# The Use of the Taxonomic Measure in Assessing the Intensity of Border Regions Interaction

Łukasz D. Wróblewski[1]

Abstract:

*This study concerns the analysis of the intensity of regional ties, in particular those between border regions. Given its strictly methodological character, the goal of this study is to delineate the possible uses of numerical taxonomy in assessing the intensity of cross-border ties. The first section of the text recounts the methodological problems resulting from the use of qualitative and quantitative data in regional studies, while also outlining a strategy of measuring cross-border ties within the scope of the taxonomic measure. This is followed by an analysis showcasing the potential of the proposed methodology in assessing ties between border regions.*

## Introduction

While a relatively new subject of investigation, borderlands studies has attracted interest from a range of authors across different academic fields, adding to its interdisciplinary character. In particular, borderlands studies have appealed to scholars grounded in political science, regional or human geography, sociology, and cultural studies. On the other hand, investigations of its legal and economic ramifications have been somewhat less prominent. As a result, no commonly accepted theories of cross-border cooperation have been established, as frequently lamented in the subject literature (Strassoldo 1974; Newman 2006; Virkkunen 2002; Perkmann 2003; Raczyk et al. 2012; Wróblewski 2017, 2018, 2020a, 2020b), let alone a comprehensive inventory of research methodologies. Hence, the vast

---

1    Łukasz D. Wróblewski, PhD (ORCID 0000-0003-3677-043X) – Poznań University of Economics and Business, Institute of International Business and Economics, Department of European Studies; e-mail: lukasz.wroblewski@ue.poznan.pl

majority of inquiries have been confined to case studies (Brenner 2013; Wróblewski 2017), essentially preventing comparative analyses and generalizations.

Existing literature on the borderland studies presents a range of models that specify different types of border regions based on the intensity of their interactions. Particularly significant are the typologies of border regions offered by Stiglbauer and Lackinger (1980), Sanguin (1983), Leimgrüber (1991), and Strassoldo (1974b), and models proposed by Strassoldo (1989), Martinez (1994), House (1981, quoted in: Minghi 1991, 1994), Minghi (1991), Brunet-Jailly (2005), Decoville, Durand, Sohn and Walther (2010), Herzog and Sohn (2014), and Sohn (2014). It has been suggested that these models may help in evaluating the intensity of cross-border interaction (Raczyk, Dołzbłasz, and Leśniak-Johann 2012; Van der Velde 2012; Wróblewski 2017, 2020a, 2020b). However, these models are rather general and are not measurable in nature, as the authors themselves admit (Leimgrüber 1991).

The aim of this paper is to demonstrate the capacity of numerical taxonomy in the assessment of interaction between border regions. The first section concerns the methodological problems resulting from the use of qualitative and quantitative data in regional studies, including borderlands studies. This is followed by a strategy of assessment of cross-border ties employing the taxonomic measure. The latter section of the study evaluates the capacities of numerical taxonomy in the analyses of multidimensional ties of border regions, based on selected Polish and German border towns.

## Taxonomic measure – strategy of analysis

The fundamental methodological problem in borderlands studies research is the limited comparability of secondary (quantitative) data, caused in particular by the differences in the aggregation, or a complete lack thereof. This hurdle is specifically noticeable in the studies of interaction at the lowest level of regional authorities (local governments). Therefore, many borderland scholars have focused their efforts on analyzing various phenomena at higher levels, e.g. NUTS-2 or NUTS-3, or have narrowed their research to specific regions, such as border towns.

The above problem can be partially resolved by employing qualitative (e.g. questionnaire-based) studies. From the methodological standpoint, such studies are of equal academic value as quantitative-based analyses, even if some scholars call this approach into question. Some researchers go as far as to entirely dismiss qualitative methods in the description of social and cultural phenomena.

Hence, a number of authors stress the superiority of quantitative methods over qualitative ones, decrying the latter on account of their subjectivity and non-representativeness.

On the other hand, qualitative studies only allow us to access a specific type of data, i.e. qualitative data categorized using an ordinal scale, usually the Likert scale. The other attendant issue with qualitative research is the relatively limited range of statistical operations performable with variables on an ordinal scale. The subject literature assumes that with this particular type of data, one can only determine a relation of equality, minority or majority, e.g. by assigning the values of (-1), (0), or (1) to the respective variables, depending on the relation of minority, equality or majority, and the sole statistical operations that may be performed in this case are medians, percentiles, rank correlation coefficients (e.g. Spearman's rank correlation coefficient), and non-parametric tests (Stanisz 2006; Gatignon 2003; Walesiak 1993, 2003, 2011a, 2011b, 2012), which substantially narrows the catalog of research methods.

Another frequently invoked argument involves variable selection, questionnaire structure, and sampling. Regardless of the adopted research methodology, however, variable selection always depends on the study goal and subject. An adequately devised questionnaire constitutes a crucial research tool in collecting key data with regard to the study goal and subject, since the very questionnaire structure stipulates that the researcher has thorough knowledge of the subject matter (Oppenheim 1992). At the same time, any qualitative study preceded with a methodologically adequate sampling must be considered representative. Thus, qualitative methods should be deemed equally important to the methods based on secondary data. In many cases, the former turn out as the sole way of demonstrating and probing specific phenomena, in particular when quantitative data prove to be incomparable (e.g. due to methodological reasons), incomplete (due to insufficient data), inaccessible (e.g. due to the lack of access clearance), or generally non-aggregatable. Cross-border ties are a perfect case in point in this context.

From the methodological standpoint, however, the variables ranked on an ordinal scale can be treated as metrical variables (Walesiak 2011a, 2012; Elliott and Woodward 2007), thus enabling statistical operations typical of metrical variables. To this end, they should be assigned specific numerical values corresponding with the adopted measurement scale and based on the selected coding method (linear and non-linear coding, ranking). The adopted measurement scale ought to have a normal distribution. Therefore, it is suggested that regional analyses employ variable coding based on ranking.

The transformation of data ranked on an ordinal scale into metrical variables enables these types of variables to be processed using numerical taxonomy methodology, e.g. the taxonomic measure (TM). While extremely useful in regional analyses, these methods essentially fail to be employed in borderlands studies.

The TM provides a tool for the exploratory data analysis aimed at the classification of the objects of research based on the distances between the respective objects or their features (both quantitative and qualitative) in a one-dimensional or multi-dimensional space. To this end, the TM uses measures (metrics) of distance, e.g. Euclidean distance and Euclidean squared distance, Manhattan distance, Chebyshev distance, and (less frequently) exponential distance or geometric incompatibility.

Each of these measures illustrates dissimilarity. The bigger the distance between the investigated objects or their characteristics, the more dissimilar they are to one another. Measures of distance assume values within a set of non-negative real numbers.

The most frequently used measure of dissimilarity is the Euclidean metric (1), which simply illustrates the geometrical distance between the analyzed objects in a multidimensional space (Stanisz 2006).

(1)

$$d(x, y) = \sqrt{\sum_{i=1}^{p} (x_i - y_i)^2}$$

If the researcher wishes to stress the importance of the objects most remote from each other, they may square the Euclidean distance, hence arriving at the Euclidean square distance.

The undoubted upside of both these metrics is their resilience to outstanding (i.e. significantly higher/lower) variables, as these variables do not impact the distance between the studied objects. Still, the Euclidean metric tends to be susceptible to the differences of units between the dimensions on the basis of which distances are calculated. Therefore, the quantitative variables describing the studied objects should be normalized (standardized or unified), thus allowing the analyzed data to be transposed to a comparable scale. Otherwise, the results

of the conducted analysis may not only prove to be erroneous but also misleading. Conversely, when pre-coded, the qualitative variables do not require normalization.

Given that the taxonomic measure is de facto a synthetic measure, it can be successfully applied in assessing different types of ties, including multidimensional ones (dependent on a number of factors) between border regions situated on both sides of the border, thus classifying them based on the degree of intensity of those ties. The value of the TM indicator falls in the [0:1] range. The closer its value gets to [1], the more intense the ties it designates. The TM is also usually based on the Euclidean metric, which in this case assumes the form of (2), illustrating the distances between individual objects or their characteristics in a multidimensional space from a hypothetical or actual pattern or anti-pattern[2], as well as the average value (3) and the standard deviation (4) for this distance. Consequently, the taxonomic measure (TM) is determined in accordance with formula (5), as a modification of Hellwig's linear ordering method (Hellwig 1967, 1968).

(2)

$$d(x,z) = \sqrt{\sum_{i=1}^{p}(x_i - z_i)^2}$$

(3)

$$\overline{d(x,z)} = \frac{1}{n}\sum_{i=1}^{n} d(x,z)_{it}$$

(4)

$$S_{d(x,z)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(d(x,z) - \overline{d(x,z)})^2}$$

(5)

$$TM = 1 - \frac{d(x,z)_{it}}{\overline{d(x,z)} + 2 * S_{d(x,z)}}$$

where: $d(x,z)$ - Euclidean distance of the variable, $x_i$ - variable value, $z_i$ - value of the hypothetical pattern; $\overline{d(x,z)}$ - Euclidean distances average; $S_{d(x,z)}$ - standard deviation for Euclidean distances; $TM$ - taxonomic measure.

This method may also prove useful in operationalization invoking the models presented in the subject literature, which specify different types of border regions depending on the types of ties between them, as determined by Strassoldo (1989), Leimgrüber (1991), Martinez (1994), Minghi (1991), and Decoville, Durand, Sohn and Walther (2010, 2013). These models are rather general, as the authors themselves admit (Leimgrüber 1991). As a result, it is difficult to use these models

---

2  "Pattern" denotes the hypothetical or actual highest possible variable value. Conversely, "anti-pattern" designates the lowest possible variable value. Their respective values depend on the measurement scale adopted by the researcher.

to determine how far the examined border region is from reaching a subsequent stage of development. To this end, one can use the class frequency formula (6) to determine the limit values for the specified stages of development (table 1) and assign the synthetic measure (TM) obtained in the course of analysis to one of these stages. One undeniable advantage of the proposed method is its objectivity because the respective class divisions are independent of the researcher's opinion.

(6)

$$h = \frac{r}{k} = \frac{maxTM - minTM}{k}$$

where: h — class frequency range, r — class frequency gap, k — projected number of classes

**Table 1. Class frequency ranges within the model of borderlands interactions**

| Type of borderlands | Class frequency range | Limit values |
|---|---|---|
| 4 - integrated borderlands | maxTM - 1h : maxTM | 0,75 : 1 |
| 3 - interdependent borderlands | maxTM - 2h : maxTM - 1h | 0,5 : 0,75 |
| 2 - coexistent borderlands | maxTM - 3h : maxTM - 2h | 0,25 : 0,5 |
| 1 - alienated borderlands | minTM : maxTM - 3h | 0 : 0,25 |

Source: own study.

In line with the above, Martinez's model of borderlands interactions (1994) coined to identify the degree of border regions integration would require the adoption of a four-point measurement scale, corresponding to the stages identified by Martinez, which would span from 1 to 4, with [1] as the anti-pattern, and [4] as the pattern. If the value of TM were equal to the uppermost limit value of a given frequency, the object should be attributed to the subsequent frequency range. Such a structure of class frequency ranges may be conducted both for stable and discrete features. The final stage of the procedure involves the assignment of the TM value to one of the classes determined by the researcher.

## Measuring the intensity of cross-border ties using the taxonomic measure: the case of Polish-German twin cities

For the purposes of this study, an analysis has been conducted to demonstrate the scope of application of the Euclidean distance and the TM in the assessment of multidimensional ties between border regions, ranked on a four-point scale, as in Martinez's model of borderlands interactions presented above. The author chose to analyze the cross-border interaction of businesses based in selected border towns located on the Polish-German border, i.e. Görlitz and Zgorzelec, Słubice and Frankfurt (Oder), Gubin and Guben. The selection of regions for analysis was strictly goal-oriented and driven by two premises. First, as indicated by the query of the subject literature, the so-called twin cities should be characterized by intensive interaction. Second, the geographic vicinity of these three twin cities may facilitate the observation of the investigated phenomena[3]. The subject literature in this regard is immensely rich and intriguing (Jakubowicz and Ciok 2003; Musiał-Karg 2010; Dołzbłasz 2008; Oβenbrügge 1996; Dołzbłasz and Raczyk 2012; Dolińska and Niedźwiecka-Iwańczak 2016; Guz-Vetter 2002; Ciok 2004; Szmigiel-Rawska and Dołzbłasz 2012; Raczyk et al. 2012; Wróblewski 2017, 2018, 2020a, 2020b; among others). Therefore, it appears legitimate to pose the following research question: What is the current intensity of cross-border economic ties between them? Due to the limited availability of quantitative data determining the analyzed business ties, quality (questionnaire-based) tests were conducted instead[4].

The analytical procedure featured three stages. The first stage involved the determination of the minimum sample size. In the second stage, a catalog of variables describing the ties between businesses was compiled. Finally, based on the empirical data obtained from the respondents, the Euclidean distance and the TM value were determined.

The sampling of the twin cities' businesses was random, based on stratified sampling without replacement, in accordance with the minimal sample size formula. Two strata were adopted: spatial (the area of the twin cities on the Polish-German border), and functional (selected business profiles)[5]. The sampling frame thus amounted to a total of 10,844 business entities (77% of all enterprises

---

3   From a methodological standpoint the TM may be applied in assessing ties between other border regions (LAUs or NUTs).

4   The survey was conducted prior to the imposition of restrictions in cross-border traffic on the Polish-German border due to the Covid-19 pandemic.

5   The sampling accounted for the 7 dominant business profiles (NACE Rev. 2), ensuring the adequate number and coherence of the functional stratum.

registered in the area): Słubice (2275) - Frankfurt (Oder) (1914); Gubin (1767) - Guben (553); Zgorzelec (2815) - Görlitz (1520). A stratified sample was adopted with a confidence interval of 1-α=0,95 and a risk factor of α = 0,05, whose accuracy (confidence level) amounted to $u_\alpha$= 1,96. The margin of statistical error was estimated at 6% (d = 0,06), and the population proportion (the stratum weight) – at 0,5. The sample size totalled to 741 business entities: Słubice (136) - Frankfurt (Oder) (115); Gubin (181) - Guben (58); Zgorzelec (163) - Görlitz (88)[6].

**Table 2. Diagnostic variables (scale: 1-4)**

| Diagnostic variables | |
|---|---|
| Relations between companies and business services and goods providers | Share of services (X1) or goods (X2) providers from the border region located across the border in the total number of services or goods provided |
| | Share of services (X3) or goods (X4) purchased from companies active in the border region located across the border in the total number of purchased services or goods |
| | Value of services (X5) or goods (X6) purchased from companies active in the border region located across the border in the total value of purchased services or goods |
| | Significance of service (X7) or goods (X8) providers from the border region located across the border to the type of business conducted by the enterprises |
| | Intensity of contacts with service (X9) or goods (X10) providers from the border region located across the border |
| Relations of enterprises with business purchasers of services and goods | Share of business purchasers of services (X11) or goods (X12) from the border region located across the border in the total number of business purchasers of services or goods |
| | Share of services (X13) or goods (X14) sold to businesses from the border region located across the border in the total number of services or goods sold to business purchasers of services or goods |
| | Value of services (X15) or goods (X16) sold to businesses from the border region located across the border measured against the total of services or goods sold to business purchasers |
| | Significance of business purchasers of services (X17) or goods (X18) from the border region located across the border to the type of business conducted by the enterprises |
| | Intensity of contacts with business purchasers of services (X19) or goods (X20) from the border region located across the border |

Source: own study.

Upon determining the above, the catalog of variables was specified. In the subject literature, it is assumed that the dominant types of businesses in border

---

6   The research sample was dominated by business entities with a track record between 11 and 20 years. They comprised 42% of the sample. 28% of the sample had conducted their business operations for over 20 years. The remaining enterprises had been on the market for 6 to 10 years (25%). The smallest group comprised of enterprises with a track record of 3 to 5 years (5%). Most of the examined enterprises were small entities hiring up to 9 employees (39%) and between 10 and 49 employees (54%). Medium enterprises with personnel of 50 to 249 amounted to as little as 7% of the research sample. No large enterprises (over 250 workers) took part in the study. The majority of the analyzed businesses were active in services, wholesale and retail trade, and vehicle repair.

regions are micro- and small enterprises, which frequently fail to engage in any form of internationalization other than the direct exchange of goods and services. Consequently, for the purposes of this study, a set of 20 diagnostic variables was created based on substantive and formal criteria, in order to describe the service- and goods-based ties of business enterprises on an ordinal scale of 1 to 4 (table 2). Based on those variables, questionnaires were drawn up, whose adequacy was verified in the course of a pilot study.

The compiled questionnaires were mailed directly to the strategic decision makers in the analyzed enterprises. The conducted research complied with the preconditions of questionnaire standardization and coherent methodology framework. The total rate of return amounted to 13.4%: Słubice - Frankfurt (Oder) (8.8%); Gubin - Guben (13.8%); Zgorzelec - Görlitz (17.5%).

On the basis of the submitted material, values of 1 to 4 were assigned to the respective diagnostic variables, in accordance with the adopted measurement scale. Such a procedure allowed the determination of Euclidean distances for each of the analyzed variables, along with the average value and the standard deviation value for these distances. This was followed by the establishment of the taxonomic measure and the subsequent classification of the obtained measure. The results of the conducted analysis are presented in the table below.

**Table 3. Interaction between selected twin cities on the Polish-German border in light of the taxonomic measure***

| Variable | Zgorzelec – Görlitz | | Słubice - Frankfurt (Oder) | | Gubin – Guben | |
|---|---|---|---|---|---|---|
| | TM | 1-4 | TM | 1-4 | TM | 1-4 |
| X1 | 0,02 | 1 | 0,01 | 1 | 0,01 | 1 |
| X2 | 0,02 | 1 | 0,01 | 1 | 0,01 | 1 |
| X3 | 0,01 | 1 | 0,01 | 1 | 0,01 | 1 |
| X4 | 0,04 | 1 | 0,03 | 1 | 0,03 | 1 |
| X5 | 0,03 | 1 | 0,02 | 1 | 0,01 | 1 |
| X6 | 0,01 | 1 | 0,04 | 1 | 0,01 | 1 |
| X7 | 0,01 | 1 | 0,01 | 1 | 0,01 | 1 |
| X8 | 0,01 | 1 | 0,03 | 1 | 0,01 | 1 |
| X9 | 0,04 | 1 | 0,05 | 1 | 0,03 | 1 |
| X10 | 0,03 | 1 | 0,05 | 1 | 0,02 | 1 |
| X11 | 0,01 | 1 | 0,01 | 1 | 0,01 | 1 |
| X12 | 0,01 | 1 | 0,01 | 1 | 0,01 | 1 |
| X13 | 0,00 | 1 | 0,01 | 1 | 0,02 | 1 |
| X14 | 0,02 | 1 | 0,01 | 1 | 0,04 | 1 |

| Variable | Zgorzelec – Görlitz | | Słubice - Frankfurt (Oder) | | Gubin – Guben | |
|---|---|---|---|---|---|---|
| | TM | 1-4 | TM | 1-4 | TM | 1-4 |
| X15 | 0,02 | 1 | 0,01 | 1 | 0,01 | 1 |
| X16 | 0,02 | 1 | 0,05 | 1 | 0,02 | 1 |
| X17 | 0,02 | 1 | 0,01 | 1 | 0,03 | 1 |
| X18 | 0,02 | 1 | 0,04 | 1 | 0,02 | 1 |
| X19 | 0,04 | 1 | 0,03 | 1 | 0,02 | 1 |
| X20 | 0,03 | 1 | 0,03 | 1 | 0,00 | 1 |

* - For editorial purposes, the results have been rounded off to the second decimal.
Source: own study.

Table 3 shows that the economic ties are marginal. This, however, does not indicate that the examined entities manifested only limited ties. Some of them demonstrated high levels of relations. Yet the differences in the Euclidean distances between particular variables were not significant enough to affect the value of the TM.

## Conclusions

The conducted research has validated the suitability of distance measurements and the taxonomic measure in the assessment of intensity of different local and regional ties, including cross-border interaction, as best exemplified by the applicability of these measures in the operationalization of the models and typologies of border regions expounded on in the subject literature. The proposed methodology can be successfully applied to different types of variables, both quantitative and qualitative ones, because from the methodological standpoint, the operational strategy is identical in both cases, aside from the fact that quantitative variables require normalization, while qualitative variables necessitate coding. As part of this study, an analysis was conducted of service- and goods-related ties between companies operating in selected Polish and German border towns, i.e. Görlitz and Zgorzelec, Słubice and Frankfurt (Oder), Gubin and Guben. However, from a methodological standpoint the proposed method may also be applied in assessing the intensity of other relations (e.g. shopping tourism). The principle goal of the analysis conducted in this study was to verify the proposed methodology.

The collected empirical material indicates that, despite their conducive location on the Polish-German border, the examined twin cities fail to manifest vital service- and goods-based interaction. Granted, the analyzed population

included a group of businesses with an above-average ranking (scoring from 3 to 4), however these businesses did not substantially impact the overall TM value. Their number was simply insufficient to reduce the distances between variables set in a multidimensional space from their hypothetical pattern. As a result, the synthetic value for all variables amounted to [1] on a four-point scale.

The subjects of investigation were also characterized by an asymmetrical pattern of cooperation. The enterprises based in the Polish regions were more prone to declare their drive towards cross-border collaboration than their German counterparts, a tendency correspondent with some findings discussed in the existing subject literature (Guz-Vetter 2002; Ciok 2004; Szmigiel-Rawska and Dołzbłasz 2012; Raczyk et al. 2012; Wróblewski 2017, 2018, 2020a, 2020b; among others). The lack of sufficient commitment of the German businesses may result from their perception of the majority of Polish enterprises in the analyzed border regions as small enterprises with no long-standing track record or significant market share. Thus, the conducted analysis differs to an extent from the research of some other authors (Raczyk et al. 2012; Guz-Vetter 2002), who demonstrated that Polish enterprises, due to their local orientation and high costs of internationalization, are less prone to engage in any form of internationalization than German businesses. Similarly, some of the respondents participating in this study declared that while they did seek international partners, their pursuits were oriented towards the interior and/or urban areas outside of the twin cities on the border (the so-called tunnel effect), as corroborated by earlier research (Raczyk et al. 2012; Guz-Vetter 2002; Wróblewski 2017, 2018, 2020b). It is evident based on such practices that the process of business cooperation seems to be determined primarily by market objectives.

**Literature:**

Brenner, C.T. (2013). The Role of Comparative Analysis in Borderlands Studies. *Public Policy and Public Affairs*, Paper 47.

Ciok, S. (2004). *Pogranicze polsko-niemieckie. Problemy współpracy transgranicznej.* Wrocław.

Decoville, A., Durand, F., Sohn, Ch., Walther, O. (2010). Spatial integration in European cross-border metropolitan regions: A comparative approach. *CEPS INSTEAD Working Papers,* No 2010–40.

Decoville, A., Durand, F., Sohn, Ch., Walther, O. (2013). Comparing Cross-border Metropolitan Integration in Europe: Towards a Functional Typology. *Journal of Borderlands Studies, Vol. 28, Issue 2.*

Dolińska, K., Niedźwiecka-Iwańczak, N. (2016). Mieszkańcy pogranicza zachodniego o niemieckich sąsiadach a Polacy o Niemcach. *Pogranicze. Studia Społeczne. vol. XXVII, issue 2.*

Dołzbłasz, S. (2008). Rozwój współpracy międzynarodowej na poziomie regionalnym i lokalnym w Europie jako element polityki spójności. In: E. Pancer-Cybulska (ed.). *Spójność społeczna, gospodarcza i terytorialna w polityce Unii Europejskiej.* Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, nr 21. Wrocław.

Dołzbłasz, S., Raczyk, A. (2012). Transborder openness of companies in a divided city: Zgorzelec/ Görlitz case study. *Tijdschrift voor economische en sociale geografie. Vol. 103. Issue 3.*

Elliott, A.C., Woodward, W.A. (2007). *Statistical analysis quick reference guidebook. With SPSS examples.* Thousand Oaks: SAGE Publications.

Gatignon, H. (2003). *Statistical Analysis of Management Data*. Norwell: Kluwer Academic Publisher.

Guz-Vetter, M. (2002). *Polsko-niemieckie pogranicze. Szanse i zagrożenia w perspektywie przystąpienia Polski do Unii Europejskiej.* Warsaw: Instytut Spraw Publicznych.

Hellwig, Z. (1967). Procedure of Evaluating High-Level Manpower Data and Typology of Countries by Means of the Taxonomic Method, COM/WS/91, Warsaw.

Hellwig, Z. (1968). Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr. *Przegląd Statystyczny, no. 15(4)*, pp. 307-326.

Herzog, A.L., Sohn, Ch., (2014). The Cross-Border Metropolis in a Global Age: A Conceptual Model and Empirical Evidence from the US–Mexico and European Border Regions. *Global Society 28(4).*

Jakubowicz, E., Ciok, S. (2003). Wybrane problemy układów bipolarnych w sieci osadniczej. In: Z. Zioło (ed.). *Bipolarny rozwój aglomeracji – kierunki rozwoju układów bipolarnych*. Biuletyn. z. 209.

Leimgrüber, W. (1991). Boundary, values and identity: The Swiss-Italian transborder region. In: Rumley D, Minghi J.V (eds) *The Geography of Border Landscapes,* London.

Martinez, O. (1994). *Border people. Life and society in the U.S. – Mexico borderlands*. Tucson.

Minghi, V.J. (1991). From conflict to harmony on border landscapes. In: Rumley D, Minghi J.V (eds) *The Geography of Border Landscapes*, London.

Musiał-Karg, M. (2010). Współpraca transgraniczna w Europie na przykładzie doświadczeń regionów i miast przygranicznych. In: J. Jańczak, M. Musiał-Karg, L. Wojnicz (eds.). *Pogranicze polsko-niemieckie na tle granic i pograniczy europejskich*. Poznań: WNPiD UAM.

Newman, D. (2006). The Progress in Human Geography lecture. The lines that continue to separate us: borders in our 'borderless' world. *Progress in Human Geography, No. 30.*

Oppenheim, A.N. (1992). *Questionnaire, design, interviewing and attitude measurement*. London: Pinter Pub Ltd.

Oβenbrügge, J. (1996). Oddziaływanie gospodarcze i współpraca na niemiecko-polskim obszarze przygranicznym – perspektywa porównawcza. In: Z. Chojnicki, T. Stryjakiewicz (eds). *Problemy współpracy regionalnej w polsko-niemieckim obszarze przygranicznym*. Biuletyn, z. 171.

Perkmann, M. (2003). Cross-border regions in Europe. significance and drivers of regional cross-border co-operation. *European Urban and Regional Studies, Vol. 10, No. 2.*

Raczyk, A., Dołzbłasz, S., Leśniak-Johann, M. (2012). *Relacje współpracy i konkurencji na pograniczu polsko-niemieckim*. Wrocław.

Sadowski-Smith, C. (2011). Introduction: Comparative Border Studies. *Comparative American Studies, Vol. 9 No. 4.*

Sohn, Ch. (2014). Modelling Cross-Border Integration: The Role of Borders as a Resource. *Geopolitics 19(3).*

Stanisz, A. (2006). *Przystępny kurs statystyki z zastosowaniem STATISTICA PL na przykładach z medycyny, Statystyki podstawowe*. Kraków: StatSoft.

Strassoldo, R. (1974). *Friaul-Julisch Venetien als europäische Außengrenzregion. Probleme grenznaher Raum II*. Innsbruck.

Strassoldo, R. (1989). Border Studies: The State of the Art in Europe. In: Asiwaju A.I, Adeniyi P.O (eds) *Borderlands in Africa. A multidisciplinary and comparative focus on Nigeria and west Africa*. Lagos.

Szmigiel-Rawska, K., Dołzbłasz, S. (2012). *Trwałość współpracy przygranicznej*. Warsaw: CeDeWu.

Virkkunen, J. (2002). *Discourses, Boundaries and Scales. Estonian Territorial Political in the „New" Europe*. Tampere.

Walesiak, M. (1993). Strategie postępowania w badaniach statystycznych w przypadku zbioru zmiennych mierzonych na skalach różnego typu. *Badania Operacyjne i Decyzje, 1.*

Walesiak, M. (2003). *Miara odległości obiektów opisanych zmiennymi mierzonymi na różnych skalach pomiaru. Prace Naukowe Akademii Ekonomicznej we Wrocławiu nr 1006/2003. Zastosowania statystyki i matematyki w ekonomii*. Wrocław: WAE.

Walesiak, M. (2011a). Porządkowanie liniowe z wykorzystaniem uogólnionej miary odległości GDM2 dla danych porządkowych i programu R. In: Dziechciarz J (ed.). *Zastosowania metod ilościowych, Prace Naukowe Akademii Ekonomicznej we Wrocławiu nr 163/2011, Ekonometria 30*. Wrocław: WAE.

Walesiak, M. (2011b). *Uogólniona miara odległości GDM w statystycznej analizie wielowymiarowej z wykorzystaniem programu R*. Wrocław: WUE.

Walesiak, M. (2012). *Pomiar odległości obiektów opisanych zmiennymi mierzonymi na skali porządkowej – strategie postępowania. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu nr 242, Taksonomia 19, Klasyfikacja i analiza danych – teoria i zastosowania*. Wrocław: WAK.

Wróblewski, Ł.D. (2017). *Koncepcja pięciostopniowej integracji regionów przygranicznych*. Warszawa: Difin.

Wróblewski, Ł.D. (2018). Powiązania społeczno-gospodarcze na pograniczu polsko-niemieckim w warunkach rynku wewnętrznego Unii Europejskiej. *Studia Regionalne i Lokalne, vol. 19, No. 4(74)*.

Wroblewski, Ł.D. (2020a). Rethinking cross-border integration. A step to further discussion. *Border and Regional Studies. 8(3)*.

Wróblewski, Ł.D., (2020b). The Integration of Border Regions in the European Union: A Model Approach. *Journal of Borderlands Studies,* DOI: 10.1080/08865655.2020.1816201.