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COMMUTING AS A SPATIAL FEATURE OF INTERNATIONAL CONCERN'S LOCATION IN A MAJOR CITY. EXAMPLE OF POZNAŃ

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ABSTRACT. The study presents the spatial aspects of the location of a branch of an international concern in a major city, viz. in Poznań, in terms of commuting streams, both from the city area, and the surrounding area, as well as their variation in the period 2000–2009. In order to characterise the spatial arrangement of commuting, the study used centrophraphic measures to analyse the variation of commuting directions and identify the areas of the greatest concentration. Furthermore, it was observed that there was a regular disproportion between the group of employees commuting from the city area, and the group of employees commuting from the region, the latter of which was smaller. It thus seems that an international concern production plant influences the local labour market to a significant extent, displaying the strongest regional impact within the range of 20 km from its location, with the direction of this influence being clearly related to the plant's location in relation to city borders, which might be linked to better communicational accessibility.

KEY WORDS: Poland, Wielkopolska voivodeship, Poznań, commuting, direction, distance, concentration areas, international concern.

ANALYSIS OF COMMUTING IN GEOGRAPHICAL RESEARCH

The aim of this study is to present the spatial aspects of the location of an international concern branch in a big city in terms of commuting streams, both from the city area, and the surrounding area, as well as their variation in the years 2000–2009. The present study is a fragment of a research project N 306 05732/3609 concerning the effects of the location of branches and divisions of international corporations on local and regional economies.

Commuting, defined as the travel from the place of residence to the working place and back (Dzieciuchowicz, 1979: 20), is a factor shaping many social and economic phenomena. The effects of commuting are analysed with reference to living standards, transportation systems, or delimitation of urban function areas. Commuting is especially important for the formation of local job markets, where the influence may be positive (e.g., it is a way to balance the local job market), as well as negative (e.g., lower productivity of commuters, higher deductible expenses). As commuting also influences the formation of a new structure and spatial range of the job market at the local and regional levels, it is also vital to consider the dichotomy of employees residing at their workplace, and those living outside it, in the region. Commuting is also one of the important factors shaping the spatial structure of the city and the urban region (Dziewoński, 1976), and forming new spatial links, and communicational conditions. The analysis of intra-urban commuting was developed in Anglo-Saxon geographical research, whereas in the Polish geography it was explored much less (Dzieciuchowicz, 1979; Lijewski, 1967; Matykowski, Stryjakiewicz, 1989). On the other hand, the studies of commuting to cities from rural areas are quite numerous (Jagielski, 1969; Cegielski, 1977; Jasiok, 1979; Stryjakiewicz, 1988; Kitowski, 1988, 1989; Matykowski, 1990; Hołowiecka, Szymańska, 2008), and these are primarily aimed at showing the spatial links between localities. The analysis of such commuting consists in a graphic presentation of commuting streams, by means of flow diagrams or tables (flow tables) allowing the calculation of commuting directions and volume indexes (Golachowski, Kostrubiec, Zagożdżon, 1974). Commuting is also the fundamental element of location analysis – it indicates the degree of conformity between places of residence and workplaces. Results of research on the location and functioning of food industry conducted by T. Stryjakiewicz (1988: 146–159) point to many regularities and factors regarding the volume and spatial structure of commuting to industrial plants.

Commuting analyses usually pay attention to two spatial features: a) variously interpreted distance from the workplace, and b) direction. Thanks to these properties it is possible to apply various mathematical and statistical methods in the commuting analysis, allowing the detection of certain regularities in their spatial structure. One of the ways to identify the spatial distribution of commuting is using the spatial models employing the exponential and parabolic function (Jasiok, 1979). The impact of travelling distance on commuting volume may also be determined through the realisation of various forms of the gravitation model, including 1) its classic version, taking into account the selective range of the effect, or 2) interaction in a regional configuration. Another, more simple way to characterise commuting is to define its volume in the system of concentric zones around the workplace. Meanwhile, the analysis of commuting directions could

apply the traditional vector analysis or the modified centrographic method in the form of a standard ellipsis deviation, displacement vector, etc. Vector analysis is used because the commuting relations display such properties as volume (the number of commuters), as well as direction, length, and sense. It is thus a vector value. Therefore, the research on spatial aspects of commuting may employ vector calculus (Jagielski, 1969; Jasiok, Kamiński, 1977; Jasiok, 1979; Stryjakiewicz, 1988). To characterise the spatial arrangement of commuting, the study used centrographic measures (Matykowski, 1990; Matykowski, Tobolska, 2009). These were used primarily to analyse the variation in commuting direction. The directions are determined by vectors going out from the factory location point to the centroid, and they mark out the area of the highest concentration of commuting. The difference in the direction and length of the vector indicates the spatial displacement of commuters' mass.

SPATIAL IMPACT OF THE LOCATION OF AN INTERNATIONAL CONCERN PLANT: THE RANGE OF DAILY SHUTTLE MIGRATION OF EMPLOYEES

The location of a plant of an international concern, as of any other plant, has multiple consequences in various areas: economic, social, spatial, and environmental. The most frequently mentioned effects of direct foreign investment location include (Stryjakiewicz, 2005: 74): the creation of new jobs and improvement of work quality and structure, generation of revenues of self-government units and people's revenues, development of regional economy, as well as the realisation of social tasks in the form of patronage or sponsoring. The various aspects of a foreign investment location also include the spatial aspect in the form of changes in the spatial structure of a given city or region, emergence of post-industrial areas, revitalisation of city parts, as well as changes in the communication network, primarily related to daily commuter streams. As a result of changes in the employment structure, which usually occur with an international concern location, there are changes in the structure of commuters to the plant.

Changes in the spatial links of an international concern plant located in a major city were characterised on the example of commuting to the EXIDE Technologies plant in Poznań at two points in time: in 2000 and 2009. The commuting analysis used a register of employee permanent residence addresses, provided by the plant's Human Resources department. The permanent residence addresses were identified as actual places of employee residence, and the initial points of their daily commuting. The distance of their travel was determined through measuring the shortest line drawn between the place of residence with

the workplace. The analysis did not include employees officially residing outside Wielkopolska voivodeship in localities over 100 km (in direct line) away from the plant, thus poorly accessible for everyday shuttle migration. The analysis of distance distribution employed the arithmetic weighted mean, as well as positional averages. Furthermore, the analysis of commuting from the communes of Wielkopolska voivodeship was complemented with the description of the spatial distribution of directions, using centrographic measures (Matykowski, 1981; Runge, 1992).

EXIDE Technologies is one of the biggest manufacturers of acid batteries in the world; it has a 21 per cent share in the global battery market, selling its products in 80 countries and employing a total of 13,800 people. The company's headquarters are in Milton, Georgia, USA. One of its plants was located in Poznań in 1995 when EXIDE bought the local battery factory "Centra" from its strategic investor, the French "CEAC". The Americans took over a total of 98% of shares and provided the Polish company with high-tech production and management methods, and access to their markets. In 2009 the plant employed 397 people

Table 1. Characterisation of commuting by employees of Centra-EXIDE in 2000 and 2009 according to their permanent residence

	2000	2009
No. of employees in total	635	397
No.(and %) of employees from Poznań	358 (56.4%)	229 (57.7%)
No. (and %) of employees from outside Wielkopolska voivodeship	47 (7.4%)	19 (4.8%)
No. (and %) of employees from outside Poznań – from the communes of Wielkopolska voivodeship	230 (36.2%)	149 (37.5%)
No. (and %) of employees from outside Poznań – from the Poznań district (and % of commuters in total)	133 (57.82%)	108 (72.48%)
No. of communes in total – places of employee residence	62	54
No. (and %) of communes from outside Wielkopolska voivodeship – places of employee residence	19 (30.6%)	16 (29.6%)
Average commuting distance of employees from Poznań	5.19 km	5.09 km
Average commuting distance of employees from outside Poznań – from the communes of Wielkopolska voivodeship	20.37 km	21.51 km
Length of resultant vector of commuting from outside Poznań – from the communes of Wielkopolska voivodeship	7.67 km	7.65 km
Azimuth of resultant vector of commuting from outside Poznań – from the communes of Wielkopolska voivodeship	112° ESE	124° ESE
Standard deviation of commuting distance of employees from outside Poznań - from the communes of Wielkopolska voivodeship	24.83 km	26.39 km

Source: Own compilation based on company data

(as of 30 June), a mere 0.7% of industrial employment in Poznań, as against 1.2% in 2000. Despite its minor significance in terms of employment volume, Centra-EXIDE comes 16th on the list of the biggest companies in Poznań in terms of sales revenues, and ranks in the top 10 of production companies (*Polityka* 2008).

In the 2000–2009 period the number of plant employees fell from 635 to 397 people, i.e., by 37.5% (Table 1). The number of employees commuting to the plant from the city area dropped from 359 (2000) to 230 (2009) – i.e., by 36%; and the number of commuters from outside Poznań fell from 277 (2000) to 168 (2009) – i.e., by 39.4%. However, the biggest drop concerned the number of Centra-EXIDE employees commuting from outside Wielkopolska voivodeship – from 47 (2000) to 19 (2009), which amounts to 59.6%. The relatively smallest drop occurred in the group of employees residing in Poznań powiat (district) but outside the city itself: their number decreased from 133 to 108, i.e., 18.8%, whereas in the plant's employee structure their share grew significantly from 20.9% to 27.2%. Therefore, Centra-EXIDE influenced the formation of a new labour market in Poznań and the region.

SPATIAL DISTRIBUTION OF INTRA-CITY COMMUTING DISTANCES IN POZNAŃ

EXIDE employees are mostly residents of Poznań: in 2000, 56.4% commuted from the city area, and in 2009 their proportion increased to 57.7%. Plain and cumulative values of the index of the residence distance structure (calculated as the ratio of commuters from a given distance interval to all commuters) indicate that commuting to Centra-EXIDE does not generally involve great distances (Table 2). The spatial distribution of employee residence places in the system of 1-kilometre-radius concentric zones around the plant shows that in both 2000 and 2009 more than a half of employees commuted from a distance no greater than 5 km, and that more employees (59.8%) commuted within that distance in 2009 than in 2000 (56.8%). Also in both years, three-fourths of commuters travelled a distance of under 7 km from the plant, and only 2% commuted from the farthest zones, from the distance exceeding 10 km. The entire intra-city commuting system was enclosed within a distance of 13 km from the plant (Fig. 1), and the distribution was very similar at both points of comparison. This is also substantiated by the calculated values of the central tendency (Table 2): the mean weighted distance (5.19 km in 2000 and 5.09 km in 2009), and the median (4.74 km in 2000 and 4.68 in 2009). The drop in the mean and median values of commuting distance, as well as a stronger concentration in the 5-km commuting zone in 2009 might be evidence that the commuting distance tends to shorten. On the other hand, the commuting distance mode value which was slightly higher in 2009 than in 2000

(4.51 km and 4.45 km, respectively), indicates that the commuting distance most typical of Centra-EXIDE employees is in the 4 to 5 km range. This means that the commuting distance for most employees in 2000 was shorter than in 2009, but the higher average distance value in 2000 shows that the other distances in minority employee groups were longer than in 2009. It should be emphasised that the arithmetic mean value of commuting distance falls within a different range than the mode value, which is proof of an inhomogeneous distribution of commuting distances, and a slight positive skewness.

Table 2. Commuting distance to Centra-EXIDE of Poznań-based employees according to concentric zones around the plant ($r = 1$ km)

Zone	2000			2009		
	A	B	C	A	B	C
I	10	2.8	2.8	5	2.2	2.2
II	8	2.2	5.0	9	3.9	6.1
III	27	7.5	12.5	25	10.9	17.0
IV	65	18.1	30.6	30	13.1	30.1
V	94	26.2	56.8	68	29.7	59.8
VI	58	16.1	72.9	32	14.0	73.8
VII	21	6.6	78.8	11	4.8	78.6
VIII	19	5.3	84.1	15	6.6	85.2
IX	33	9.2	93.3	18	7.8	93.0
X	15	4.2	97.5	11	4.8	97.8
XI	3	0.8	98.3	1	0.5	98.3
XII	1	0.3	98.6	2	0.9	99.1
XIII	5	1.4	100.0	2	0.9	100.0
In total	359	100.0	100.0	229	100.0	100.0
	D		5.19 km	D		5.09 km
	E		4.45 km	E		4.51 km
	F		4.74 km	F		4.68 km

Explanation: A – number of commuters; B – % of commuters; C – cum of commuters; D – arithmetic weighted mean of distance; E – mode of distance; F – median distance

Source: Own compilation based on company data

In both 2000 and 2009, only slightly over 2% of Centra-EXIDE employees lived in the zone closest to the plant, i.e., within a 1-km, or walking distance (Fig. 1). What is also characteristic is the small proportion of employees commuting from other zones close to the plant, i.e., within 1 to 3-km distance, even though one might expect a particularly high volume of commuting from these zones. Such a situation might result from a significantly lower area capacity of the zone directly surrounding the plant in comparison to the farther zones. What is also

important is the location of the plant right by the eastern city border, in a quarter with poorly developed residential functions and prevailing industrial ones; the direct surroundings include a few other large industrial plants, warehouses, and construction areas. A certain role is also played by the Warta river, which flows just behind the plant and which separates it from residential areas of the city.

When considering the variability of the number of commuters to Centra-EXIDE in particular zones around the plant, one might notice that the number of employees grew quite regularly in consecutive 1-km zones (except for zone 2 in 2000, in which fewer employees resided than in zone 1), up to its maximum in zone 5, i.e., within 4–5 km from the plant. In 2000, this zone was inhabited by 26.2% of employees and by 29.7% in 2009. These were residents of some major residential districts – the housing estates in the northern part of the city: Piątkowo and Rataje, as well as some older city areas such as Winiary, Solacz and the city centre. Going away from that zone towards the southern and western city borders, the number of employees residing there decreased, both in 2000 and 2009. However, zone 9 embracing such densely populated areas as the Kopernik housing estate, older parts of the Grunwald district, as well as Dębiec and Starołęka, was an exception here, as it was inhabited by more employees than the zone preceding it in. Such a surge in the number of commuters from that zone may be attributed to the former direction of commuting to the plant, because until the 1990s Starołęka was the location of a branch of the old Centra plant. Commuting fades in zone 13, i.e., in the belt up to 13 km away from the plant.

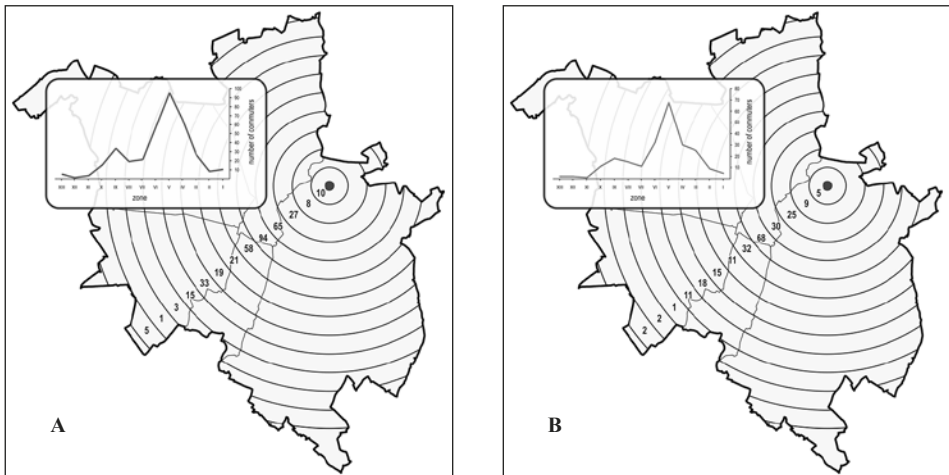


Fig. 1. Distribution of commuters travelling to Centra-EXIDE from Poznań according to concentric zones around the plant ($r = 1$ km) in 2000 (A) and 2009 (B)

Source: Own compilation based on company data

DIRECTIONS AND SPATIAL DISTRIBUTION OF COMMUTING FROM OUTSIDE POZNAŃ

Employees from outside Poznań reside not only in Wielkopolska but also in communes outside the voivodeship. In 2000 the plant employees came from 62 communes, and in 2009 from 54 communes (Table 1). However, further analysis of commuting makes it possible to exclude the residents of communes outside the voivodeship, which are all more than 100 km away from the plant (in a direct line), thus hardly accessible for daily shuttle migration. Even though in 2000 this concerned as many as 19 communes, i.e., about 30% of the total (Fig. 2), and in 2009, 16 (Fig. 3). The groups of employees from outside Wielkopolska voivodeship are rather small. In 2000 they amounted to 7.4% of all plant staff, and in 2009, 4.5%. Among them are field sales representatives of EXIDE and service technicians residing in various distant regions of the country. There is also a group of employees who live in rented flats near the workplace without changing their official address which is actually far away from the plant.

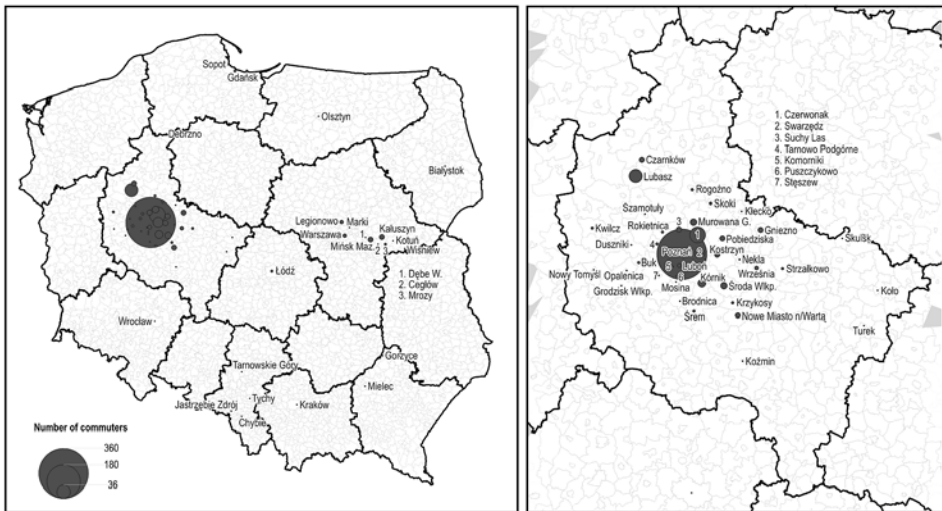


Fig. 2. Spatial distribution of Centra-EXIDE employees' residence in 2000

Source: Own compilation based on company data

Moreover, in 2000, the list of Centra-EXIDE employees included a numerous group of those working at the DETA plant, an EXIDE branch in Mińsk Mazowiecki. After the plant was liquidated in 2005, 7 employees living in Mazowieckie voivodeship – sales representatives and service technicians – remained on the

list. The residential pattern of EXIDE employees also changed after the sale of the plant at Lubasz near Czarnków in 2005. In 2000, 42 EXIDE employees lived in the communes of Lubasz and Czarnków, as against only one in 2009.

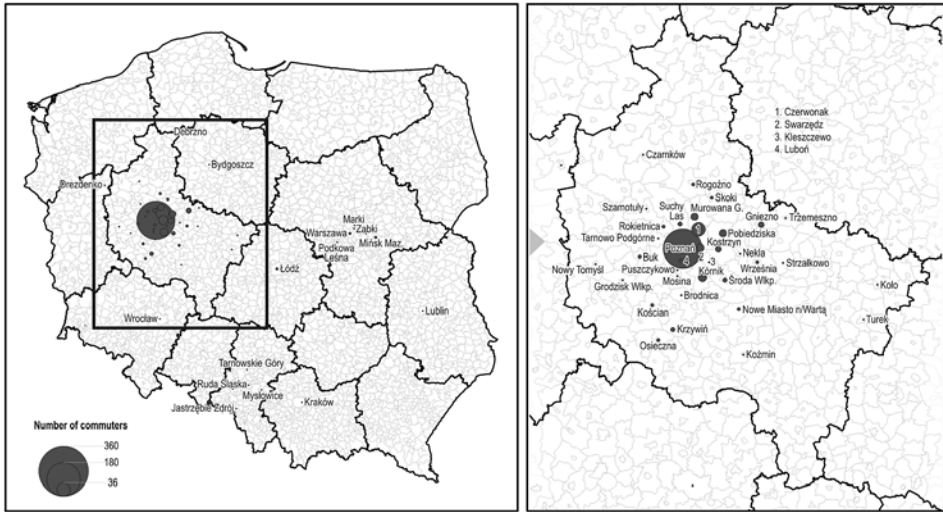


Fig. 3. Spatial distribution of Centra-EXIDE employees' residence in 2009

Source: Own compilation based on company data

In order to characterise the spatial pattern of commuters' places of residence, centographic measures were used (Matykowski, 1990; Matykowski, Tobolska, 2009). They enabled the detection of changes in commuting directions and areas of the greatest commuting concentration.

The analysis of commuting using centographic measures did not take into account the employees from the communes of Lubasz and Czarnków who were employed at the company's branch in Lubasz in 2000, nor did it include in any of the studied periods the employees residing in the communes of Koło and Turek, as the distance from there exceeds 100 km in direct line, thus being too difficult to travel on a daily basis. In the case of employees from outside Poznań commuting to the Centra-EXIDE plant from Wielkopolska voivodeship area (thus concerning 29.1% of employees in 2000, and 37.0% of employees in 2009), the central point of the analysed arrangement was situated in both periods under study in the commune of Swarzędz, about 7.7 km east-southeast of the workplace. Over the study period the centroid location shifted only slightly, by a few degrees south, a little closer to the plant. The resultant vector linking the plant location with the centroid location was shorter by 10 m in 2009 than in 2000. In turn, the dynamic

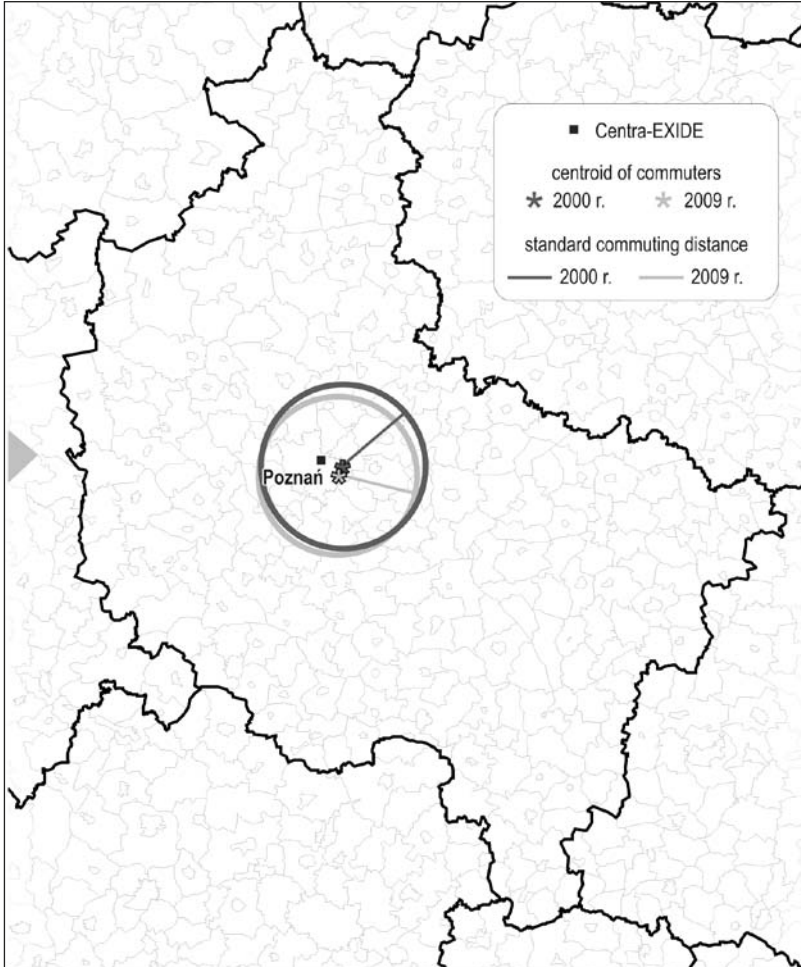


Fig. 4. Centrographic measures of commuting to Centra-EXIDE in 2000 and 2009

Source: Own compilation based on company data

radius (i.e., the standard deviation of distance) was 24.83 km in 2000 (Table 2, Fig. 4) and extended slightly to 26.39 km by 2009. This indicates a greater dispersion of commuters in the latter year, with a simultaneous south-east shift of the entire commuting system. The standard length of a distance and the circle drawn by it indicates the area of highest commuting concentration. Therefore, the calculations show that a whole mass of commuting shifted south-east, i.e., the group of employees is dominated by persons living in this area. The deviation of centroids from the plant location (7.67 km and 7.66 km) is evidence of a rather weak spatial convergence of the workplace and places of residence of employees

commuting from outside Poznań. On the other hand, the centroids are situated quite close to the factory, in the Swarzędz commune, a direct eastern neighbour of Poznań, so their distance is not relatively great.

The analysis of concentration of commuters to the Centra-EXIDE plant from the concentric 10-km zones around it indicates that over a half of them resided within less than 20 km of the plant. From as many as 122, i.e., 65.6%, in 2000, they dwindled to 97 in 2009, though the percentage even grew slightly to 66.0% (Table 3). It is worth adding that the calculated weighted mean distance (in a direct line) from employees' places of residence (in Wielkopolska voivodeship) to the plant amounted to 20.37 km in 2000, and to 21.51 km in 2009.

Table 3. No. and % of employees of Centra-EXIDE commuting from communes outside Poznań in 2000 and 2009 according to concentric zones (r = 10 km – in a direct line)

Zone (km)	2000			2009		
	No.	%	Communes	No.	%	Communes
<10	80	43.1	Czerwonak, Luboń, Suchy Las, Swarzędz	59	40.1	Czerwonak, Luboń, Suchy Las, Swarzędz
10-20	42	22.5	Rokietnica, Murowana Goślina, Mosina, Kórnik, Kostrzyn, Komorniki, Puszczykowo, Tarnowo Podgórne	38	25.9	Rokietnica, Murowana Goślina, Mosina, Kleszczewo, Kórnik, Kostrzyn, Puszczykowo, Tarnowo Podgórne
20-30	26	14.1	Brodnica, Buk, Nekla, Pobiedziska, Stęszew, Środa Wielkopolska	17	11.6	Brodnica, Buk, Nekla, Pobiedziska, Stęszew, Środa Wielkopolska
30-40	8	4.2	Duszniki, Opalenica, Skoki, Szamotuły, Śrem	11	7.5	Kościan, Krzywiń, Skoki, Szamotuły, Śrem
40-50	23	12.3	Gniezno, Grodzisk Wielkopolski, Kłecko, Krzykosy, Nowe Miasto n. Wartą, Rogoźno, Września	17	11.6	Gniezno, Grodzisk Wielkopolski, Nowe Miasto n. Wartą, Rogoźno, Września, Osieczna
50-60	3	1.6	Strzałkowo, Nowy Tomyśl	3	2.0	Strzałkowo, Nowy Tomyśl, Trzemeszno
60-70	2	1.1	Kwilcz	1	0.7	Czarnków
70-80	2	1.1	Skulsk, Koźmin	1	0.7	Koźmin
In total	185	100		147	100	

Source: Own compilation based on company data

The subregional impact of the Centra-EXIDE plant on the labour market is also evidenced by the concentration of employees in Poznań powiat. In 2000 nearly 58% of commuters from Wielkopolska voivodeship resided in Poznań powiat, while in 2009 their share grew to 72.5%.

SUMMARY

The analysis of commuting by employees of the EXIDE plant located in Poznań has shown an interesting phenomenon related to the distance of intra-city commuting. It is not the most intense in the zones closest to the plant, but in the most densely populated residential areas. Furthermore, it has been observed that there is a regular disproportion between the group of employees commuting from the city area and the group commuting from the region, the latter being smaller. It thus seems that a plant of a foreign concern influences the local labour market to a greater extent than the regional one. As to the latter, it exerts the strongest impact within the range of 20 km from its location, with the direction of this influence being clearly connected with the plant's location relative to the city borders (eastern border), which might be linked to better transportation accessibility. Another important trend noticed here is a stronger concentration of commuting from Poznań powiat as well as the tendency (although weak) to reduce the distance of intra-city commuting.

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