Przemysław SZCZUCIŃSKI*

THE HIERARCHY AND RELATIONSHIPS
BETWEEN TOWNS IN LUBUSKIE PROVINCE

HIERARCHIA I RELACJE MIAST
W WOJEWÓDZTWIE LUBUSKIM

ABSTRACT: In socio-economic geography any regional settlement system makes one of its major factors of development. It is towns that play a specific role in this system, the meaning of which can be approached from different perspectives. This paper focuses on the hierarchies and relationships between towns in the Province of Lubuskie seen from the spatial point of view. The volume and sequence rule of Zipf's law as well as the gravitation model have been used as the statistical tools. The data valid as in 2015 were accounted for in the analysis. Results from the empirical studies show that despite a similar urban density in Lubuskie Province and generally across Poland, the town system in the region is visibly specific. Apart from two largest cities playing a regional and cross-regional function, i.e. Zielona Góra and Gorzów Wlkp., the issue of how small and middle-sized towns function in the province comes to the fore.

KEY WORDS: settlement system, hierarchy of towns, gravity catchment, Lubuskie Voivodeship, spatial analysis

ABSTRAKT: Ukształtowany na terytorium regionu system osadniczy stanowi w geografii społeczno-ekonomicznej jeden z głównych czynników rozwoju. Szczególną rolę w systemie tym odgrywają miasta, których znaczenie rozpatrywać można z różnych perspektyw. W artykule z perspektywy przestrzennej badaniom poddano hierarchię i relacje miast w województwie lubuskim. Spośród narzędzi statystycznych wykorzystano regułę wielkości i kolejności Zipfa oraz model grawitacji. Analizę przeprowadzono na podstawie danych za rok 2015. Wyniki badań empirycznych wskazują, że pomimo podobnego zagęszczenia miast w województwie lubuskim jak ogólnie w kraju system miast w regionie charakteryzuje wyraźna specyfika. Obok dwóch największych miast pełniących funkcje regionalne i ponadregionalne, którymi są Zielona Góra i Gorzów Wlkp., duże znaczenie ma problematyka funkcjonowania małych i średnich miast w województwie.

SŁOWA KLUCZOWE: system osadniczy, hierarchia miast, ciążenia grawitacyjne, województwo lubuskie, analiza przestrzenna

* The Jacob of Paradies University in Gorzów Wlkp., Faculty of Economics, Department of Entrepreneurship and Innovation, 52 F. Chopina St., 66-400 Gorzów Wlkp., Poland, e-mail:pszczucinski@ajp.edu.pl, https://orcid.org/0000-0001-7796-579X

Introduction

A region can be defined as a zone subsystem that has a spatial quality. To make the definition more precise, it will be a set of areas bordering on each other and distinctively standing out as regards similar qualities (Korenik 2011: 9). A region comprises specific components, namely its natural environment, settlement system, its population, economic resources and infrastructure. Poland's administrative division makes a region refer to a province. Districts and municipalities are local tiers.

The settlement system of a region comprises a set of settlement units in its territory (Kuciński 2015: 348). On account of the status of the individual units, there are two basic types: towns and villages. A characteristic quality of a settlement system is its hierarchical structure. The hierarchy of settlement systems is expressed by their size, functions they perform within the system (e.g. administrative, production or service) and their spatial distribution.

The essence of hierarchy lies in that larger settlements are less numerous and are located at longer distances from each other, while smaller ones are closer to each other and are more numerous. In that context, it is towns that play a specific role; that of a village is less distinctive. Relationships between towns imply a flow of goods, of services, of humans and of information. These, in turn, affect the performance of the whole settlement system as well as its individual components.

The factors that shape a region's settlement system can be looked at from the historical, spatial and socio-economic perspectives. Among contemporary processes urbanisation, suburbanisation and counter-urbanisation are predominant (see Liszewski 2012: 198). Urbanisation plays an important role among them. It consists in a growth in the number and percentage of townspeople and in a rise in their socio-economic role. On the other hand, suburbanisation, which consists in movements of townspeople (generally out of a larger town) to its suburbs, becomes visible. Counter-urbanisation means that townspeople move further out – beyond the adjacent suburbs.

The report *Miasta przyszłości. Wyzwania, wizje, perspektywy* [Towns of the future. Challenges, visions, perspectives] states that urban development is indispensable for sustainable regional development of the European Union (KE 2011: 5). A significant role in the process is attached, beside large towns, to small and medium-sized ones. They make for important centres providing political and private services, accumulation of knowledge, fostering innovation and building infrastructure at a regional and local level. They exert their impact not only on the wealth and maintenance of their inhabitants, but on local population as well.

Regional spatial coherence and development of urban functional areas make for a tough challenge as defined in *Strategia Rozwoju Województwa Lubuskiego* [The development strategy for Lubuskie Province] (Sejmik Województwa Lubuskiego 2011: 10). Towns in the *Strategia* are called centres that absorb signals of development and transmit them onto rural areas. The objective behind this paper is to carry out an analysis into the formation of the size of towns in the region, their location and mutual

interrelationship. Statistical tools such as Zipf's sequence-size and the gravity model have been applied. The empirical data used refer to the state as in 2015.

Research method

One of the basic regularities that occur in a settlement system is a relationship between the sequence of towns and their size (Runge 2006: 439). That relationship is described by the so-called Zipf's rule of size-sequence. It can be expressed by the formula given below:

$$P_j = P_1 \cdot j^{-a} \quad (j = 1, 2, \ldots, n) \tag{1}$$

where:

P_j – j-town population,
P_1 – population of the largest town in a given set,
j – town number in the population sequence from the most densely populated one,
a – town size contrast exponent in the researched set.

In order to assess the parameters, this model has to be reduced to a linear form by finding the logarithm (see Formula 2):

$$\log P_j = b - a \cdot \log j \tag{2}$$

According to Zipf's law, the distribution of settlement units is affected by two forces: differentiating and uniting (Męczyński, Konecka-Szydłowska and Gadziński 2010: 14). The value of the contrast exponent $|a|=1$ means that the forces are in equilibrium and the system itself is balanced. Towns have been developed uniformly, with the principal town placed in the relative position. In the case where $|a|<1$, the force differentiating the town population is prevailing. This means that medium-sized towns are dominant, while the principal one plays a minor role. Conversely, when $|a|>1$, the unifying force prevails. The principal town holds a very strong position, with smaller towns dominating. To assess the parameters one of these methods can be applied: graphic, least squares or a mean exponent.

In the settlement system, relationships between towns in the region also play an important role. For towns can be seen as two centres separated from each other between which flows of humans, goods, funds and information take place. The force of integration between towns can be expressed by the gravity formula (see Formula 3):[1]

$$I_{ij} = \frac{P_i^{\alpha} \cdot P_j^{\beta}}{d_{ij}^{b}} \cdot k \quad (i, j = 1, 2, \ldots, n) \tag{3}$$

---

[1] Formulated by I. Newton (1687), the law of universal gravity says that two material particles attract one another proportionally to the product of their masses and inversely proportionally to the square of the distance between their centres. This dependency has been used outside physics proper to describe spatial formation of various economic and social events. The formulas here are after (Runge 2006: 468).

where:

   I_{ij} – interactive force between the towns i and *j*,

P_i, P_j – mass magnitude (population) of the towns i and *j*,

   d_{ij} – distance between the towns i and

   j, *k* – constant.

The formula parameters are found out empirically, applying various units depending on the specific quality of the researched set of units, types of masses and distances. Providing $k = \alpha = \beta = 1$, this formula may also be presented as follows (see Formula 4):

$$I_{ij} = \frac{P_i \cdot P_j}{d_{ij}^b} \tag{4}$$

In practical terms, the concept of distance also needs defining. It could be a straight line, road distance, temporal span, economic or social distance (for example available labour).

Towns in the region against the background of Poland

When the area and population are to be considered, the Province of Lubuskie places itself as one of the smallest in Poland. The region has the area of 13 988 km^2 and has two capitals: Gorzów Wielkopolski (seat of the province governor) and Zielona Góra (seat of the local diet). With respect to its administrative division, the province is divided into 12 landed districts and two municipal ones (the province capitals). Out of its 82 municipalities, 9 hold the status of an urban municipality, 33 are mixed urban-rural municipalities, and 40 ones are rural. The 2015 vital statistics show the population of 1 020 307 people, which makes 2.65% of Poland's population (GUS 2015).

The settlement system in a given region means a certain functional unity, a collection of interdependent and co-actively involved settlement units (Liszewski and Maik 2000: 281). In the Province of Lubuskie such a system is composed of 42 towns and 1 297 rural localities. Basic indices characterising how densely populated towns in the region are are given in Table 1.

It can be concluded that the density of towns in the province is comparable to the density of town networks in Poland. The number of towns in the region is 30.0 per 10 thousand square kilometres, while in Poland that index is 29.3 towns. It is also a similar area per a single town that both the province and Poland have. In the region it is 333.0 km^2, in Poland it is 341.7 km^2 on the average. On the whole, 42 towns in the region have the population of 663 334 people, that is 65.0% of the region's total. That index for Poland is 60.4%.

As regards the size structure of towns, the province has two such ones with 100 000 + inhabitants (Gorzów Wlkp. and Zielona Góra), 4 towns have their population between 20 and 100 thousand (Świebodzin, Żagań, Żary, Nowa Sól) and 34 towns with their

Table 1

Town density in Lubuskie Province against Poland for the year 2015

Specification	Lubuskie Province	Poland
Towns total	42	915
Towns per 10 km^2	30.0	29.3
Area per one town in km^2	333.0	341.7
Urban population in population total	65.0	60.4
Average population of one town	15 794	25 392
Number of rural localities per a single town	30.9	57.4

Source: own work based on GUS 2015 (access: 15.10.2017, http://www.stat.gov.pl).

population below 20 thousand.[2] As regards their spatial distribution, 26 towns are in the Zielona Góra subregion, and 16 in the Gorzów Wlkp. subregion. Both province capitals are of importance. They are described in Table 2 in comparison to some other capitals.

Table 2

Lubuskie Province capitals against selected provinces in 2015

Specification	Zielona Góra	Gorzów Wlkp.	Warszawa	Poznań	Katowice	Olsztyn	Opole
Population	138 711	123 762	1 744 351	542 348	299 910	173 444	118 931
Percentage of province population	13.6	12.2	32.6	15.6	6.6	12.0	11.9
Percentage of those at work*	17.0	16.3	47.5	21.5	12.6	19.0	20.9

* Data applies to entities employing more than 9 people.

Source: own work based on BDL GUS (access: 15.10.2017, http://www.stat.gov.pl).

Bearing in mind how big the region is, it can be said that the Province capitals play a similar role to that of other capitals. If the capital of Poland is out of comparison, then it appears that the population percentage for Zielona Góra (13.6%) and Gorzów Wlkp. (12/2%) is comparable to that of other provinces: Wielkopolskie (15.6%), Warmia-Mazury (12.0%), Opole (11.9%). That figure is even higher than that for Katowice – the capital of Śląskie Province (6.6%).[3] As regards the percentage of people at work,

---

[2] The references will name towns with 100 000 and more people as large towns, those between 20 and 100 000 are medium-sized towns, below 20 thousand are defined as small towns (see Runge 2006, 438).

[3] This case, however, calls for its specificity, namely Katowice is surrounded by towns like: Chorzów, Sosnowiec, Bytom, Zabrze, Gliwice, Tychy and Dąbrowa Górnicza. Together, they form *Aglomeracja Górnośląska* (the Upper Silesian Agglomeration) which counts a total of 2.8 million.

their percentage is more or less similar. It equals 17.0% for Zielona Góra, and 16.3% for Gorzów Wlkp. This proves what rank these towns have in the region's settlement system and economy.

However, it has to be emphasised, that the majority of towns in the Province of Lubuskie are small towns. All told, there are 34 such towns, while the medium-sized ones count only four. Hence, the average population of a single town in the region is only 15 794, while a typical Polish town will count 25 392 inhabitants. A characteristic quality is that in the region there are fewer rural localities (30.9) per a town than in Poland (57.4).

Size and rank of towns in the region

In agreement with Zipf's law the size of a town located in a region is the function of the position it holds in the town size sequence. That size makes an important factor in urban development. An increase in population means that towns will generate higher income, expand sales markets, in effect will provide an enlarged intellectual pool and strengthen the town's political position (Kuciński 2015: 363). A specification of towns in Lubuskie Province is shown in Table 3.

Table 3

Size and rank of towns in Lubuskie Province for 2015

Pos.	Town	Population	Pos.	Town	Population	Pos.	Town	Population
1.	Zielona Góra	138 711	15.	Krosno Odrzańskie	11 637	29.	Iłowa	3 978
2.	Gorzów Wielkopolski	123 762	16.	Drezdenko	10 377	30.	Babimost	3 943
3.	Nowa Sól	39 512	17.	Sulęcin	10 231	31.	Ośno Lubuskie	3 880
4.	Żary	38 287	18.	Strzelce Krajeńskie	10 120	32.	Kargowa	3 778
5.	Żagań	26 235	19.	Skwierzyna	9 797	33.	Małomice	3 580
6.	Świebodzin	21 963	20.	Kożuchów	9 604	34.	Gozdnica	3 195
7.	Międzyrzecz	18 392	21.	Witnica	6 908	35.	Dobiegniew	3 095
8.	Kostrzyn nad Odrą	18 031	22.	Rzepin	6 666	36.	Nowe Miasteczko	2 857
9.	Sulechów	17 176	23.	Nowogród Bobrzański	5 147	37.	Cybinka	2 791
10.	Słubice	16 918	24.	Zbąszynek	5 054	38.	Torzym	2 561
11.	Gubin	16 815	25.	Jasień	4 405	39.	Łęknica	2 531
12.	Lubsko	14 335	26.	Bytom Odrzański	4 387	40.	Trzciel	2 475

Pos.	Town	Population	Pos.	Town	Population	Pos.	Town	Population
13.	Wschowa	14 217	27.	Sława	4 307	41.	Lubniewice	2 055
14.	Szprotawa	12 176	28.	Czerwieńsk	4 115	42.	Szlichtyngowa	1 317

Source: own work based on BDL GUS (access: 15.10.2017, http://www.stat.gov.pl).

Subject to assessment was the distribution of the town sizes in the region. With that in view, Zipf's model (Formula 2) was assessed by least squares. The following formula was obtained:

$$\log P_j = 5.323 - 1.167 \cdot \log j, \quad R^2 = 0.952 \tag{5}$$

The value of the contrast exponent $a = -1.167$ shows that the distribution in the Province of Lubuskie is not uniform. The dominant roles are played by the capitals Zielona Góra and Gorzów Wlkp. There is a disturbance, that is a shortage of medium-sized towns and an excess in the number of small towns. The obtained model explains in 95.2% the formation of the urban population in the region (cf. Męczyński, Konecka-Szydłowska and Gadziński 2010). The graphic presentation of the results is shown in Figure 1.

Worth noticing is the gap between the two largest towns in the region and the group of medium-sized towns. This becomes visible in the difference of the population of Zielona Góra and Gorzów Wlkp. (more than 120 thousand) and Nowa Sól (39.5 thousand). Disproportions come to surface in the subregions, especially in the Gorzów Wlkp. subregion. In this case the second largest town besides Gorzów Wlkp.
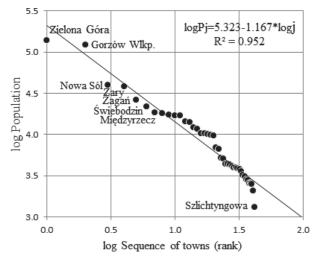

Fig. 1. Regression of size-rank of towns in Lubuskie Province for 2015

Source: Author's own.

(123.8 thousand) is Międzyrzecz (18.4 thousand). This shows that the proportion of the development of the medium-sized towns in the region is out of balance. Towns with 50 thousand and more people are absent from the map. With respect to medium-sized towns small towns are in surplus.

Gravity forces between towns in the region

Save size, relative geographic location will also affect urban functions. Its impact consists chiefly in the fact that a given town is located here, not anywhere else, and that the town itself enters into a specific relationship with other towns and its environment (Szymańska 2009: 194).

To assess relationships between towns the gravity model set out by Formula 4 was used. The calculations were carried out for two different exponents at the variable d_{ij}. To accentuate subregional relationships $b = 3$ was used, while $b = 6$ was used to accentuate local relationships. In order to draw up a comparison a classical formula of gravitation $(b = 2)$[4] was applied. The calculations accounted for the road distances. The strongest gravity in the region is shown in Table 4.

Table 4

Strongest gravity forces in the Province of Lubuskie for 2015

Accentuation of local relationships ($b = 6$)				Accentuation of subregional relationships ($b = 3$)			
Pos.	Towns	[km]	Gravity force [population²/km⁶]	Pos.	Towns	[km]	Gravity force [population²/km³]
1.	Szprotawa Małomice	6	934.2	1.	Zielona Góra Nowa Sól	26	311 831.4
2.	Żary Żagań	15	88.1	2.	Żary Żagań	15	297 617.6
3.	Nowa Sól Bytom Odrzański	18	35.9	3.	Zielona Góra Sulechów	21	257 261.6
4.	Nowa Sól Kożuchów	15	33.3	4.	Szprotawa Małomice	6	201 805.9
5.	Zielona Góra Sulechów	21	27.8	5.	Zielona Góra Kożuchów	21	143 848.4
6.	Zielona Góra Nowa Sól	26	17.7	6.	Nowa Sól Kożuchów	15	112 436.5
7.	Zielona Góra Czerwieńsk	18	16.8	7.	Zielona Góra Czerwieńsk	18	97 873.1

---

[4] Komornicki, Śleszyński and Siłka (2012: 12) hold that for $b = 2$ it is regional relationships that are accentuated (interregional), for $b = 3$ – subregional relationships, while with $b = 4$ – local ones, for $b = 6$ local relationships are strong.

Table 4 contd.

	Accentuation of local relationships ($b = 6$)				Accentuation of subregional relationships ($b = 3$)		
Pos.	Towns	[km]	Gravity force [population^2/km^6]	Pos.	Towns	[km]	Gravity force [population^2/km^3]
8.	Zielona Góra Kożuchów	21	15.5	8.	Nowa Sól Bytom Odrzański	18	78 898.1
9.	Lubsko Jasień	13	13.1	9.	Zielona Góra Żary	45	58 280.7
10.	Żagań Małomice	14	12.5	10.	Gorzów Wlkp. Strzelce Krajeńskie	28	57 055.0

Source: own calculations.

At the exponent $b = 6$, gravity is stronger for those towns which are closer to each other geographically, e.g. Szprotawa and Małomice. The gravity force in that case is 934.2 [inhabitants^2/km^6]. At the exponent $b = 3$, gravity appears to be stronger between larger towns, for instance between Zielona Góra and Nowa Sól. The gravity force approaches 311.8 [inhabitants^2/km^3]. In the case of the other province capital, Gorzów Wlkp., the strongest relationship takes place with Strzelce Krajeńskie [57.0 inhabitants^2/km^3].

In order to illustrate the existing relationships graphs were made use of. By applying the exponent $b = 3$ a connected graph was obtained in 129 relationships, while the exponent $b = 6$ yielded 108 interrelationships.[5] The obtained graphs are shown in Figure 2.

The graph obtained at $b = 6$ points out to two distinct areas of gravitation in the region (Fig. 2a). These areas have much in common with the division of the province into two subregions: Zielona Góra and Gorzów Wlkp. Here, the role that the two capitals, which have the largest number of gravity relationships, play is very important. Gorzów Wlkp. within its own subregion holds 8 such relationships. Apart from Strzelce Krajńskie, these are relationships with Kostrzyn nad Odrą, Witnica, Sulęcin, Lubniewice, Skwierzyna, Drezdenko and Międzyrzecz. Zielona Góra, apart from its relationship with Nowa Sól, remains related with 18 other towns in its subregion. The strongest relationships are with Sulechów, Czerwieńsk, Kożuchów, Nowogród Bobrzański, Krosno Odrzańskie, Żary, Świebodzin, Żagań, Kargowa and Babimost. Numerous relationships take place also between such towns as: Żary (11 relationships), Nowa Sól and Żagań (10 relationships) and Świebodzin (7 relationships). Fewer relationships exist between smaller towns.

---

[5] By applying the classic formula $b = 2$ the number of relationships required to produce a connected graph equalled 151. The obtained graph was less readable, while the additional relationships were hard to give justification to the content. Therefore, it was assumed that the results so obtained would not be subjected to any further review.
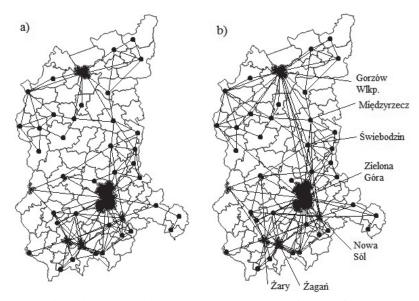
Fig. 2. Gravity relationships between the towns in Lubuskie Province for 2015: a) Accentuation of local relationships (b = 6); b) Accentuation of subregional relationships (b = 3);
Source: Own study.

With the exponent b = 3, besides a number of additional relationships within both subregions, that is Gorzów Wlkp. and Ośno Lubuskie and Rzepin, or Zielona Góra and Sława, gravities between the two most important towns from the opposing subregions become visible. The relationships between Zielona Góra, Nowa Sól, Świebodzin and Sulechów with Gorzów Wlkp. come to the fore. Zielona Góra maintains relationships with Słubice and Międzyrzecz (Fig. 2b). Visible are also – due to concentration of the towns – more gravity relationships in the Zielona Góra subregion, and, conversely, fewer gravity ones in the Gorzów Wlkp. subregion.

Conclusions

The settlement system in the Province of Lubskie is made of towns of varied sizes, showing different spatial relationships among them. Analyses indicate that Zielona Góra and Gorzów Wlkp. – towns with a population exceeding 100 000 – are two major centres that are of regional and supra-regional importance. However, when Zipf's rule of size and rank is accounted for, the distribution of towns in the region shows a certain imbalance with respect to the position held by medium-sized towns. None of the medium-sized towns in the province has a population exceeding 50 thousand, while the Gorzów Wlkp. subregion does not have even a single town so numerous. The Zielona Góra subregion has a more developed network of gravity relationships between towns compared to the Gorzów Wlkp. subregion. The strength of these relationships

depends, apart from the town size, on the distances between the towns as well. It is also worth emphasising that due to their number, the issue of small town development in the region becomes important.

References

BDL (Bank Danych Lokalnych), GUS. Access: 15.10.2017. http://www.stat.gov.pl.

GUS (Główny Urząd Statystyczny). 2015. *Powierzchnia i ludność w przekroju terytorialnym w 2015 r.* Warszawa. Access: 15.10.2017. http://www.stat.gov.pl.

KE (Komisja Europejska), Dyrekcja Generalna ds. Polityki Regionalnej. 2011. *Miasta przyszłości. Wyzwania, wizje, perspektywy.* Access: 15.10.2017. http://ec.europa.eu/regional_policy/pl.

Komornicki, Tomasz, Przemysław Śleszyński and Piotr Siłka. 2012. *Charakterystyka systemu osadniczego województwa podkarpackiego z identyfikacją biegunów wzrostu oraz wyróżnieniem obszarów funkcjonalnych na poziomie regionalnym i lokalnym.* Warszawa: PAN, IGiPZ. Access: 15.10.2017. http://www.monitoruj.podkarpackie.pl.

Korenik, Stanisław. 2011. *Region ekonomiczny w nowych realiach społeczno-gospodarczych.* Warszawa: Wydawnictwo CeDeWu.

Kuciński, Kazimierz (ed.). 2015. *Geografia ekonomiczna.* Warszawa: Wydawnictwo Wolters Kluwer Business.

Liszewski, Stanisław and Wiesław Maik. 2000. *Osadnictwo.* Poznań: Wydawnictwo Kurpisz.

Liszewski, Stanisław (ed.). 2012. *Geografia urbanistyczna.* Warszawa: Wydawnictwo Naukowe PWN.

Męczyński, Michał, Barbara Konecka-Szydłowska and Jędrzej Gadziński. 2010. *Poziom rozwoju społeczno-gospodarczego i klasyfikacja małych miast w Wielkopolsce.* Poznań: Uniwersytet Adama Mickiewicza w Poznaniu, Instytut Geografii Społeczno-Ekonomicznej i Gospodarki Przestrzennej. Access: 15.10.2017. http://www.wrot.umww.pl.

Runge, Jerzy. 2006. *Metody badań w geografii społeczno-ekonomicznej. Elementy metodologii, wybrane narzędzia badawcze.* Katowice: Wydawnictwo Uniwersytetu Śląskiego.

Sejmik Województwa Lubuskiego. 2012. *Strategia Rozwoju Województwa Lubuskiego 2020.* Zielona Góra. Access: 15.10.2017. http://lubuskie.pl.

Szymańska, Daniela. 2009. *Geografia osadnictwa.* Warszawa: Wydawnictwo Naukowe PWN.