źródła utrzymania. Wśród niepełnosprawnych zdecydowanie więcej niż wśród sprawnych jest osób biernych zawodowo i tym samym utrzymujących się z niezarobkowych źródeł, jak emerytury czy renty, natomiast mniej jest osób aktywnych zawodowo i utrzymujących się z dochodów z pracy. Osoby sprawne szybciej przechodzą na własne źródło utrzymania niż osoby niepełnosprawne. Niższy niż wśród osób pełnosprawnych poziom wykształcenia oraz aktywności zawodowej to obecnie bez wątpienia podstawowe, a zarazem najtrudniejsze wyzwania stojące przed polityką państwa wobec grupy osób niepełnosprawnych.

**Słowa kluczowe:** osoby niepełnosprawne, dyskryminacja, wskaźnik podobieństwa struktur, współczynnik Giniego, rynek pracy.

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# A MULTIVARIATE STATISTICAL ANALYSIS OF THE INFORMATION SOCIETY IN POLAND

**Abstract**

Widespread access to high-speed Internet, user-friendly public e-services and the increasing digital competence of society are the main goals for the coming years according to the latest reports published by the Central Statistical Office in Poland. These goals are included in the Operational Programme Digital Poland. This technological development is also connected with the development of economic areas and public services. The rapidly increasing significance of information and electronic services, and thus the application of information and communication technologies (ICT) in the economy, public administration (central and local), and in the everyday life of citizens has triggered a new transformation trend – a transformation towards the information society. This term describes a society for which the processing of information with the use of ICT solutions creates significant economic, social and cultural value.

In this paper we present the current state, main aspects, vision and mission of the information society in Poland and carry out a statistical analysis of the information society in Poland using multivariate statistical methods. All the calculations are based on data from the Central Statistical Office and they are conducted using R software.

**Keywords:** information society in Poland, multivariate statistical analysis, categorical data analysis, R software.
**JEL Classification:** C30, C35, C40.

## 1. Introduction

Information technology (IT) has a huge impact on people, society, and the economy. We briefly present some facts on the information society in 2015 in Poland that will help us understand the impact of IT on the economy.

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The information and communication technology (ICT) sector plays an important role in the modern economy, directly affecting the growth of productivity, employment, productivity and, indirectly, other branches of the economy.

The development of modern enterprises is inextricably linked with the use of ICT. Companies generally use computers with broadband Internet access. The dynamic growth of Internet use in business stems from its essential characteristics, such as: lack of bureaucratic restrictions, the possibility of international cooperation among specialists, global reach and flexibility. As a result, the Internet has become a key business tool implemented in companies engaged in services, sales, information exchange, or acquiring suppliers in the financial field, and thus has become tool for building competitive advantage. In an age of broad technological development, ICT information and the knowledge linked to it is becoming a strategic product. The ability to gain such knowledge and data and its transmission through the network often determines market success. Information also is changing the business world by creating broad opportunities for business contacts, the conduct of transactions and the acquisition of market news around the world.

From 2012, the percentage of large companies with Internet access was close to 100%, which indicates saturation among this group of entities. In 2015, 92.7% of companies had Internet access and mostly used broadband (91.9%). Mobile broadband was used by over 61.5% of companies. The proportion of enterprises with their own website in 2015 was 65.4%. Nearly two-thirds of companies used their own websites to present the products and services they offer. In 2014, every fifth company received orders via computer networks, and every tenth company received orders via the Internet. In 2015, almost half of large enterprises used social media. One quarter of large enterprises used the services of cloud computing in 2015 (www.gus.pl).

The financial perspective for the 2014 to 2020 period has opened up new possibilities for supporting the development of the information society. Widespread and easy access to the Internet, user-friendly public e-services, and the increasing digital competence of society are the aims for the coming years. ICT has a bigger and bigger influence on our daily lives. In particular, the Internet is creating a new layer of participation for individuals in social and economic life. New services on the Internet affect a wide range of activities, such as information retrieval, communication, training and education, commerce and finance, participation in social networks and

leisure activities. The growing pervasiveness of ICT leads to user-friendlier applications on the one hand but requires access to ICT and basic Internet and computer skills on the other.

The goal of this paper is to provide knowledge about the information society in Poland with the use of statistical analysis as well as to identify qualitative development trends in the process of transforming Poland's society. Furthermore, we provide a survey of new trends, processes and phenomena, focusing of those groups and economic sectors of the information society in Poland which are at the stage of highest development. The statistical analysis includes correspondence analysis, hierarchical clustering using the Ward method and modern visualising tools for categorical data. We present a comprehensive description of the dynamic change of the information society in Poland and use multivariate statistical analysis to study the strengths and weaknesses of the information society in Poland using up-to-date empirical data. The main hypothesis is: there are sectors of the information society in Poland that can be clustered into similar sectors. The hypothesis will be tested using multivariate statistical methods and visualising tools for categorical data. All the calculations are conducted using R software.

## 2. Facts and Figures on the ICT Sector and ICT Products

In 2014, the number of enterprises hiring 10 or more persons in the ICT sector amounted to 2146 (a 6.3% increase compared to the previous year), of which 89.1% offered ICT services. Almost three quarters of ICT service enterprises provided IT services. In comparison with 2011, the number of ICT enterprises steadily increased and was higher by 24.5% (including service enterprises, which increased 29.2%). The number of persons employed in the sector amounted to 196,400 (an increase of 6.5% compared to the previous year and 10.7% compared to 2011), with persons hired in ICT services constituting over three quarters. IT services was also the field of activity in which enterprises hired the biggest number of persons of all those employed in ICT services (66.1%). The value of net revenues from sales in the ICT sector increased by 8.8% compared to 2011 and amounted to over PLN 132 billion in 2014 (only in 2013 was a slight decrease noted in comparison with 2012 – 0.7%). Services, in particular telecommunications, made the biggest contribution to the generation of revenues in the ICT sector. In 2014, ICT manufacturing enterprises earned almost two thirds of their revenue from export sales, while ICT service enterprises earned

only 15.4%. In 2011–2013, these revenues steadily decreased in ICT manufacturing enterprises but in 2014 they recorded an annual growth of 8.3%. In service enterprises, revenues from exports were continually increased. Enterprises providing IT services had the biggest share in these revenues (63.5% in 2014). An increase of expenditure on R&D in the ICT sector was noted in the years 2011–2014 (by PLN 553 million). Enterprises offering ICT services incurred approximately 90% of their expenditure on R&D in each surveyed year. In the analysed period, ICT sector enterprises were more innovative than enterprises in the economy as a whole (all manufacturing and service enterprises). The ICT sector most frequently implemented new or improved products.

According to the annual report published by the Central Statistical Office entitled *Information Society in Poland. Results of Statistical Surveys in the Years 2012–2016*, in 2015 the number of enterprises hiring 10 or more persons in the ICT sector amounted to 2045 (a 4.7% decrease compared to the previous year), of which 88.5% offered ICT services. Almost three quarters of ICT service enterprises provided IT services. The number of persons employed in the sector amounted to 214,200 (an increase of 9.1% compared to the previous year and 18.5% compared to 2012), with persons hired in ICT services constituting over three quarters of that figure. IT services was also the field of activity in which enterprises hired the biggest number of persons of all those employed in ICT services (70.2%). The value of net revenues from sales in the ICT sector increased by 9.8% compared to 2012, up to PLN 139 billion in 2015 (only in 2013 was a slight decrease noted in comparison with 2012 – 0.7%). Services, in particular telecommunications, made the biggest contribution to the generation of revenues in the ICT sector. In 2015, ICT manufacturing enterprises earned almost three quarters of their revenue from export sales, while ICT service enterprises earned under one fifth. In the analysed period, these revenues in ICT manufacturing enterprises slightly fluctuated, while in service enterprises revenues from exports were steadily on the rise. Enterprises providing IT services had the biggest share in these revenues (67.0% in 2015). An increase of expenditure on R&D in the ICT sector (by PLN 654 million) was noted in the years 2012–2015. Enterprises offering ICT services incurred over 90% of their expenditure on R&D in the ICT sector in each surveyed year. In the analysed period, ICT sector enterprises were more innovative than enterprises in the economy as a whole (all manufacturing and service enterprises). The ICT sector most frequently implemented new or significantly improved products. In 2015, the value of sold production

of ICT products decreased by PLN 1 billion compared to 2014. Over the analysed period, the value of exports and imports of ICT products steadily increased. In the years 2012–2015, exports increased by 24.4% and imports by 14.3%.

There are many papers on this topic in the literature: UNDP (2002), A. M. J. Skulimowski (*Transfer…* 2006), L. Z. Karvalics (2007) and A. Szewczyk (2007).

## 3. The Information Society

The Polish government, having in mind the good of Poland and its inhabitants, is striving to ensure rapid and sustainable economic growth and social development that will improve the living conditions of citizens. One of the key stimulants of economic growth is citizens' ability to acquire, accumulate and use information as a result of the dynamic development of ICT. The importance of this factor for economic growth is confirmed by various research, which concludes that ICT accounts for approximately one quarter of GDP growth and 40% of productivity growth in the European Union. The rapidly increasing significance of information and electronic services, and thus the application of information and communication technologies (ICT) in the economy, public administration (central and local), and in the everyday life of citizens has triggered a new transformation trend – a transformation towards the information society. The term "information society", as adopted for the purposes of this paper, is defined as a society for which the processing of information with the use of ICT solutions creates significant economic, social and cultural value. This strategy is sectoral and, as such, defines the vision and mission for the development of the information society in Poland until 2013. Within each of its three areas – Human, Economy and State – it maps out strategic directions and determines the objectives that should be accomplished in order to achieve the desired development status for the information society in Poland in 2013. The creation of the strategy was preceded by a series of extensive consultations with experts representing organisations and institutions most competent to express views on the issue of information society development. The outcomes of the consultations and the strategic development directions adopted by the Polish government were the basis for the formulation in 2013 of the vision of the information society in Poland and the core principles of its development. Within the framework of the partial subject areas, the vision of the information society in Poland in 2013 is presented in detail.

This paper presents the most vital activities initiated thus far and selected directions for further action required to accomplish the adopted objectives.

Research on the links between the diffusion of ICTs and social and economic development has been underway for decades. Evidence of links between social and digital engagement, particularly with respect to the Internet, has been the focus of many studies conducted by academic as well as government institutions. These studies have consistently shown that individuals who have access to ICTs, from the telephone to the Internet, tend to have more schooling, higher incomes, and higher status occupations than do those who do not have access. To analyse this study in the next part of this paper we present a statistical analysis based on data from the Central Statistical Office on the information society in Poland. According to a report published by the Central Statistical Office entitled *Information Society in Poland. Results of Statistical Surveys in the Years 2010–2014*, ICT usage in enterprises is as follows: in 2014, 94.4% of enterprises, including almost all large enterprises, used computers. The value of this indicator in 2013 placed Poland slightly below the EU average. Since 2010, the percentage of enterprises with access to the Internet has exceeded 90%, with almost all large enterprises having such access. In 2014, the highest level was recorded in the Dolnośląskie voivodship (95%) and the lowest in the Zachodniopomorskie voivodship (89.6%). The number of enterprises using broadband (fixed and mobile 3G) connections increased in 2014 compared to the previous year. The biggest rise in Internet access using broadband connections occurred among small enterprises. The value of this indicator increased annually in the majority of voivodships, with the biggest values being in the Mazowieckie and Śląskie voivodships. The systematic growth in the share of employees using computers, including ones with access to the Internet, was noticed in the analysed period. However, the value of this indicator varied considerably depending on the region and type of activity. In 2014, over one half of enterprises equipped their employees with devices enabling mobile access to the Internet. As for large enterprises, 9 out of 10 offered their employees the possibility to use mobile devices. In 2014, 10.2% of enterprises in Poland employed ICT specialists, with the biggest activity in this regard among large enterprises. In the years 2010–2013, an increase in the percentage of enterprises receiving and sending orders via computer networks by 1.7 and 7.2 percentage points was recorded. As for the automatic sharing of information within the enterprise in 2014, the percentage of ERP and CRM system usage was almost identical and amounted to 22.0% and 21.8%, respectively. The percentage of enterprises using the Internet for

interaction with public authorities slightly decreased, reaching 88% in 2013. In the same year more than one third of enterprises incurred expenditure on purchasing ICT equipment, mostly IT equipment. Large enterprises prevailed in this group. Entities classified in the financial and insurance activities and electricity, gas, steam and conditioning supply sections were the ones doing purchasing most often.

Information published on the ITC usage of households is as follows: in 2014, 77.1% of households were equipped with at least one computer. This percentage has steadily increased in recent years and is significantly higher in households with children. The number of regular computer users also increased over the 2010–2014 period. Three quarters of households had access to the Internet in 2014, which is a 2.9 percentage point increase in comparison with the previous year. This indicator was also on the rise during the analysed period. The percentage varied depending on the type of household, degree of urbanisation, place of residence and region. Households with children more frequently owned a computer and had access to the Internet. This percentage was also higher in big cities and in Central Poland. Reported reasons for the lack of Internet access in households varied over the surveyed period, although no need for Internet access at home was mentioned most often. In the years 2010–2014, the share of households with broadband access to the Internet increased faster than access to the Internet in general and reached 71.1% in 2014. As in the previous cases, having children and a place of residence were advantageous factors. A total of 63.0% of persons aged 16–74 used the Internet on a regular basis in 2014. However, differentiation depending on age, economic activity, level of education and place of residence was also observed. The highest number of regular users was found among pupils and students (98.6%), the self--employed (85.0%) as well as residents of big cities and persons with tertiary education. The number of regular Internet users was higher among the residents of Central Poland than other regions. The Pomorskie voivodship was dominant when it came to households with computers and access to the Internet as well as persons using computers and the Internet (including regular users) in 2014. As for the purposes of using the Internet in Poland, e-mail users constituted the biggest share. In 2014, the share of e-mail users in the total population aged 16–74 amounted to 52.9%, while the share of e-mail users among Internet users was 79.5%. In 2014, over 34% of Poles aged 16–74 purchased goods and services over the Internet. Men made such purchases more frequently than women. The highest number of persons ordering or purchasing goods or services for private use in 2014 was in the

Mazowieckie voivodship. In 2014, the share of persons using e-government services in the previous 12 months amounted to 26.9%. Compared to the previous year, there was an increase in the percentage of persons using these services by 4.3 percentage points. Searching for information on the websites of public authorities was the most popular way of using e-government. The highest percentage of e-government service users was found in the Mazowieckie voivodship. In 2014, the ICT usage survey was supplemented with an additional module concerning the use of cloud computing services (storage space) and advanced ICT. The results show that nearly 9% of persons aged 16–74 used storage space on the Internet in the previous 3 months. The most common reason for using cloud computing services was the possibility to use files from several devices or locations. In 2014, over one quarter of surveyed persons used such advanced ICT as a smartphone and 14% of persons had a smart TV set at home, enabling them to access the Internet and use advanced functions. In 2014, an additional survey covered persons aged 12–15, among whom almost every person (99.2%) had used a computer of any type in the past, with regular computer users amounting to 97.2%. A total of 98.6% of 12–15 year-olds used the Internet, with regular Internet users amounting to 95.4%, which is 32.4 percentage points more than among persons aged 16–74. Use of social media was the most popular purpose of using the Internet for 77.2% of 12–15 year olds, which is 40.4 percentage points more than among persons aged 16–74. Persons using the Internet to search for information in order to facilitate learning also accounted for a substantial share (59.2%) of 12–15 year olds.

## 4. Research Methodology

The primary objectives of the research required commencing work on theoretical and empirical characteristics. Various statistical research methods were applied in the paper in order to test the research hypothesis.

We present a multivariate statistical analysis of the information society in Poland with the use of R software. We use data from the report published by the Central Statistical Office entitled *Information Society in Poland*. All the calculations were conducted in R software using: `vcd`, `vcdExtra`, `Mass` and `ca` packages.

## 5. The Survey Results and Application in R

We present the analysis using data on the number of enterprises and employees in the ICT sector in 2011–2014 (Table 1).

First, we conduct a correspondence analysis for the number of enterprises in the ICT sector in 2011–2014. The analysis is based on data from the Central Statistical Office on the number of enterprises in the ICT sector in 2011–2014.

We present the results of the correspondence analysis in Table 1.

Table 1. Number of Enterprises in the ICT Sector

| Specification | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| ICT production | 245 | 239 | 225 | 235 |
| ICT wholesale | 190 | 207 | 230 | 235 |
| Telecommunications | 219 | 231 | 258 | 289 |
| IT services | 1070 | 1181 | 1305 | 1387 |

Source: Central Statistical Office.

The percentage being explained by the first dimension is 94.22%, and for the second dimension – 5.38%. These two dimensions explain 99.6% of the total inertia. The total inertia is 0.0017, which shows that there is a very weak association between two variables: year and specification. The row and column masses, chi-square distance and inertia for both categories of row and column are presented below:

```
Principal inertias (eigenvalues):
                1              2              3
Value           0.001629       9.3e-05        7e-06
Percentage      94.22%         5.38%          0.4%

Rows:
                ICT            ICT            Telecommu-     ICT
              production     wholesale        nications      services
Mass            0.121869       0.111283       0.128712       0.638136
ChiDist         0.107785       0.015622       0.030357       0.016220
Inertia         0.001416       0.000027       0.000119       0.000168
Dim. 1         -2.669651       0.091573       0.490427       0.394954
Dim. 2          0.207310      -1.431880       2.366810      -0.267273

Columns:
                  2011           2012           2013           2014
Mass           0.222566       0.239866       0.260522       0.277046
ChiDist        0.062238       0.023124       0.032682       0.040783
Inertia        0.000862       0.000128       0.000278       0.000461
Dim. 1        -1.532660      -0.524810       0.765233       0.966059
Dim. 2         0.664981      -0.877842      -1.068300       1.230398
```

We can display the results of the simple correspondence analysis in the form of a perceptual map (Fig. 1).

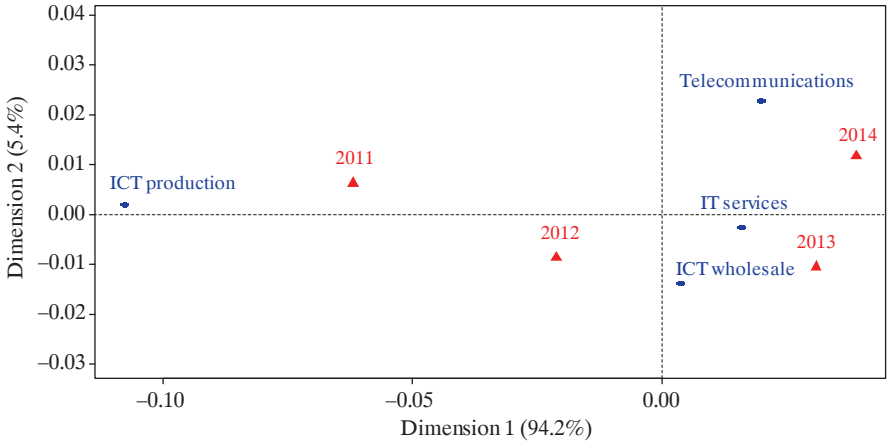


Fig. 1. Two-dimensional Perceptual Map for Correspondence Analysis for the Number of Enterprises in the ICT Sector

Source: author's own elaboration.

Looking at the graph (Fig. 1) we see that ICT production is situated very close to the year 2011. ICT wholesales and IT services are related with the years 2012 and 2013. Finally, telecommunications is situated very near to the year 2014. This graphical presentation may suggest that there is a trend moving ICT production from 2011 to telecommunications services in 2014.

To present graphically a tree diagram for categories of rows for the number of enterprises in the ICT sector (ICT production, ICT wholesale, Telecommunications, and IT services), we will apply agglomerative hierarchical clustering. What follows is a dendrogram of the results of running this data through the Ward clustering algorithm (Fig. 2).

We can see that there are three clusters of ICT specifications separated. One cluster contains two categories: ICT production and ICT wholesale, the second cluster contains only one category – Telecommunications, and last cluster also contains one category – IT services. The analysis is based on data from the Central Statistical Office on the number of employees in the ICT sector in 2011–2014.

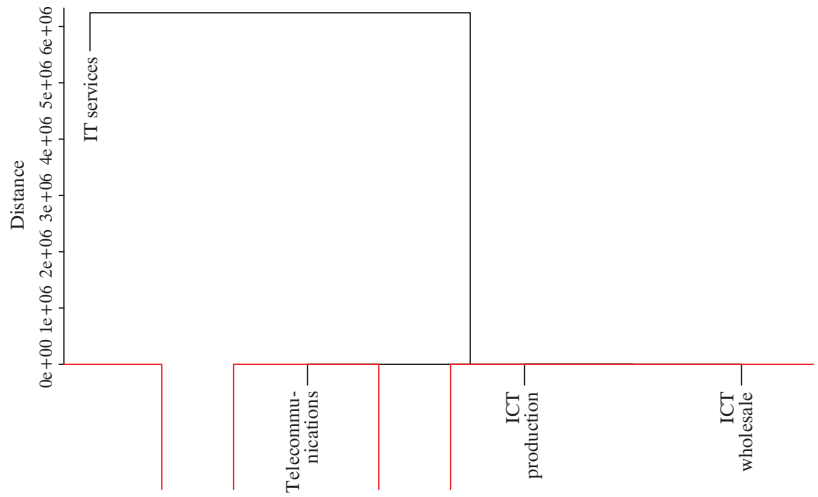


Fig. 2. Dendrogram for the Number of Enterprises in the ICT Sector Using the Ward Method

Source: author's own elaboration.

A correspondence analysis was also conducted for the number of employees in the ICT sector (Table 2).

Table 2. Number of Employees in the ICT Sector

| Specification | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| ICT production | 44,930 | 41,150 | 36,892 | 39,337 |
| ICT wholesale | 10,363 | 10,598 | 11,372 | 11,496 |
| Telecommunications | 46,516 | 43,890 | 42,634 | 41,786 |
| IT services | 75,539 | 85,178 | 93,422 | 103,739 |

Source: Central Statistical Office.

The percentage being explained by first dimension is 97.72%, and for the second dimension – 2.27%. These two dimensions explain 99.99% of the total inertia. The total inertia is 0.0067, which shows that there is a very weak association between two variables: year and specification. The row and column masses, chi-square distance and inertia for both categories of row and column are presented below:

Principal inertias (eigenvalues):

| | 1 | 2 | 3 |
|---|---|---|---|
| Value | 0.006547 | 0.000152 | 1e-06 |
| Percentage | 97.72% | 2.27% | 0.01% |

Rows:

| | ICT production | ICT wholesale | Telecommu-nications | ICT services |
|---|---|---|---|---|
| Mass | 0.219680 | 0.059321 | 0.236622 | 0.484377 |
| ChiDist | 0.099928 | 0.023115 | 0.076194 | 0.080015 |
| Inertia | 0.002194 | 0.000032 | 0.001374 | 0.003101 |
| Dim. 1 | −1.216980 | 0.110858 | −0.921128 | 0.988340 |
| Dim. 2 | 1.378733 | −1.703701 | −1.282066 | 0.209650 |

Columns:

| | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Mass | 0.240035 | 0.244729 | 0.249471 | 0.265765 |
| ChiDist | 0.122501 | 0.028559 | 0.054708 | 0.089983 |
| Inertia | 0.003602 | 0.000200 | 0.000747 | 0.002152 |
| Dim. 1 | −1.513489 | −0.351812 | 0.631948 | 1.097723 |
| Dim. 2 | 0.224847 | 0.119762 | −1.578475 | 1.168343 |

We can display the results of the simple correspondence analysis in the form of a perceptual map (Fig. 3).

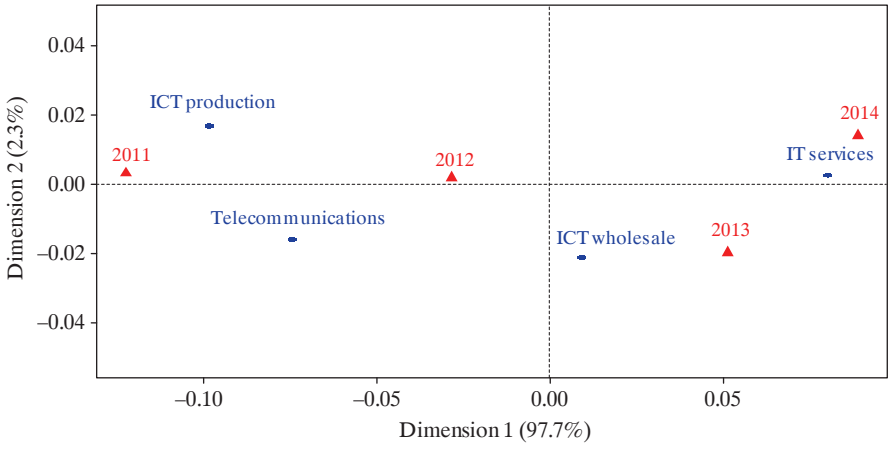


Fig. 3. Two-dimensional Perceptual Map for Correspondence Analysis for the Number of Employees in the ICT Sector

Source: author's own elaboration.

Looking at the two-dimensional perceptual map above (Fig. 3), we can see that the points are situated in a different way to the analysis conducted for enterprises. ICT production is situated very close to the year 2011. Telecommunications are related with the year 2012. ICT wholesale is situated very near to the category 2013, and IT services are plotted near to the year 2013.

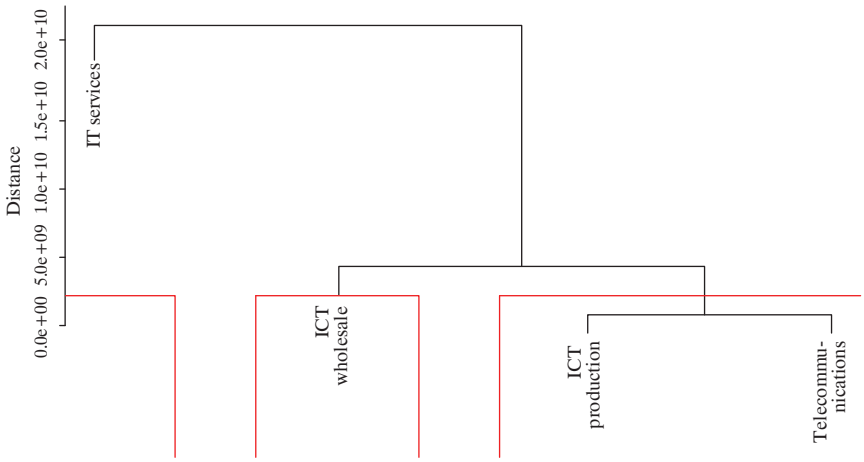


Fig. 4. Dendrogram for the Number of Employees in the ICT Sector Using the Ward Method

Source: author's own elaboration.

Looking at the dendrogram for the number of employees in the ICT sector (Fig. 4), we can see that there are three separated clusters. The first cluster contains two categories: ICT production and Telecommunications, the second cluster contains one category – ICT wholesale, and finally the last cluster also contains one category – IT services. Using multivariate methods, we can see which categories of analysed variables belong to the cluster of objects that are similar to each other.

## 6. Visualising the ICT Sector

We can also provide a graphical presentation for categorical data in R using the `vcd` library. Here we provide basic plots for visualising categorical data such as: mosaic, sieve, association and double-decker plot.

The mosaic plot was first introduced by J. A. Hartigan and B. Kleiner (1981, 1984), and M. Theus and R. W. Lauer (1999), and is one of the most popular and useful methods of log-linear modelling. Mosaic plots are a generalisation of multi-way tables and a direct tool for testing log-linear models. A mosaic represents each cell of the table by a rectangle (or tile) whose area is proportional to the cell count. The mosaic is constructed by dividing a unit square vertically by one variable, then horizontally by another. Further variables are introduced by recursively subdividing each tile by the conditional proportions of the categories of the next variable in each cell, alternating on the vertical and horizontal dimensions of the display.

First, we apply the `mosaicplot` function to present the mosaic plot for our dataset, the number of enterprises and number of employees, respectively (Fig. 5).

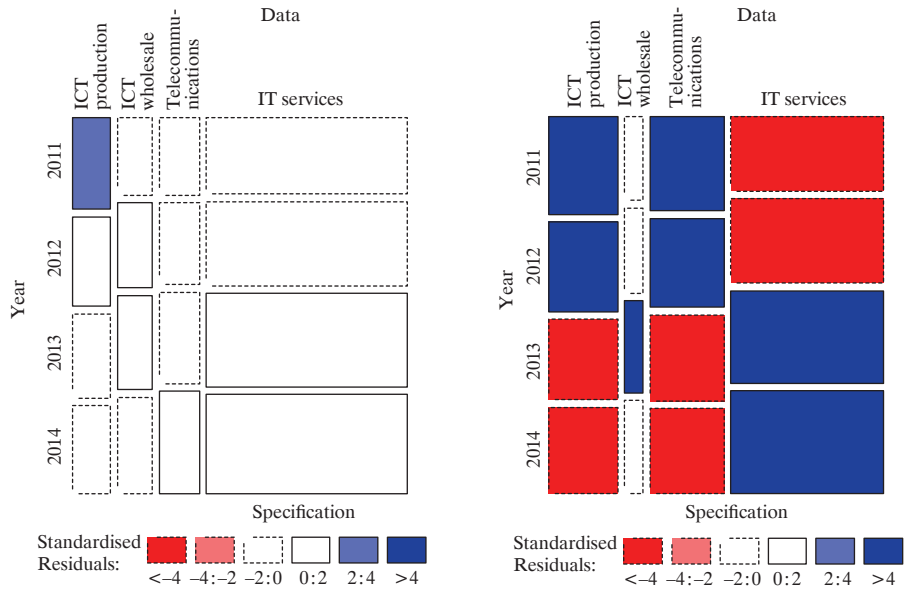


Fig. 5. Mosaic Plot for the Number of Enterprises and Employees in the ICT Sector
Source: author's own elaboration.

The mosaic plots show that there are strong differences between the ICT sector for enterprises and employees. From the mosaic plot we can conclude that blue means that there are more observations in that cell than would be expected under the null model (independence). Red means that there are

fewer observations than would have been expected. White cells in the first plot indicate very small Pearson's residuals for enterprises, which means that the difference between the observed and theoretical cell counts is very small and the model is close to independence. By contrast, in the second picture there are large Pearson's residuals shown in blue (positive) and red (negative) for employees. This means that the dependence between the analysed variables is strong.

H. Riedwyl and M. Schüpbach (1983, 1994) proposed a sieve diagram (later called a parquet diagram) based on this principle. In this display, the area of each rectangle is proportional to expected frequency, and observed frequency is shown by the number of squares in each rectangle. Hence, the difference between observed and expected frequency appears as the density of shading, using colour to indicate whether the deviation from independence is positive or negative. In the next step we apply the `sieve` function to present the sieve plot for the number of enterprises and number of employees, respectively (Fig. 6).

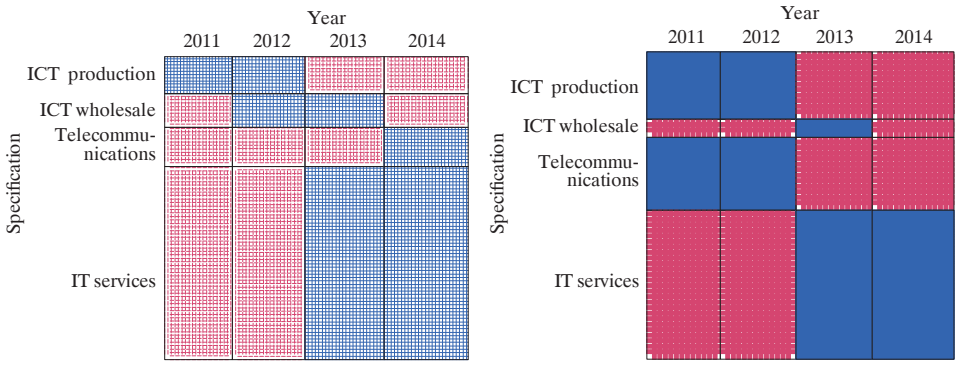


Fig. 6. Sieve Plot for the Number of Enterprises and Employees in the ICT Sector

Source: author's own elaboration.

Each rectangle in the sieve plot is then cross-ruled based on the observed frequency. The deviations from independence are reflected in the density of the shading. Denser shading indicates that the observed frequency is greater than expected, while sparse shading indicates that the observed frequency is less than expected. As an additional cue, positive and negative departures from independence can be coded with different colours.

From the analysis of Figure 6 we can observe stronger differences for employees compared to enterprises. The differences for IT production and

services in 2011–2014 are the same sign, but the density is stronger for the number of employees, which indicates the stronger dependence of variables.

Another plot available in R software that can be used for visualising categorical data is `assoc` in the `vcd` package (Meyer, Zeileis & Hornik 2005). It produces a Cohen-Friendly association plot that indicates deviations from the independence of rows and columns in a two-dimensional contingency table. If the observed frequency of a particular cell is greater than the expected one, the box rises above the baseline and is shaded in the colour specified by the first element of col, which defaults to black; otherwise, the box falls below the baseline and is shaded in the colour specified by the second element of col, which defaults to red.

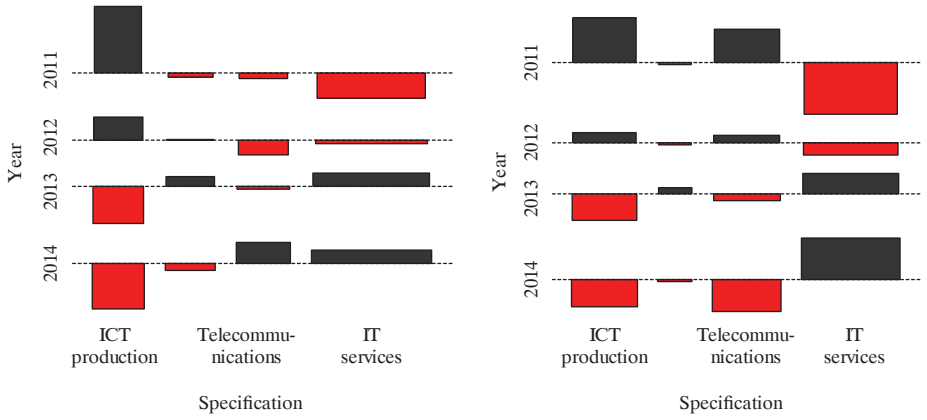


Fig. 7. Association Plot for the Number of Enterprises and Employees in the ICT Sector

Source: author's own elaboration.

From the analysis of Figure 7 we can see that the comparison between the number of enterprises and employees in the ICT sector is very similar in term of deviations for ICT production and IT services during the years 2011–2014. However, it varies for ICT wholesale (second column) and Telecommunications (third column). The differences in such ICT areas are very similar to those observed in the sieve plot (Fig. 6), indicating differences in particular specification.

In order to optimise the comparison of all crossings of all input variables, a doubledecker plot is most efficient. This plot can be done using the `vcd` package in R software. In a doubledecker plot the conditional layout of the mosaic plot is linearised by putting all category crossings side by side just

as in a spine plot. This plot is in grey, with a different colour shade for each category.

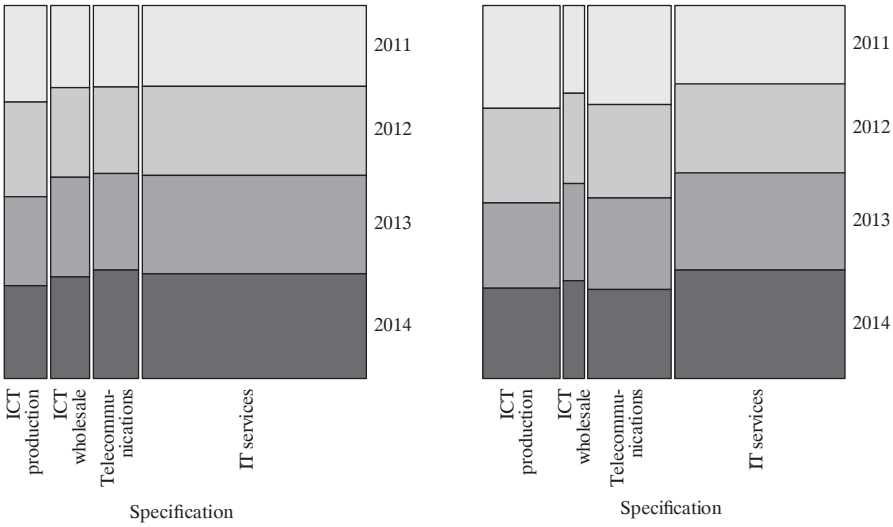


Fig. 8. Doubledecker Plot for the Number of Enterprises and Employees in the ICT Sector

Source: author's own elaboration.

From the plots in Figure 8 we can see the structure of our datasets. For the number of enterprises in the ICT sector we see that the highest number of enterprises falls in the IT services category, and the largest area is for 2014. Smaller numbers are visible for enterprises and employees in the ICT production, ICT wholesale and Telecommunications. There is a slight difference for the number of employees in the ICT sector, where the largest areas are also for IT services, and the smallest area is for ICT wholesale.

## 7. Conclusions

The statistical methods applied in the empirical part of this paper allow us to see the deeper structure of the number of enterprises in the ICT sector as well as the number of employees in the ICT sector in 2011–2014. The analysis is based on data from the Central Statistical Office. Statistical methods for analysing categorical data were applied, such as: correspondence analysis and hierarchical clustering analysis using the Ward method. As a result, a perception map and dendrogram were obtained for

a number of enterprises as well as employees in the ICT sector in 2011–2014. Such methods allow us to see which of the analysed categories are similar to each other in successive years. We also used the `vcd` package to visualise categorical data. Mosaic, sieve, association and doubledecker plots were presented for the number of employees and enterprises in 2011–2014 and an interpretation was provided.

The analysis allows us to conclude that, using correspondence analysis for enterprises, three clusters can be distinguished: ICT production, telecommunication, and IT services and ICT wholesale in one cluster. For the employees group, there are also three clusters: ICT production, telecommunication, and ICT wholesale and IT services in one cluster. Similar results were obtained in the hierarchical analysis. Three clusters were separated for enterprise data: IT services, telecommunication, and in last cluster ICT production with ICT wholesale. For employee data there were also three clusters, but with different categories: IT services, ICT production, and in the last cluster ICT production with telecommunication. The analysis conducted in the paper shows different business areas that are similar in the years 2011–2014. It also shows the trend over time, which areas are more developed and on top in successive years, and how the passage of time in business enables a change from one area of activity to another. The conducted analysis allowed the hypothesis to be tested and showed that there may some clusters in different sectors of the Polish economy in the area of the information society. The conducted research may be used in future studies to analyse the information society in term of sectors and future trends and economic situation in order to predict and analyse clusters and groups similar to each other in terms of characteristics. Also graphical presentation, which is unique as regards analysing the information society problem, may be used for a detailed interpretation of results. The use of computer software and the application of R software as well as the use of advanced visualising methods are added value and a unique feature of research in this area.

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## Abstract

### Wielowymiarowa analiza statystyczna społeczeństwa informacyjnego w Polsce

Powszechny dostęp do szybkiego internetu, przyjazne dla użytkownika e-usługi publiczne i rosnące kompetencje cyfrowe społeczeństwa są głównymi celami na najbliższe lata według najnowszych raportów opublikowanych przez Główny Urząd Statystyczny w Polsce. Cele te zawarte są w Programie Operacyjnym Polska Cyfrowa. Rozwój technologiczny wiąże się również z rozwojem obszarów gospodarczych i usług publicznych. Szybko rosnące znaczenie informacji i elektroniki usług, a tym samym zastosowania technologii informacyjnych i komunikacyjnych (Information and Communication Technologies – ICT) w gospodarce, administracji publicznej (centralnej i lokalnej), a także w codziennym życiu obywateli spowodowało nowy trend transformacji – transformację w kierunku społeczeństwa informacyjnego. Termin ten opisuje społeczeństwo, dla którego przetwarzane informacje z wykorzystaniem rozwiązań ICT stwarzają istotną ekonomiczną, społeczną oraz kulturową wartość. W artykule przedstawiono obecny stan, główne aspekty oraz wizję i misję społeczeństwa informacyjnego w Polsce. Przeprowadzono statystyczną analizę społeczeństwa informacyjnego w Polsce za pomocą wielowymiarowych metod statystycznych. Wszystkie obliczenia oparto na danych pochodzących z Głównego Urzędu Statystycznego i wykonano z wykorzystaniem programu R.

**Słowa kluczowe:** społeczeństwo informacyjne w Polsce, wielowymiarowa analiza statystyczna, analiza danych jakościowych, program R.

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Kalim Siddiqui

# THE POLITICAL ECONOMY OF INDIA'S ECONOMIC CHANGES SINCE THE LAST CENTURY

**Abstract**

The objective of this study is to examine India's transformation from a colonial to a modern economy on the basis of the macro-economic changes that have occurred over the last century. This is important because it will help us to understand the associated growth performance and its impact on sectoral changes and employment in the wider context of developing economies such as India. The methodology to be followed here is derived from the aims of the study and comparisons of international statistics that provide the means by which to address the research questions and the objectives of this paper. The study found that during the colonial period, the Indian economy became subservient rather than sovereign in terms of policy matters. As a result, economic development was hampered by the removal of "surplus", along with very high land rents and tribute charges. A densely populated country like India was drawn into the orbit of exploitation in the mid-18th century. Soon after independence in 1947, the Indian government took a number of initiatives to enhance industrial and agricultural development, but the biggest failure was that it did not make any real impression on the country's huge unemployment problems.

**Keywords:** Indian economy, colonial period, famines, growth rates and neoliberal reforms.
**JEL Classification:** O1, O5, N0, N5.

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## 1. Introduction

The aim of this paper is to analyse economic policy and its performance in India during the past century. In doing so, the article examines the limitations of such policies. This study is important because India is the second-largest populated country in the world, now having almost same population as China, and also the study of a longer period of economic changes and polices provides us with a better understanding of the past and present. A critical examination of the Indian economy, besides India, can also help other developing countries to draw lessons from its strengths and weaknesses.

The methodology to be followed here is derived from the aims of the study and comparisons of international statistics that provide the means by which to address the research questions and the objectives of this paper. Analysing pre-existing secondary data is the only possible way to obtain macroeconomic data. These include data from official sources and from international institutions such as the IMF (International Monetary Fund), World Bank and OECD. Due to the nature of the topic, it is considered that such methods will be appropriate to undertake this study.

The objective of this study is to examine India's transformation from a colonial to a modern economy on the basis of the macro-economic changes that have occurred over the last century. This is important because it will help us to understand the associated growth performance and its impact on sectoral changes and employment in the wider context of developing economies such as India.

In recent years, India has experienced remarkably high economic growth rates, which have led to much speculation in the media that India is an emerging economic superpower. However, such discussions have overlooked the fact that this growth has not been accompanied by an associated rise in equality or reduction in social ethnic conflict. Yet despite all the failings and mistakes, the record of Indian government since the country became independent (about 70 years ago) in most respects has shown vastly better growth and performance than under the previous British colonial rule, especially on such indices as GDP growth rates, living conditions, health, literacy rates, life expectancy and overcoming famine and mass hunger (Siddiqui 2015).

We need to look at basic facts about India's experience with British colonialism and why colonial (mis) rule cannot be put aside. The study also intends to examine the legacy of the *British Raj* and also post-colonial

development, and also that later failures do not in any sense invalidate my criticism of colonial exploitation and subjugation. British economic historian Angus Maddison (2003) calculated that India's share of the world economy was a quarter of the world's GDP in the mid-18th century, larger than that of all European countries combined at that time. In fact, in 1705, this figure was as high as 27% when Mughal Emperor Aurangzeb ruled the country. By the time the British departed India, GDP share had dropped to 3% (Tharoor 2017). The reason was that India was ruled to benefit Britain and, as a colony for two hundred years, India was financing not only the industrialisation of Britain but also its military ventures in Asia, East Africa and the Middle East (Bagchi 2010).

This article is organised as follows. Following the introduction to this topic in Section 1, Section 2 will briefly discuss the colonial legacy. Section 3 analyses the economic policies and performance of the post-independent period, in particular from 1947 to 1990, whilst Section 4 examines the period of neoliberal economic reforms, i.e., from 1991 to date, followed by a conclusion which summarises the findings.

At independence in 1947, modern large-scale industries and mining constituted just 7% of India's GDP, while small-scale industries accounted for 10%, the agricultural sector, 49%, and services and construction, 34%. Total employment in the industrial sector was just 2.9 million people, which amounted to less than 2% of the total workforce. In contrast to this, small industries employed a much higher proportion, some 7% of the workforce, while nearly 72% of the Indian workforce was employed in agriculture; services including construction employed 18.7%. Cotton and jute were among the main modern industries established in the early 20th century in India (Siddiqui 1996).

The tasks for independent India in 1947 were to accelerate the transition towards a modern economy, as dominated by industry. This was because on the eve of independence, the agricultural sector accounted for half of the country's GDP and modern industry contributed only 7% of the total GDP. In fact, despite the development of a few industries during colonial rule, India was still predominantly an agrarian country with low productivity that suffered from widespread poverty and illiteracy. During the 1950s, the government took a number of measures in industrial and agricultural sectors through public investment in accord with its plans to establish several heavy and capital-intensive industries in crucial areas such as steel, machines and tools, power generation, and in irrigation and technical and scientific institutions such as the Indian Institute of Technology. As a result, in the

1950s growth rates rose to be higher than in previous decades, but still lower than those of other East Asian economies (Siddiqui 2016a). The most important issue was that this growth left unemployment and poverty largely unaffected. Moreover, by the late 1960s, the economy began to slow, heralding the start of a crisis that subsequently became more severe in the late 1970s and in the early 1980s where in order to fund populist measures the government resorted to heavy foreign loans. This seemed, and indeed was, to represent only short-terms relief for the country, and the situation became more critical in the 1990s (Siddiqui 2018).

World oil prices rose in response to the Iraqi invasion of Kuwait in 1990 and, as a result, India's import bills increased sharply; so, when the Soviet Union collapsed in 1991, India experienced a balance of payments crisis. During that time, the then Finance Minister Manmohan Singh stated in his budget speech: "There is no time to lose. Neither the government nor the economy can live beyond its means year after year. The room for manoeuvre, to live on borrowed money or time, does not exist anymore. Any further postponement of macro-economic adjustment, long overdue, would mean that the balance of payments situation, now exceedingly difficult, would become unmanageable and inflation, already high, would exceed limits of tolerance" (Ministry of Finance 1991–92).

India asked for an IMF loan in 1991 and, in return, the country was asked to implement neoliberal reforms also known as 'Structural Adjustment Programmes' (Siddiqui 2012). The mainstream economists welcomed this and emphasised that these reforms would increase competition and efficiency. According to them, any distortions were associated with government intervention and regulation of markets and the crucial issue of aggregate employment determination. Any distortions induced by the government involving the use of monetary and fiscal policy to raise employment would merely generate inflation. They maintained that economic development requires rapid GDP growth, which has a "trickle--down effect", ultimately benefitting the poor (World Bank 2016).

## 2. India's Colonial Legacies

It is widely recognised that, until 1760, India was the second-largest manufacturing economy after China. India exported cotton textiles to Africa, Europe and South East Asia (Bagchi 2010). As J. T. Sunderland (1929, p. 367), a British-born and US minister, noted, "India was a far greater industrial and manufacturing nation than any in Europe or any other

in Asia. Her textile goods – the fine products of her looms, in cotton, wool, linen and silk – were famous over the civilized world; so were her exquisite jewellery and her precious stones (…); so were her fine works in metal--iron, steel, silver and gold (…). [India] had great architecture (…) great businessmen, great bankers and financiers. Not only was she the greatest shipbuilding nation, but she had a great commerce and trade by land and sea which extended to all known civilized countries. Such was the India which the British found when they came".

However, in 1757, Robert Clive defeated Nawab Siraj-ud-Duala and Bengal was taken over by the (British) East India Company; at the time, Bengal was the richest province of India. However, after the British imposed colonial rule Bengal in 1757, and especially after the end of the Napoleonic Wars, India's textile industries were systematically destroyed, large urban centres known for textile industries were depopulated, and as a result the proportion of people dependent on agriculture rose dramatically. The textile industries in Manchester were protected, while "free trade" was forced on India. As a result, Indian-made cloths paid higher duties than cloths imported from Manchester. This, of course, had very serious implications for Indian handicraft industries and for social structure and the structure of the rural economy as a whole (Siddiqui 1990).

India dominated in global textile trade until 1760, but with the onset of colonialism this no longer remained the case. Britain imposed tariffs and duties of 70% to 80% on Indian textiles exported to Britain, making their sale unviable for Indian exporters. This made Indian textiles expensive in the British markets, while India could not impose retaliatory tariffs on British goods since the British controlled the ports and the government (Tharoor 2017). Under colonialism, Indian manufactures did not receive any assistance from the government, despite lower wages and locally produced raw materials of which the domestic manufacturers could not take advantage. India still grew cotton as a raw material that was exported to Britain. The devastation of textiles' deindustrialisation and the devastation of the textile industry as a whole significantly reduced the urban population, which is also known as de-urbanisation. As the number of people subsequently dependent on agriculture rose sharply, such development drove rural wages down. Of course, there were some good periods too. For example, the American Civil War interrupted supplies of raw cotton from the New World. This resulted in a boom for Indian cotton growers, but once American supplies were resumed in 1865, they suffered again (Siddiqui 1990).

In a very short period, India moved from being an exporter of high--quality finished goods to a mere exporter of raw materials such as cotton, jute, opium, spices, tea and rice. The huge increase in the cultivation of opium, indigo, tea and jute led to the decline of land available for the cultivation of food crops. Between 1770 and 1800, India's share in world manufacturing exports fell from 27% to 2%, while exports from Britain to India rose sharply under the duty-free and free trade regime imposed by colonialism (Bagchi 2010).

In the agricultural sector, the British created layers of intermediaries between actual cultivators and the landlords who paid land rent directly to the colonial administration. Land rent increased sharply as compared to the pre-colonial period, and during poor monsoon and famine, rents were not reduced, which led to increased reliance on money lenders who exploited the peasants with their high usurious rates of interest, thus keeping borrowers in a position of virtual bondage (Bagchi 2010).

In contrast to the Mughal period, under the British land revenue system, if a farmer's crop failed he was not exempted from paying taxes. The British revenue system was based on potential rather than actual output. The land taxes were not returned in the form of public goods or services, but were rather sent to the British government in London. The lack of investment either from public or private sources destroyed Indian agriculture. As Sir George Wingate notes, "Taxes spent in the country from which they are raised are totally different in their effect from taxes raised in one country and spent in another. In the former case the taxes collected from the population (…) are again returned to the industrious classes (…) But the case is wholly different when the taxes are not spent in the country from which they are raised (…). They constitute [an] absolute loss and extinction of the whole amount withdrawn from the taxed country (…). [The money] might as well be thrown into the sea. Such is the nature of the tribute we have long extracted from India" (cited in Tharoor 2017, p. 26).

F. J. Shore, who worked as British administrator in Bengal, testified before the House of Commons in 1857: "The fundamental principle of the English has been to make the whole Indian nation subservient, in every possible way, to the interest and benefits of themselves. They have been taxed to the utmost limit; every successive province, as it has fallen into our possession, has been made a field for higher extraction; and it has always been our boast how greatly we have raised the revenue above that which the native rulers were able to extort" (cited in Tharoor 2017, p. 16).

In the 18th and 19th centuries under Britain, opium was produced in India and exported to China. The British used the profits from the sale of opium to pay for imports from China such as tea, silk and porcelain, which were in great demand in Europe, while there was no demand in the Chinese markets for European-manufactured goods. Consequently, European traders had to pay for Chinese products with gold and silver. The (British) East India Company established a monopoly on opium cultivation in the Indian province of Bengal, where they forced peasants to grow opium poppies. The opium trade solved this chronic trade imbalance. The efforts of the Qing dynasty to enforce the opium restrictions led to two armed conflicts between China and Britain, known as the Opium Wars, i.e., the first opium war (1839–42) and the second war (1856–60), when British and French troops attacked, and forced China to legalise the opium trade (Bagchi 2010).

As Tharoor (2017, p. 5) finds: "Britain's industrial revolution was built on the destruction of India's thriving manufacturing industries. Textiles were an emblematic case in point: the British systematically set about destroying India's textile manufacturing and exports, substituting Indian textiles by British ones manufactured in England. Ironically, the British used Indian raw material and exported the finished products back to India and rest of the world". Tharoor (2017, pp. 5–6) further notes: "The British destruction of textile competition from India led to the first great deindustrialisation of the modern world. Indian handloom fabrics were much in demand in England; (…) For centuries the handloom weavers of Bengal had produced some of the world's most desirable fabrics, especially the fine muslins, light as 'woven air', that were coveted by European dressmakers. As late as the mid-eighteenth century, Bengal textiles were still being exported to Egypt, Turkey and Persia in the West, and to Java, China in the East, along well--established trade routes, as well as to Europe".

On top of this, Paul Baran calculated that about 8% of the India's GNP was transferred annually to Britain as "Home Charges" (Tharoor 2017). Naoroji's book *Poverty and Un-British Rule in India*, which was published in 1892, presented the "drain theory". According to Naoroji, this transfer of surplus was the main cause of poverty in India (Bagchi 2010). Another study by British economic historian Angus Maddison concluded: "There can be no denial that there was a substantial outflow which lasted for 190 years. If these funds had been invested in India, they could have made a significant contribution to raising income levels" (cited in Tharoor 2017, p. 22). On top of this, thousands of British officials, who worked in India and received

inflated wages and pensions and remittances, were another big drain on resources.

However, recently, apologists for imperialism such as Niall Ferguson and others have denied that the possession of colonies benefitted Britain or that it contributed to the destruction of the Indian economy and society in any way. This is the reason that it is important to briefly examine the economic and social consequences of colonial rule in India. Bagchi (2010, p. XXII) notes: "[in] the years between 1896 and 1913, [Britain superimposed a] long-term downward trend in income and living standards (…) hundreds of thousands of artisans lost their livelihoods, productivity-increasing investment in agriculture shrank, and business communities in many parts of colonial India were pushed out of the most profitable avenues of trade or became subordinate collaborators of European businessmen. India witnessed some of the biggest famines in history, in Bengal from 1769, in south India from the 1780s down to the 1830s, again between the 1870s and early 1900s in western and southern India, apart from many smaller famines that were not officially recognised". Many artisans became tenants or agricultural labourers or simply starved to death during these famines. Moreover, the colonial government was insensitive to the deaths of tens of millions of Indians during such periods, including several hundred million alone due to avoidable malnutrition and poverty-related diseases (Sen 1981).

After Britain colonised Bengal, the surplus extracted helped Britain in its military success against France. As Bagchi (2010, p. XXVI) emphasised: "the tribute extracted from India played a critical part in sustaining the British war against the French, and in facilitating the building up of the overseas settlements of Europeans through the process of European migration and British foreign investment from the 1870s to the First World War. Moreover, the migration of indentured labourers to European-controlled plantations stretching from the Caribbean to Malaysia provided sugar, tea, and other plantation products much needed by the global capitalist economy. Thus, Indian history is a critical part of global history as, indeed, global history is a part of Indian history".

Indian nationalists such as D. Naoroji, M. G. Ranade, R. C. Dutt, Mahatma Gandhi and Nehru were highly critical of the economic policy pursued by the British colonial administration in India. These policies were "free trade" and the role of the state was only limited to constructing ports, railways and roads to facilitate the transport of raw materials from interior regions to port and return British-manufactured goods to the Indian markets. Despite certain modifications after World War I, most of

the profitable industries, for instance mining and plantations, were still controlled by British businesses. The Indian nationalists believed that state intervention in the economy could help to build basic industries. Unlike imperialist historians such as Vera Anstey, who blamed Indian culture for the country's backwardness and mass poverty in the country (Siddiqui 1996), nationalists, on the other hand, pointed to the transfer of the annual tribute to the British rulers, and also the further drain of resources to finance British military ventures from Kabul (Anglo-Afghan War from 1839 to 1842), Burma, Malaysia, Egypt, Sudan and Mesopotamia in the 1860s. The British Indian Army was not only maintaining India's security, but was also sent on foreign colonial expeditions to fight for British imperial interests. In 1922, for example, 64% of the total revenue of the government of India was spent on paying for British Indian troops despatched overseas (Bagchi 2010).

A major characteristic of colonial rule in India was the destruction of indigenous industries, and the failure to replace them with modern industries accentuated the situation in India. On the top of this, problems were compounded by high taxes, the drain of wealth and negligible growth in agricultural productivity, and the exploitation of the peasantry by landlords and money lenders, reducing the rural population to extreme poverty. This resulted in widespread famine in India, beginning in 1770 with the Bengal famine, which is estimated to have killed one-third of the entire Bengali population (i.e. around 10 million). With regard to the total number of deaths in major famines in India, British writer William Digby calculated that nearly 29 million had died between 1854 and 1901 alone (Sen 1981). Bagchi (2010, p. XXVI) concluded that: "The process of colonisation of the Indian economy involved the extraction of a tribute from the economy at an unprecedented rate. That extraction, in turn, required the structural adjustment of the economy in the sense that the domestic absorption of the commodities produced by India had to be continually squeezed so as to yield an exportable surplus that would be remitted to the ruling country (…). Deindustrialisation in India was accompanied not by reallocation of normally growing resources to agriculture but depression of growth rates in both industry and agriculture".

In fact, through the control and subjugation of former colonial countries (i.e. the periphery), the "core" had established the practice of setting the prices not only of primary commodities such as oil and minerals, but also tropical agricultural commodities which could not be produced in the temperate regions of the "core" countries. The rise in demand for certain

tropical agricultural commodities was not accompanied by an increase in their prices, however. As Patnaik (2014, p. 3) argues: "The fact that this did not happen, and has not happened to date, needs to be examined. And this explanation lies in the fact that capitalism imposes an 'income deflation' on the people of the 'outlaying regions', which restricts, even reduces, their purchasing power and hence their demand either for these goods directly, or for other goods which are their substitutes in the sense of being producible on the same land mass (…). 'Income deflation' thus ensures that the increasing amounts of goods demanded at the 'core', but produced on the tropical land mass, are made available to it without any increase in their prices, even though tropical agriculture as a whole remains stagnant".

Table 1. China and India in the World Economy and World Population, 1705–1950 (%)

| Specification | Share in World GDP in 1990 (Geary-Khamis PPP), International Dollars | | | | |
|---|---|---|---|---|---|
| | 1700 | 1820 | 1870 | 1913 | 1950 |
| China | 23.6 | 33.0 | 17.1 | 8.8 | 4.6 |
| India | 27.0 | 16.1 | 12.2 | 7.5 | 4.2 |
| Developing Countries | 71.1 | 63.0 | 42.1 | 29.6 | 27.0 |
| Western Europe | 21.3 | 22.9 | 32.6 | 34.1 | 26.2 |
| World | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Proportion of the World Population | | | | | |
| China | 33.0 | 36.3 | 28.1 | 24.4 | 21.26 |
| India | 21.6 | 20.1 | 19.8 | 16.9 | 14.2 |
| Developing Countries | 76.2 | 74.4 | 67.8 | 63.2 | 67.0 |
| Western Europe | 13.2 | 12.8 | 14.2 | 14.9 | 12.1 |
| World | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Maddison (2003), Bagchi (2010), Tharoor (2017).

As Table 1 indicates, in 1700 India was the largest economy in the world, and its GDP share alone was 27%. However, a few decades after colonisation, India's share of global GDP had declined to 16.1% in 1820, 7.5% in 1913, and was only 4.2% in 1950. China's share of global GDP declined also, especially in the aftermath of the second opium war, i.e., 33% in 1820 to 17.1% in 1870, and continued to decline to 4.6% in 1950 (see Table 1).

India was one of the richest and most industrialised economies of the world, which together with China accounted for about 75% of the world's

industrial output in 1750. In 1600, when the (British) East India Company was first established, Britain was producing only 1.8% of the world's GDP, while India's share was 27%. By 1950, after two hundred years of British rule, Britain accounted for 4.2% of the world's GDP, while India had been reduced to mass poverty, illiteracy and hunger. Moreover, between 1900 and 1947, India's average annual GDP growth was 0.9%, while the population was growing at over 3.5% (Siddiqui 1996), which was only negated by the high levels of infant and child mortality that reduced population growth to zero and life expectancy to only 27 years. Figure 1 presents the per capita economic growth of India between 1920 and 2015. The figure clearly shows that per capita income did not undergo any increase during the period between 1820 and 1950. However, after gaining independence in 1947, per capita income rose steadily, as indicated in Figure 1.

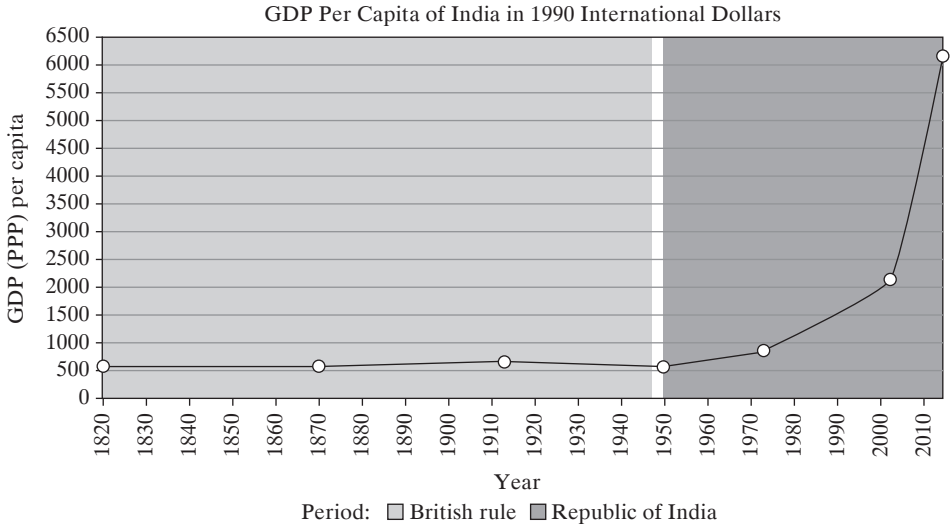


Fig. 1. India's Per Capita GDP from 1820 to 2015

Source: Tables of Angus Maddison (2003). The per capita GDP over various years and estimate is retrieved from the IMF (2017) and OECD (2017) (accessed: 5 June 2017).

On social issues such as the Hindu caste system, colonial rule did not make much difference. Caste is a reality in Indian society and is the predominant social identity in the villages. The castes also reinforce relations of dominance and dependence in rural India. Indian society has been marked historically by a level of institutional inequality due to the Hindu caste system, which includes even "untouchability" against

the "lower castes". Despite the inclusion of judicial equality, the colonial administration did not take any concrete measure to undermine this caste social inequality. As Patnaik (2016, p. 5) notes: "there was formal equality before the law for everybody under colonialism, but this hardly had any impact in weakening caste discrimination at the ground level (…) the absence of alternative opportunities to the most menial and degrading occupation, and [these 'untouchables'] were even prevented over large parts of the country from owning any land. What is more, the 'lower castes' were among the worst victims of the economic exploitation of the country under colonial rule, through the twin processes of 'drain of surplus' (which meant a transfer without any *quid pro quo* of resources to the metropolis) and 'deindustrialisation' (which meant the destruction of local craft production by the import of machine-made manufactured goods from metropolis). The burden of this exploitation greatly increased the pressure of population on land through a process of pauperisation of the peasantry, and this growing pressure entailed a lowering of real wages of agricultural labourers, among whom, of course, the 'lower castes' had an overwhelming presence".

## 3. Economic Performance from 1947 to 1990

After independence, India's first Prime Minister, Jawaharlal Nehru, recognised that without the economic diversification and expansion of Indian industries, the aims of modernisation would not be accomplished. He believed that science and technology held the key to India's development and thus the consequent elimination of backwardness and poverty. It was hoped that such policies would increase productivity and generate employment, the latter required to absorb India's large number of unemployed and address the poverty and deprivation colonial rule left behind. The Second Five Year Plan was launched in 1956 with the target of increasing investment in key industries, power and infrastructure.

An "inward-looking" dirigiste economic strategy was adopted in India from the 1950s onwards, which was seen as the most suitable option by the ruling elites. Also known as the "import substitution" strategy, under this strategy the public sector was assigned a leading role in the development process. Between 1951 and 1965, annual average industrial growth was 7%, which was much higher than anything that had been seen in the past. There was also a notable shift as the importance of traditional industries such as jute and cotton declined, while modern industries such as machinery, engineering, chemicals, rubber, pharmaceuticals, power and

steel became more important. However, industrial growth also coincided with huge increments in foreign debts and foreign aid, which meant that industrialisation in India did not allow for financial self-reliance. Moreover, Indian industries did not allocate much money for research and development, which resulted in increased reliance on imported technology and foreign multinational corporations. Although pre-reform industrialisation in India was impressive in terms of its growth, it failed to make any real impression on growing unemployment (Siddiqui 2014a).

However, such policies were criticised by the neoclassical economists as inefficient, promoting delays and corruption. The proponents of neoliberal reforms argue that rather than adopting the classic Asian strategy – exporting labour-intensive low-priced manufactured goods to the West – India has relied on its domestic market more than exports, and consumption more than investment. In fact, the then government aimed to remove serious gaps in the production structure. Due to the long gestation period, private investors saw such investments as high risk, and also lacked the funds to support them. In fact, the government was determined not to tax the rich. Therefore, for public sector investment funding, the government relied on foreign aid, deficit financing and indirect taxation. As a result, for example, the share of indirect taxes in total tax revenue increased from 61.9% in 1955 to 70.7% in 1966 (Siddiqui 2015). Both indirect taxes and deficit financing were regressive, meaning that they had a dampening effect on income for the majority of people. As a result, the domestic market for mass consumer goods did not increase.

Regarding the agricultural sector, from which nearly three-quarters of India's population received its income, in the 1950s the Indian government passed legislation to implement land reforms, including the removal of rent-seeking absentee landlords. But these modest reforms were met with opposition from the government's own ministers and administrators, and further agrarian reforms in the 1950s failed to make any real impression on rural inequality. As a result, the reforms failed in removing the agrarian constraints, both in terms of the hurdle to the expansion of the domestic market and also in their inability to end the landlords' domination in rural areas. As Das Gupta notes: "This has four dimensions: first, it defined the demand constraint in the country and perpetuated the huge labour reserves inherited from the colonial period. Second, it ruled out a classical capitalist transformation in ruling out a process of development through creation and channelling of an agrarian surplus into industry. Third, it perpetuated one of the strongest links in preserving the links between caste, gender, and

property relations in the hierarchy of definition of property rights. Fourth, it ensured the perpetuation of labour regimes based on extra-economic coercion" (Das Gupta 2016, p. 123).

However, post-independent agrarian reform – though not fully implemented and uneven in its depth from state to state – did manage to restrict, though not remove, rent-based landlordism and encourage rural capitalism. The land reform measures in the 1950s, while benefitting some tenants, failed to break land concentration and the top 15% of landowners continued to hold the same percentage of land as before the measures were undertaken (Siddiqui 1999). Rural inequality persisted, which had obvious socio-economic implications as it restricted the domestic market, including demand for manufacturing goods. On the social front, few changes were witnessed: landlords' oppressive Hindu caste system remained largely intact and untouchables (also known as Dalits), who constituted the core of the landless class and were denied land ownership under the old Hindu caste system, remained landless (Siddiqui 2014b).

In the mid-1960s, the rising prices and balance of payments crisis became unmanageable, leading to the devaluation of the rupee and forcing India to seek a loan from the IMF. Moreover, in the late 1960s, the adoption of HYV (High Yielding Varieties) seeds in certain crops, also known as the Green Revolution, raised agricultural output if HYV seeds were applied in the correct proportion with water, fertilisers and pesticides. Initially it encouraged large landholders towards direct cultivation as additional investment was assured to bring in higher profits due to the availability of subsidised credit, irrigation, and fertilisers. Soon, the Green Revolution also spread to middle farmers. At the time, this did manage to raise agricultural output and yields in certain crops (Siddiqui 1999); however, now some of the negative effects are more visible such as damage to soil, the level of the water table and the quality of water. But, overall, it did improve the incomes of certain sections of the rural population, which proved to be temporary relief.

The dirigiste economic strategy brought a very positive change in the industrial sector by building industries in key areas such as power generation, steel and manufacturing industries. However, it failed to achieve land reforms in the sense of curbing the rural power of the landlords and bringing socio-economic equality across the countryside. Despite a number of land reform measures, it did not break the social and economic power of the landlords and also failed to fully implement the "land to the tiller" policy. The rural poor did not experience any betterment as the majority of these sections also belonged to the lower castes. The government undertook

measures to nationalise banks, which meant more credit was made available to the agricultural sector, and subsidies were also extended to agricultural inputs to support the "Green Revolution". These measures ultimately increased food production and reduced reliance on food imports. However, such a dirigiste strategy promoted capitalist development in agriculture and exposed certain inner contradictions, especially the fiscal crisis of the state. In the 1980s, government began to gradually liberalise trade so that by the mid-1980s India's current account deficit and external debt started to grow. Also, imports grew at a faster rate and the rising current account deficit became increasingly financed by commercial borrowing and non-resident Indian (NIR) remittances, which meant a greater dependence on foreign sources and at higher costs and short-term financing. And as a result, India's foreign debt sharply rose from USD 20.5 billion in 1980 to USD 72 billion in 1992, making India the world's third largest debtor after Brazil and Mexico (Nayyar 2017).

More such short relief came in the 1980s in the form of the availability of foreign funds for borrowing. Actually, extensive funds from oil exporting countries found their way into the Indian financial system. This private financial capital was now available for borrowing, and India took this opportunity and borrowed from commercial banks and non-resident Indians. Access to such capital allowed the government to increase its debt-financed investment. This came as a big relief for the government as the money was used to pay for imports that kept domestic inflation under control.

The government reliance on foreign borrowing provided short-term financial relief, and in the late-1980s easy access to international credit resulted in the rise of both public and foreign debt. Moreover, the Gulf War and the decline in remittances from Indian workers in that region, a dramatic rise in oil prices and, ultimately, the collapse of Soviet Union, created a very challenging situation for India. All these adverse domestic and international factors led to an increase in the current account deficit, which created fear among foreign lenders that India may not be able to meet its debt service obligations. As a result, the availability of foreign funds began to dry up, which led to a sharp reduction in reserves and, in July 1991, a balance of payments crisis.

## 4. Economic Performance from 1991 to 2017

India saw a severe balance of payments crisis in 1991, when it approached IMF for emergency loans. In return, the IMF demanded the implementation

of neoliberal economic reforms involving trade liberalisation, a more favourable climate for foreign investors and also wide-ranging deregulation measures. The adoption of the "Structural Adjustment Programme" meant increased reliance on market forces and a new policy towards foreign capital. With the adoption of market-friendly policies towards foreign capital, the net inflows of capital rose from less than USD 1 billion in 1993 to USD 6 billion by 1999, which further rose from USD 15.7 billion in 2003 to USD 65 billion in 2014 (Chandrasekhar 2013). However, despite the government's efforts to attract foreign capital, India still received less FDI than other developing countries such as Mexico, Turkey and China, as shown in Figure 2.

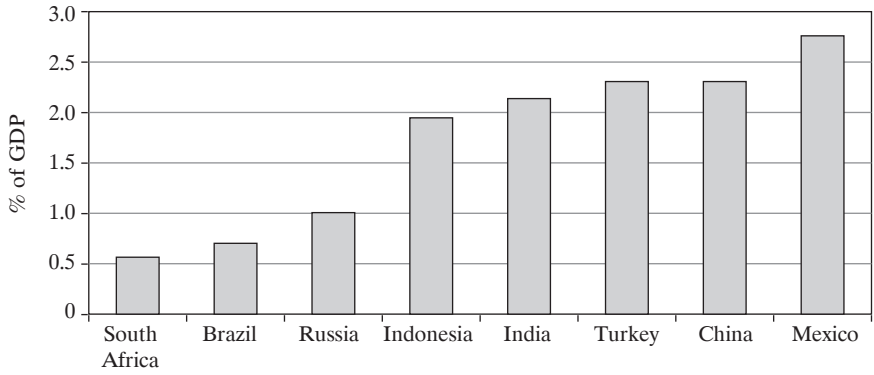


Fig. 2. FDI Net Inflows across Countries, 2016

Source: OECD (2017, p. 35), http://www.oecd.org/eco/surveys/economic-survey-india.htm (accessed: 15 January 2018).

The inflow of capital in such amounts would not have been possible without the relaxation in laws governing foreign capital and the removal of regulations regarding foreign shareholding and the liberalisation of rules governing foreign investments and the repatriation of profit and money from India (Siddiqui 2016a). The sharp increase in non-debt inflows of foreign capital, especially in portfolio and foreign direct investment, indicates a new trend. As Chandrasekhar (2013, p. 32) concluded: "India's relationship with foreign capital has shifted from muted hostility to one of attracting and winning its confidence, the nature of the regime of accumulation has changed as well. These changes had indeed taken India onto a high growth trajectory by activating mechanisms that were very different in the 1980s, 1990s and 2000s. The long period of relatively high growth created the impression that (…) the high growth was now irreversible. The argument

seeks to establish that (…) the regimes of accumulation themselves were fragile, besides the fact that growth driven by dependence on financial flows is vulnerable because of the possibility that such inflows can stop, and capital outflows could occur, including for reasons unrelated to circumstances in the host country".

However, greater reliance on foreign capital pressurised India to implement fiscal reforms by bringing legislation in the form of the Fiscal Responsibility and Budgetary Management Act (FRBM), which was passed in 2003 to bring down the fiscal deficit to GDP ratio to 3%. This was an attempt to restrain any attempt to raise growth based on debt-financed government spending (Patnaik 2016). In the post-2003 period, foreign capital inflows surged, triggering a credit boom that was largely available only to rich and upper-middle class consumers for housing loans, automobiles, and to government for infrastructure. This created optimism and spurred growth, but also increased vulnerability and potential defaulting. In recent years, soon after the boom began, non-performing assets in the banking system have risen sharply and banks profitability could currently be under threat.

It seems that the removal of restrictions on technology imports – so that foreign firms will find it more attractive to set up collaborative enterprises – would be likely to boost domestic production along with foreign capital, technology and management skills. Further capital liberalisation measures taken by the government provided opportunities for retail lending in Indian commercial banks' portfolios. Suddenly, the influx of foreign capital provided excessive liquidity in the system, which could be lent to consumers to allow the purchase of housing, automobiles and consumer durables. This credit was also extended without any collateral and on the basis of speculative projections of borrowers' current earning profiles. Such individuals have often borrowed excessive amounts of money from multiple sources without revealing this to creditors. The availability of external funds resulted in an increase in debt-finance demand in the late 1990s. As Chandrasekhar (2013, p. 20) argues: "[T]here was evidence of an incipient change in the regime of accumulation. There were two aspects to this change. The first was that private consumption expenditure on manufactured consumption goods and private investment in housing began to play a more important role (relative to public expenditure) in driving demand and growth. Second, associated with this, were signs that debt--financed private consumption expenditure was displacing debt-financed expenditure as a leading stimulus to growth".

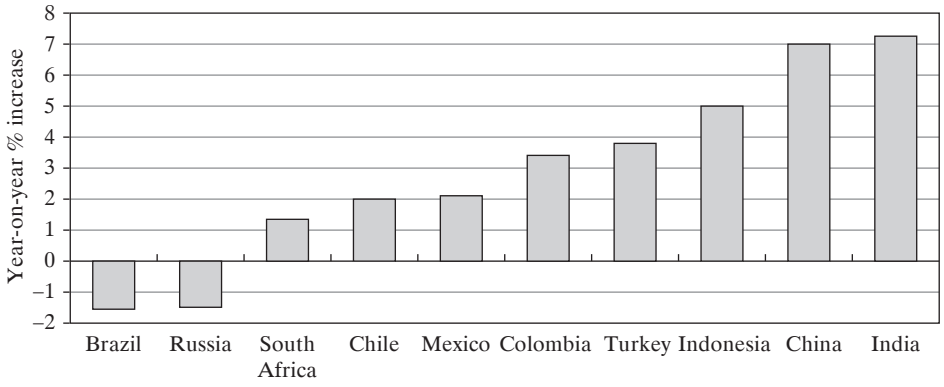


Fig. 3. Annual Average Growth Increase, 2015–16

Source: OECD (2017), http://www.oecd.org/eco/surveys/economic-survey-india.htm (accessed: 20 January 2018).

In 2015–16, India's growth performance was the highest in the world, slightly above China, as shown in Figure 3. However, only looking at overall growth does not give us the full picture; rather, we need to analyse sectoral growth later on in this article.

On the question of capital stock, during the pre-reform period the public sector was given the leading tasks of most capital-intensive projects such as irrigation canals, dams, electricity, steel mills, and so on. This accounted for a growing share of the country's capital stock. The public sector constituted 41% of the Indian economy's total capital stock in the 1980. However, the public sector's share in India's domestic output has stagnated since the late 1980s. Indeed, its share in capital stock has declined since 1990 and employment has contracted by 10% since the mid-1990s. As Nagaraj (2015, p. 42) argues, "The public sector's share in GDP (…) plummeted to 20% by 2008–09, an unprecedented decline of 5 percentage points in five years. However, as the boom went bust after the global financial crisis, the private corporate sector floundered, contracting investment demand, and affecting the banking sector with burgeoning bad debts (…). Thus, after more than two decades of economic reforms, in 2012–13, the public sector's share in GDP stood at 23% (2 percentage points less than in 1991), employing 17 million workers (two million less than in 1991)".

There is no doubt that since the early 1990s industrial production has diversified with improvements in the quality of its products. However, the manufacturing sector's share has stagnated at about 15%, while the

industrial share has stagnated at around 26% of GDP after the reforms (Girdner & Siddiqui 2008). When we look at the experiences in other countries, such as in East Asia and China, Indian industries have clearly not done very well. For instance, when we compare with China, both countries had roughly same levels of industrialisation in the 1950s; India, rather, at this time had slightly more developed industries than China, but by 2015 China became the world's second-largest manufacturing country (Siddiqui 2009), while India ranked tenth, producing one-quarter of China's industrial output (Nagaraj 2017). As Figure 4 indicates, in 2010, among the top manufacturing nations India was above Brazil, while China was second from top, just behind the US; over a period of only ten years, i.e., from 2000 to 2010, manufacturing declined in the US, but rose sharply in China, while India's manufacturing also increased but to much less of a degree than China (see Figure 4).

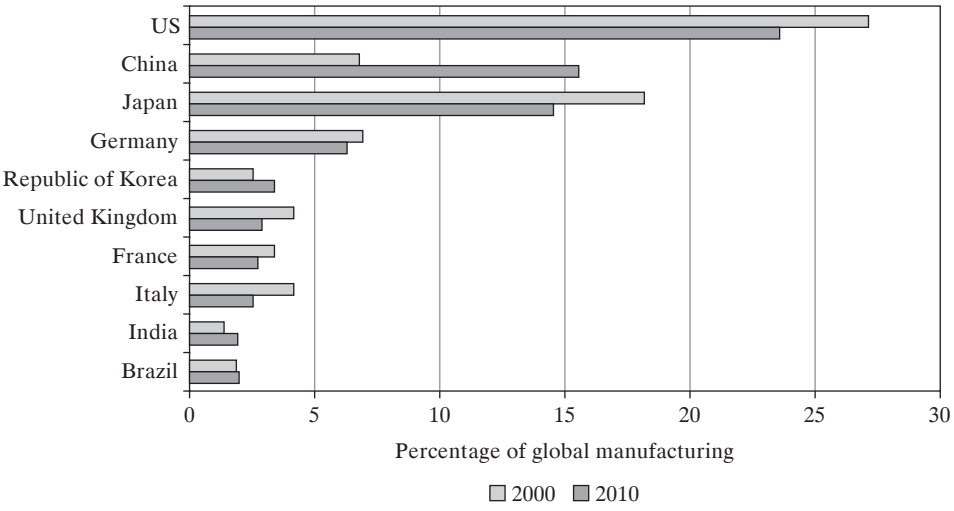


Fig. 4. World Top 10 Manufacturing Nations in 2000 and 2010
Source: UNIDO (2014).

On the subjects of post-liberal reforms and industrial performance, Nagaraj (2017, p. 63) summarises that: "the 25-year period can be subdivided into three distinct phases: 1992–96, 1997–2003 and 2003–14. The first phase represents the initial euphoria of reforms, with booming output and investment in the anticipation of a virtuous cycle of faster growth and exports. However, with the expectations of a boost in demand not being

realised, industrial growth decelerated. It coincided with the Asian financial crisis, burst of the dot.com bubble, and freezing of credit markets in the US in the early 2000s. The period from 2003 to 2014 represents (…) the recent debt-led cycle of boom and bust (…). The turnaround in industrial domestic output growth rates [in 2014] are not supported by the trends in (i) credit growth and (ii) capacity utilisation in industry". Nagaraj further (2017, p. 67) notes: "the market-friendly policy framework constructed over the last quarter century has not served the manufacturing sector well, despite faster economic growth, and output diversification. The goal of rapid industrialising to catch up with the Asian peers, in an open trade and capital regime employing abundant labour for labour-intensive exports, did not materialise".

At present, the manufacturing sector contributes nearly 16% to India's GDP, provides jobs for 10% of the country's total workforce and produces nearly 80% of its total merchandise exports. Although the manufacturing sector is relatively small in comparison to India's whole economy, this sector could nevertheless play an important role in raising India's productivity and in its development efforts (Siddiqui 2014b).

In the light of a recent study by Dani Rodrik (2016), there is a need to revisit the question of industrialisation, which is still very important for creating employment, diversifying the economy and removing the low productivity workforce from agriculture. However, according to this study, the increased global integration and liberalisation has led to de-industrialisation in some regions. It is very important for a country like India to draw lessons from such a potentially adverse impact, which could be a huge destabilising factor in India. As Rodrik (2016, p. 2) argues: "With some exceptions, confined largely to [East] Asia, developing countries have experienced falling manufacturing shares in both employment and real value added, especially since the 1980s. For the most part, these countries had built up modest manufacturing during the 1950s and 60s, behind protective walls and under policies of import substitution. These industries have been shrinking significantly since then. The low-income economies of sub-Saharan Africa have been affected nearly as much by these trends as the middle-income economies of Latin America – though there was less manufacturing to begin with in the former group of countries (…). Developing countries are turning into service economies without having gone through a proper experience of industrialisation. I call this premature deindustrialisation." Rodrik further narrates (2016, p. 2–3): "There are two senses in which the shrinking of manufacturing in low and medium

economies can be viewed as premature. The first, purely descriptive, sense is that these economies are undergoing deindustrialisation much earlier than the historical norms (…). The second sense in which this is premature is that early deindustrialisation may have detrimental effects on economic growth. Manufacturing activities have some features that make them instrumental in the process of growth".

Table 2. India's Macroeconomic Indicators and Projections (Annual % Changes) from 2013–14 to 2018–19

| Specification | 2013–14 | 2014–15 | 2015–16 | 2016–17 | 2017–18[b] | 2018–19[b] |
|---|---|---|---|---|---|---|
| Real GDP[a] | 6.6 | 7.2 | 7.6 | 7.0 | 7.3 | 7.7 |
| Consumer Price Index (CPI) | 9.4 | 5.8 | 4.9 | 4.8 | 5.0 | 4.6 |
| Wholesale Price Index (WPI) | 6.0 | 2.0 | –2.5 | 2.8 | 4.0 | 4.2 |
| Fiscal Balance (% of GDP) | –6.7 | –6.5 | –7.2 | –7.0 | –6.7 | –6.4 |
| Current Account Balance (% of GDP) | –1.7 | –1.3 | –1.1 | –0.8 | –0.9 | –0.9 |
| Gross Fixed Capital Formation | 3.4 | 4.9 | 3.9 | 0.4 | 4.3 | 7.3 |
| Total Domestic Expenditure | 2.0 | 6.9 | 8.0 | 5.4 | 7.5 | 7.9 |
| Exports of Goods and Services, National Accounts Basis | 7.8 | 1.7 | –5.2 | 4.5 | 4.6 | 5.2 |
| Imports of Goods and Services, National Accounts Basis | –8.2 | 0.8 | –2.8 | –2.3 | 5.4 | 6.3 |
| Net Exports, Contribution to Growth of Real GDP | 4.5 | 0.2 | –0.5 | 1.5 | –0.2 | –0.2 |

[a] GDP measured in market prices (i.e. at factor costs plus indirect taxes, minus subsidies), [b] estimated.

Source: OECD (2017, p. 12), http://www.oecd.org/eco/surveys/economic-survey-india.htm (accessed: 6 January 2018).

Table 2 shows India's macroeconomic changes (average annual % changes) from 2013–14 to 2018–19. The figures for 2017–18 and 2018–19 are projected data from the OECD. India's rates are projected to remain above 7% per annum, while the consumer price index is expected to remain low. Also, imports will remain higher than exports (see Table 2).

The share of agriculture in terms of GDP in 1950–51 was 56.7%, while its share in total employment was 85% for the same period. The share of

agriculture in GDP fell sharply thereafter, and by 2014–15 it was 13%, while the fall in the share in agricultural employment was much slower (55%), and more than half the population still depends on agriculture for their livelihood, as shown in Table 3.

Table 3. Share of Agriculture in GDP and Employment in India

| Year | Share of Agriculture in GDP at 1999–2000 Prices (%) | Share of Agriculture in Employment (%) |
|---|---|---|
| 1950–51 | 56.70 | 85.0 |
| 1960–61 | 52.48 | 77.3 |
| 1970–71 | 46.00 | 63.9 |
| 1980–81 | 40.00 | 60.0 |
| 1991–92 | 34.04 | 58.1 |
| 2001–02 | 25.18 | 57.3 |
| 2011–12 | 14.00 | 56.0 |
| 2015–16 | 13.05 | 55.0 |

Source: National Sample Survey (1950–2018).

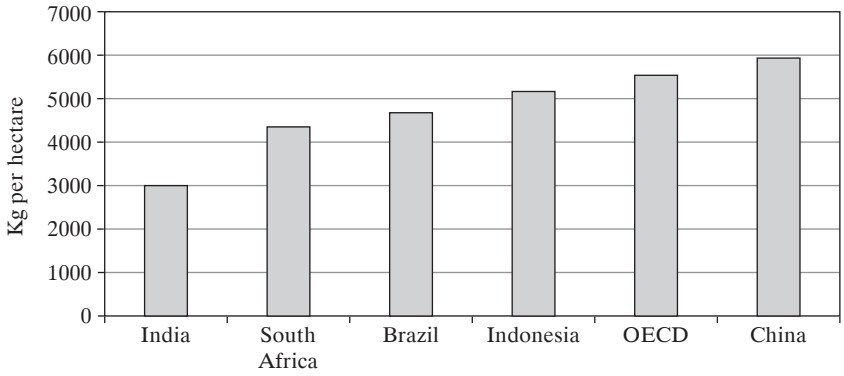


Fig. 5. Productivity in the Agriculture Sector: Cereal Yield, 2015

Source: OECD (2017, p. 48), http://www.oecd.org/eco/surveys/economic-survey-india.htm (accessed: 4 January 2018).

Although India's annual growth rate was the highest in the world in 2016, when we look at productivity in agriculture, this is quite low for India and nearly half that of China, as indicated in Figure 5. India's productivity in the agricultural sector is less than in other developing countries such as Indonesia, South Africa and Brazil.

During the neoliberal reforms, the agriculture sector had been completely ignored, despite nearly two-thirds of the population relying on it for employment and income. Also, the majority of India's poor live in rural areas, and rely heavily on the performance of the agricultural sector. The 1991 economic reforms package did not consider specific policy regarding agriculture, especially in terms of helping small and medium farmers. Moreover, it was presumed that freeing the agricultural markets and liberalising external trade in agricultural commodities would provide price incentives, leading to a rapid increase in the incomes of farmers and investment in agriculture. With the greater role of market forces leading to a sharp decline in the availability of institutional credit, subsides on fertiliser and electricity were also reduced drastically. All these developments increased difficulties for small and marginal farmers, who were forced into greater reliance on informal credit from money lenders and input from suppliers cum merchants.

There has been little increase in income and productivity for the people trapped in the agricultural and informal sectors, which continue to employ around 90% of India's entire workforce. Agricultural stagnation, poverty, and sectarian and religious conflicts have caused social instability and political division, which may well plague India in the future (Siddiqui 2017a). In order to achieve sustainable growth in the future, India has to radically change the direction of its economic strategy towards domestic wage-led growth and employment creation, and also employment diversification to shift workers away from the low-productivity agricultural sector to activities with higher productivity and value added in manufacturing.

Since the introduction of the reforms, the government's priority has changed from self-sufficiency in food production and consumption to production for export. Under the WTO (World Trade Organisation), further adoption of trade liberalisation led to the removal of restrictions on exports for certain agricultural goods, particularly rice and wheat; import tariffs were also removed from a number of agricultural commodities. India becoming party to the WTO raised hopes that farmers would benefit from access to global markets. India agreed to zero tariffs on a wide range of crops; however, global uncertainties in prices and the nature of competition were ignored. Indian farmers operated in highly uncertain and volatile global markets, competing against highly subsidised and capital-intensive agribusiness in developed countries. When global prices fell between 1996 and 2002, the adverse impact of imports was realised and India was forced to renegotiate with the WTO (Siddiqui 2016a).

However, neoliberal reforms overlooked the agriculture sector, which was a deliberate policy as government was keen to resolve the balance of payments crisis but seemed to have no long-term strategy. This decision was difficult to understand as about two-thirds of the workforce and more than three-quarters of the poor in rural areas were directly or indirectly employed in the agriculture sector in the Indian economy. The economic reforms did not take into consideration this very important sector.

In the early 2000s, the rise of demand for IT services abroad created an IT services boom as profits in this sector rose, providing opportunities for further foreign capital investment collaboration in this sector. This period also coincided with India beginning to be seen as a favoured destination for foreign financial investors. This was also a period when Indian businesses went for excessive borrowing from foreign securities. Moreover, in the 2010s, capital inflows exceeded the balance of payments, leading to an appreciation of the Indian currency. In fact, excessive foreign capital inflows have resulted in surplus foreign exchange reserves, though it is important to note that these reserves are not earned through exports but are rather borrowed from foreign capital investors.

With its increased integration with the global market, the Indian information technology (IT) industry has grown phenomenally. With increased demand for software following the personal computer (PC) revolution of the 1980s, Indian IT companies have responded to the growing demand for networking. The commercialisation of the internet in the 1990s and growing demands for IT engineers from India to repair and maintain computers prompted the rapid growth of the IT industry. After the economic reforms of 1991, as observed by Das and Sagara (2017, p. 57), "India's position as the preferred business process outsourcing (BPO) and knowledge process outsourcing (KPO) destination in the world had been established. India entered the global IT market by capitalising on the demand for low-cost but high-quality programming skills (…). Besides a favourable domestic policy climate and highly attractive export promotion schemes, a host of external factors was crucial for the growth of the software industry". Analysing the impressive performance of Indian IT services in recent years, Das and Sagara (2017, p. 57) further note that: "in 2005 alone, IT and BPO/BPM had generated revenue worth USD 148 billion (amounting to 8.1% of GDP), and its exports had amounted to approximately USD 98 billion. The Indian IT companies have set up to over 600 delivery centres across 78 countries, thus maintaining their leadership position in the global sourcing arena (…) the

Indian IT sector is still viewed by the major MNCs from the industrialised nations as a destination where cheap labour is available".

The important question is whether the rapid economic growth was actually due to the economic liberalisation policy of the 1991, to which it is often attributed. To answer this, Nayyar (2017, p. 45) states: "If we consider the 20th century in its entirety, the turning point in economic performance, or the structural break in economic growth, is 1951–52. If we consider the period 1950–1951 to 2000–01, the turning point in economic growth is 1980–81 (…). During the 20th century, the most significant structural break, or departure from the long-term trend in economic growth, was 1951–52, followed by 1980–81. In either case, 1991 was not a turning point (…)". He further (2017, p. 46) notes: "The biggest failure of the last 25 years is that, despite such rapid economic growth, employment creation has simply not been commensurate. In fact, the employment elasticity of output declined steadily from reasonably high levels during 1972–73 to 1983 (0.60) through modest levels during 1983 to 1993–94 (0.41), to low levels during 1993–94 to 2004–05 (0.17) and 2004–05 to 2011–12 (0.04). In fact, between 2004–05 and 2011–12, employment elasticity of output in agriculture (–0.42) and in manufacturing (0.13) plummeted, as compared to the 1983 to 1993–94 period when in was much higher in both agriculture (0.49) and manufacturing (0.47)".

## 5. Concluding Remarks

India and China were the top two manufacturing nations worldwide until the British conquest of Bengal and the defeat of the Chinese in the first opium war. In fact, colonialism degraded the Indian economy and squeezed the incentives for local investment in industry and agriculture. For the majority of the colonial period, Indian agriculture stagnated and foodgrain output fell. As a result, peasants became highly indebted to money lenders and had hardly any support from public expenditure on irrigation, soil management or rural infrastructure, particularly devastating when the agricultural sector experienced crop failure and drought. The primary goal for the British colonial administration was to extract revenues from the peasantry. From the mid-18th century, India's economy was integrated into the British colonial system which, besides extracting surplus value, also imposed an international division of labour with unequal terms of trade where India was turned into a supplier of primary commodities.

During the colonial period, the Indian economy became subservient rather than sovereign in terms of policy matters. The Indian economic surplus was transferred to Britain, which did not lead to job creation in the local economy. As a result, economic development was hampered by the removal of "surplus", along with very high land rents and tribute charges. A densely populated country like India was drawn into the orbit of exploitation in the mid-18th century and, later on, into the interest of British industry. Such development created mass poverty, de-industrialisation, starvation and famine across the entirety of India.

The study found that soon after independence in 1947, the Indian government took a number of initiatives to enhance industrial and agricultural development. Initially, these met with some modest success, including building key industries, becoming self-sufficient in terms of food production and improving literacy rates. However, the biggest failure was that it did not make any real impression on the country's huge unemployment problems. By the mid-1960s economic growth had begun to falter and the fiscal crisis of the state deepened. Finally, India sought an IMF loan in 1991 to avert a balance of payments crisis. In return, India was asked to adopt neoliberal reforms.

To compare Indian economic policies under neoliberal reforms with those of the previous period under dirigisme would seem to be important, particularly when we consider this comparison in terms of employment expansion. In the period of neoliberal reform, growth rates accelerated to 7% annually, but the rate of growth of employment has remained at only 1%, while in the dirigiste period the average growth rate was 3.5%, but the expansion of employment was doubled i.e. 2% annually. It seems that the rate of employment growth was far below the natural growth rate of the workforce. This is greater when we further consider displaced peasants and petty producers due to the accelerated process of "primitive accumulation" unleashed by the economic reforms. The neoliberal reform, rather than creating new jobs, saw the total number of unemployed rise and the steady growth of the relative size of the labour reserve.

In fact, in the late 1950s and 1960s the industrial sector did witness a sharp rise. For example, the share of manufacturing in GDP rose from 9% in 1951 to 16% in 1961. Indeed, a decade later this share reached 18% before reaching its peak of 20% in 1996. However, the industrial share in GDP was still less in comparison to other developing economies, particularly in East Asia. For example, in 1971, the manufacturing share in GDP for South

Korea was 25%, Malaysia 28%, Thailand 26%, China 35% and Brazil 29% (Siddiqui 2017b).

The Indian growth story is one of around 4% per annum from the 1950s through to 1981, and then 6.3% from 1982 to 2016 (Nayyar 2017). The source of recent high growth appears to be rooted in services such as real estate, construction, automobiles, IT industries, commercial centres, and the financial sector. Many of these new developments are taking place around urban and semi-urban centres. By contrast, India's rural economy has experienced very slow growth and, indeed, near stagnation during the pro--market reform period (Dreze & Sen 2013). The study has argued that India's progress towards industrialisation has been disappointing and the optimism that foreign capital and technology would bring efficiency and boost growth in manufacturing has largely been proven unfounded.

Since neoliberal reforms were undertaken in 1991, the agriculture sector hardly saw any benefits and, during this period, its growth rates were negligible (Siddiqui 2010). The pursuit of neoliberal economic policies has led to the withdrawal of the state in assisting farmers in particular and the rural sector in general, and instead the state is promoting the interests of global financial capital, with which Indian corporate capital is closely integrated. Despite the fact that the majority of the country's population has not witnessed any improvement in its living conditions, the government nevertheless celebrates this as a "great achievement"; it has completely ignored economists such as John Stuart Mill, who said that he did not mind a zero growth rate if workers were better off in such a stationary state than in a growing economy. For him, improvements in workers' real incomes should take priority over high GDP growth rates.

It seems that recent growth based on neoliberal economic policies is fragile as their success relies heavily on foreign capital inflows (Siddiqui 1998); if such inflows reverse for external reasons or due to the global situation, then this could lead to a similar situation as that experienced during the 1997 East Asian crisis.

Now, after more than a quarter of a century since the inception of the neoliberal market reforms, it seems that the high growth rate has failed to make any impression on the expansion of employment. Therefore, the study argues that the problems lie not just in rapid growth rates, but in the reliance on unsustainable stimuli to growth. The current growth is not sustainable as it is unable to address the problems of mass unemployment and other forms of social deprivation in India.

India faces many challenges of poverty and growing inequality. It needs to stimulate growth within its manufacturing sector rather than increase its dependence on export-led growth, as such a strategy relies on foreign demands and markets which are already stagnant and for which there is little hope of a dramatic reversal. The study suggests that an alternative economic policy is needed, which should be based on raising the incomes of agricultural workers, expanding domestic markets, and the revival of public investment in crucial areas such as irrigation, education and health. Such measures would eliminate illiteracy and improve health and would raise productivity and domestic markets. Therefore, government intervention is needed to achieve inclusive growth; such intervention should be aimed at increasing employment and redistributing incomes, and ultimately ensuring access to basic services such as food, education and healthcare.

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## Abstract
(przekład: Agnieszka Wałęga i Grzegorz Wałęga)

### Ekonomia polityczna a zmiany gospodarcze w Indiach w ostatnim stuleciu

Celem opracowania jest ocena transformacji Indii kolonialnych w nowoczesną gospodarkę w ostatnim stuleciu na podstawie zmian wskaźników makroekonomicznych. Kwestia ta jest o tyle ważna, że pomaga zrozumieć w szerszym kontekście związki pomiędzy wzrostem gospodarczym i wynikającymi z niego zmianami sektorowymi oraz dotyczącymi zatrudnienia w krajach rozwijających się, takich jak Indie. Zastosowana metodologia badań wynika z przyjętych celów badawczych i uwzględnia międzynarodowe statystyki, zapewniające narzędzia do realizacji celów i udzielenia odpowiedzi na postawione pytania badawcze. W opracowaniu wykazano, że w okresie kolonialnym politykę ekonomiczną Indii bardziej określały związki polityczne z Wielką Brytanią, aniżeli prowadzono ją w sposób samodzielny. W konsekwencji rozwój gospodarczy kraju był utrudniony przez odpływ nadwyżek zasobów ekonomicznych do metropolii oraz stosowanie bardzo wysokich opłat i danin. Indie, jako gęsto zaludniony kraj, został wciągnięty w orbitę wyzysku ekonomicznego w połowie XVIII wieku. Wkrótce po odzyskaniu niepodległości w 1947 r. rząd Indii podjął szereg inicjatyw mających na celu rozwój przemysłu i rolnictwa, jednak ich największym niepowodzeniem było to, że nie wywarły one rzeczywistego wpływu na ogromne problemy z bezrobociem.

**Słowa kluczowe:** gospodarka indyjska, okres kolonialny, głód, wskaźniki wzrostu gospodarczego i reformy neoliberalne.

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# THE SOCIO-ECONOMIC DIMENSION OF INDUSTRY IN SUBREGIONS

**Abstract**

Industry is one of the key sectors of the economy, which affects a number of other areas as well as society and the environment. In its socio-economic dimension it has impact on the job market, wages, innovation, and the competitiveness of enterprises and territorial units.

The purpose of this article is to classify and assess the situation of 72 Polish subregions (NUTS-3) in terms of industrialisation as one of the components affecting the level and structure of subregional development. The classification was performed on the basis of employment structure and regional productivity data with reference to gross added value. Due to data availability the analysis was carried out based on the information about the activity of enterprises in PKD (Polish Statistical Classification of Economic Activities) sections B to F (including construction) in the years 2010–2014 and for selected aspects in 2015. The study applied classification methods (Ward method) and linear ordering (SDM with a common development model). The analysis allowed the author to identify classes of subregions presenting a particular industrial development profile (general, social or economic) and characterised by one development type in accordance with L. Klaassen's classification.

The conclusions resulting from the presented analysis indicate visible differences in the role played by industry in subregions as a regional employer (social aspect) or economic leader (economic aspect). The results of the change dynamics analysis pointed to a strengthening of the role of industry in subregions in terms of the economic aspect and a simultaneous decline in the importance of the social aspect (in this study related to jobs).

**Keywords:** industry, subregions (NUTS-3), classification, synthetic measure of development.
**JEL Classification:** O14, O18.

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## 1. Introduction

Development is defined as a dynamic phenomenon, covering many areas, which are expected to develop and transform in terms of quality and structure. Regional development is considered a complex phenomenon that integrates various activities within a particular territory. According to the proposal by Klasik and Kuźnik (2001), regional development consists of the following components:

– economic growth and employment,
– increased well-being and life quality of the population,
– technological development and innovation,
– restructuring of economic activities,
– development of services and social resources,
– increase in occupational, social and spatial mobility,
– development of institutional infrastructure,
– improved quality of the environment,
– enrichment of regional identity and integration processes.

Development processes occur in different regions in various ways. This is influenced by the current development level, the availability of resources and the management style. The differences in capital provision for regions, including human capital and also other production factors, jointly decide about their competitive power.

When assessing developmental changes in a cross-section of territorial units, attention should be paid to both the position of units relative to others and the changes that are occurring. The position of a unit allows one to assess the archived level of competitiveness and current availability of resources. Changes, in turn, have an impact on the future competitive position and possibilities for adaptability.

These two components – the level of development and changes – represent two basic assessment criteria for the processes occurring in territorial units. They are fundamental to the classical typology of regions proposed by L. Klaassen (1965) (after Szymla 2005). He distinguishes a four-level classification of regions, simultaneously taking into account their development level in relation to the pace of occurring changes (where the national average is the reference point). In line with this classification, four classes of regions can be distinguished:

– WW – prosperity area, better developed and faster developing regions,
– nn – distressed area, less developed and slower developing regions,

– nW – distressed area in the process of development, less developed and faster developing regions,

– Wn – declining prosperity area, better developed and slower developing regions.

The results of the conducted analysis are presented below. The analysis was focused on the position of industrial enterprises in 72 Polish subregions. The activity of enterprises, including industrial ones, is reflected in many social aspects of regional development (e.g. the consumer goods market, job market, wage levels and thus the purchasing power of society), economic aspects (GDP creation), environmental aspects (e.g. emissions, noise, waste, consumption of resources) and also technological aspects – the development of technology and knowledge application, thus developing the efficiency of the economy (economic, environmental, social).

One consulting company (*Poland 2025*… 2015) presents Poland as an EU growth engine and recognises that "the Polish economy has doubled in size, as measured by real GDP. (…) Poland was the only EU country to avoid recession as a result of the global financial crisis and is today the eighth-largest EU economy", and further "(…) despite the progress, Poland's comparative labour productivity in 2012 remained low in a few key sectors (e.g. mining, energy, agriculture)". The authors of this report consider the process manufacturing sector to be built on the proven advantages of the economy with the potential to become a major engine of growth. This sector covers such segments as automotive, food processing, furniture, textiles and chemicals.

In the aforementioned study, industry is presented as one of the basic sectors of the economy, producing goods and creating a job market. The study is focused on the characteristics of the spatial diversification of industrial enterprises' activities regarding an assessment of the level of involvement in a given area as well as the dynamics and direction of the changes under way.

Based on recognising the structure, spatial differentiation and activity range of industrial enterprises, it is possible to reliably identify the strategic assumptions of development. The statistical perspective allows for more precision in defining the profile and spatial dependence (diffusion effect) and specifying the strengths and weaknesses of subregions. Because of this it is possible to carry out development-oriented activities which can support the regional strengths that determine competitive advantages and all other positive aspects of development along with the simultaneous elimination of the weaknesses and negative effects of changes. Having taken

into account the dynamics in the conducted analysis, it is also possible to observe structural changes, which are perceived as the basic component of development. In the opinion of Karpiński (1986), "the deeper the changes in structure the faster the pace of development". Thus, the causative nature of structural changes was recognised. It should, however, be emphasised that this is a mutual relationship and the level of development also influences the possibilities of structural transformations.

The purpose of the analysis is to identify classes of subregions (NUTS-3) in terms of industrial enterprise activity in two aspects:

– social, covering employment in industry,

– economic, focused on product volume produced in a subregion, identified using gross added value.

Taking the aforementioned two aspects into account allowed the author to assess industry in terms of its direct input in economic growth and employment (listed as the first element in Klasik and Kuźnik's definition of development (2001)). The analysis applied taxonomic methods based on the data covering the 2010–2014 period. The conducted analysis allowed questions to be answered about:

– the role of industry and construction in subregions in terms of social and economic aspects in the following sections: C, BDE and F in 2014/2015,

– the development profiles of subregions in terms of the industrial development level in accordance with social and economic priorities in 2014,

– the changes in the industrial development level in subregions in 2014 compared to 2010 for industry as a whole and for social and economic aspects separately,

– the classification of subregions by classes according to Klaassen's typology and their spatial distribution for industry as a whole and for each of the aspects separately. Their definition allowed the author to assess the level and type and also the profile of industrial development in subregions.

## 2. The Scope and Procedure of the Study

Identification of the research problem and the data available in public statistics allowed the author to propose a set of indicators to diagnose the activity of enterprises in subregions. The assessment of industrial level in subregions was based on indicators taking into account a total of 5 sections of the industrial sector: section C – industrial processing; B – mining and quarrying; D – production and supply of electricity, gas, steam, hot water and air for air-conditioning systems; E – water supply, sewage and waste

management and reclamation related activities; and additionally F – construction.

The analysis was focused on both the economic and social role of industry in the region. The phenomena within the scope of industrial development in subregions were measured using two indicators in two aspects:

– social aspect – the share of employment in sections B, D, E, F in total employment (*E*) in %,

– economic aspect – regional productivity, i.e. gross added value (*GAV*) produced by the sections of the industry and construction sector (B, C, D, E, F) in PLN calculated for 1 person of working age.

While defining the *GAV* indicator, in terms of its economic aspect, the traditional productivity measure structure was modified. Modified *GAV* refers to total employment in the subregion instead of employment in the sections of industry and construction. By constructing the indicator in this way it is possible to avoid distortions in the picture of subregions where high productivity (measured as gross added value per 1 employee in industry) is obtained by a relatively small group of industrial enterprises playing a minor role in the scale of the region.

The analysis aimed to achieve two goals: (1) to identify subregions characterised by a similar industrial structure (which was carried out using classification methods) and (2) to assess positions and changes in time related to the level of industrial development in subregions (for which a synthetic development measure *SDM* was used). The following research procedure was adopted to achieve these goals:

1. Collecting statistical data for subregions in the years 2010–2014 and 2015.

2. Conducting a preliminary data analysis.

3. Preparing the classification of subregions in terms of industrial structure based on economic and social aspects regarding the indicator levels achieved in 3 groups created by: C – industrial processing, B, D, E – other industrial sectors, and F – construction. A distance matrix was applied in the classification based on Euclidean distance and one of the cluster analysis hierarchical methods, i.e. Ward's agglomeration method (cluster trees) (Ward 1963). The calculations were made in the STATA program.

4. Defining the value of the synthetic development measure with the common model for the years 2010–2014 for each aspect separately (*SDM_GAV* and *SDM_E*) and jointly (*SDM*). The non-model linear ordering method was used to specify *SDM* – standardised sums method. *SDM* values were determined as the mean value of industrial development

indicators after prior transformation using the zero unitarisation method (*Taksonomiczna analiza*… 2000, Walesiak 2006).

5. Determining weights for each of the variables: it was assumed that both the social and economic aspects are of the same significance and were assigned a 0.5 weight. Ultimately, the general *SDM* was determined as an *SDM* weighted average for the *E* variable and for *GAV* and took the following form:

$$SDM = 0.5\ SDM\_E + 0.5\ SDM\_GAV$$

6. The classes of subregions were formed to identify groups of subregions by the dominant role of industry in terms of economic or social aspects, based on the median value of the *GAV* and *E* variables. The classes were defined according to the median criterion (median value $SDM\_GAV_{wi} = 0.07$ and $SDM\_E = 0.2$) as follows:

– socio-economic priority subregions – characterised by a relatively high level of industry involvement, measured by both the *GAV* and *E* variables (both variables higher than the median),

– subregions with economic priority – presenting a relatively high level of industry involvement measured by *GAV* and a low employment level in industry *E* ($SDM\_GAV_{wi} > 0.07$ and $SDM\_E < 0.2$),

– subregions with social priority – a relatively low level of industry involvement measured by *GAV* and a high employment level in industry *E* ($SDM\ \_GAV_{wi} < 0.07$ and $SDM\_E > 0.2$),

– subregions with a low level of industry development – minor industry involvement measured by both *GAV* and a low level of employment in industry *E* (both variables lower than the median).

7. *SDM* values and changes in them allowed the regions to be grouped into four classes in line with the classical typology of regions proposed by L. Klaassen. The division was based on the median value for the level of general *SDM* in 2014 and changes in *SDM* in 2014 compared to 2010. The classes were defined in the following way (see above): WW – prosperity area, nn – distressed area, nW – distressed area in the process of development, Wn – declining prosperity.

One of the more important elements in the construction of the classes of subregions by type of development (according to Klaassen) was to determine the division boundary. In the majority of cases the median value of the measure was used, which allowed subregions to be divided according to the average level achieved by half of the subregions. However, in the case of changes in the synthetic development measure regarding the social

aspect (*SDM_E*), this criterion proved insufficient. As many as 53 out of 72 subregions recorded a decline in *SDM_E* in 2014 compared to 2010. As a result, the median value was negative and using it for the division into developing regions turned out to be useful. In this case, the *a priori* specified value of 0.01 was used, which allowed the author to identify those subregions which featured minor or negative changes and also ones which recorded a small but – when compared with the others – noticeable improvement (developing subregions). Ultimately, the adopted median value for *SDM_E* was 0.21, and for the changes in *SDM_E*: 0.01. Unfortunately, only 7 regions exceeded the improvement level in the social aspect (amounting to 0.01). For the general *SDM*, a median value equal to 0.3 was adopted, whereas for the changes in general *SDM*: 0.02. In the case of classification regarding the economic aspect, the median value for *SDM_GAV* was 0.08 and for the changes in *SDM_GAV*: 0.03.

The study covered 72 Polish subregions for industry and construction jointly. The basic analysis period covered the years 2010–2014. Due to data availability, the first part of analysis, covering the structure of industry in subregions, was presented for one year. In the case of the economic aspect, based on regional productivity, it was 2014, whereas for the social aspect, based on employment structure, the data originated from 2015. The next section presents an analysis of the industrial development level taking into account the dynamics of changes in 2014 compared to 2010.

## 3. The Results of the Importance of Regional Industrial* Diversification in Subregions

### 3.1. The Structure of the Industrial Sector and Construction in Subregions

The assessment of subregions in terms of industrial development, regarding regional productivity and the development of the regional job market, was carried out by assessing industrial structure in the social and economic aspects for selected groups of sections: C, BDE, and F. The classification of subregions allowed subregions with a similar industrial development structure to be identified.

For both aspects, subregions were divided into four classes. The number of classes was adopted *a priori* based on a dendrogram analysis. In the case of the social aspect, the major differentiating feature was industrial processing. Moreover, in one of the classes a visibly large role was played by

* Construction is included wherever industry is concerned.

sections BDE, including mining. The level of employment in construction did not differ much between classes.

The class characterised by well-developed BDE sections was class 2, "processing-mining", which included only 3 subregions identified in terms of an extensive mining function (Figure 1). These regions are as follows: Legnicko-Głogowski, Rybnicki and Tyski. The subregions covered by class 1 are placed at the opposite end, i.e. "low industrialised" (in which processing and mining played a minor role on the job market). This class included all subregions representing entire cities with *powiat* (district) status and four subregions from eastern Poland: Bialski, Białostocki, Chełmsko-Zamojski and Lubelski. The limited role of industry in cities with *powiat* (district) status is associated with their function as regional centres dominated by services. The most numerous group of subregions was made up of those formed by class 3, "with developed processing sector". This class included 44 units, in which industrial processing was an important element of the job market, providing employment for 20% to 25% of persons employed.

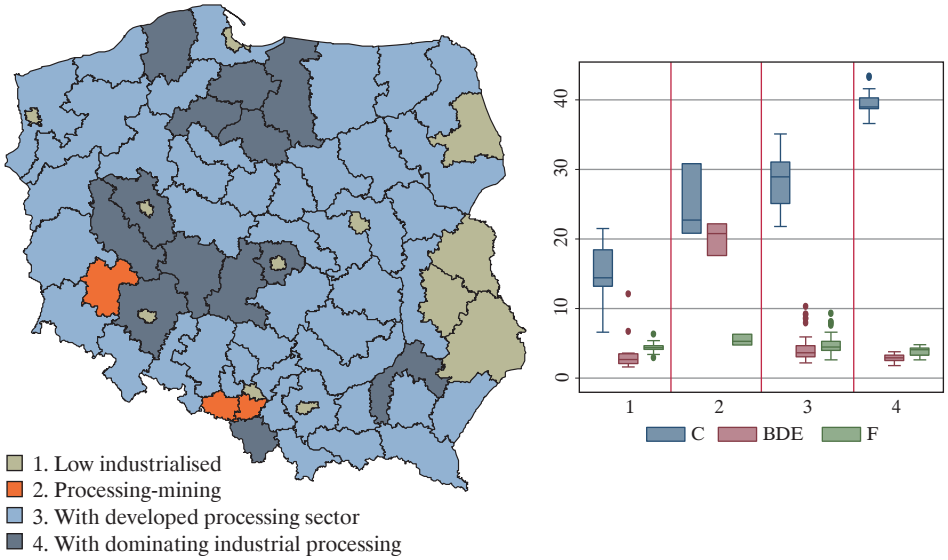


Fig. 1. Classes of Subregions by the Share of Employment in Sections C, BDE and F in Total Employment in 72 Subregions (Left Side) and the Distribution of Indicator Values in Classes in % (Right Side) in 2015

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

Having analysed the situation of industry and construction in the economic aspect, a slightly different situation becomes noticeable (Figure 2). Similarly to the social aspect, the largest differences in classes defined in the economic aspect were visible in the development level of processing industry (section C). Class 3, characterised by "dominant processing", covered only two subregions: Legnicko-Głogowski and Płocki.

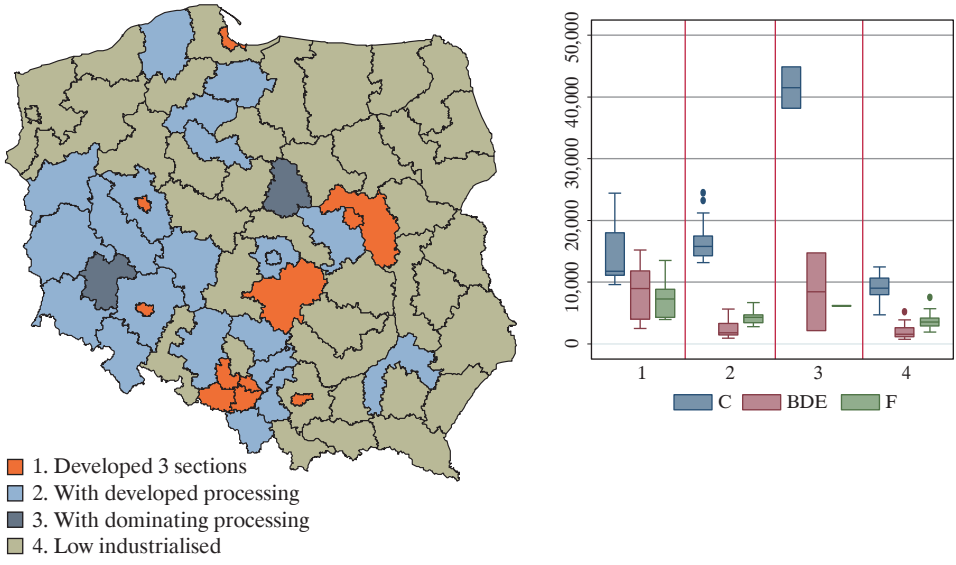


Fig. 2. Classes of Subregions in Terms of Regional Productivity in Sections C, BDE and F in 72 Subregions (Left Side) and the Distribution of Indicator Values in Classes in PLN for 1 Person of Working Age (Right Side) in 2014

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

Class 1, i.e. "three sections developed" and 2, "with developed processing", should be recognised in terms of the economic aspect as classes whose subregions obtain the major part of regional *GAV* from industry processing enterprises, and in case of class 1, also from the construction and BDE sections. Class 1 was made up of 11 subregions characterised by high regional productivity in all three sections (C, BDE, F). The majority of them were cities with *powiat* (district) status and capital subregions (Tri--City, Warszawski, Katowicki) as well as the Piotrkowski subregion. Class 2 is numerous and covers 21 units located mainly in the south-western belt of Poland, in the area of Łódź and Warsaw, and in Bydgoszcz, Toruń and

Słupsk. The other 38 units were assessed as subregions presenting relatively low regional productivity in sections C, BDE and F and were included in class 4., i.e. "low industrialised").

### 3.2. The Level and Dynamics of the Industrial Sector and Construction

This part of analysis presents the assessment results of industrial and construction development in subregions in terms of social and economic aspects taking into account the level, diversification and dynamics of changes. Figures 3 and 4 present the range of input values adopted by the analysed *GAV* and *E* indicators in the years 2010–2014.

The level of employment in industry was differed significantly between subregions – in 2014 from 13% up to almost 49%. Larger disproportions were visible in the group of subregions with an above median share of employment in industry and construction. In 50% of subregions the value of the *E* indicator exceeded 27.9% (median value), reaching a level higher by even 21 percentage points for selected units, whereas in the case of the remaining 50% of units the level was lower by 14 percentage points. At the same time, a negative tendency for each of the discussed statistics was observed (min. value, median and max. value) confirming the decline in the role of industry on the regional job market.

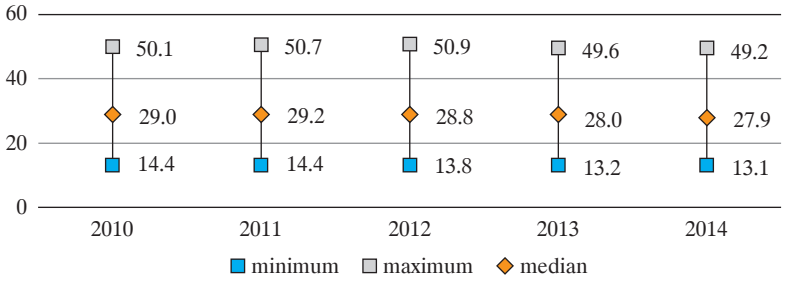


Fig. 3. Employment in Industry and Construction as a Share of Total Employment (%) in 72 Subregions in the Years 2010–2014

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

The differences are even more extensive in the case of the *GAV* indicator level for low and high values. The median is approximately twice higher than the minimum value, whereas the maximum value in 2014 was over three times higher than the median. Different tendencies in time characterised the presented statistics. After an increase in 2011,

maximum values declined, while the median and minimum values showed an improvement in the situation of subregions. The higher pace of median value improvement should be regarded as a very positive symptom, as it went up by approximately 30% in 2014 compared to 2010 (for the minimum value it was approximately 25%), which suggests that some subregions recorded a relatively fast increase.

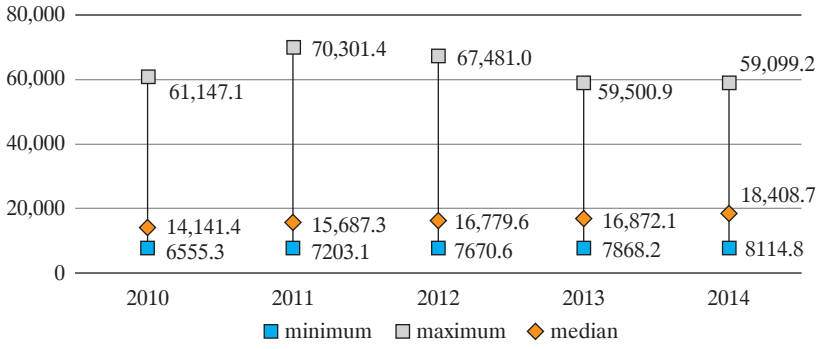


Fig. 4. The Values of Regional Productivity (in PLN per 1 Person of Working Age) in 72 Subregions in the Years 2010–2014

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

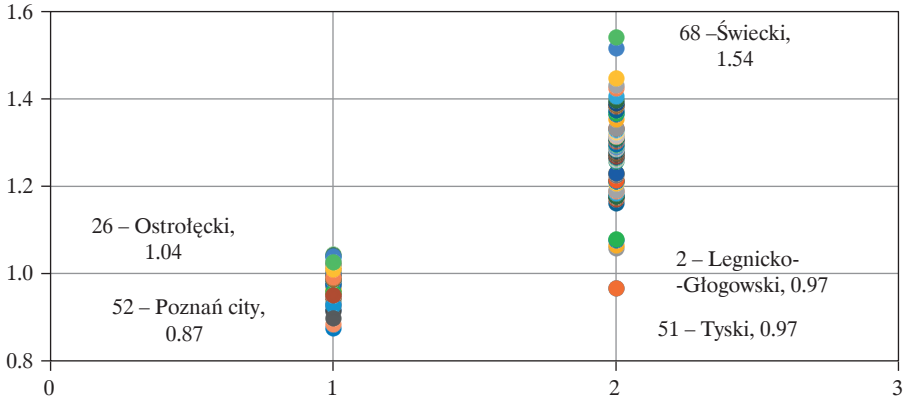


Fig. 5. Changes in Regional Productivity (Marked 2 on the *x* Axis) and Employment Share (Marked 1 on the *x* Axis) in Industry and Construction in 72 Subregions in 2014 Compared to 2010

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

Figure 5 presents changes in the values of the *GAV* and *E* indicators in 2014 compared to 2010. The share of employment in industry and construction (*E*) in 53 subregions in 2014 was lower than in 2010. The highest decline was recorded in Poznań and amounted to 13%, whereas in the Ostrołęcki subregion the largest recorded increase was only 4%. An increase in the importance of industry and construction on the regional job market was recorded in 19 subregions only.

The highest increase in regional productivity (*GAV*) was observed in the Świecki subregion and was as high as 54%. Only two subregions recorded a drop in regional productivity – by as little as 3% only.

Synthetic measures of development were defined in order to compare industrial and construction levels in subregions. The general measure (*SDM*) was established on the basis of partial values in the social (*SDM_E*) and economic (*SDM_GAV*) aspects. Their preliminary analysis allowed the following conclusions to be presented:

– A small group of subregions achieved visibly higher results than the other subregions, i.e. Tyski and Głogowsko-Legnicki. These subregions took the position of leaders in the economic aspect, and in case of the Tyski subregion also in the social aspect. The group of economic aspect leaders also includes the Płocki subregion. It should be emphasised that the position of leaders deteriorated considerably in the last analysed years, i.e. in 2013 and 2014,

– The differences in development level regarding the economic aspect are larger than in the case of the social aspect,

– The changes in development level occurred differently – in terms of the social aspect, a gradual decline in the situation was observed in many subregions, which indicated the decreasing role of the industrial and construction sectors as job providers. As far as economic aspect is concerned, an improvement was observed in subsequent years, showing the higher productivity of this sector. These observations are confirmed by the values of the correlation coefficient between *SDM_E* and *SDM_GAV*, which was relatively low and continued the decreasing trend in the following years (Table 1).

Table 1. The Values of the Correlation Coefficient of Synthetic Development Measures in the Social and Economic Aspect (*SDM_E* and *SDM_GAV*)

| Specification | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| *SDM_GAV* and *SDM_E* | 0.480 | 0.469 | 0.472 | 0.469 | 0.457 |

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

Figure 6 presents the spatial distribution of subregions which show both a high level of industrial development in the economic and spatial aspect as well as ones which recorded a high position in one aspect only compared to other subregions. The regions were qualified to a particular group if they achieved s partial *SDM* value exceeding the median (*SDM_GAV* > 0.07; *SDM_E* > 0.2). The regions which, in both aspects, achieved indicators higher than the median were referred to as the industrial ones.

The regions characterised by a developed industrial sector in both aspects were located in the south-western and central part of the country and in part comprised the Podkarpackie, Pomorskie and Kujawsko-Pomorskie voivodships. The Tarnobrzeski and Warszawski wschodni subregions were the only areas presenting high industrial level in the east of the country. A total of 24 such regions were identified in 2014. As was stated by Kudełko (2016), "in comparison with other Polish regions, the regions of Eastern Poland are less industrialised. Industry plays the most important role in the Podkarpackie Voivodeship, whereas in the Lubelskie Voivodeship its importance is least significant. The leading industry domains in which the analysed regions can develop and become competitive include: food processing, the furniture industry, ceramics and other non-metallic mineral products, motor vehicles and chemical products".

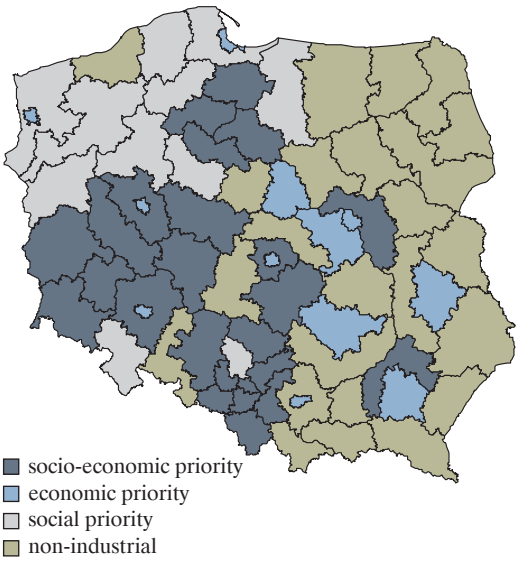


Fig. 6. Profiles of Subregions by Type of Industrialisation in 2014

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

A special position in the conducted analysis was achieved by cities with *powiat* (district) status constituting independent subregions and also by selected subregions in central Poland (e.g. concentrated around Warsaw). They achieved very good results for regional productivity and at the same time did not play the role of an important employer on the regional job market. These 12 subregions were qualified among those presenting a distinctive economic priority (Figure 6).

The third group of 12 subregions is made up of those offering a relatively large number of jobs on the regional market, and despite that their regional productivity was assessed as low, thus their importance as economic centres was small. This group included subregions located in the north-western part of the country and in Wałbrzyski and Bytomski in the southern part (Figure 6).

In the case of 9 units, very large differences in the social and economic aspects were recorded, and for many units the difference exceeded 25 positions (Table 2). The Płocki subregion was one of the units in this group, which in the overall ranking achieved a high third place and which, as an employer on the regional market, was ranked at a low 41st position but simultaneously played the role of one of the leaders (2nd position) in terms of regional productivity. The largest differences in industrial development, regarding the social and economic aspect, were observed in the subregion covering the area of the capital city of Warsaw. This subregion should be included among areas presenting the highest productivity levels (6th position), along with the insignificant importance attributed to industry and construction on the regional job market (72nd position). This situation was present in all cities representing independent subregions (Table 2 and Figures 1 and 2). It is determined by the employment structure, which in capital subregions is, to a large extent, connected with services.

A large group (24 subregions) comprised subregions in which the industrial function was not identified on a level higher than the median for *SDM_GAV* and *SDM_E*. These subregions were predominantly located in the east of Poland and in its central belt. The lowest level of industrial development was characteristic of the following subregions: Sandomiersko-Jędrzejowski, Przemyski, Bialski and Chełmsko-Zamojski.

Changes in the level of industrial development were noticed in the 2010–2014 period. Many regions saw their situation deteriorate in subsequent years. In 2014, a deterioration in general industrial development was observed in 9 subregions (Figure 7, left side) compared to 2010. In another 9 subregions a significant improvement was recorded. In the case of the

remaining subregions, only a small improvement or no change was observed. As mentioned earlier, particularly unfavourable changes were found in terms of employment in industry and construction. A decline in employment share in the analysed sections was recorded in as many as 53 subregions, whereas a drop in regional productivity was recorded in only two.

Table 2. The Positions of Selected Subregions in the Social and Economic Aspect in 2014 (the Difference in Positions over 25 Places)

| Subregion | General Development Level | Economic Aspect | Social Aspect | Difference in Positions in the Social and Economic Aspect |
|---|---|---|---|---|
| Social Aspect Dominance | | | | |
| 72 – Chojnicki | 38 | 63 | 28 | –35 |
| 54 – Elbląski | 26 | 53 | 18 | –35 |
| 64 – Szczecinecko-Pyrzycki | 39 | 65 | 32 | –33 |
| 55 – Ełcki | 52 | 68 | 39 | –29 |
| 7 – Grudziądzki | 33 | 52 | 26 | –26 |
| 31 – Nyski | 44 | 62 | 37 | –25 |
| Economic Aspect Dominance | | | | |
| 16 – Łódź city | 37 | 19 | 45 | 26 |
| 65 – Szczecin city | 58 | 33 | 60 | 27 |
| 30 – Warszawski zachodni | 36 | 13 | 48 | 35 |
| 43 – Trójmiejski | 43 | 17 | 55 | 38 |
| 70 – Płocki | 3 | 2 | 41 | 39 |
| 5 – Wrocław city | 50 | 16 | 66 | 50 |
| 21 – Kraków city | 48 | 15 | 65 | 50 |
| 62 – Poznań city | 35 | 5 | 61 | 56 |
| 28 – Warsaw capital city | 53 | 6 | 72 | 66 |

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

In the context of the conducted analysis, it is interesting to find out whether the regions recording a decline represent those characterised by an initially low or high development level. The subregions' classification results, in line with Klaassen's proposal, are presented in Figure 7 (right side).

Twenty-two subregions, representing "prosperity area" (developing leader) status, were identified in the general classification (based on both selected variables combined in *SDM*). These regions were characterised

by a high level of industrial and construction development and were continuously improving their position at a level above the median of the general *SDM* changes. They are located in the western and central part of the country. Only 3 of them – Słupski, Kaliski and Świecki – also represented the status of leaders in both analysed aspects, i.e. social and economic.

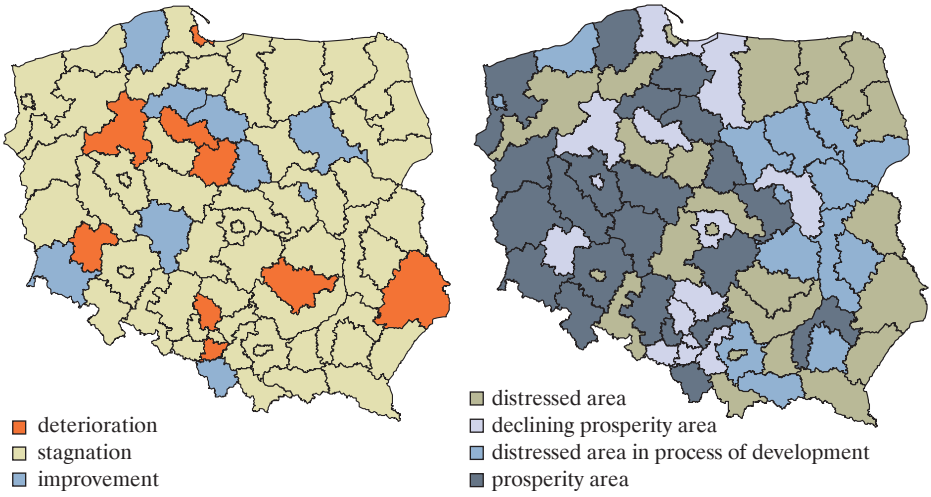


Fig. 7. Changes in SDM Value in 2014 Compared to 2010 (Left) and Classes of Subregions in Accordance with Klaassen's Typology in 2014 (Right)

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

The second group that recorded a positive situation comprised 13 subregions presenting a low level of general development in industry and construction, albeit with an improving situation. In these regions, referred to as "distressed areas in the process of development", in spite of a low initial level of industrial development, one of the higher development measure increases was observed (above the median of the general *SDM* changes). These subregions are located in the east-central part of the country and surround the subregion of Warsaw capital city, and in the area of Kraków city, whereas one subregion from this group is located in the north (Koszaliński).

The situation of 14 subregions raises concerns. These regions were going through a period of stagnation and presented a high level of industrial and construction development, but ceased to develop during the analysed period ("declining prosperity areas"). This group included such ranking leaders

as the Tyski and Legicko-Głogowski subregions and also Poznań city, the Katowicki subregion and the adjacent ones, and subregions that neighbour large cities: Gdański, Łódzki, Bydgosko-Toruński, Częstochowski, Warszawski Wschodni, Pilski and Elbląski.

The most difficult situation was characteristic of subregions that featured a low level of industrial development and, at the same time, did not show any improvement. There were 23 distressed areas, i.e. 32% of units. In the case of 13 of these – Chełmsko-Zamojski, Sandomiersko-Jędrzejowski, Bialski, Inowrocławski, Ełcki, Nowotarski, Suwalski, Krośnieński, Przemyski, Nyski, Włocławski, Tarnowski and Białostocki – the difficult situation concerned both analysed aspects, i.e. economic and social. In the remaining ones, despite a low general *SDM* assessment, at least in one of the areas the level of changes can be considered moderately positive compared to other units covered by the analysis.

Figure 8 shows classes of regions grouped in accordance with Klaassen's proposal in both analysed aspects: social (left side) and economic (right side).

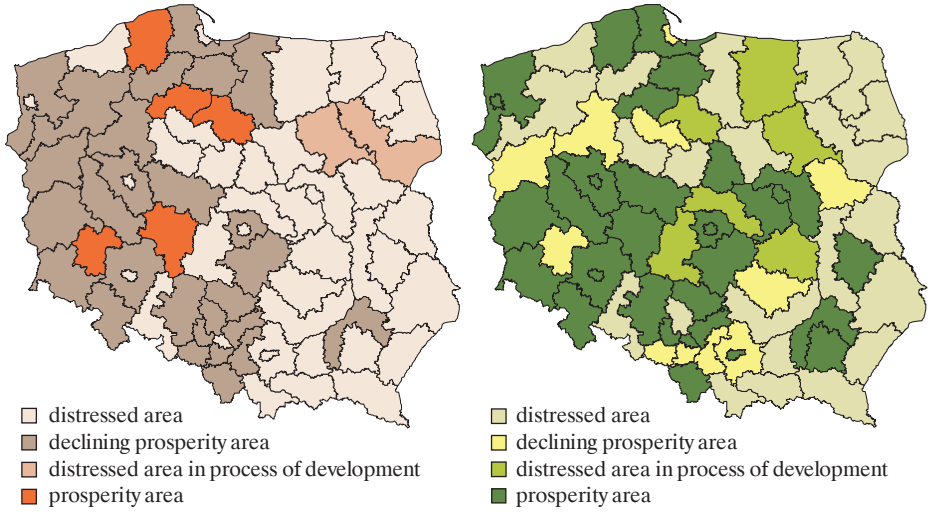


Fig. 8. Classes of Subregions in Line with Klaassen's Typology in the Social (Left) and Economic (Right) Aspect

Source: author's compilation based on data from the Local Data Bank of Statistics Poland.

As regards the social aspect, the class of "distressed area" regions included as many as 38 units, predominantly cities with *powiat* (district)

status and subregions in the central and eastern part of Poland. A large group of 27 subregions comprised the class of "declining prosperity areas", mainly located in the western part of the country. Only seven subregions, forming "distressed area in process of development" and "prosperity area" groups, could be assessed positively, two of them due to an observed improvement in their situation in recent years (Łomżyński and Ostrołęcki). Only five subregions recorded a high position compared to others in terms of the regional job market they created, which was also, in the years 2010–2014, continuously strengthened ("prosperity area"). These were the following subregions: Legnicko-Głogowski, Grudziądzki, Słupski, Kaliski and Świecki.

The situation of subregions in terms of their spatial distribution in the economic aspect was different. In this case, a less numerous although still large group of subregions (33) presenting the least favourable situation was visible. These are referred to as "distressed areas", i.e. areas in which the pace of change in 2014 compared to 2010 was minor or negative and which in 2014 were simultaneously included in the group of subregions with the lowest regional productivity level. These subregions are mainly located along the eastern border and in the following voivodships: Zachodniopomorskie, Kujawsko-Pomorskie and Małopolskie. In the years 2010–2014, an improvement in the situation was recorded in 6 subregions only, included in the group of subregions characterised by low productivity. The group of subregions called "distressed areas in the process of development" covered: Olszyński, Sieradzki, Skierniewicki, Radomski, Ostrołęcki and Grudziądzki. In the case of 11 subregions, in which industry and construction represented a significant source of gross added value, the years 2010–2014 were lacking progress or even recorded a drop in regional productivity. In this class, the decline concerned only two leaders in the ranking of industrial activity – the Tyski and Legnicko-Głogowski subregions. This group also covered a few subregions from the Śląskie voivodship and single regions from other voivodships.

## 4. Conclusions

The analysis of the spatial diversification of industrial development in subregions confirmed the existing differences in the level of development in eastern and western Poland that are highlighted in various studies and analyses. In the summary of the presented research results, the following should be emphasised:

– Among the analysed groups of sections (C, BDE and F) in industry and construction, the industrial processing sector plays the dominant role in subregions as a provider of jobs and *GAV*.

– The subregions that achieved the best results for the analysed indicators were those characterised by a well-developed mining sector (included in the assessed group of B, D and E sections).

– Cities with *powiat* (district) status play a relatively small role on the regional job market in terms of employment in industry.

– Distinctive development profiles of subregions were visible in terms of industrial development in line with social and economic priorities in 2014; both aspects were well-developed, mainly in the voivodships of western and central Poland.

– The tendency to reduce the importance of industry as an employer, which persists in many subregions, is a cause for concern. This situation was still observed several years after the 2008 crisis, which suggests that these negative phenomena have persisted not just as the direct effect of the crisis, but also due to other unfavourable phenomena.

– Only a few of the subregions with a low development level recorded an improvement in their situation in recent years, particularly if the assessment covered only one aspect (in the case of the social aspect this concerned 2 units, and in the case of economic aspect – 6 units). The situation was slightly better for the cumulative effect measured in the overall *SDM*. The improvement of backward regions (distressed areas in the process of development) mainly concerned the area surrounding the subregions of the second ring of Warsaw.

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## Abstract

### Społeczno-gospodarczy wymiar przemysłu w podregionach

Przemysł stanowi jeden z podstawowych sektorów gospodarki, który oddziałuje na szereg innych jej obszarów, a także na społeczeństwo i środowisko. W obszarze społeczno-gospodarczym kształtuje rynek pracy, poziom wynagrodzeń, innowacyjność i konkurencyjność przedsiębiorstw oraz jednostek terytorialnych.

Celem artykułu jest klasyfikacja i ocena sytuacji 72 podregionów Polski (NUTS-3) pod względem poziomu uprzemysłowienia jako jednego z elementów oddziałujących na poziom i strukturę rozwoju podregionów. Klasyfikacji dokonano na podstawie danych na temat struktury pracujących i produktywności regionalnej opartej na wartości dodanej brutto. Z uwagi na dostępność danych analizę przeprowadzono na podstawie informacji o aktywności przedsiębiorstw w sekcjach PKD od B do F (łącznie z budownictwem) w latach 2010–2014 oraz dla wybranych aspektów w 2015 r. W badaniu wykorzystano metody klasyfikacji (metodę Warda) oraz porządkowania liniowego (SMR ze wspólnym wzorcem rozwoju). Analiza pozwoliła na wskazanie klas podregionów o określonym profilu rozwoju przemysłu (ogólnym, społecznym bądź gospodarczym) oraz o jednym z typów rozwoju zgodnych z klasyfikacją L. Klaassena (1965).

Wnioski z przedstawionych badań wskazują znaczenie przedsiębiorstw przemysłowych, będącvych regionalnymi pracodawcami (aspekt społeczny) bądź liderami gospodarczymi (aspekt gospodarczy). Z analizy dynamiki zmian wynika, że wzmocnieniu uległa rola przemysłu w podregionach w aspekcie gospodarczym, przy jednoczesnym zmniejszeniu znaczenia w aspekcie społecznym (w niniejszym opracowaniu powiązanym z miejscami pracy).

**Słowa kluczowe:** przemysł, podregiony (NUTS-3), klasyfikacja, syntetyczna miara rozwoju.

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# THE IMPACT OF THE MACROECONOMIC SITUATION ON THE LABOUR MARKET IN THE BALTIC STATES IN 2000–2016

**Abstract**

The accession of the Baltic states to EU structures required a number of structural reforms, including labour market reforms. It should be noted that unemployment in these countries throughout the research period remained high. This condition was largely dependent on the macroeconomic situation of the particular country. An important role was also played by the migration factor.

The aim of this paper is therefore to analyse the impact of the macroeconomic situation on the labour market in the Baltic states.

**Keywords:** Baltic states, labour market, unemployment, employment, emigration, economic growth.
**JEL Classification:** A100.

## 1. Introduction

The Baltic countries – Estonia, Latvia and Lithuania – share common features and similar history. After regaining independence in 1991, these three countries quickly opened their small economies to international competition and started their preparations for accession to the European Union (EU). The admission of these countries into the EU in 2004 signified that they had well-functioning democratic systems and competitive market economies. The admission to the Euro area of Estonia in 2011, Latvia in 2014 and Lithuania in 2015 signalled a high degree of convergence in inflation, interest rates, budget balance and public debt. Accession to EU structures required a number of structural reforms, including the labour

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market. It should be noted that unemployment remains persistently high in the Baltic countries. While it has fallen significantly from its post-crisis peak, it remains in the 8–12% range and is particularly high among young people.

The aim of this paper is to analyse the impact of the macroeconomic situation on the labour market in the Baltic States.

The methodology used in the article is based on an analysis of data provided by the European Statistical Office (Eurostat). Indicators such as: GDP growth in individual countries, the unemployment rate measured as the unemployment rate in relation to the working population, and the employment rate measured as the percentage of the labour force in work were used to assess the labour market situation in the Baltics.

## 2. Macroeconomic Situation in the Baltics in 2000–2016

The Baltics share common development and key structural features: their overall economic situation and policies, the structure of their production, their main trading partners and their population flows underline their similarities but also their differences. Among the conspicuous similarities between the Baltic countries are synchronised economic cycles as well as the overall population decline over recent decades. This situation contrasts with the EU as a whole where the economic cycle has been less pronounced and the population has increased. The three Baltic countries also share a high level of inequality and have the highest Gini coefficients in the EU. Their economic policies are very similar given their common recent history and competition. The adjustment to the market economy after regaining independence followed a similar pattern and all three countries shared a common goal, which was accession to the EU and joining the monetary union. The Baltic states have relatively small government sectors and liberal economic policies. They compete in trade and to attract foreign investment. In practice, foreign investors tend to view the Baltics as a single market and have a single, local headquarters and sales policy for all three countries. In the Baltics, monetary policy and the banking sectors are also very similar. Since the early 1990s, monetary authorities have aimed at stable exchange rates for their currencies. The Estonian Kroon was pegged to the Deutsche Mark from its introduction in 1992. The Latvian Lats was initially pegged to the IMF special drawing rights. The Lithuanian Litas was pegged to the US Dollar starting in 1994. The three Baltic currencies later switched to a peg to the Euro and joined the European exchange rate mechanism (ERMII)

in 2004 and 2005 before joining the Euro area between 2011 and 2015. The banking sector is the main source of financing for the private sector in the three countries. It is dominated by Nordic banks – Swedbank (Sweden), SEB bank (Sweden), DNB (Norway), Nordea bank (Finland) – which cover a large majority of the banking sector in the three Baltic countries (Staehr 2015; OECD 2003; Kasperowicz-Stępień 2014, pp. 59–70; Stępień & Kasperowicz-Stępień 2015, pp. 40–48).

It should be noted that after large GDP declines in the early 1990s, the second half of the decade saw rapid economic growth, interrupted only by the fallouts due to the Russian crisis of 1999. The period from 2000 to 2007 was characterised by high and increasing rates of economic growth. This growth spurt came to an end after the onset of the global financial crisis. All three Baltic states were severely affected by the great recession. The decline of their GDP was deeper than that of any other EU country. The crisis was characterised by a housing bubble fuelled by credit supply in all three countries which burst in 2009. Latvia was the most severely affected and required specific assistance regarding its external imbalances. Yet all three countries rapidly experienced a credit-less recovery and are now growing closer to their potential. GDP growth bounced back in 2011–2016 but has since then been at subdued levels (European Commission 2017a; European Commission 2017b; European Commission 2017c; Grajauskas 2014; Kasperowicz-Stępień 2014, pp. 59–70; Stępień & Kasperowicz-Stępień 2015, pp. 40–48).

Table 1. GDP Growth in the Baltic States in 2000–2016 (Percentage Change Compared with the Previous Period)

| Specification | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 |
| European Union (28) | 3.3 | 2.2 | 2.4 | 2.3 | 0.1 | 2.1 | 2.4 | 1.6 | –1.2 |
| Euro area (19) | 1.3 | 2.4 | 1.9 | 1.9 | 2.1 | 0.7 | 1.2 | 0.9 | 0.8 |
| Estonia | 3.8 | 5.0 | 4.9 | 8.9 | 7.5 | 1.7 | 3.2 | 1.7 | 1.7 |
| Latvia | 15.9 | 1.3 | 2.8 | 12.4 | 11.4 | –1.4 | 5.0 | 1.4 | 0.7 |
| Lithuania | 16.9 | 3.9 | 2.7 | 6.7 | 9.7 | 2.4 | 2.7 | 1.0 | 1.2 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

The dynamics of economic growth are mirrored in the GDP level per capita in Table 2. The GDP per capita showed a particularly upward trend following the accession of these countries to the structures of the European Union.

Table 2. GDP Per Capita in the Baltic States in 2000–2016 (Percentage Change Compared with the Previous Period)

| Specification | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2011 | 2012 | 2014 | 2016 |
| European Union (28 countries) | 3.6 | 1.1 | 2.2 | 2.9 | 0.0 | 1.8 | 1.5 | –0.7 | 1.4 | 1.5 |
| Euro area (19 countries) | 3.5 | 0.5 | 1.8 | 2.8 | –0.1 | 1.8 | 1.4 | –1.1 | 1.0 | 1.4 |
| Estonia | 8.8 | 6.8 | 7.0 | 10.9 | –5.1 | 2.4 | 7.9 | 4.7 | 3.2 | 1.4 |
| Latvia | 6.4 | 8.4 | 9.5 | 12.9 | –2.6 | –1.7 | 8.4 | 5.3 | 3.1 | 2.8 |
| Lithuania | 4.6 | 7.6 | 7.8 | 9.1 | 3.7 | 3.8 | 8.5 | 5.2 | 4.4 | 3.6 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

The three countries differ slightly in their economic development and size. Estonia stands out as the most advanced of the three. Its population was only 1.3 million in 2016 (Figure 1) but its GDP per capita was the highest and was about 76% of the EU28 average in purchasing power parity. The population of Latvia was almost 2 million and GDP per capita was about 64% of the EU28 average. Lithuania was the largest of the three with 2.9 million inhabitants and a GDP per capita similar to Estonia in PPP – about 75% of the EU28 average.

The Baltic countries have a similar economic structure and, despite their gradual convergence with West European countries, still specialise in the production of low-tech goods. Their agricultural sectors are of similar size and are well above the EU average. The production of goods is mostly based on wood and paper products as well as furniture and textiles, while the production of machinery and transport equipment is significantly lower than the EU average. When looking at specific sectors, one can observe differences in areas of specialisation. While Latvia and Lithuania both have a relatively sizeable food sector, Estonia is the only oil producer of the three and its electronic and electrical equipment industry is relatively more developed. Lithuania also has an important chemical sector, while Latvia specialises in the pharmaceutical industry. Baltic services are mainly connected to the major trade activities in the area. In 2014–2016, trade openness was as high as 160% of GDP in Estonia and Lithuania, while in Latvia it was around 120% of GDP; all three are far above the 83% of GDP for the EU as a whole. Consequently, transportation and storage activities are well developed in these three countries and account for 9%, 13% and 10%, respectively, of value added compared to only 5% on average

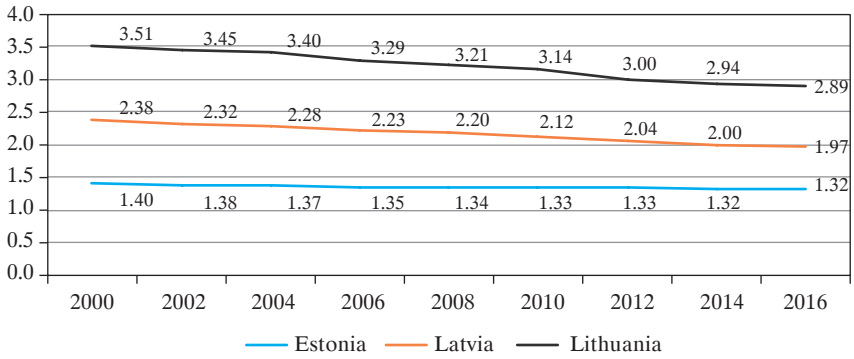


Fig. 1. Population Change in the Baltic States in 2000–2016 in Million Units (Millions of People)

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

Table 3. Export and Import Share by Trading Partners (Average 2010–2015) in %

| Specification | Estonia | | Latvia | | Lithuania | |
|---|---|---|---|---|---|---|
| | Exports | Imports | Exports | Imports | Exports | Imports |
| Baltics | 13 | 11 | 30 | 26 | 16 | 9 |
| Estonia | n/a | n/a | 13 | 8 | 6 | 3 |
| Latvia | 9 | 5 | n/a | n/a | 10 | 7 |
| Lithuania | 5 | 6 | 18 | 19 | n/a | n/a |
| Finland | 14 | 10 | 3 | 5 | 1 | 2 |
| Germany | 4 | 10 | 8 | 12 | 8 | 11 |
| Other Euro area | 9 | 12 | 10 | 15 | 14 | 18 |
| Poland | 2 | 5 | 6 | 9 | 8 | 9 |
| Sweden | 15 | 7 | 6 | 3 | 4 | 3 |
| United Kingdom | 2 | 3 | 4 | 2 | 5 | 2 |
| Other European Union non Euro area | 3 | 4 | 6 | 5 | 4 | 4 |
| Russia | 15 | 11 | 10 | 9 | 18 | 27 |
| Other Commonwealth of Independent States | 2 | 2 | 3 | 4 | 8 | 4 |
| USA | 5 | 2 | 1 | 1 | 3 | 1 |
| Japan | 0 | 2 | 0 | 0 | 0 | 0 |
| China | 1 | 7 | 1 | 3 | 0 | 2 |
| Rest of the world | 14 | 14 | 13 | 6 | 14 | 6 |

Source: https://comtrade.un.org/ (accessed: 29 August 2017).

in the EU. On the other hand, financial services, business services and public administration are smaller sectors in all three countries (European Commission 2017a; European Commission 2017b; European Commission 2017c; Grajauskas 2014; Kasperowicz-Stępień 2014, pp. 59–70).

Foreign trade by country of origin and destination is displayed in Table 3. Despite their small market size, trade within the Baltic area accounts for 10 to 30% of each country's exports and imports. There is also a high coincidence of trading partners outside of the Baltics, such as Russia. At the same time, there are some marked differences: Finland and Sweden are more important trading partners for Estonia, while Lithuania and Latvia have larger trade links with Poland (Poissonnier 2017).

## 3. Labour Market in the Baltic States in 2000–2016

The economic growth prior to the crisis had a strong positive impact on the labour market in the Baltic states. Very positive changes took place in the labour market after the 2004 accession to the European Union. The accelerated reforms improved the flexibility of the market and also opened up new financing opportunities through EU funds and government programmes which supported entrepreneurs. The Baltic states also had unusually low labour costs. This resulted in improved competitiveness for workers in the European markets and for the goods and services they produced in the country. The opening of borders led to the possibility of migration, which has resulted in a significant decline in unemployment and in turn led to higher wages and higher standards of living. Unemployment fell to a historic low in early 2008, a rate slightly lower than the average in the EU and Eurozone countries (Ebeke & Everaert 2014).

Thus, the decline in unemployment in the Baltic countries was largely caused by the migration of citizens to other countries for profit. Hence, there is a slight degree of correlation between the level of unemployment and the size of GDP. This can be demonstrated using statistical methods, for example, the Pearson correlation coefficient, which is a measure of the linear correlation between two variables $X$ and $Y$[1]. A Pearson correlation is a number between –1 and 1 that indicates the extent to which two variables are linearly related. Using this coefficient, one can examine to what

[1] The correlation coefficient ranges from −1 to 1. A value of 1 implies that a linear equation describes the relationship between $X$ and $Y$ perfectly, with all data points lying on a line for which $Y$ increases as $X$ increases. A value of −1 implies that all data points lie on a line for which $Y$ decreases as $X$ increases. A value of 0 implies that there is no linear correlation between the variables.

Table 4. Unemployment in Baltic States in 2000–2016 (% of the Active Population)

| Specification | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 |
| Unemployment (% of the Active Population) | | | | | | | | | |
| European Union (28 countries) | 8.9 | 9.0 | 9.3 | 8.2 | 7.0 | 9.6 | 10.5 | 10.2 | 8.6 |
| Euro area (19 countries) | 8.9 | 8.6 | 9.3 | 8.4 | 7.6 | 10.2 | 11.4 | 11.6 | 10.0 |
| Estonia | 14.6 | 11.2 | 10.1 | 5.9 | 5.5 | 16.7 | 10.0 | 7.4 | 6.8 |
| Latvia | 14.3 | 12.5 | 11.7 | 7.0 | 7.7 | 19.5 | 15.0 | 10.8 | 9.6 |
| Lithuania | 16.4 | 13.8 | 10.9 | 5.8 | 5.8 | 17.8 | 13.4 | 10.7 | 7.9 |
| Unemployment of Males (% of the Active Population) | | | | | | | | | |
| European Union (28 countries) | 8.1 | 8.4 | 8.6 | 7.6 | 6.6 | 9.7 | 10.4 | 10.1 | 8.4 |
| Euro area (19 countries) | 7.7 | 7.7 | 8.3 | 7.5 | 6.9 | 10.1 | 11.2 | 11.5 | 9.7 |
| Estonia | 15.9 | 12.4 | 11.1 | 6.2 | 5.8 | 19.3 | 10.9 | 7.9 | 7.4 |
| Latvia | 15.3 | 13.2 | 11.5 | 7.3 | 8.4 | 22.7 | 16.2 | 11.8 | 10.9 |
| Lithuania | 18.8 | 14.6 | 10.5 | 6.0 | 6.0 | 21.2 | 15.2 | 12.2 | 9.1 |
| Unemployment of Females (% of the Active Population) | | | | | | | | | |
| European Union (28 countries) | 9.9 | 9.8 | 10.1 | 9.0 | 7.5 | 9.6 | 10.5 | 10.3 | 8.8 |
| Euro area (19 countries) | 10.4 | 9.7 | 10.5 | 9.5 | 8.3 | 10.3 | 11.5 | 11.8 | 10.4 |
| Estonia | 13.3 | 10.0 | 9.1 | 5.6 | 5.1 | 14.1 | 9.1 | 6.8 | 6.1 |
| Latvia | 13.3 | 11.7 | 12.0 | 6.7 | 7.1 | 16.3 | 14.0 | 9.8 | 8.4 |
| Lithuania | 14.0 | 12.9 | 11.3 | 5.6 | 5.6 | 14.5 | 11.6 | 9.2 | 6.7 |
| Youth Unemployment (% of Unemployment among the Active Population) | | | | | | | | | |
| European Union (28 countries) | 19.3 | 19.2 | 17.7 | 15.9 | 21.4 | 21.7 | 23.3 | 22.2 | 18.7 |
| Euro area (19 countries) | 19.7 | 18.5 | 17.2 | 16.1 | 21.4 | 21.3 | 23.6 | 23.8 | 20.9 |
| Estonia | 23.9 | 23.9 | 12.1 | 12.0 | 32.9 | 22.4 | 20.9 | 15.0 | 13.4 |
| Latvia | 22.4 | 20.0 | 13.6 | 13.6 | 36.2 | 31.0 | 28.5 | 19.6 | 17.3 |
| Lithuania | 30.0 | 21.8 | 10.0 | 13.3 | 35.7 | 32.6 | 26.7 | 19.3 | 14.5 |
| Long Term Unemployment (% of the Active Population) | | | | | | | | | |
| European Union (28 countries) | n/a | n/a | n/a | 3.7 | 2.6 | 3.8 | 4.6 | 5.0 | 4.0 |
| Euro area (19 countries) | n/a | n/a | n/a | 3.8 | 2.9 | 4.3 | 5.2 | 6.0 | 5.0 |
| Estonia | 6.7 | 6.1 | 5.2 | 2.9 | 1.7 | 7.6 | 5.5 | 3.3 | 2.1 |
| Latvia | n/a | 5.7 | 5.0 | 2.4 | 1.9 | 8.8 | 7.8 | 4.6 | 4.0 |
| Lithuania | n/a | 7.4 | 5.6 | 2.6 | 1.3 | 7.4 | 6.6 | 4.8 | 3.0 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

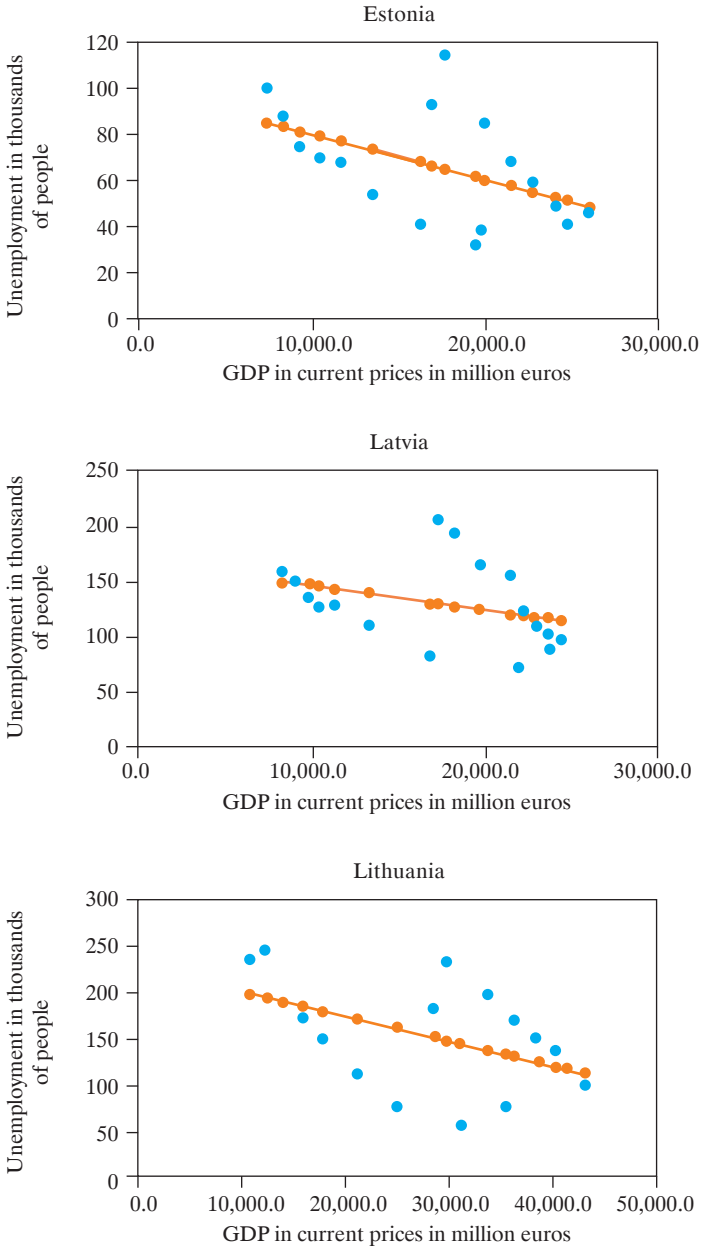


Fig. 2. Correlation between GDP and Unemployment in the Baltic States

Source: author's own study based on Pearson's linear correlation coefficient.

extent two variables such as GDP and unemployment are linearly related. The research sample included the correlation of two variables (GDP and unemployment) over a period of 17 years. Pearson's linear correlation coefficient showed negative values in all the Baltic countries, which means that GDP growth was accompanied by a drop in unemployment. This is also presented on the scatterplot with the aid of a trend line for each of the Baltic States. However, the low level of the indicators shows a weak correlation between the independent variable GDP and the dependent variable unemployment (Figure 2). This means that other factors such as social migration have also had a significant impact on the decline in unemployment.

Pearson's linear correlation coefficient:

– Estonia: –0.497;

– Latvia: –0.340;

– Lithuania: –0.499.

The increase in domestic production in the Baltic economies in 2003–2007 was mainly based on foreign investment and exports (in 2007 their total value reached 35.5% of GDP, of which as much as one third was accounted for by foreign investment). The economic downturn in global markets resulted in sudden and short-term withdrawal of foreign capital and a fall in demand for export products. This also affected internal production and domestic demand. Latvian, Lithuanian and Estonian GDP decreased by almost 25% between 2007 and 2009. At the same time, unfavourable phenomena arose on the labour market, such as: a decrease in employment, an increase in unemployment, the freezing of wages and even a reduction in wages. Consequently, the real income of society decreased, the standard of living decreased, and poverty increased. The global crisis forced the governments of Lithuania, Latvia and Estonia to undertake further reforms, such as raising taxes and cutting budget spending, which in turn caused wage freezes and reduced employment in both the private and public sectors. The crisis affected construction workers and the banking sector most severely. However, the problem of migration grew in the time of crisis. After 2004, the population fell drastically: in Estonia by about 6%, and in Lithuania and Latvia by 13–14%. This resulted in a decrease in unemployment in 2004–2007, but during the crisis a large proportion of emigrants returned to their country due to the difficult economic conditions throughout Europe. It should be noted that the largest social group to leave the Baltic countries for economic reasons in 2004–2007 was uneducated people and young people, and therefore during the crisis they were the ones who contributed

to the increase in unemployment. There is a great concern about youth unemployment and long-term unemployment, which remains high in the research period (Table 4). In contrast to the average for the European Union and the Euro area countries, unemployment among women in the Baltic states was significantly lower than among men over the analysed period. This is mainly due to a significant reduction in jobs in the construction and industrial sectors.

The growth of economic activity in the Baltic countries, following accession to the EU, also led to significant employment growth in Estonia and Latvia for all age categories and both genders (Figure 3), but especially for women. Among the Baltic states, only Lithuania in 2000–2008 failed to rebuild its labour market. At this time, there was a declining trend in the number of employees.

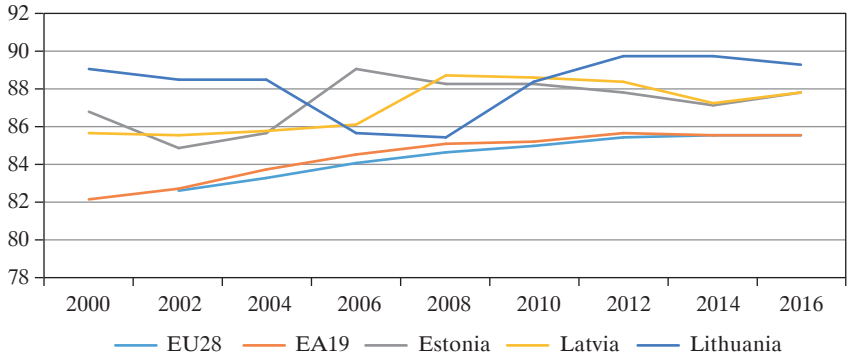


Fig. 3. Employment Growth in Baltic States in 2000–2016 (% of Active Population)
Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

High demand for labour encouraged groups who were previously in a disadvantageous situation, including women, young people and older workers to seize new opportunities. The boom-induced labour shortages also reduced the incidence of long-term unemployment in 2000–2007. Employment thus fell in agriculture and industry, while net job creation was concentrated in the services sector and, in more recent years, in the construction sector. By 2008, the services sector accounted for 60% of total employment. It was lower than the average in EU countries. The employment share of agriculture and industry in total employment, 4%–8% and 27%–34% respectively, was still higher than the average in EU countries (Table 5).

The crisis of 2008–2009 reduced the number of people employed, possibly due to problems in the services industry. It was only in 2010 that the labour market improved, supported by a growing economy and a sizeable decline in the working-age population (OECD 2010, Purju 2013). Moderate but steady GDP growth was instrumental in the decline of unemployment. The decline in the working-age population was, in turn, the result of an ageing

Table 5. Employment Structure in the Baltic States in 2000–2006

| Specification | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2011 | 2012 | 2014 |
| Services (% of Total Employment) | | | | | | | | | |
| European Union (28 countries) | 66.1 | 67.6 | 68.7 | 69.5 | 70.1 | 71.8 | 72.1 | 72.5 | 73.1 |
| Euro area (19 countries) | 69.1 | 70.0 | 71.0 | 71.7 | 72.5 | 74.1 | 74.5 | 74.8 | 75.4 |
| Estonia | 60.5 | 62.3 | 60.4 | 62.4 | 61.7 | 66.9 | 64.6 | 65.7 | 67.4 |
| Latvia | 60.7 | 59.6 | 62.9 | 62.4 | 65.3 | 68.8 | 68.2 | 68.1 | 68.8 |
| Lithuania | 55.0 | 55.3 | 56.4 | 55.6 | 61.5 | 66.6 | 67.0 | 66.1 | 66.1 |
| Industry (% of Total Employment) | | | | | | | | | |
| European Union (28 countries) | 26.2 | 25.7 | 25.1 | 24.7 | 24.5 | 22.8 | 22.7 | 22.4 | 21.9 |
| Euro area (19 countries) | 26.2 | 25.6 | 24.9 | 24.4 | 24.0 | 22.4 | 22.1 | 21.8 | 21.2 |
| Estonia | 32.8 | 30.9 | 33.8 | 32.8 | 34.4 | 28.9 | 31.0 | 29.8 | 28.8 |
| Latvia | 24.7 | 25.6 | 26.4 | 27.3 | 27.1 | 23.3 | 23.8 | 24.0 | 23.7 |
| Lithuania | 26.4 | 27.1 | 28.0 | 30.6 | 30.5 | 24.6 | 24.6 | 25.1 | 24.7 |
| Agriculture (% of Total Employment) | | | | | | | | | |
| European Union (28 countries) | 7.7 | 6.7 | 6.2 | 5.7 | 5.4 | 5.4 | 5.2 | 5.1 | 5.0 |
| Euro area (19 countries) | 4.7 | 4.4 | 4.1 | 3.9 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 |
| Estonia | 6.6 | 6.8 | 5.8 | 4.8 | 3.9 | 4.2 | 4.4 | 4.5 | 3.7 |
| Latvia | 14.6 | 14.8 | 10.8 | 10.3 | 7.6 | 7.8 | 8.0 | 7.8 | 7.4 |
| Lithuania | 18.6 | 17.7 | 15.6 | 13.8 | 8.0 | 8.8 | 8.5 | 8.8 | 9.2 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

Table 6. The International Migration Balance in the Baltic States in 2000–2006

| Country | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 |
| Estonia | –2.3 | –2.2 | –2.7 | –4.0 | –1.5 | –2.8 | –2.8 | –0.5 | 0.8 |
| Latvia | –6.9 | –4.0 | –6.8 | –4.0 | –10.3 | –17.0 | –5.8 | –4.3 | –6.2 |
| Lithuania | –5.8 | –3.4 | –9.5 | –7.5 | –5.1 | –25.2 | –7.1 | –4.2 | –10.5 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

Table 7. Monthly Minimum Wages in the Baltic States in 2000–2016 (in Euro)

| Country | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 |
| Belgium | 1 095.89 | 1 163.02 | 1 186.31 | 1 234.00 | 1 387.50 | 1 387.50 | 1 472.42 | 1 501.82 | 1 531.93 |
| Bulgaria | 38.35 | 51.24 | 61.35 | 81.81 | 122.71 | 122.71 | 148.28 | 173.84 | 214.75 |
| Czech Republic | 126.33 | 194.76 | 210.99 | 279.19 | 309.10 | 311.39 | 312.01 | 309.62 | 364.90 |
| Germany | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 1 440.00 |
| Estonia | 89.48 | 118.24 | 158.50 | 191.73 | 278.02 | 278.02 | 290.00 | 355.00 | 430.00 |
| Ireland | 944.71 | 1 008.93 | 1 183.00 | 1 292.85 | 1 461.85 | 1 461.85 | 1 461.85 | 1 461.85 | 1 546.35 |
| Greece | 540.14 | 582.00 | 630.77 | 709.71 | 862.82 | 862.82 | 683.76 | 683.76 | 683.76 |
| Spain | 495.60 | 515.90 | 572.60 | 631.05 | 728.00 | 738.85 | 748.30 | 752.85 | 764.40 |
| France | 1 083.29 | 1 154.27 | 1 286.09 | 1 254.28 | 1 337.70 | 1 343.77 | 1 425.67 | 1 445.38 | 1 466.62 |
| Croatia | n/a | n/a | n/a | n/a | 386.91 | 390.94 | 374.31 | 398.31 | 414.45 |
| Latvia | 87.78 | 100.18 | 121.77 | 129.29 | 255.83 | 253.77 | 287.07 | 320.00 | 370.00 |
| Lithuania | 112.61 | 124.55 | 144.81 | 173.77 | 231.70 | 231.70 | 231.70 | 289.62 | 380.00 |
| Luxembourg | 1 220.88 | 1 322.47 | 1 402.96 | 1 503.42 | 1 682.76 | 1 724.81 | 1 801.49 | 1 921.03 | 1 922.96 |
| Hungary | 98.02 | 204.14 | 210.65 | 220.58 | 263.30 | 256.99 | 323.17 | 328.16 | 350.09 |
| Malta | 509.60 | 532.40 | 547.69 | 584.23 | 634.88 | 659.92 | 685.14 | 717.95 | 728.04 |
| Netherlands | 1 110.80 | 1 231.80 | 1 264.80 | 1 284.60 | 1 398.60 | 1 416.00 | 1 456.20 | 1 495.20 | 1 537.20 |
| Poland | 167.32 | 187.20 | 182.16 | 221.72 | 286.61 | 317.58 | 353.04 | 404.16 | 417.02 |
| Portugal | 371.27 | 406.01 | 425.95 | 449.98 | 525.00 | 554.17 | 565.83 | 565.83 | 618.33 |
| Romania | 34.29 | 52.38 | 68.92 | 92.43 | 142.61 | 137.30 | 157.26 | 205.34 | 276.34 |
| Slovenia | 371.40 | 417.87 | 464.54 | 511.62 | 589.19 | 734.15 | 763.06 | 789.15 | 790.73 |
| Slovakia | 93.81 | 112.02 | 152.48 | 179.92 | 295.50 | 307.70 | 327.00 | 352.00 | 405.00 |
| United Kingdom | 936.26 | 1 038.78 | 1 107.72 | 1 200.69 | 1 112.55 | 1 169.49 | 1 244.42 | 1 301.31 | 1 447.07 |

Source: http://ec.europa.eu/eurostat/data/database (accessed: 29 August 2017).

population and persistent net emigration (Hazans 2011, Aidukaite 2011). The international migration balance continued to be negative (Table 6). Nevertheless, the unemployment rate in 2010–2016 remained above its pre--crisis level.

The reasons for the high level of emigration in the Baltic states were: the difficulty in finding a job due to the low number of job offers, failure to meet the criteria and expectations of employers, the low level of wages (the minimum wage in the Baltic states is one of the lowest in the EU – Table 7), and the impoverishment of society[2]. This led to the situation that a large proportion of the population (particularly young people) did not see a future for themselves in these countries. That is why many people chose to leave their country to seek work, especially in West European countries (Gruzevskis & Blaziene 2013, Lulle 2013, Aidukaite 2011).

The problems of increasing emigration have put Lithuania, Latvia and Estonia in a complex situation. While heavy emigration may provide limited short-term relief to the region's unemployment problems, the region's demographic issues will pose serious economic and political challenges in the long run.

Therefore, Baltic countries will have to deal with a shrinking workforce and a growing number of retirees – factors that will reduce each country's tax base while increasing fiscal pressure on governments, since the latter will need to devote greater resources to areas such as pensions and health care. Demographic change will also lead to growing competition for skilled and semi-skilled workers in Europe. Unless they can find ways to keep their most valuable workers at home, Baltic countries will likely be among the losers in the EU-wide race for workers.

## 4. Conclusions

Facing high unemployment (especially among young people), modest incomes and a more unequal income distribution than in many European countries, Baltic policy-makers have limited room for manoeuvre. In employment policy, the chief goal must be to improve the institutional framework for innovation and job creation. Most elements of the labour market and social policy have been thoroughly reformed over the past decade. For obvious reasons, reform activity until now has been largely inspired by policy examples set in EU countries. However, policy-makers

[2] For comparison, labour costs in other EU countries and in Poland are discussed in European Commission (2017d) and in Maślanka (2010, 2011).

must also take into account the more difficult situation in the Baltic states, the market with a significantly low labour supply, modest living standards and relatively unequal income distributions. Social spending needs to be contained because taxes and social insurance contributions are relatively high, placing a heavy burden on employment.

Finding a solution to unemployment depends mainly on whether it reflects cyclical or structural factors. Policies to address cyclical unemployment primarily focus on demand management. However, addressing structural unemployment tends to require deep and targeted reforms that tackle the underlying forces of why the unemployed do not find their way to jobs that match their skills and expectations).

The governments of the Baltic countries should look for new solutions to combat unemployment, raise standards of living, and improve life prospects for citizens (especially for young people) as well as create a support programme for the poorest households.

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## Abstract

### Wpływ sytuacji makroekonomicznej na rynek pracy w krajach nadbałtyckich w latach 2000–2016

Przystąpienie państw nadbałtyckich do struktur Unii Europejskiej wymagało przeprowadzenia licznych reform strukturalnych, w tym reformy rynku pracy. Należy zauważyć, że bezrobocie w tych krajach w całym okresie badawczym utrzymywało się na wysokim poziomie. Taki stan uzależniony był w dużej mierze od sytuacji makroekonomicznej kraju. Celem artykułu jest zatem analiza wpływu sytuacji makroekonomicznej na rynek pracy w krajach nadbałtyckich.

**Słowa kluczowe:** kraje bałtyckie, rynek pracy, bezrobocie, zatrudnienie, emigracja, wzrost gospodarczy.

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