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Comparative Study on Urban Logistics and Last Mile Delivery Processes in Germany and China

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List of Abbreviations

B2B	Business-to-Business
B2C	Business-to-Consumer
BIEK	Federal Association of Parcel and Express Logistics (Bundesverband Paket und Expresslogistik)
BImSchG/BImSchV	Federal Immission Control Act (Bundes-Immissionsschutzgesetz/ Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes)
CEP	Courier, express and parcel; parcel logistics segment in Germany
CR	Concentration ratio of the biggest enterprises
EUR	Euro
EMS	Express Mail Service, international cooperative of postal operators for express parcel delivery, in China synonymous with parcel delivery service offered by state-owned China Post Group
EU	European Union
FCD	Floating car data
FMCG	Fast-moving consumable goods
g	Gramme
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic information system
GVW	Gross vehicle weight
HBEFA	Handbook Emission Factors for Road Transport (Handbuch für Emissionsfaktoren des Straßenverkehrs)
IWVK	Integrated Concept for Commercial Transportation (Integriertes Wirtschaftsverkehrskonzept)
KBA	Federal Motor Transport Agency (Kraftfahrtbundesamt)
kg	Kilogramme
km	Kilometre
m^2	Square metre
MNR	Ministry of Natural Resources of the People's Republic of China
NGO	Non-governmental organisation
NTSP	National territory spatial planning

PPP-USD	Purchasing power parity, expressed in US dollar. Conversion rates used: Organisation for Economic Co-operation and Development (2021)
RMB	Renminbi
SPB	State Post Bureau of the People's Republic of China
UDP	Urban development plan

"China" and "Germany" are used as short forms for the People's Republic of China and the Federal Republic of Germany, respectively.

Definitions

Parcel delivery is understood as the logistics segment which ships parcels. In Germany, this segment is referred to as **Courier, Express and Parcel Service (CEP)**. This segment includes logistics service providers that focus on the transport of shipments weighing between 2 and 31.5 kilogrammes (kg) with a maximum combined length and a maximum circumference of 3 m per loading unit (Schwemmer 2019). In China, sometimes the English term express service is used for this segment. Loading gauges are similar, but the maximum weight for parcels in China is 50 kg. The unit of parcel delivery volumes are shipments, here interchangeably also called parcels or pieces.

Business-to-Consumer (B2C) refers to shipments from companies to end customers, while **Business-to-Business (B2B)** refers to shipments between companies. In China, these subsegments are not differentiated.

Parcel station (China) and **pick-up point** (Germany) are used as umbrella terms for end nodes of the parcel delivery network. These nodes can take the form of **parcel lockers** (also called intelligent parcel locker, self-express service machine or automated parcel locker) or parcel shops (operated by the delivery enterprises or as agents). Typically, these end nodes are only operated by or associated with one delivery company. This is supplemented by **third-party parcel stations** (also called joint delivery), which are operated by independent enterprises, local authorities or agents and receive deliveries from more than one parcel delivery enterprise.

In the context of parcel delivery, the **last mile** is defined as the last delivery tour in the parcel network, from the last transloading facility (sorting centre) to the end customer (cp. Brabänder 2020). **Bundling** in this context is understood as a consolidation of shipments in the last mile through the use of parcel stations, where customers can pick up their parcel. This bundling can take the form of joint delivery (with different enterprises cooperating) or in an existing parcel delivery network.

Executive Summary

Objectives and content of the study

The increasing importance of parcel deliveries in urban supply can be observed worldwide. There are country-specific differences, which result on the one hand from the organisation of parcel markets at national level (e. g. political framework conditions), on the other hand from the challenges at urban level with its differences in political and urban landscapes. A comparative study contrasting both conditions of the parcel markets in Germany and China and also the effects of transportation at urban level does not exist so far. This study thus fills a gap when it comes to comparing national and urban parcel market conditions between Germany (Berlin) and China (Suzhou).

Main findings

The comparison of the parcel delivery market at national and city level has shown the following:

- At the national level, political and planning policies show that no official authority in Germany directly regulates parcel delivery. Rather, German planning documents often set few concrete goals concerning all segments of freight transport. In China, government involvement and oversight permeate all aspects of parcel delivery.
- Parcel delivery in China and Germany is carried out by private enterprises (only exception: state-owned China Post Group with its Express Mail Service) in a free market and is subject to national laws. This analysis shows that China exerts more direct control over its parcel delivery enterprises, while German policies are seldomly restrictive. The German parcel delivery sector is characterised by a multitude of stakeholders with higher degrees of autonomy. Both markets show a high degree of market concentration, with more monopolistic tendencies in Germany and more oligopolistic tendencies in China.
- Spatial planning systems in Germany and China differ mainly in their degrees of autonomy: A decentralised, but top-down approach in China and the principle of "mutual feedback" with higher degrees of self-government in Germany. Measures are usually specified at the lowest level. Suzhou places a stronger focus on governance and direct control over the parcel delivery market to promote cooperation between delivery companies, while Berlin only addresses urban freight transport in general and emphasises infrastructure measures.

Typical for the German planning culture is a bundle of interconnected, specialised concepts. In this context, no planning documents in Berlin apply directly to parcel deliveries, similar to

the parcel market on national level in Germany. Instead, parcel delivery is addressed by multiple documents, not only transport concepts. On a contrasting note, concepts in Suzhou, based on national policies, directly formulate objectives and measures for parcel deliveries. The two planning concepts are also used to set benchmarks to improve the development of the parcel delivery market. An additional concept describes goals for the parcel market, from which measures are derived. Parcel volumes are on a historical high, propelled by online retail, which is much more prevalent in China. The rise in volumes is expected to continue in both countries, but at a reduced rate. Main growth drivers will be perishables and convenience goods.

Since 2011, parcel volumes increased 16-fold in China in this period up to 2019; and "only" by half in Germany. Volumes per household or per capita are difficult to compare, but on a national level, shipments per capita were quite similar between China and Germany, with around 44 to 45 pieces per inhabitant in 2019. Regional differences within both countries are much higher: For Berlin, 47 parcels per capita are reported, compared to 161 in Suzhou.

- Bundled last mile delivery, as promoted by measures in Suzhou, could lead to significant savings in emissions in Berlin, especially on smaller streets. In two model scenarios, positive effects of comprehensive bundling infrastructures in comparison to a base scenario become apparent. Additionally, electrification of the delivery fleet would reduce emissions and could be achieved with existing technology and infrastructures.

A model simulating two essential concepts of Chinese bundling practices was developed in Berlin. It models bundling at existing pick-up points, similar to the central pick-up points often available at the main entrance of residential compounds in Suzhou, and third-party parcel stations, an independent network of pick-up points used by different delivery enterprises at convenient locations. The model shows that both concepts, applied comprehensively, can lead to significant emission savings in Berlin, especially on the subordinate access road network.

A strong cooperation between public and private actors for last mile bundling, as implemented in Suzhou, offers valuable insights for German planning, leading to overall more efficient deliveries.

Through promotion of cooperation between enterprises, the settlement structure and higher volumes in general, last mile bundling is more widespread in Suzhou. Berlin pursues a more integrated form of planning in urban logistics.

1 Introduction

This study builds on two previous studies about the CEP market in Germany and China[1] both at national and municipal level (Berlin and Suzhou respectively). The aim of this study is to compare similarities as well as differences and to derive recommendations for public and private stakeholders from this comparison.

Main background of this study is the development in e-commerce and online retail that resulted in an unparalleled rise in parcel volumes. Never before in history, parcel delivery companies handled more pieces, both in China and in Germany, where in China the growth in the last decade was on a completely different level compared to Germany and made China the biggest global market for e-commerce (International Trade Administration 2021).

A recent development, only briefly mentioned in the two previous studies, is the COVID-19 pandemic. Now, almost two years into the pandemic, its effects have become measurable. The shift to more online activities has significantly boosted e-commerce development and will have a lasting and probably irreversible impact on retail (Rusche 2021).

Many trends in the 2020s will change e-commerce, parcel delivery and urban logistics in general, like further digitalisation, the merging of social and commercial spheres, international trade complications and the unforeseeable effects of the climate crisis. Tech advancements, maturing markets and the rise of platform economies have led to highly concentrated markets and enterprises of unprecedented economic power. Increasingly, these platforms are met with governments willing to control them more tightly.

Climate protection has become a high priority in international, national, and subnational plans, but global climate targets seem hard to reach. On a lower administrative level, cities are trying to mitigate negative effects[2] of a rise in parcel deliveries with a plethora of measures like delivery zones, joint deliveries, driving bans or data sharing.

In this study, the backgrounds of e-commerce and parcel delivery in China and Germany are compared in the first part, along with a look at Berlin's and Suzhou's city profiles in terms of economy, transport, and parcel delivery network. Framework conditions and relevant stakeholders at a national level in both countries are elaborated, while similarities are identified. In addition to a comparison of the political and legal framework conditions, key figures, past developments and recent forecasts for e-commerce and parcel delivery are pinpointed and juxtaposed.

1 Published as Leerkamp et al. 2021 and Transport Planning and Research Institute (TPRI) 2021. English and Chinese versions available at https://transition-china.org/mobilityposts/case-study-research-on-urban-logistics-and-last-mile-delivery-processes-in-germany/ and https://transition-china.org/mobilityposts/case-study-research-on-urban-logistics-and-last-mile-delivery-processes-in-china-a-case-study-of-suzhou-en-version/

2 Urban logistics account for an overproportionate share of emissions and road safety risks in urban road transport, cp. Agora Verkehrswende 2019.

In addition to the comparison on a national level, the parcel markets in Suzhou and Berlin are examined in terms of both planning and transport. Above all, the design of the planning competences and the plans in the municipalities provide information on the handling of the last mile, which cannot be made visible in the same form at the national level.

2 Comparison of CEP Logistics in China and Germany at National Level

2.1 Regulatory and Political Conditions on National Level

In China and Germany, multiple national governmental authorities supervise different parts of the parcel delivery sector. With the State Post Bureau (SPB), China has a central governmental body for postal issues that also supervises the parcel delivery market. The SPB has sub-departments on provincial and municipal levels and carries out planning and research. There is no similar governmental organisation in Germany. Its respective role in the parcel delivery industry is spread between different bodies of various departments and sub-departments. The transportation ministries in China (Ministry of Transport of the People's Republic of China) and Germany (Federal Ministry for Digital and Transport) coordinate the general development of transport infrastructure and fulfil similar tasks (Transport Planning and Research Institute (TPRI) 2021; Leerkamp et al. 2021).

Both in China and Germany, non-governmental organisations (NGOs) involved in the parcel delivery sector have been formed on the national level. While the German NGOs have different interests and backgrounds and are mainly interested in representation and lobbying for their respective stakeholders (e. g. workers issues, consumer protection or commercial interests), the Chinese organisations function more as a link between the government and private sector. These so-called "social organisations" are strongly intertwined with the government and can thus be classified as government-organised NGOs (Yuanfeng 2015; Brie and Pietzcker 2004; China Express Association n. d.; China Federation of Logistics & Purchasing 2014). Unionisation is weak both in Germany and China, as deliveries are mostly carried out by independent subcontractors. Relevant stakeholders for the parcel delivery sector are listed in Figure 1.

Both countries have ratified various laws and planning documents for the parcel delivery sector. Following the different governmental structures in both countries, China issued more regulations directly addressing the parcel delivery sector, while most relevant laws in Germany, e. g. environment protection regulations, apply to other sectors as well. Similarly, all-encompassing regulations (e. g. the Circular Economy Promotion Law) also exist in China. In both countries the legislative and executive branches seem to have taken more interest in the parcel delivery sector and its sustainability during the past five years, as many regulations have been issued recently (Transport Planning and Research Institute (TPRI) 2021; Leerkamp et al. 2021).

The framework in which the privately organised parcel delivery companies operate is dictated by national regulations, laws, and standards. For China, these are mainly the Postal

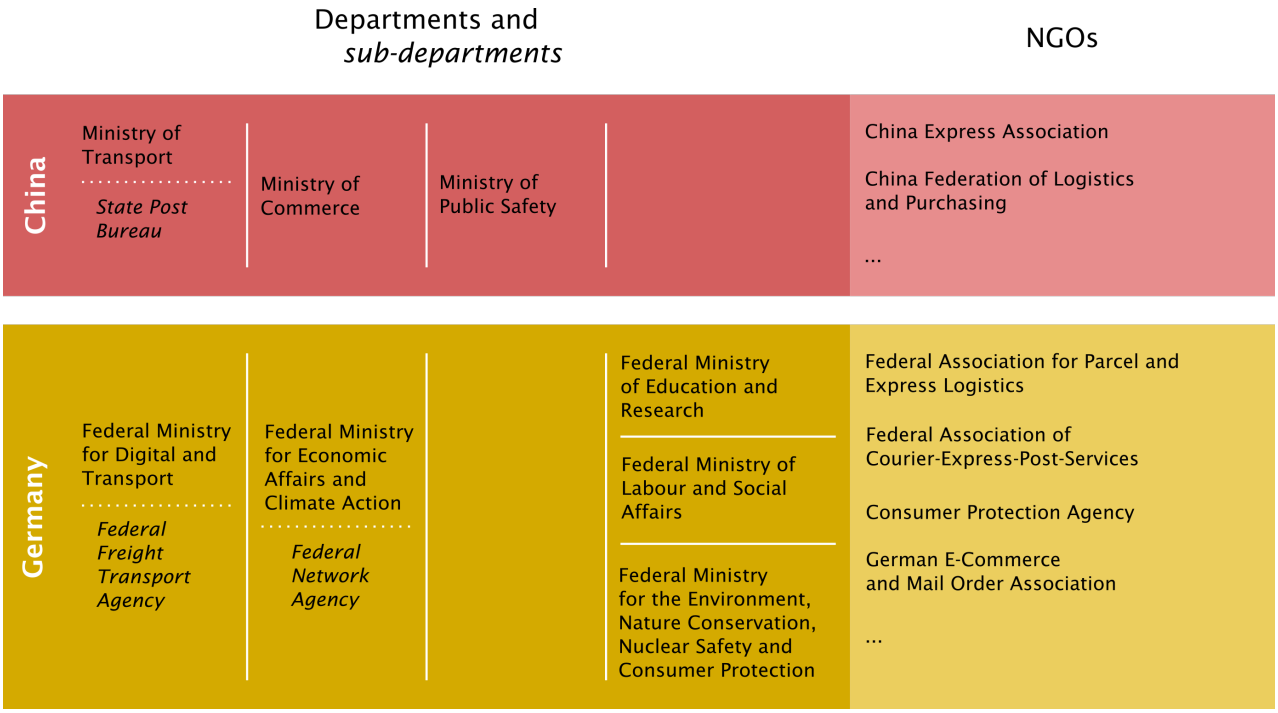

Figure 1: Relevant regulatory and political stakeholders in China and Germany for pacel logistics. Own figure, based on Transport Planning and Research Institute (TPRI) 2021; Leerkamp et al. 2021

Law and the Interim Regulations for Parcel, with some more specific industry standards issued by the SPB. Such standards concern for example packaging and packaging operations, COVID-19 prevention measures in the parcel delivery sector or the design of parcel delivery cargo bikes (Transport Planning and Research Institute (TPRI) 2021). The German Postal Act (Federal Ministry for Economic Affairs and Energy (BMWI) 1997) is comparable to its counterpart in China, but no state-issued standards for parcel delivery exist in Germany. Additional regulations like the German Parcel Courier Protection Law target specific shortcomings in the parcel delivery sector, in this case unpaid social security contributions by subcontractors (Federal Ministry of Labour and Social Affairs n. d.). As a member state of the European Union (EU), German regulations also implement rules and frameworks set by the EU (Leerkamp et al. 2021).

In their planning, funding, and development policies, both countries are set to decrease the environmental impact of parcel deliveries, with the main focus on greenhouse gas (GHG) emissions (Transport Planning and Research Institute (TPRI) 2021; Leerkamp et al. 2021). Additionally, the stakeholders in China seek to modernise and grow the national parcel delivery market as a whole, and thus focus more on energy efficiency than a net reduction of GHG emissions. Planning documents such

as the "Opinions on Accelerating the Green Transformation of Parcel Packaging" also target more sustainable forms of packaging (Transport Planning and Research Institute (TPRI) 2021). On the federal level, Germany ratified a packaging law with a similar background. It mandates that online retailers register their packaging and participate in the so-called "dual system" to finance recycling (Kumar 2020).

Planning and development documents have different levels of impact in terms of implementation and bindingness in China and Germany. Documents issued by China's State Council or the SPB set specific goals or regulate certain developments in the parcel delivery sector, like the use of reusable packaging or delivery times (Transport Planning and Research Institute (TPRI) 2021). Similar strategic plans in Germany (e. g. the Concept for Climate-Friendly Commercial Vehicles or the Innovation Programme Logistics 2030) mainly use subsidies and promotions to facilitate a green transformation in the sector, without much regulatory power. These development programmes are paid by federal and other public funds, with some of the funding going to governments on municipal level (Leerkamp et al. 2021). Many strategies are set out to reduce net GHG emissions of urban logistics with limited progress until now. National targets on GHG emission reduction are also projected to be missed (Umweltbundesamt 2020).

2.2 Comparison of Development in E-commerce and Parcel Delivery Markets

E-commerce is a growing business in both countries and has recorded steady growth for years. Internet penetration in China and Germany rapidly increased over the past years, up to 70.6% and 89.8% in 2020 respectively (International Telecommunication Union 2021). In Germany, 76% of individuals between ages 16 to 74 shopped online in 2021, a number slightly higher than the EU mean (Eurostat 2022). By size, China's e-commerce market dwarfs the German one: E-commerce transactions in China climbed to a volume of RMB 34.81 trillion (8.27 trillion PPP-USD) in 2019, with online retail amounting to RMB 10.63 trillion (2.53 trillion PPP-USD) (Transport Planning and Research Institute (TPRI) 2021). In the same year, online retail in Germany rose to a volume of EUR 72.6 billion (97.7 billion PPP-USD) (BEVH 2020), amounting to about 10.9% of all retail channels (IFH Köln GmbH 2020). In China, 20.7% of total consumer goods sales were made online in 2019 (National Bureau of Statistics of China 2020b). This share rose to 24.5% in the year 2021 (National Bureau of Statistics of China 2022b).

Outlooks on e-commerce for the next five to ten years expect considerable growth (cp. Figure 2), but with reduced growth rates due to saturation. Overall, online retail in China is

considered to be faster growing than in Germany, but similar trends, like a shift to online service sales and more fast-moving consumable goods (FMCG) being sold online, are mentioned.

For China, a report prepared by the investment bank Morgan Stanley foresees a decline in the year-on-year growth of e-commerce, with a compound annual growth rate of 12%. Along with weakening effects of the COVID-19 pandemic on consumer spending, especially the sale of FMCG is expected to grow online. The report also characterises the Chinese market as being highly accepting of new formats of e-commerce with more "social" components like live-stream shopping. It projects the share of online retail to rise to 45% of total sales in 2030, at the same time total consumer consumption is expected to grow by 7.9% annually (Morgan Stanley Research 2021). The Ministry of Commerce plans to grow the national e-commerce market to RMB 17 trillion by 2025 (Reuters 2021).

For Germany, growth rates of 7.2 to 13.7% annually in e-commerce sales are predicted for the years leading up to 2025. For the scenario with the highest growth, 21% of total retail sales could be made online in 2025. Driving factors are also a growth in FMCG and the pandemic shock (IFH Köln GmbH 2021).

As COVID-19 prevention measures encouraged staying at home and contactless forms of shopping, the pandemic was a major, lasting stimulus of e-commerce activities both in Germany and in China (Johnston 2021; Rusche 2021). Various uncertainties in these forecasts remain, mainly (Morgan Stanley Rese-

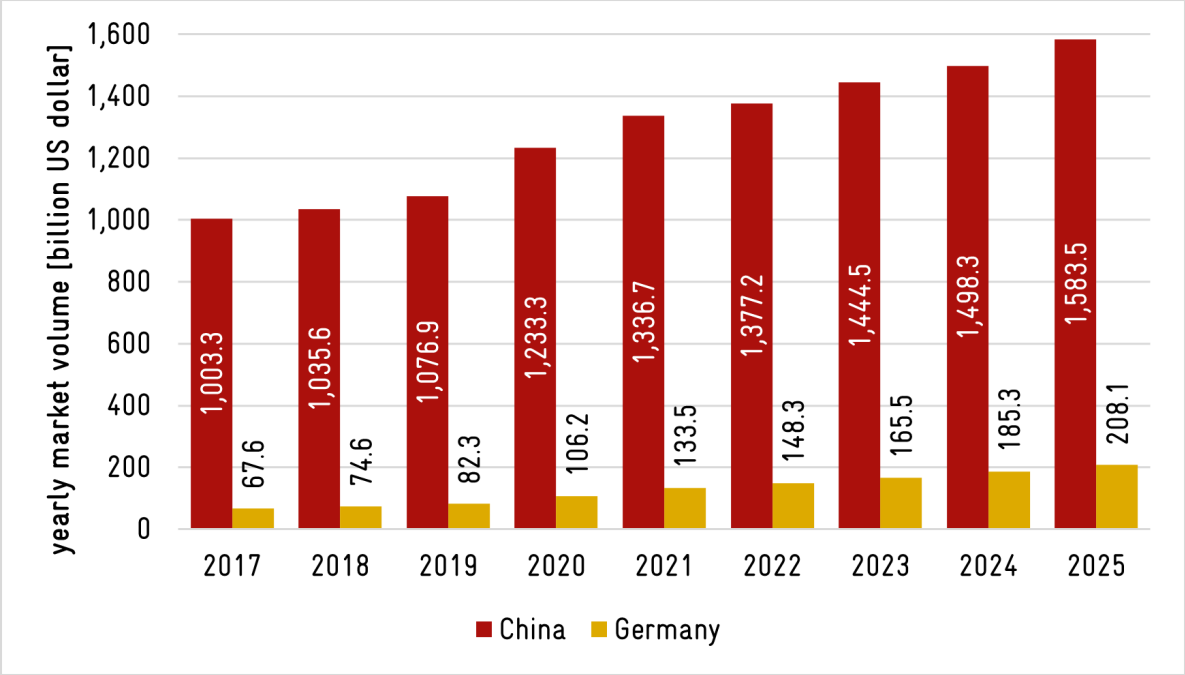

Figure 2: E-commerce market volume and outlook in billion US dollar, with yearly exchange rates. Own figure, with data from Statista GmbH 2021

arch 2021):

- effects of the ongoing pandemic, also affecting supply chains,
- possibly rising privacy concerns,
- anti-monopoly policies for platforms and tech companies.

This growth in online retail also reflects the parcel delivery market, especially with a rising number of B2C pieces. Since 2011, year-on-year growth in the Chinese parcel delivery sector has been even higher than the revenue growth of the e-commerce sector, ignoring the year 2014 (Transport Planning and Research Institute (TPRI) 2021). The growth rate declined over the same time period but lies still well above the German rates. In the year 2019, parcel volumes rose by 25.3% and 3.8% (KE-CONSULT 2020) respectively in China and Germany. Since 2011, the volume in China increased over 16-fold (Transport Planning and Research Institute (TPRI) 2021), and 0.48-fold in Germany (KE-CONSULT 2020), as pictured in Figure 3.

In China, a compound annual growth rate of 15% in sales is estimated for the ten years leading up to 2030, with parcels per capita rising to 365 annually in major cities and 110 in rural areas by then (Morgan Stanley Research 2021). German parcel delivery volumes are also ex-

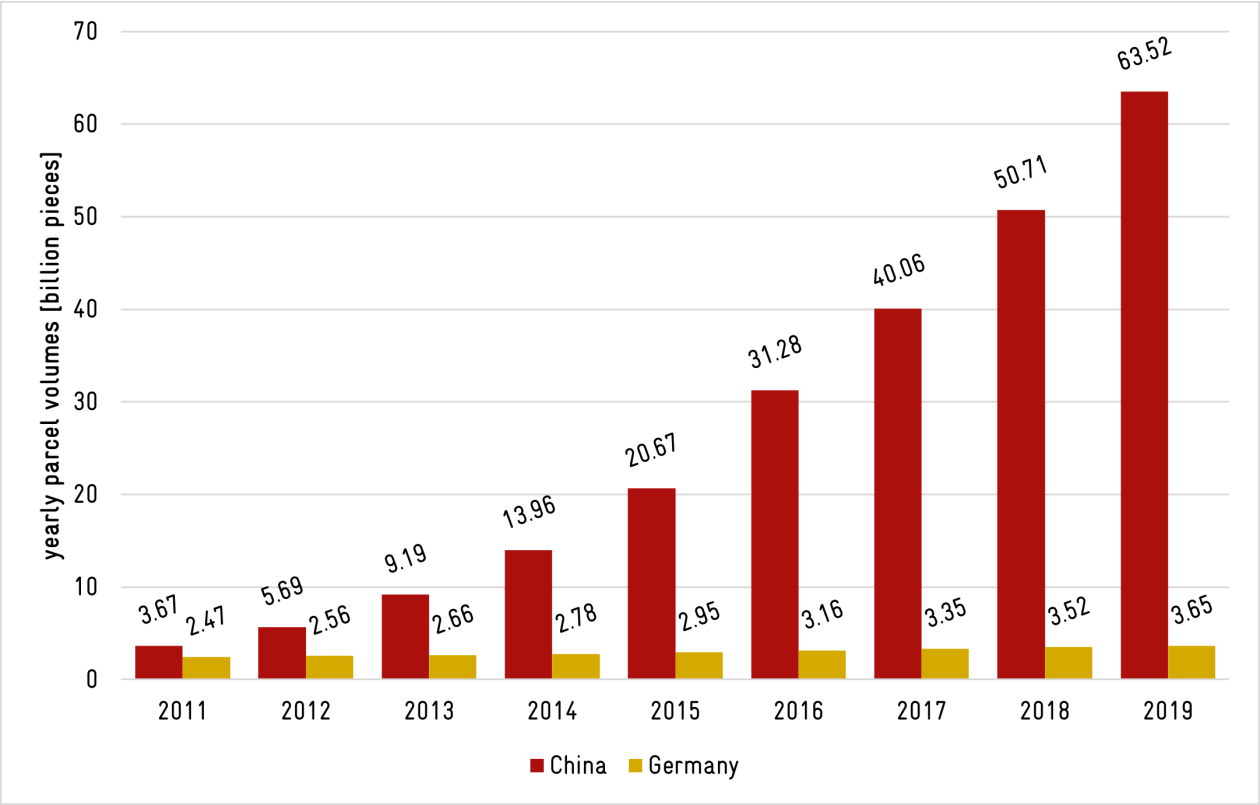

Figure 3: Parcel delivery volumes (in billion pieces) in China and Germany, years 2011 to 2019. Own figure, with data from Transport Planning and Research Institute (TPRI) 2021; KE-CONSULT 2020

pected to rise, with a 7% growth rate in volume and 5.68 billion pieces in 2025. Driven by online retail outlooks, especially the parcel segment, itself the largest sub-segment of the CEP market in terms of volume, and B2C deliveries are expected to grow (KE-CONSULT 2021a). Parcel delivery in Germany is characterised by highly standardised, lightweight parcels which weigh up to 31.5 kg and highly systematised shipping processes (Schwemmer et al. 2020).

Parcel delivery markets in both countries show a high level of concentration, with a small number of companies at the forefront. The Chinese parcel delivery market is mainly divided into private companies and the state-owned China Post Group with its Express Mail Service (EMS). Market concentration rose over the past few years, the concentration ratio of the biggest eight enterprises (CR8) was 82.5% in 2019 (Transport Planning and Research Institute (TPRI) 2021). For the year 2020, the CR8 in the German CEP segment was 73.6% while the CR4 was still 61.9%. This is mainly due to DHL being the dominating company in Germany with a market share of 35.3% by revenue (Schwemmer et al. 2020). This concentration is even more distinct in the B2C subsegment (Schlautmann 2018). The biggest parcel delivery enterprise in China is ZTO with a market share of 20.4% (ZTO Express (Caiman) Inc. 2020). Following these findings, market concentration is apparent in both countries, with rather monopolistic tendencies in Germany and oligopolistic structures in China.

For 2018, the German parcel delivery market had a sales volume of around EUR 11.4 billion (15.34 billion PPP-USD) (Wambach et al. 2019), compared to RMB 749.78 billion (178.18 billion PPP-USD) in China in 2019. The shipping volume in China increased to 63.52 billion pieces (Transport Planning and Research Institute (TPRI) 2021); in Germany it rose to 4.05 billion pieces in 2020 (KE-CONSULT 2021a). On a per capita basis (parcel shipments per inhabitant) this gives a similar average number of parcels per inhabitant in both countries, with a slightly higher number in China, as shown in Table 1.[3]

Parcel volume varies both between regions and segments.

- Shipment volumes per inhabitant vary regionally, following the population density. In China, this means that the Eastern regions receive a larger amount of parcel deliveries (Kang et al. 2021). For Suzhou, a number of 151.1 pieces per person is reported for the year 2019, with no differentiation between B2C and other segments (Transport Planning and Research Institute (TPRI) 2021). German post code districts also receive highly varying volumes of par-

3 Data for China is taken from Transport Planning and Research Institute (TPRI) 2021. For Germany the data for parcel volume is taken from KE-CONSULT 2020 and the parcels per capita for Germany are caluclated: CEP shipments divided by Germany‘spopulation with data from Statistisches Bundesamt 2020.

cels per inhabitant, more urban districts reporting more than ten times the number of rural districts (Manner-Romberg et al. 2017).

- In the B2C subsegment, an average parcel volume of 18 parcels per capita was assumed for Germany in the year 2017, also with regional variations (Manner-Romberg und Müller-Steinfahrt 2017). According to other data, 65% of CEP parcels in Germany were B2C (Schwemmer et al. 2020), resulting in an average of 28.5 parcels delivered to private customers yearly. Similar shares might also apply to China, where parcel deliveries are not recorded in this segmentation.

The vehicle fleet in the CEP segment in Germany consisted of a total of 140,000 vehicles in 2016 (Leerkamp et al. 2021), compared to 214,000 express parcel delivery vehicles in the same year in China. After that, the fleet of Chinese express parcel delivery companies only grew at a reduced rate, and even decreased in one year to 237,000 vehicles in 2019 (Transport Planning and Research Institute (TPRI) 2021). Fleet numbers of parcel delivery enterprises does not include vehicles of subcontractors or micro mobility devices, which fall between definitions in government statistics. Micro mobility for example includes the tricycles used in China and Suzhou, which are electrified and dominate the streetscape. In the Chinese general logistics segment, the share of so called "new energy logistics vehicles" reached 1.4% in 2019, which amounts to 360,000 alternatively powered vehicles in total (Jiang and Guo 2020). No total number for tricycles used for parcel deliveries could be found, but in Suzhou municipality alone, 13,900 vehicle licences were given out (Transport Planning and Research Institute (TPRI) 2021).

In Germany, around 95% of the vehicles used in the CEP segment are powered by fossil fuels.

In 2016, about 5,000 electric-powered vehicles were used for last mile delivery (Kienzler et al. 2019). Last mile delivery is predominantly carried out with light commercial vehicles in Germany and with micro mobility devices in China (Kienzler et al. 2019; Transport Planning and Research Institute (TPRI) 2021).

Table 1: Parcel volumes in 2019

	China	Germany
Parcel volume [billion pieces/year]	63.52	3.65
Parcel per capita [pieces/person and year]	45.4	43.9

3 Comparison of Parcel Delivery Networks in China and Germany at City Level, Using the Cities of Suzhou and Berlin as Examples

3.1 Comparison of Key Facts and Characteristics of the Cities

As a follow-up to the research on parcel deliveries in China and Germany, this study compares Suzhou in China's Jiangsu province and Berlin, the capital of Germany. Some key facts of both cities are presented in Table 2, maps are provided in Figures 4 and 5.

Suzhou is a prefectural-level city in the Yangtze River Delta with around 12.71 million inhabitants, 10.37 of which were classified as "urban population" in 2019[4]. The municipality is composed of five county-level cities and six districts that make up Suzhou proper. Half of these districts are highly urbanised, especially Guzu district in the city centre. The urban districts Xiangcheng, Wuzhong and Wujiang have significant levels of rural populations (ca. 26-30%), which is comparable to the county-level cities not included in the Suzhou Urban Area (National Bureau of Statistics of China 2021). The city state Berlin is divided into twelve districts. It has a population of about 3.66 million (Statistical Office for Berlin-Brandenburg 2021b), compared to 6.70 million in the Suzhou Urban Area. Berlin's population density (4,108 inhabitants/ km²) lies well above Suzhou municipality as a whole with 1,468 inhabitants/km². The area of Suzhou municipality also includes a higher proportion of water features (Suzhou: 36.6% (National Bureau of Statistics of China 2021), Berlin: 3.45% (Statistical Office for Berlin-Brandenburg n. d.)). Between the three most urbanised districts of

4 "Permanent residents", as per National Bureau of Statistics of China 2022a. The case study on Suzhou worked with 2019 data, which underestimated the municipal population by about two million. As the 2020 census showed, the "floating population" in the eastern provinces is much higher than in the previous census (cp. Cheng and Duan 2021).

Table 2: Comparison of key facts, 2019 data

	Suzhou		Berlin	
Inhabitants	12.71 million[1]		3.66 million[2]	
Area	8,657.2 km²		891.12 km² [3]	
Population density	1,468 inhabitants/km²		4,108 inhabitants/km²	
	nominal	in PPP-USD[4]	nominal	in PPP-USD
GDP	RMB 1.92 trillion[5]	456.3 billion	EUR 156.8 billion[6]	213.7 billion
GDP per capita	-	42.4 thousand	-	58.4 thousand
Disposable income	RMB 60,109[7]	14,282	EUR 21,327[8]	28,704

1 National Bureau of Statistics of China 2022a.
2 Statistical Office for Berlin-Brandenburg 2021b.
3 Statistical Office for Berlin-Brandenburg n.d.
4 Conversion rates from Organisation for Economic Co-operation and Development 2021.
5 National Bureau of Statistics of China 2021.
6 Senatsverwaltung für Wirtschaft, Energie und Betriebe n.d.
7 National Bureau of Statistics of China 2021.
8 Statistical Office for Berlin-Brandenburg 2021a.

Suzhou proper (Guzu, Industrial Park, High-tech Zone) and the Berlin districts, the density varies greatly, but the most central areas are almost equally dense (11,500 vs. 11,700 residents/ km²) (Senate Department for Urban Development and Housing; National Bureau of Statistics of China 2021). Both Suzhou's and Berlin's population have been growing steadily over the last decades, especially since 2014 (Transport Planning and Research Institute (TPRI) 2021; Statistical Office for Berlin-Brandenburg 2021b).

3.1.1 Economy

Measured in gross domestic product (GDP), Suzhou's economy is bigger, while Berlin's economic output per capita overtops Suzhou's by almost 38%. The GDP of both cities has

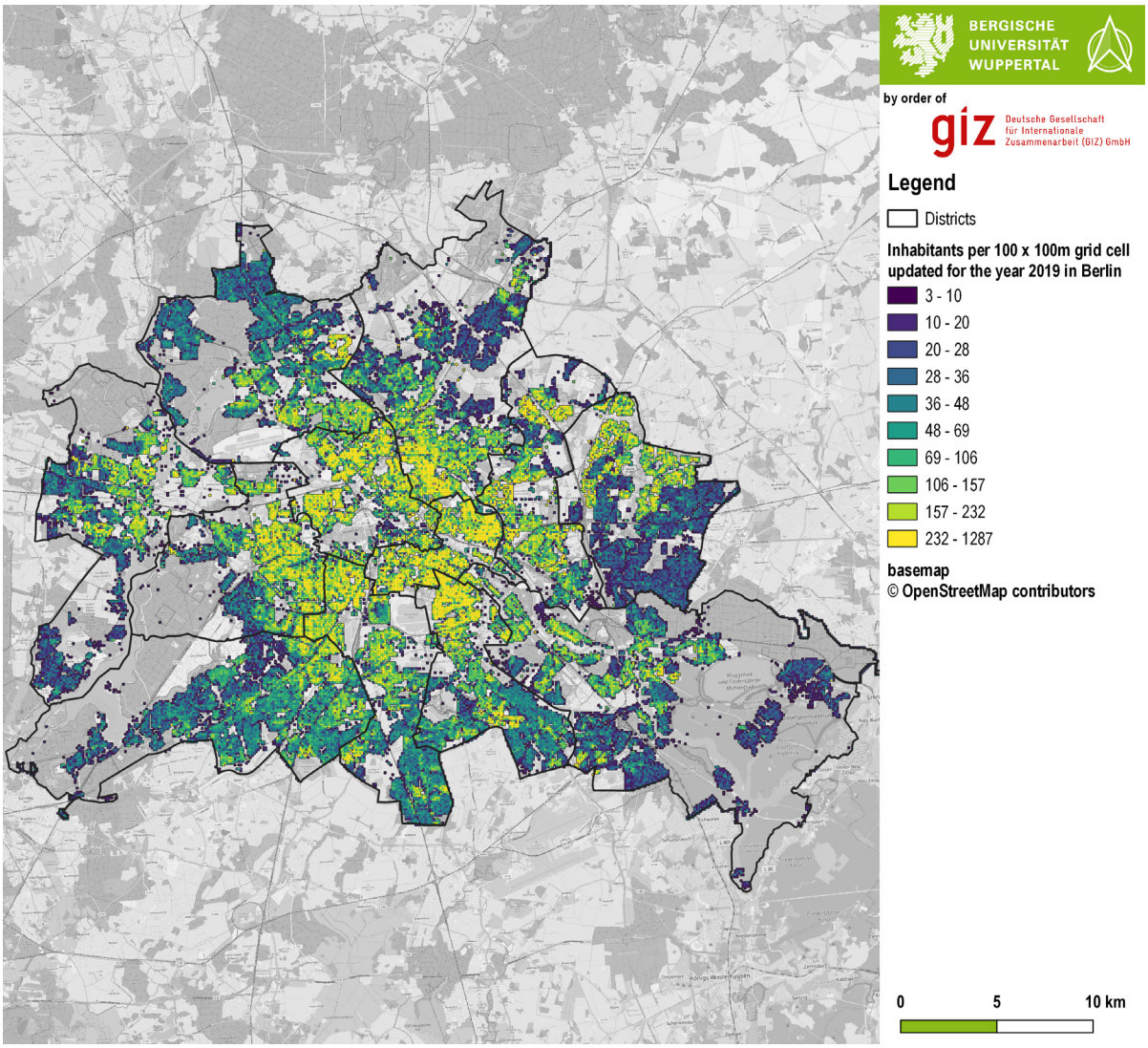

Figure 4: Berlin inhabitants per 100x100 m² grid cell. Figure from Leerkamp et al. 2021

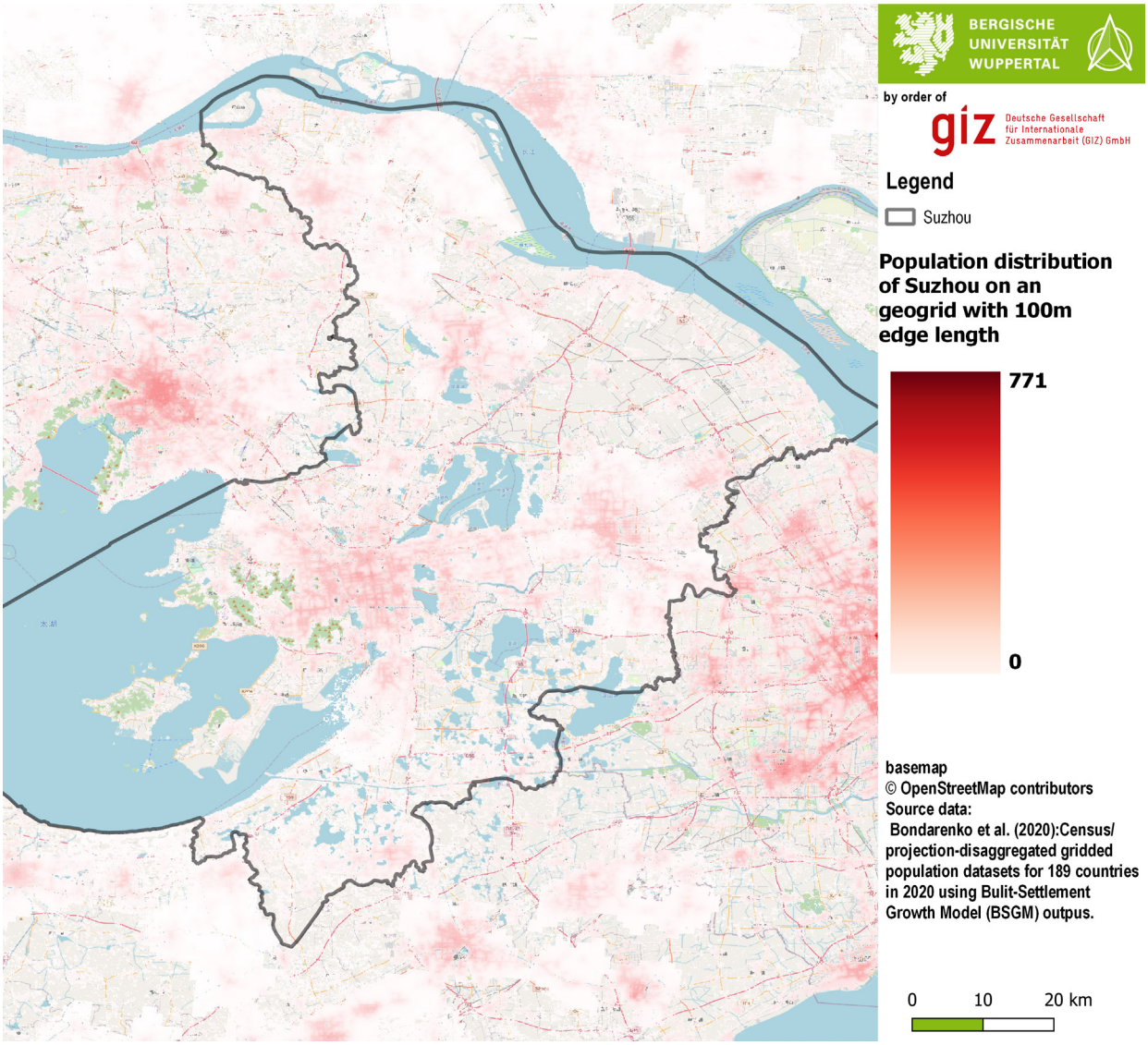

Figure 5: Suzhou inhabitants per 100x100 m² grid cell.
Own figure, with data from Bondarenko et al. 2020

been growing over the last decade until 2019, in the following year Berlin's GDP shrank slightly due to the COVID-19 pandemic (IHK Berlin 2021). Per capita, the GDP of Berlin ranks similar to the German average, with Berlin contributing about 4.6% to the national GDP (Senatsverwaltung für Wirtschaft, Energie und Betriebe n. d.). By GDP, Suzhou is the sixth richest city in China, amounting to 1.9% of the national GDP (National Bureau of Statistics of China 2020a). As shown in Table 2, disposable income of Berlin residents is almost double that of Suzhou residents.

Online retail sales in Suzhou went up to RMB 298.3 billion (71.26 billion PPP-USD) and amount to 38.7% of total retail sales in 2020 (National Bureau of Statistics of China 2022a). No similar statistic exists for Berlin. Only numbers for retail enterprises registered in Berlin are available. These retailers made 21.5% of their sales outside of shops (including online retail, sales at markets, direct sales, vending etc.) (Amt für Statistik Berlin-Brandenburg 2020). According to research carried out by the German retail association, online retail amounted to 10.5% of total retail sales nationally (IFH Köln GmbH 2020). Similar numbers might be inferred for Berlin. Overall, this shows a stronger preference of Suzhou residents for online retail compared to Berlin or Germany in general, while Berlin residents have a larger disposable income than Suzhou's inhabitants. For a juxtaposition of online retail spending per capita, no data basis exists.

3.1.2 Transport

As the spatial area of the state Berlin is much smaller (891.12 km² (Statistical Office for Berlin-Brandenburg n. d.) vs. 8,657.32 km² in Suzhou) in comparison and more urbanised than the whole Suzhou municipality, differences in the city's traffic arise. To compare the road infrastructure, an analysis of the different road classifications is important: For example, the highway density in Suzhou is either 139.2 km/100 km² or 70.2 km/100 km², when referring to national expressways only (Transport Planning and Research Institute (TPRI) 2021). Berlin has 86.1 km/100 km² of national highways ("Bundesautobahn"). Below that class of roads, Berlin as a city state defines a "superordinate road network" of inner-city streets and highways with a higher importance. Its length is 1,530 km (Senate Department for the Environment, Transport and Climate Protection 2017), compared to Suzhou's higher-level road network of 11,818 km. Translated to the areas of Berlin and Suzhou, this amounts to 1,716.98 km/100 km² and 1,365.09 km/100 km² respectively. No clear conclusion can be drawn due to the different definitions, but it becomes clear that both cities have a stratified road network, tailored to their spatial structure.

Instead, an analysis of the transport network usage is useful. Residents of Suzhou undertook 2.4 trips per day with a slightly rising trend (0.5% growth between 2017 and 2018) (Transport Planning and Research Institute (TPRI) 2021), compared to 3.5 in Berlin (Gerike et al. 2019). For their trips, urban residents in Suzhou and Berlin use active forms of transport about half of the time, the share being slightly larger in Suzhou. Berlin residents are more likely to use public transit, while Suzhou urban residents prefer motorised private transport (cp. Figure 6).

Average trip length in Berlin is 5.9 km, with the share of public and motorised private trans-

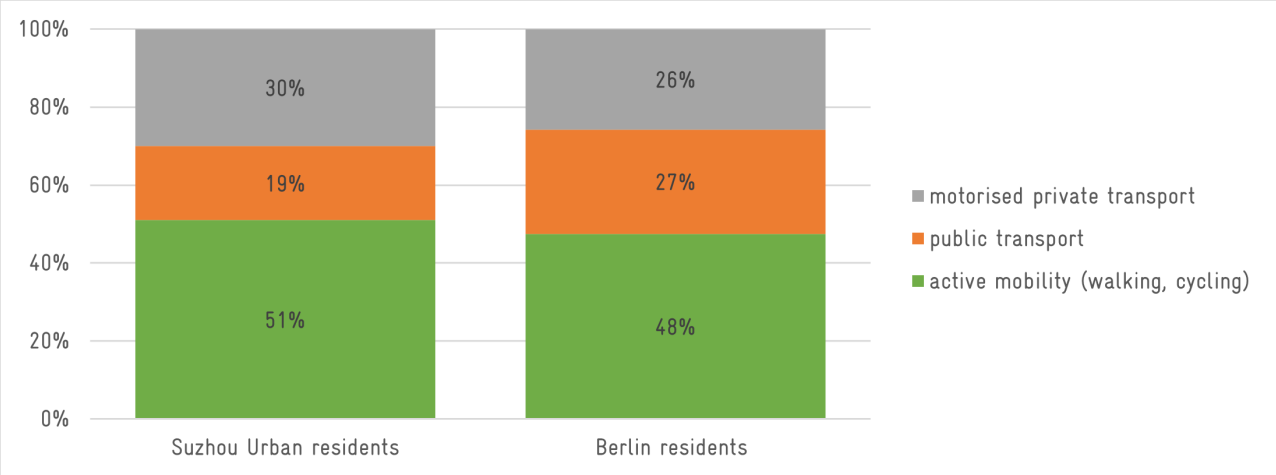

Figure 6: Modal split of Suzhou and Berlin residents, 2018 data. Own figure, with data from Transport Planning and Research Institute (TPRI) 2021; Gerike et al. 2019

port increasing for longer trips (Gerike et al. 2019). No data was given on the trip length in Suzhou, but as active mobility is usually used for shorter distances, a similar relation between mode of transport and trip length can be inferred[5].

3.1.3 Parcel Delivery Networks

Parcel sorting and distribution networks in China and Germany are structured and named slightly differently, as shown in Figure 7. It focusses on the "main leg" (also called "main run" or "transhipment network"), the transport process after a parcel is collected from the shipper ("pre-run"), and last mile delivery. The main leg consists usually of a series of consolidated transports and transhipments in automated sorting centres. In the end, customers receive their parcels either by door delivery or by picking them up from local facilities. These transport processes are similar, but between China and Germany, some differences arise:

- Chinese parcel delivery companies use sorting centres on different levels, the lowest being city-level sorting centres. These sorting centres are connected by deliveries made by different classes of vehicles. It is understood that parcels can go through sorting centres of different levels in different ways, depending on the destination (Transport Planning and Research Institute (TPRI) 2021).
- German CEP companies use local sorting centres ("depots") on the lowest network level and one- or two-level transhipping networks, consisting of higher-levels sorting centres ("parcel centres" or "hubs"), bridged by consolidated transports

5 Due to their low travel speed, active modes of mobility are usually used for smaller distances, especially walking. For longer trips, faster modes of travel are preferred. This universal behaviour can be seen in Gerike et al. 2019: Walking is the dominant mode for trips below one km, but is insignificant for distances above five km. Cycling is also rarely used for longer trips.

(Schwemmer et al. 2020).

There are 19 depots in Berlin, compared to 21 sorting centres in Suzhou (region-, prefectural- and city-level). Both Berlin and Suzhou are also served by sorting centres[6] outside of their administrative boundaries, like the Kunshan city-level sorting centres in Taicang being connected to the regional sorting centre in Shanghai municipality. Higher-level sorting centres in China are often used by more than one parcel delivery enterprise. Nationally, 17.4% of the total parcel volume in China never leaves the city boundaries (intra-city business) (Leerkamp et al. 2021; Transport Planning and Research Institute (TPRI) 2021).

As this study focuses on last mile delivery, the differences between China and Germany are important. In Germany, the main leg ends in a "local sorting centre" or "depot", where all last mile delivery tours begin and end. From these 19 Berlin depots, some of which are operated by subcontractors, parcels are distributed to the addressees (door delivery) and "pick-up points"[7] (Persiel 2021). From there, customers can pick up their parcels themselves. Pick-up points can take the form of shops, agents or intelligent lockers, and are either operated by delivery companies or by franchisees. It is hence comparable to the "parcel stations" in Suzhou. Jointly used parcel stations receive shipments from more than one delivery enterprise. This practice is more common in Suzhou, where third-party parcel stations exist both as shops and as parcel lockers, than in Germany[8]. Major companies and local authorities back or operate these joint delivery concepts in Suzhou, in contrast to Germany. In Suzhou, parcel stations are often placed at convenient places in close proximity to its customers, like in the entrance of housing compounds ("property office") or at schools (Transport Planning and Research Institute (TPRI) 2021).

Last mile delivery is carried out with micro mobility vehicles in China, while German parcel delivery companies mainly employ light commercial vehicles with a gross vehicle weight up to 7.5 tons. Delivery tours originate from the lowest level of sorting centres ("city-level" in China and "depots" in Germany). Last mile delivery both in Berlin and in Suzhou is mainly carried out by subcontractors and franchisees, sometimes operating their own, small-scale delivery networks (Transport Planning and Research Institute (TPRI) 2021; Leerkamp et al. 2021).

6 Local nomenclature varies between China and Germany as noted in Figure 7.

7 The term pick-up point as used in the Berlin case study means either an automated parcel locker, a parcel shop or another shop, operating as an agent for a parcel delivery enterprise.

8 In the German city of Mainz for example, some shops act as agents for more than one delivery enterprise. A small share of agents (44 out of 237 pick-up points) functions that way, as surveyed in Leerkamp et al. 2022. Third-party parcel lockers are very uncommon in Germany and are not present in Berlin.

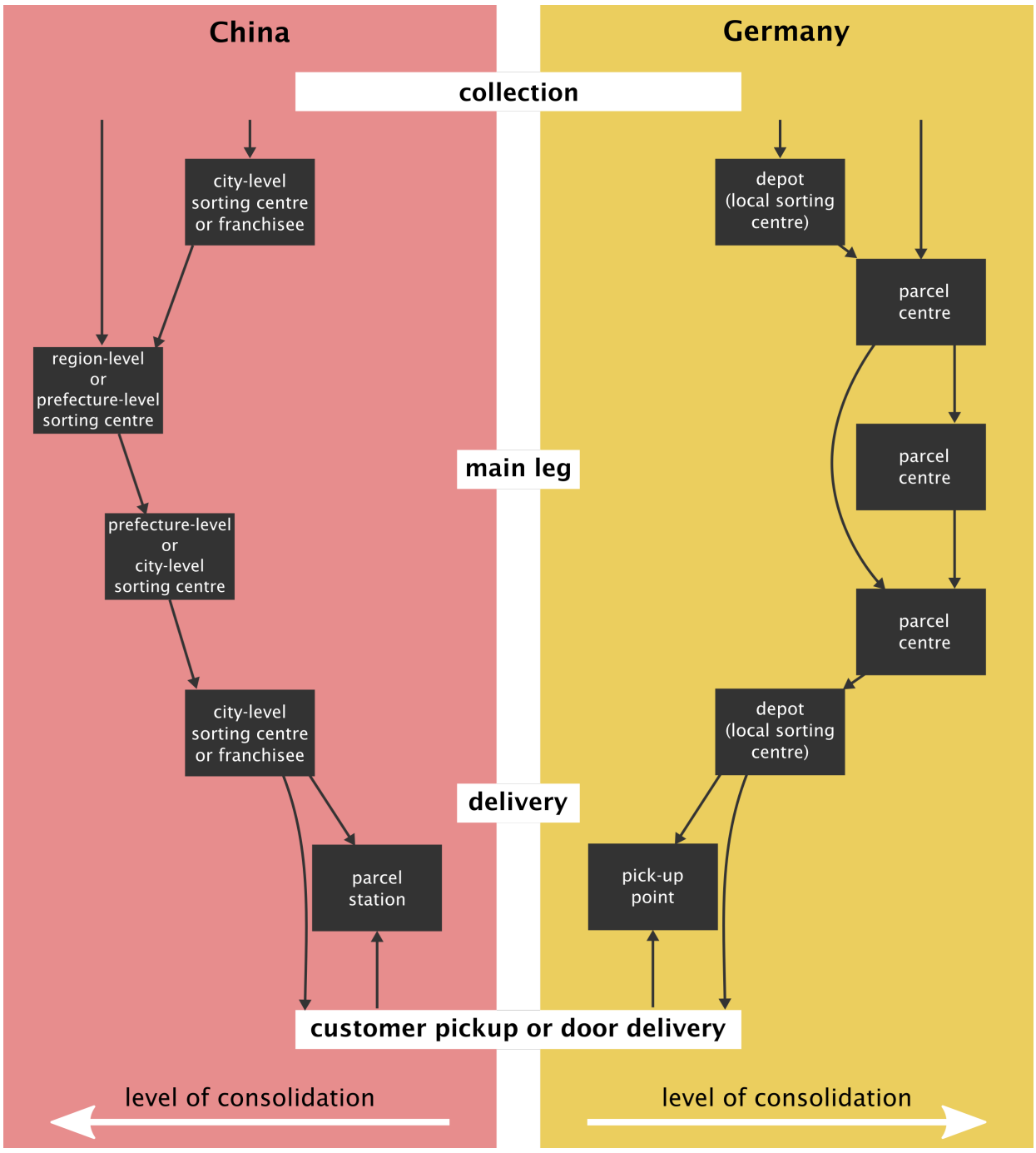

Figure 7: Parcel distribution networks in China and Germany. Own figure, based on Transport Planning and Research Institute (TPRI) 2021; Schwemmer et al. 2020; Persiel 2021

3.2 Comparison of Citywide Logistics Strategies and Plans

The success or successful implementation of various bundles of measures depends decisively on the substantive detail and binding character of urban logistics concepts. In Germany, a wave of green city plans has been triggered by the "Clean Air" emergency programme in the period from 2017-2020, which offers a wide range of measures. In addition, there are other plans and concepts in German cities that differ in terms of their mandatory character. In these concepts, urban freight transport often plays only a subordinate role.

To be able to work out similarities and differences in the handling of urban logistics at city level, the spatial planning systems of both countries are briefly compared in a first step. The shape of Chinese spatial planning (urban and rural planning) has changed considerably in recent decades. Above all, the institutional changes in spatial planning over the past 15 years are crucial for the current design of the system. Zhao und Pan (2020) made a historical comparison of the Chinese planning system. Given China's size, they reason that spatial planning should be both decentralised and uniform in terms of structure. Pilot projects showed that the old planning system could no longer withstand the challenges of the present time (e. g. the sustainable management with limited resources). Strong and internal competition between the relevant planning fields could also be observed. During the institutional reform over the past years, all issues relating to spatial planning were transferred to the newly created Ministry of Natural Resources (MNR) in order to resolve the differences in terms of policy between the various planning units. The MNR has integrated the spatial planning functions which were scattered across multiple departments. The new planning system is known as "five levels, three categories/types and four systems". The five levels represent the administrative divisions of China (national, provincial, municipal, county and township), with three types of overall planning (master planning/comprehensive planning), detailed planning and special planning which are operated in four systems: the preparation and approval system, the implementation supervision system, the regulatory policy system and the technical standard system (Wang and Wang 2021; Zhao and Pan 2020; Liu and Zhou 2021).

On a macro level, the recently implemented spatial planning system is also known as the National Territory Spatial Planning (NTSP), which describes the concept of „multiple planning in one" (Urban Planning Society of China (UPSC) 2022). The NTSP shown in Figure 8 is a global arrangement for land use planning which focuses on a strategic coordination (Liu and Zhou 2021). The different plans and their impact (strategic, coordinate or implementab-

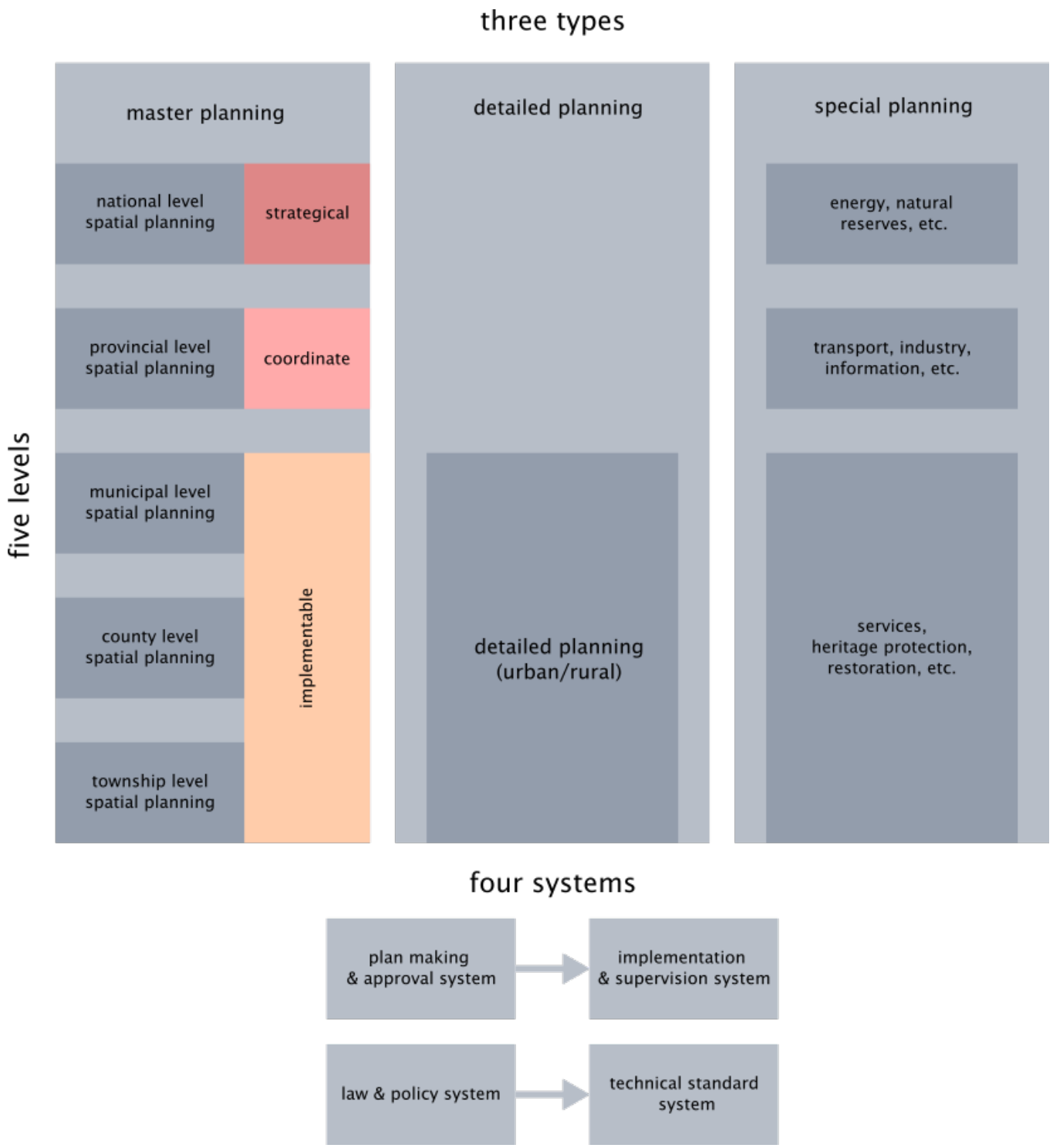

Figure 8: China's national territory spatial planning system. Figure based on Zhao and Pan 2020; Xinhua 2019

le) are derived from the administrative division. The plans, which are subsumed under master plans, strive for a coordinated and arranged set of plans that work in a specific region (administrative division). They emphasise the comprehensiveness of planning. The master plans (comprehensive NSTP) are the basis for the detailed and specific planning. Detailed plans specify land plots functions and issue the planning permissions for urban and rural construction projects. Special plans aim to formulate goals on a policy level (e. g. transport) (Urban Planning Society of China (UPSC) 2022).

German spatial planning (see Figure 9) is organised in a decentralised manner in accordance with the federal state system with four levels: The federal government; the federal states (including the regional level, which is organised differently depending on the state); and the municipalities.

Federal spatial planning is essentially limited to the development of guiding principles and principles of spatial planning and at the same time functions as the legal basis for the spatial planning of the states.

State planning concretises the principles formulated at the federal level, while the objectives set at the higher levels are concretised at regional or municipal level. Following the depiction of the Chinese spatial planning system, three subsystems can also be identified

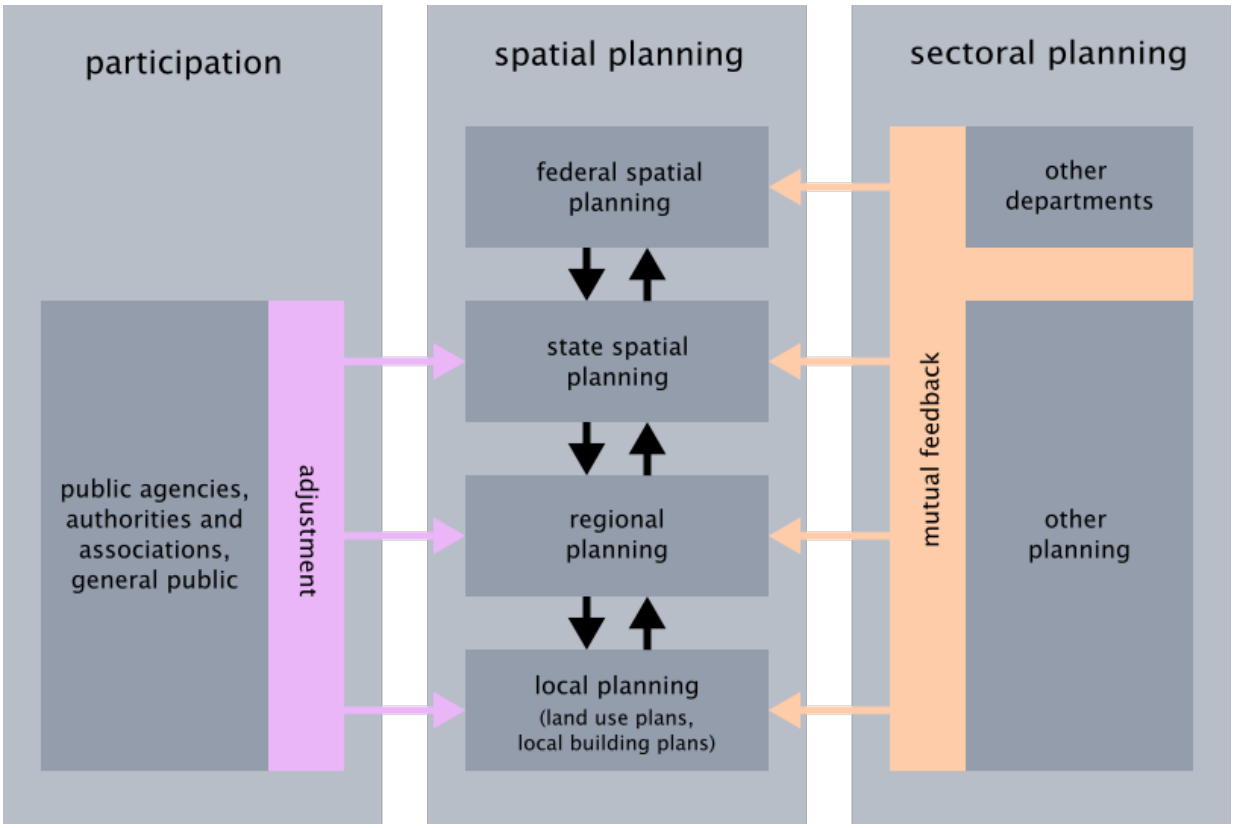

Figure 9: German spatial planning system with the mutual feedback principle. Own figure, based on Pahl-Weber and Henckel 2008

for Germany, which interact with each other on a horizontal level. Contrary to the Chinese system, however, the direction of action is both vertical and horizontal (cp. Figure 9). On the vertical level, participatory processes are taken up and sectoral planning contributions are included in the actual planning (spatial planning). The mutual feedback principle, which characterises the two-way influence on all planning levels, is essential for German spatial planning (Pahl-Weber and Henckel 2008; Academy for Territorial Development in the Leibniz Association (ARL) n. d.).

The brief comparison shows that there are similarities between the two countries at the spatial planning level. The concretisation of the planning level becomes more detailed with each lower level. However, there are also differences that become apparent in the direction of action of the planning systems.

The comparisons illustrate that municipal concepts in both countries are derived from higher levels (goals and principles) and that conceptual planning at the municipal level always depends on other actors (interdependence or mutual feedback principle). The following is an in-depth look at the lowest level (the municipalities) in terms of spatial planning systems. At this point, it should be emphasised once again that Berlin, as a city state, has different competences than comparable German cities, such as Munich or Cologne. However, the measures implemented, which are described in more detail, can also be realised in cities that are located in territorial states.

In Berlin, there are different planning concepts that differ in terms of formality and bindingness. The main concepts that can be identified are the Urban Development Plan for Mobility and Transport and the Integrated Concept for Commercial Transportation (IWVK). Figure 10 shows a hierarchy of these two concepts in the planning system of the state of Berlin.

Regarding the planning hierarchy in Germany, the land use plan is the preparatory level for the local building plans. In Berlin, as a city state, the land use plan is equivalent to the regional plan (cp. Figure 9). In between the two planning levels (land use plans vs. local building plans), urban development plans are informal instruments of urban planning that cover the entire city. They are coordinated with each other so that competing land uses can be resolved at an early stage. Through the mutual feedback principle, which is important for spatial planning in Germany, urban development plans influence both the higher level of land use plans and the local building plans and indicate necessary measures, thereby actively shaping Berlin‘s urban development (Senatsverwaltung für Stadtentwicklung und Wohnen 2021).

Contextualising urban freight transport in the present planning system (cp. Figure 10), the

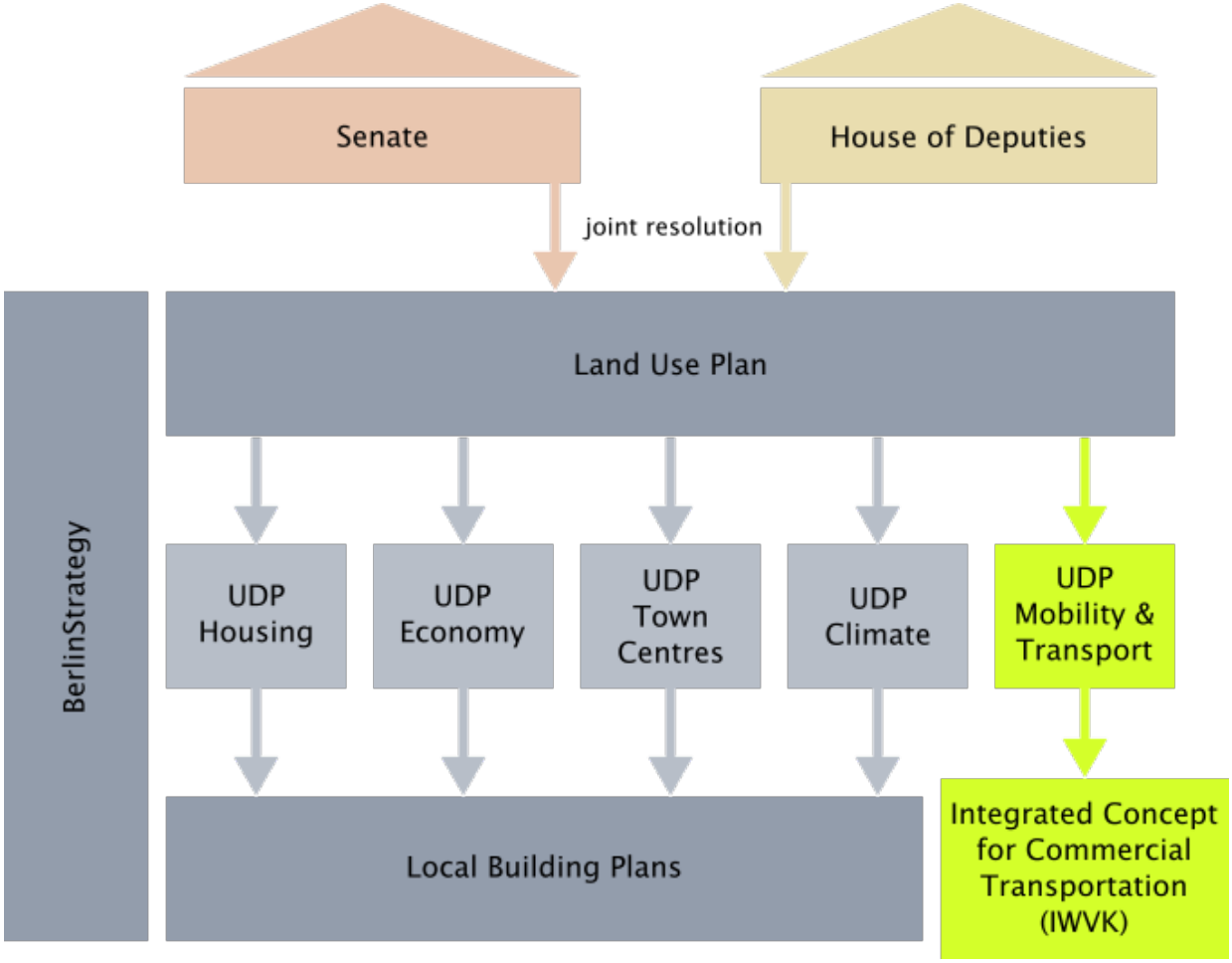

Figure 10: Planning system in Berlin and the IWVK. Figure based on Senatsverwaltung für Stadtentwicklung und Wohnen 2021

land use plan represents the type and density of land use and the higher-level transport network, which have an influence on the volume of freight transport and the spatial distribution of traffic flows. In addition to the land use plan, the Berlin Senate has a citywide and interdepartmental vision for Berlin called "Berlin-Strategie" that defines medium- to long-term development paths and goals. The strategy has an influence on all further planning concepts and levels as can be seen in Figure 10 (Senate Department for the Environment, Transport and Climate Protection 2021). Following Germany's spatial planning culture, all development plans aim to achieve a balance within the different policy fields in Berlin. This means that flanking measures or objectives of freight transport are also formulated in the other so-called "Urban Development Plans" (UDP). The Urban Development Plan Economy for

example primarily deals with the provision of appropriate areas for commerce, industry and logistics and activates further land potential. The Urban Development Plan for Town Centres, which formulates guidelines and goals for protecting and developing the polycentric centre structure in Berlin, sets requirements for urban development in order to provide the respective centres with sufficient logistics areas (Senatsverwaltung für Stadtentwicklung und Wohnen 2021). The Urban Development Plan for Mobility and Transport sets out the framework conditions and development expectations and combines them into a guiding principle with precise objectives. The aim of the IWVK is to substantiate the paths of action defined in the Urban Development Plan for Transport and Mobility. The current IWVK is an update of the first IWVK from 2006. Based on the objectives of the first UDK for Transport, the IWVK contained a programme of measures with five main areas of action and 21 priority measures. Fixed approaches of the IWVK have been integrated into other central plans of other policy areas. This became particularly clear in areas where no direct action is taken by the public authorities (federal government, state, districts) (Senate Department for the Environment, Transport and Climate Protection 2021). The core tasks are the following ones (Senate Department for the Environment, Transport and Climate Protection 2021):

- Identifying relevant requirements for action for urban freight transport,
- identification and initiation of regulatory and traffic organisation measures,
- taking all modes of transport into account,
- ensuring the functionality of Berlin's centres by securing transportation for provision and disposal as well as high-quality accessibility to the centres of commercial value creation.

The presentation of the different planning levels, their different timeframes for action and the measures derived from the plans make clear that freight transport is dealt with by different stakeholders and policy fields in Germany.

Concrete concepts that only concern the CEP segment do not exist in Berlin. Yet, the IWVK actively picks up on the stakeholder reference. This mix underlines the complexity of freight transport in the city. The inclusion of the stakeholder reference also results indirectly from the integrated approach of the IWVK and is reflected in the planning concept of integrated freight transport, which aims to unite different planning approaches, different modes of transport and different interests of the stakeholders. Ultimately, the IWVK contributes to the consolidation of divergent planning goals and provides the municipality with a concrete framework for implementing measures (Senate Department for the Environment, Trans-

port and Climate Protection 2021). Like Berlin, Suzhou also has higher-level plans from which sectoral plans can be derived, as can be seen in Figure 11. Each of the city's sectoral planning authorities develops sectoral plans based on the master plan, but contrary to the present planning framework in Berlin, these are not used as a basis for developing plans at a smaller scale.

The development plans at county level are not derived from the sectoral development plans, as in Berlin, but instead are based on the objectives formulated in the master plan. Nevertheless, they are integrative, similar to Berlin, since all government agencies of the respective administrative division participate. In addition to the classification of the planning responsibilities of the individual administrative divisions of Suzhou, two concepts can also be identified that formulate measures and goals specifically for CEP logistics, which does not apply to Berlin. In Suzhou, two higher planning concepts or binding legal ordinances ("Postal Law of the People Republic of China" and the "Interim Regulations on Parcel Delivery") are used to set benchmarks to improve the development of the CEP segment. Thus, bund-

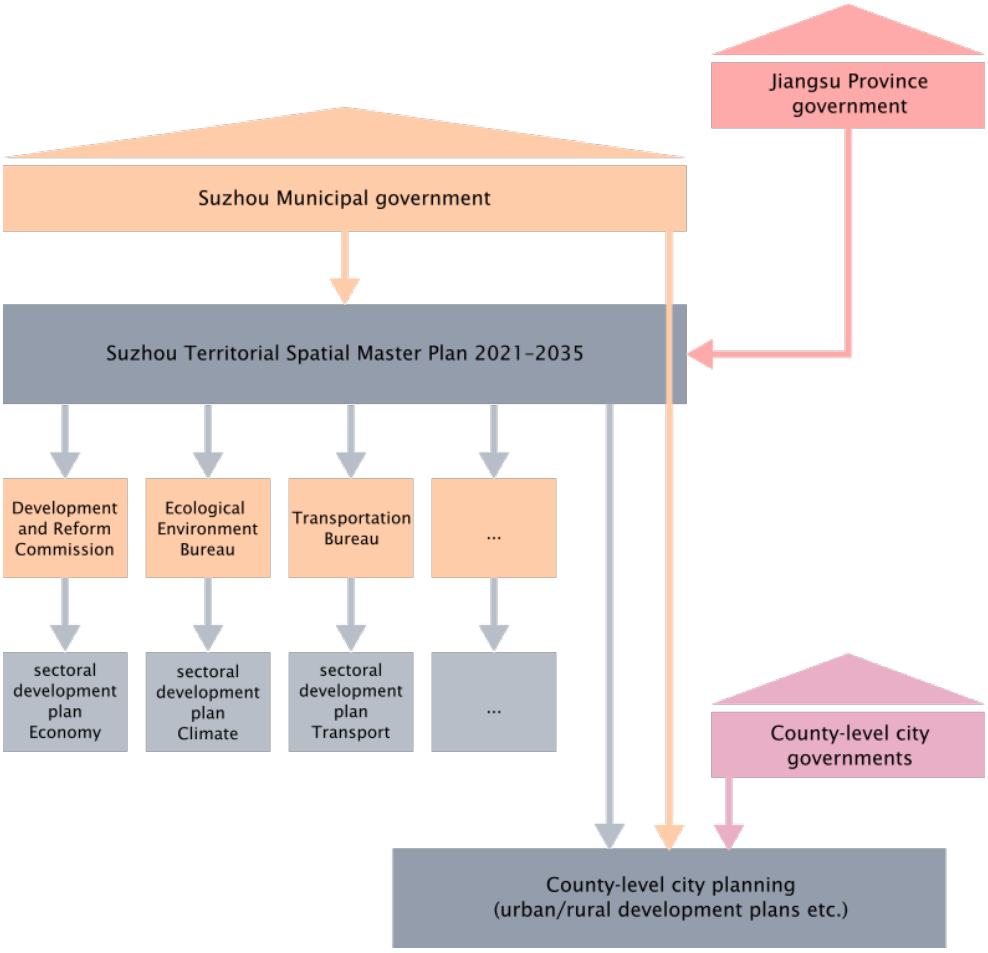

Figure 11: Planning sytem in Suzhou. Own figure

les of measures are also directly derived from regulations adopted at national level. There is also a strategy that formulates goals for CEP logistics which is presented below. (Transport Planning and Research Institute (TPRI) 2021)

Within the development strategy of the parcel market in Suzhou, four targets are formulated, from which measures are derived. The objectives are briefly outlined below.

1. **Promoting the Integrated Warehouse and Distribution Service**

- The concept aims to achieve positive effects through the integrated approach of different stages of CEP production in order to achieve efficiency and costs in last mile handling. In addition, incentives are created to establish collaborative and vertical process steps across company boundaries.

2. **Promoting the Urban and Rural Distribution**

- Urban and rural logistics distribution focuses on solving the problem of two-way collection, location and delivery for industrial products, etc. The concept reflects the different spatial types of Suzhou and suggests alternative delivery concepts such as delivery to alternative locations to ensure the supply of rural areas and to simultaneously reduce the mileage through possible bundling.

3. **Promoting the Development of Technological Innovation**

- To monitor the sorting of shipments as well as transports, the administration actively supports efforts to switch to digital applications such as Internet of Things and other modern information technology. The incentives are not substantiated in terms of content. However, it can be concluded from the objectives that both operating and environmental costs can be saved by the company.

4. **Promoting Green and Low-Carbon Development**

- Within the objective to implement green alternatives in the CEP segment, several concepts arise to meet these objectives. In addition to newer packaging methods, they also include the switch to alternative vehicles that travel around 10,000 km per year.

Comparing the objectives of existing concepts in both cities, the following differences in content become clear: For Berlin, targets are formulated in a more general context, which may concern all stakeholders in urban freight transport. Objectives concerning the reorganisation of parcel deliveries, as formulated in Suzhou, do not exist for Berlin at the conceptual level. Suzhou develops approaches on a conceptual level to achieve the goals of the integration of

different CEP enterprises and at the same time implement bundling strategies that achieve medium-term positive effects. On a conceptual level, this sharpness cannot be observed for Berlin. Ultimately, it can be said that both cities reflect the different planning cultures of their countries. The consensus on setting framework conditions at the planning level, which is common in Germany, can be found in Berlin.

3.3 Citywide Measures in Urban Logistics

Logistics concepts offer a wide range of measures. Unlike public transport, there are no specific and legally based control obligations for urban freight transport in Germany. The lack of municipal commitment in Germany means that concepts are often developed that diverge in their legal sharpness. Another challenge arises in the implementation of transport planning measures, which are not only implemented by the municipality, but can also fall within the scope of logistics companies (Thiemermann et al. 2021).

In Germany, there are two main legal areas for municipalities to design and control urban freight transport based on measures, which will be summarised below with regard to their differences and similarities. The two areas of jurisdiction can be differentiated into road law and road traffic law, which are based on different areas of competence. Road traffic law is federal law based on the Road Traffic Act and Road Traffic Regulations and regulates the use of public roads. Regulations of road traffic law are the setting up of road signs, e. g. a well-known measure of road traffic law is the ordering of pedestrian zones and the temporary opening to freight transport (Sommer 2021).

Road law, in contrast, regulates the permissible use of roads, e. g. roads can only be designated for pedestrian traffic. Whereas in road traffic law the municipality can only decide on traffic restrictions and is dependent on the cooperation of the road traffic authority, road law offers the acting municipality greater scope of action (Sommer 2021).

A process for the implementation of measures at the municipal level can be exemplified for Germany in the following example. The Federal Immission Control Act (BImSchG/BImSchV), which was transposed into German law on the basis of a Council of Europe decree, is chosen as a representative example. In Berlin, local clean air plans are developed on this basis and are submitted by Berlin‘s highest environmental authority. In the clean air plans, specific transport related problem areas and zones are identified. For the concrete organisation of freight transport, instruments of road law or road traffic law can be chosen at the lowest municipal level in order to direct the traffic spatially and temporally in a different

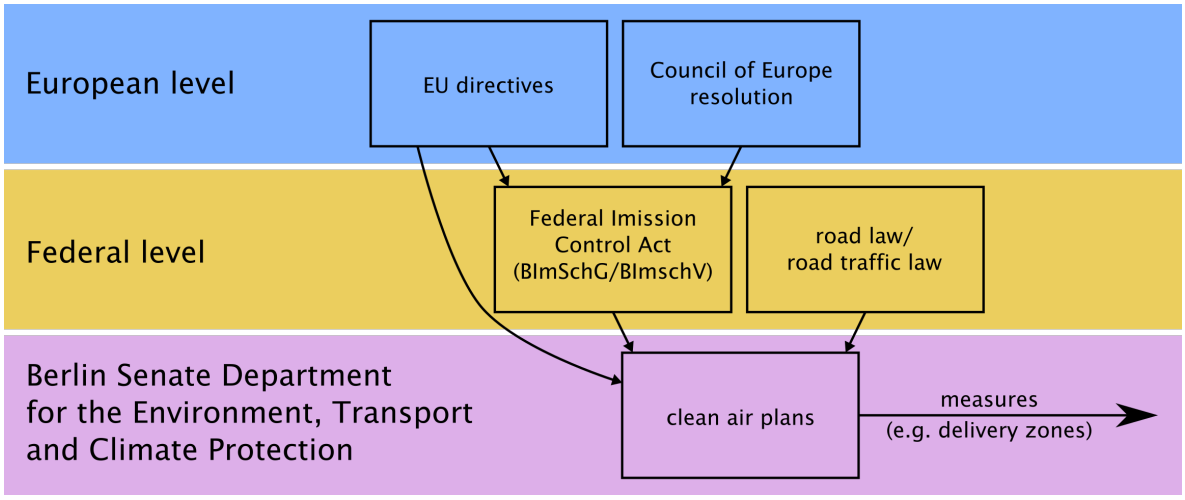

Figure 12: Exemplary presentation of the implementation of a measure at different planning levels in Germany. Own figure

way. Urban transport planning measures could, for example, be the establishment of delivery and loading zones (Senate Department for the Environment, Transport and Climate Protection 2021). The example of clean air planning and its intended transport planning measures at the local level clearly demonstrates how the different planning levels in Germany (Europe) interact (Figure 12).

As a similar analysis cannot be offered for China or Suzhou within the scope of the study, measures are compared using the nomenclature shown in Figure 13. This classification of measures in urban logistics is common in research literature and also serves as the guiding principle for this report. The modular perspective, based on Leerkamp et al. (2020) and Russo and Comi (2011), allows a simple comparability and combines the different options for actions of the stakeholders in urban freight transport. Measures are sorted into four interconnected dimensions (material and immaterial infrastructure, equipment and governance), all of which can be influenced directly or indirectly, by setting incentives (or regulations), by public authorities.

The measures identified in both cities and countries differ considerably (cp. Figure 14 and Figure 15). Whereas in Germany (Berlin) measures are rather subsumed under the area of material infrastructure, the measures implemented in China pursue bundling strategies that indirectly lead to reductions because delivery tours are optimised. Nonetheless, there are pilot experiments in Berlin that are similar to Chinese delivery concepts.

Kiezbote, for instance, is a delivery concept that bundles shipments on the recipient‘s side and for example delivers them via cargo bike (Hochschule für Technik und Wirtschaft Ber-

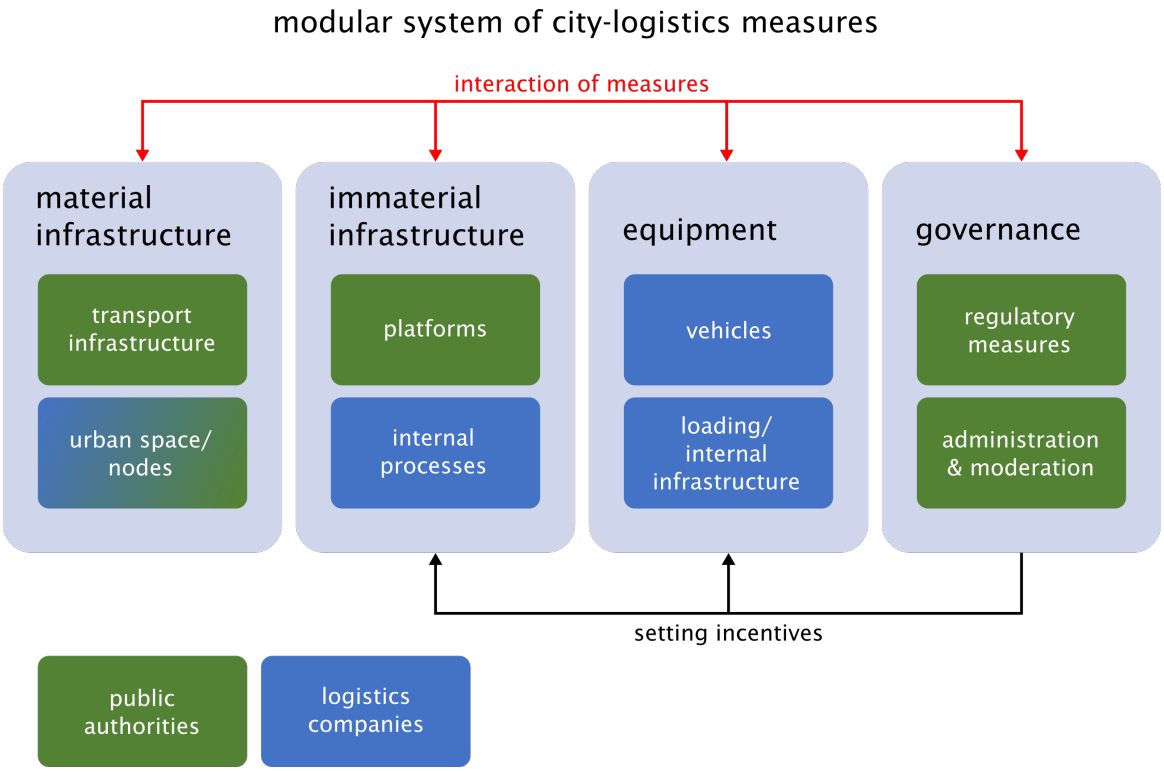

Figure 13: Modular system for measures in urban freight transport. Figure based on Leerkamp et al. 2020; Russo and Comi 2011

lin, 2021). However, the Kiezbote concept is not applied comprehensively in Berlin, so ultimately there are differences between the two cities in terms of effectiveness. The model calculations of Leerkamp et al. (2021) clearly show the positive results systematic bundling could achieve for Berlin, taking the Chinese model of compounds bundling as an example. The comparison of the measures and concepts leads to the conclusion that in Berlin and Germany, respectively, pilot programmes are often financed, implemented and then discontinued, after the funding has expired. Leerkamp et al. (2021) show that the use of one depot[9] can only achieve limited modal shifting and bundling effects and that mileage savings realised by small-scale measures have minor impacts on citywide traffic (modelling results show only 0.2% mileage savings). Only a city-wide transition of parcel distribution to an alternative form of delivery (e. g. widespread use of micro-depots) can have positive effects.

Widespread implementation of alternative de-

9 E. g. KoMoDo ("Kooperative Nutzung von Mikro-Depots durch die Kurier-, Express-, Paket-Branche für den nachhaltigen Einsatz von Lastenrädern in Berlin") was a research project in Berlin for cooperative use of a so-called "micro-depot", in which five CEP service providers delivered parcels by cargo bike from a jointly used transloading hub third-party parcel lockers are very uncommon in Germany and are not present in Berlin.

livery concepts, such as those in Suzhou, can contribute to significantly reducing the mileage of the CEP segment in cities.

Figure 14 and Figure 15 represent measures applying to parcel delivery, as expressed in concepts of both cities. For Suzhou, it is noticeable that the focus of the measures can be subsumed under governance. Looking at the many joint delivery concepts in Suzhou, it becomes clear that the bundling principle is applied more consistently on the last mile (Transport Planning and Research Institute (TPRI) 2021). In Berlin, the individual measures are distributed more equally across the modules. The IWVK is a planning document which, in addition to analysing the current situation and formulating objectives on a higher level (integration of the IWVK into the planning framework), derives measures that often affect several segments of freight transport. Attractive areas close to the city centre are not only needed by CEP service providers, but also by other logistics-segments. The integrated and cross-segmental approach in Berlin reflects, one the one hand, the fact that freight transport in the city is shaped by many stakeholders and, on the other hand, that measures often do not have to be formulated specifically for one segment. The integrated approach in Berlin can be pointed out as the biggest difference to Suzhou, because their plans and measures regarding parcel delivery prevail.

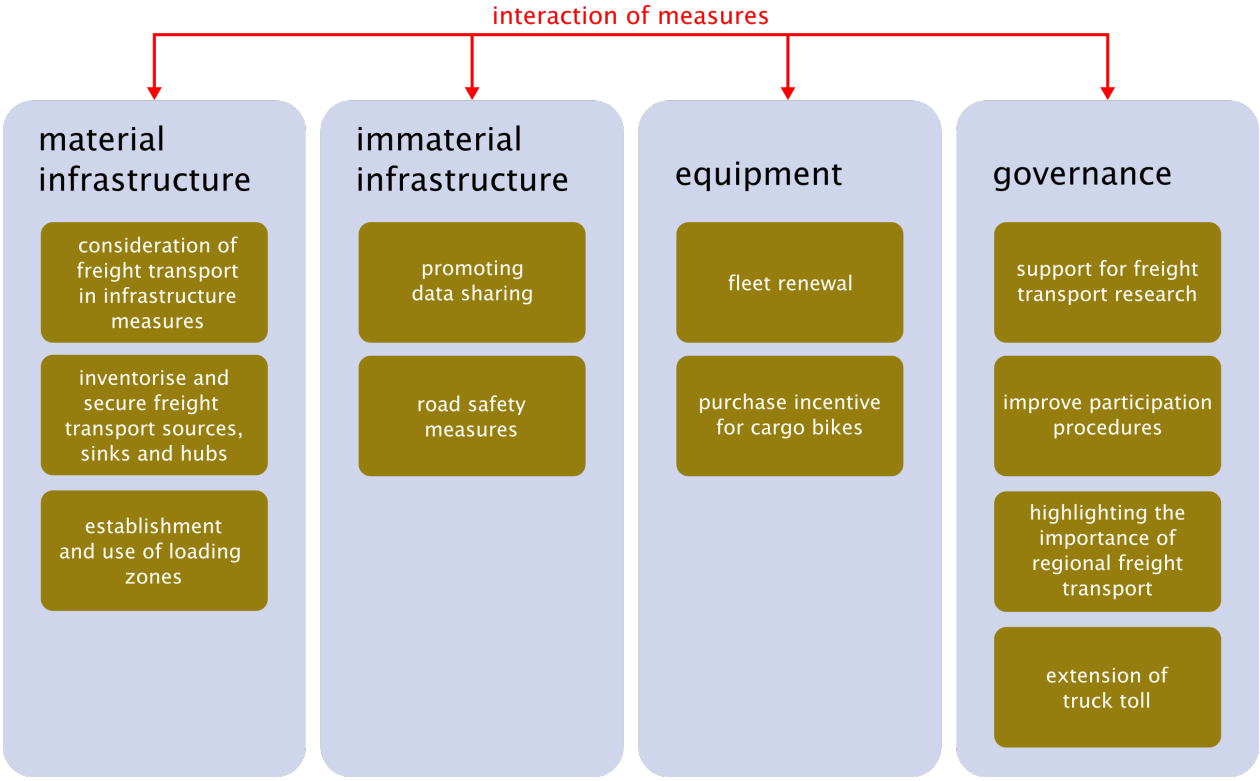

Figure 14: IWVK measures related to parcel deliveries, applied to the modular system of city-logistics measures. Own figure, based on Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2021

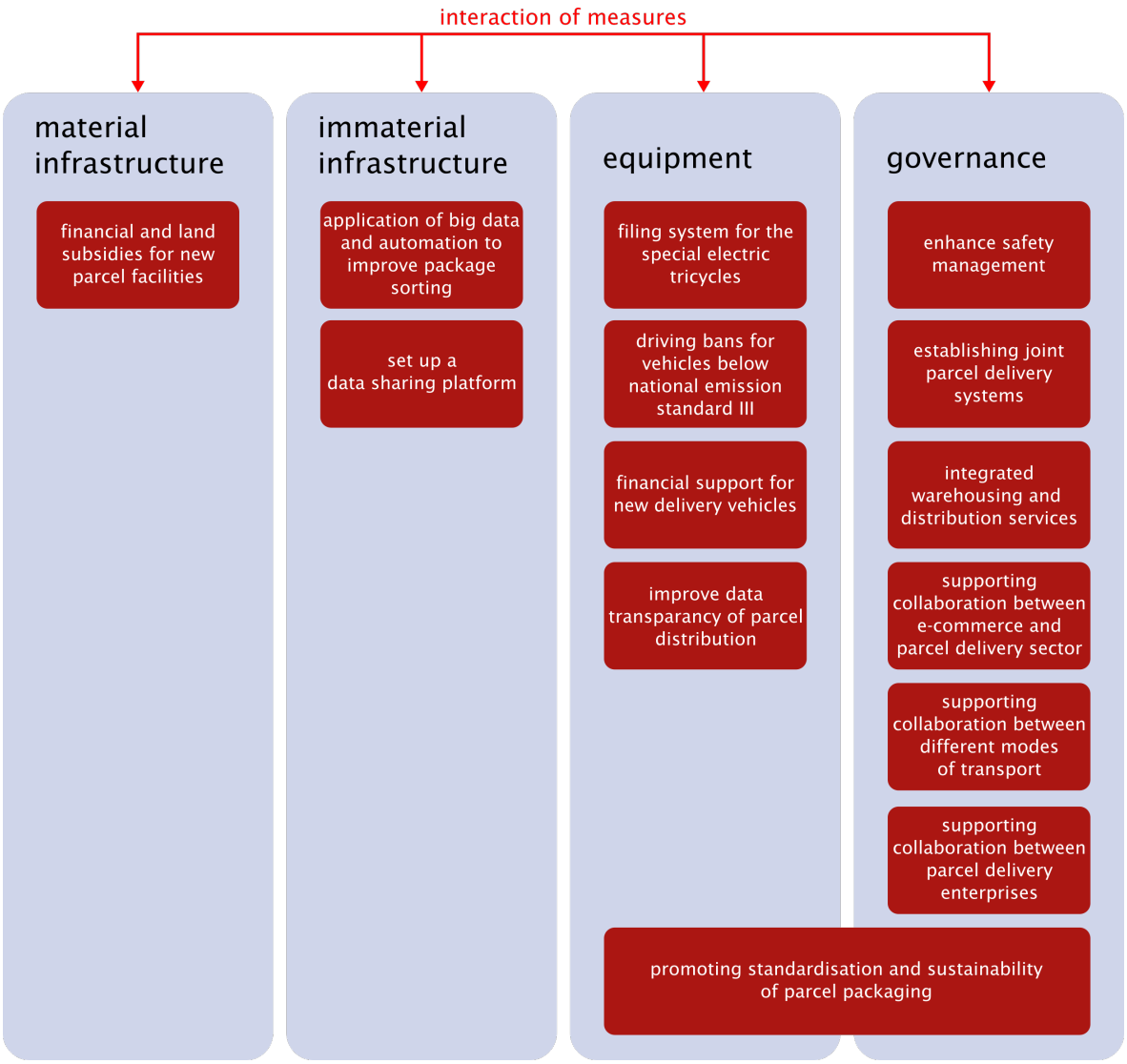

Figure 15: Suzhou measures related to parcel deliveries, applied to the modular system of city-logistics measures. Own figure, based on Transport Planning and Research Institute (TRPI) 2021

3.4 Comparison of Relevant Economic Factors for Logistics

Comparing the economic factors of the last mile logistics is complex, as there is hardly any officially reported data that would allow quantitative comparison in its entirety. In general, the last mile costs consist of different types of costs, and different definitions on what is included in the calculation. The most important cost component is labour, followed by vehicle costs and warehousing costs, if included in the calculation.

In China, parcel delivery enterprises mostly

outsource the delivery to subcontractors and thus have no information on the cost structure. For a large delivery company, these outsourcing costs sum up to over 58% of total expenses. It is estimated that delivery makes up for about 58% of total costs of a parcel shipment (Transport Planning and Research Institute (TPRI) 2021). Brabänder (2020) estimated costs for delivery tours in Germany, split into personal costs, vehicle readiness costs and vehicle operational costs. According to this study, a typical last mile delivery tour costs about EUR 275.

- Labour costs make up for about 79% of expenses, comprising wages and non-wage labour costs.
- Vehicle readiness costs consist of depreciation of acquisition cost, insurances and vehicle taxes, and amount to about 7%.
- Operational costs for the vehicle (fuel, repairs, depreciation through mileage, other expenses) add up to about 15% of total costs.

According to publications of the Federal Association of Parcel and Express Logistics (BIEK), revenues per shipment have been falling slightly[10] for years in Germany. The decline is explained by structural changes in the market and tougher competition. Primary causes are the stronger growth of the B2C subsegment compared to other segments of parcel delivery, and price pressure in the market (KE-CONSULT 2021a). Actual costs or the average unit price of a shipment for the delivery company are not publicised for Germany and must therefore be inferred from the revenue development. For Suzhou, such time series, showing the costs per parcel, are available. These figures show a significant drop in costs (about 43% of nominal prices over the years 2011-2019). Multiple causes are identified, including the adaption of digital technologies, which has led to more efficient processes in the parcel market, competition factors and fixed cost degression due to more efficient utilisation of facilities like sorting centres. Similar to Germany, an increase in competitive pressure can be observed for Suzhou. As mentioned before, cost structures for parcel delivery in Germany are not available, therefore the extent to which a falling price development in Germany can be derived from the average revenue trend cannot be answered conclusively. However, when the developments observed in China are applied to Germany (digitalisation, automation and economies of scale), it can be assumed that prices will also fall in Germany.

3.5 Comparative Analysis and Display of Similarities and Differences in Spatial Structures

In the following, comparisons between the

10 nominal revenue per shipment dropped overall by 4% in the years 2010 to 2020, down to EUR 5.81.

structures of the parcel delivery in the two cities are made based on spatial analyses. Geographic information system (GIS) analyses are informative in deriving clues as to the extent to which alternative delivery concepts can be applied in a city on existing infrastructure or to assess which spaces in the city are particularly burdened with traffic. First, the parcel delivery volume for both cities is compared.

Delivery volumes are available for Berlin and Suzhou for the years 2019 and 2020 respectively, as presented in Table 3.

The per capita volume for Suzhou is almost four times as large as the Berlin per capita shipment volume. On average, residents in Berlin make 3.5 to 3.7 journeys daily, without differentiation by purpose (Gerike et al. 2019), compared to only 2.4 journeys per day in Suzhou. For Germany, it is known that the number of daily journeys between spatial types (e.g. urban and rural regions) is stable (Nobis and Kuhnimhof 2018). An explanation lies in the different spatial and urban planning structures of German or European cities compared to Chinese ones. For Germany, empirical studies have shown that the volume of shipments in large cities is lower than in medium-sized cities (Manner-Romberg and Müller-Steinfahrt 2017). As a European metropolis, Berlin has a diverse retail structure, so offline shopping still plays a major role.

The parameter of the volume of shipments can be used as input data for Berlin in order to represent the CEP structures spatially in the form of a data model. The modelling of CEP delivery tours provides information on the spatial distribution of CEP-induced environmental pollution. This is particularly informative for identifying areas of concentrated environmental impact. As the delivery tours are only assumption-based model calculations, they may deviate from actual processing[11].

Figure 16 clearly shows that in Berlin, the higher-level road network is particularly important for handling delivery tours. A share of 32.7% of the mileage of the delivery tours within the city of Berlin occurs on the higher-level road

11 More insights to the modelling of the last mile in Berlin can be found in Leerkamp et al. 2021.

Table 3: Shipment volumes for both cities

	Suzhou[1]	Berlin[2]
Parcel volume [pieces/year] in billion	1.73	0.17
Parcels per capita and year	161.1	47
Parcels to consumers per capita and year	No differentiation	29

1 2019 data from Transport Planning and Research Institue (TPRI) 2021.
2 2020 data based on allocation modelling from KE-Consult 2021b.

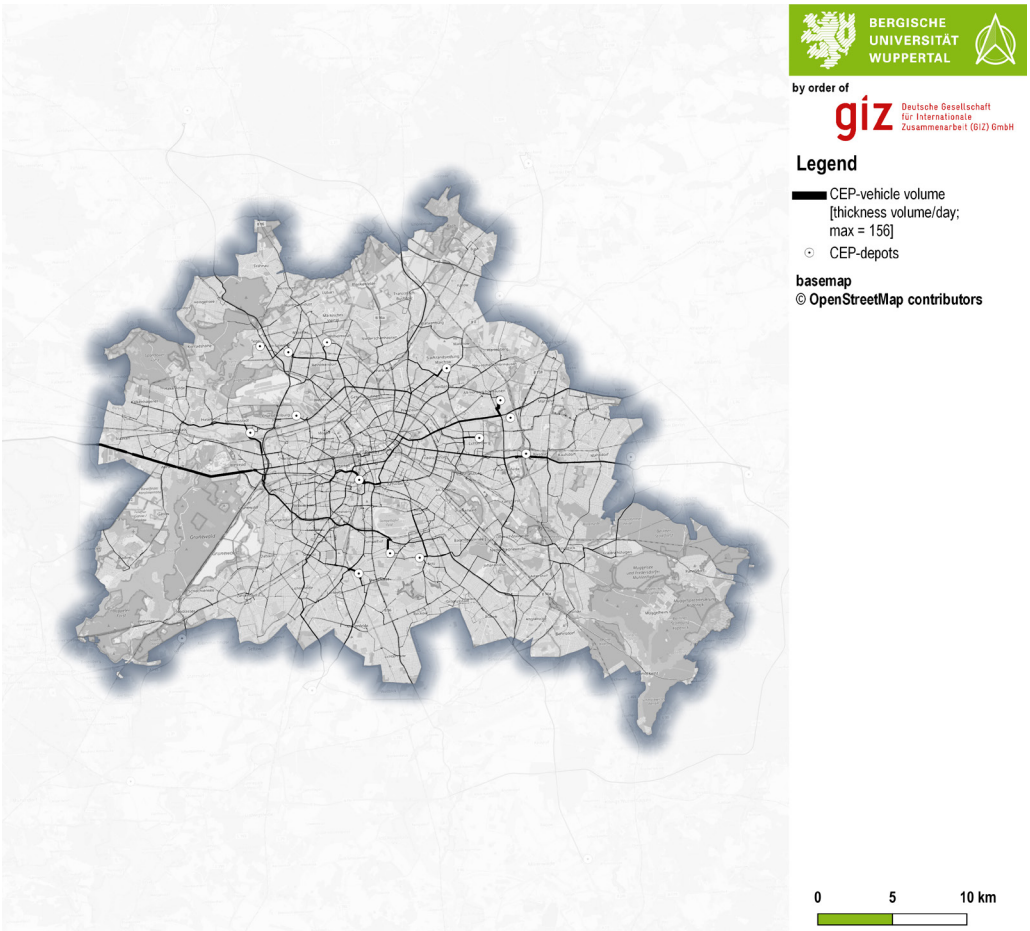

Figure 16: Vehicle volume on the road network - base scenario. Figure from Leerkamp et al. 2021

networks. In total, this results in a daily mileage of around 77,322 km (base scenario which depicts the ordinary delivery tours in Berlin) (Leerkamp et al. 2021).

For Berlin, the Suzhou-inspired approach to joint delivery (different parcel service providers deliver to a joint pick-up point) is compared to models worked out in the previous study. These are:

- the base scenario: Parcel delivery modelled after the current German practice, meaning a combination of door delivery with light commercial vehicles and delivery to pick-up points.
- bundling at existing pick-up points: delivery tours, size of parcel stations and delivery vehicles are optimised, resulting in more bundled delivery and less frequent door deliveries.
- third-party parcel stations: pick-up points at central locations, used by different delivery enterprises, resulting in less frequent

door deliveries.

- KoMoDo: base scenario with an added "micro-depot" for delivery by cargo bike as a pilot project.

Comparable data is not available for Suzhou. However, if the third-party parcel stations which are typical for Suzhou are modelled in Berlin, there are differences in regard to last mile processing. As an illustration, the parcel volume is disaggregated to a theoretical capacity size of the pick-up points, which are spatially distributed at all nodes of the main roads in Berlin. If one considers the mileage in the subordinate network for the usual delivery route handling in Berlin, approx. 32.7% of the mileage is performed there (Leerkamp et al. 2021). The application of joint delivery allows to draw conclusions about the handling of the last mile in Suzhou in regard to the most relevant information for transport planning, namely the spatial distribution of mileage. The model calculation shows that around 71% of mileage could be saved. (Leerkamp et al. 2021) As couriers can drop more parcels per stop in this model, mileage is predominantly saved on the subordinate roads. It can therefore be assumed that the compound bundling strategy, which is widespread in Suzhou, leads to less mileage in comparison to the ordinary delivery tour planning in Berlin. Due to the different city structure, the modelled results cannot be

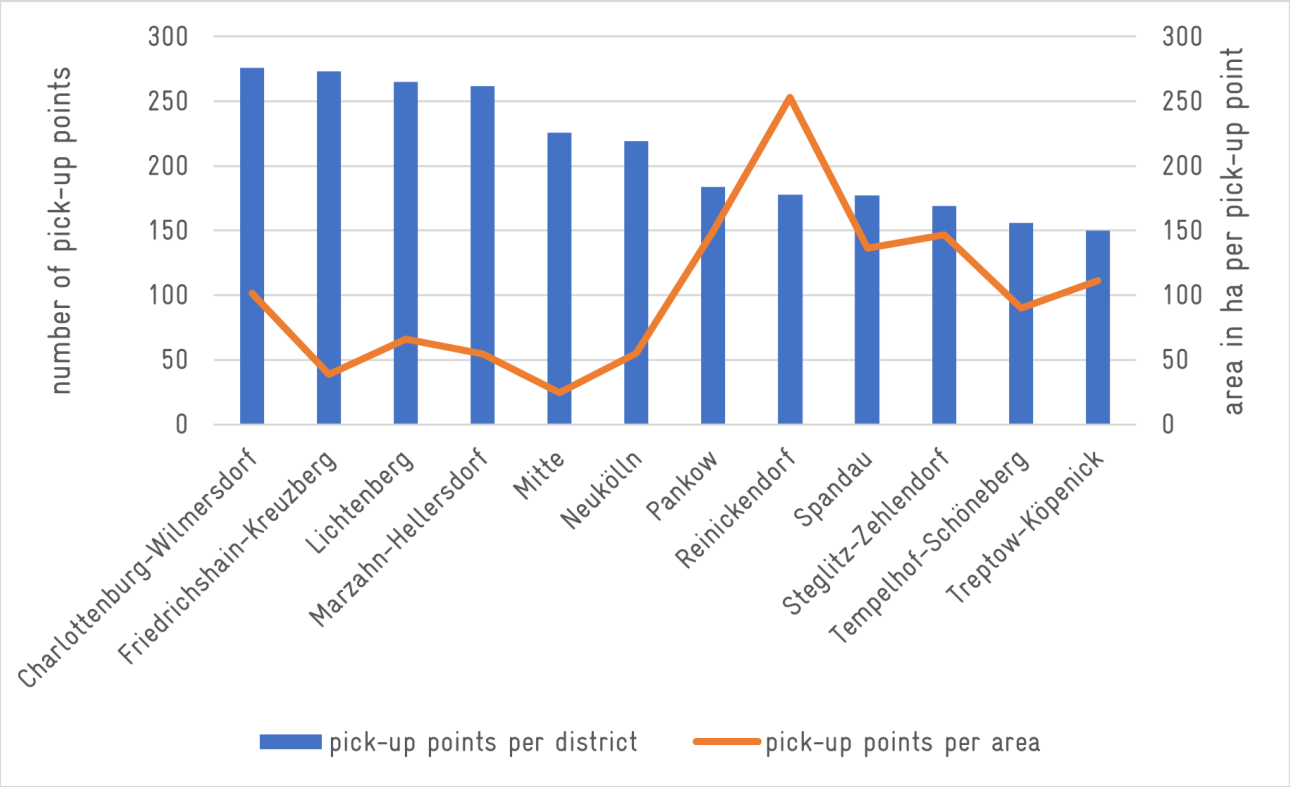

Figure 17: Pick-up points per district and area in Berlin. Figure from Leerkamp et al. 2021

transferred to Suzhou one-to-one.

As already mentioned in chapter 6.1.3 on parcel delivery networks, there are different forms of serving the last mile. Pick-up points in Germany are similar to parcel stations on the network level. To establish comparability for the spatial distribution of these network nodes, the respective stages of the delivery processes are compared.

When comparing the catchment areas of pick-up points/parcel stations, the coverage is around 35.3% for Suzhou and around 76.5% for Berlin[12]. Explanations for the difference are a higher proportion of rural areas and waterbodies in Suzhou (as mentioned in chapter 6.1), different city structures and location planning.

A comparison of the number of pick-up points within the Berlin districts shows that the more sparsely populated districts have less coverage, as seen in Figure 17.

A further differentiated GIS analysis is also available for Berlin, which shows the accessibility of the pick-up points weighted by tra-

12 Catchment areas are calculated using a 1 km radius, and jointly set in relation to the municipalities' territory.

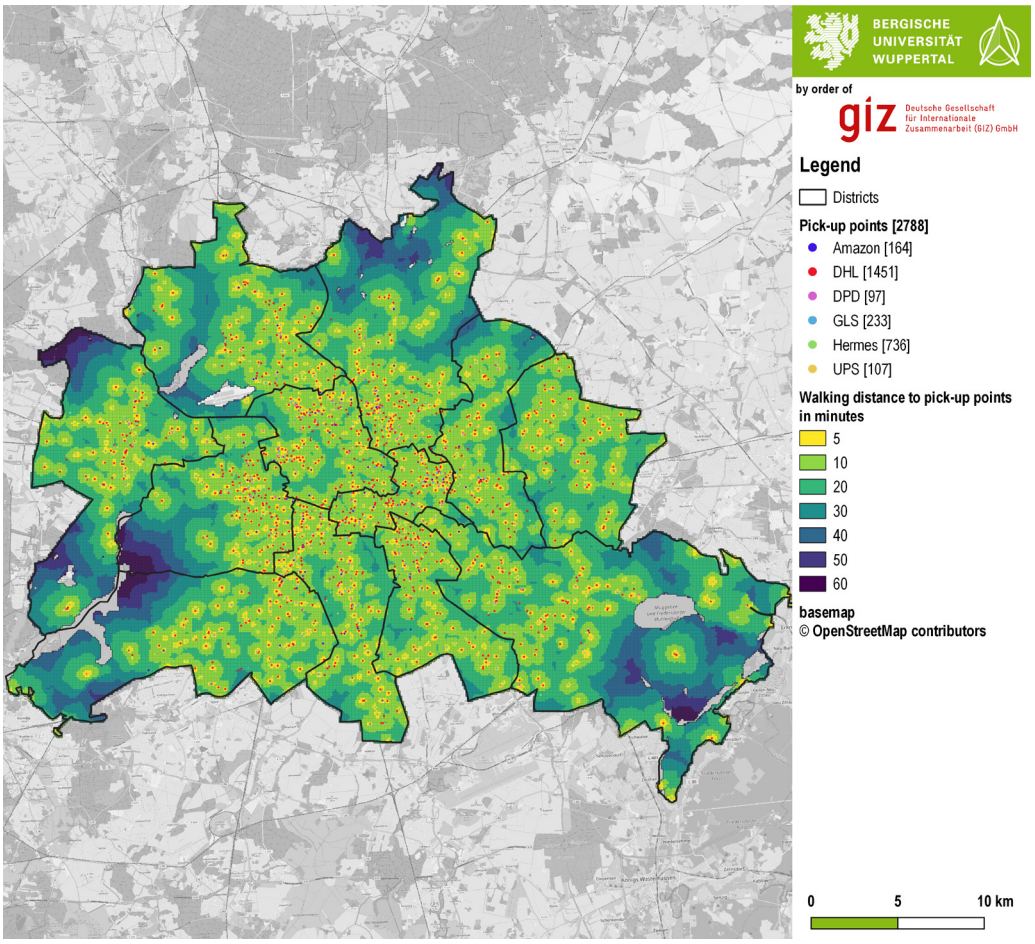

Figure 18: Walking distance to pick-up points in minutes. Figure from Leerkamp et al. 2021

vel time and allows conclusions to be drawn about the population distribution (Leerkamp et al. 2021).

Figure 18 shows the spatial distribution of different parcel delivery companies' pick-up points, combined with walking distances and their isochrones. Since the 2011 Census in Germany, population data is distributed on a geogrid. By intersecting these layers, about 2.85 million inhabitants who reach a pick-up point within ten minutes walking time can be identified. This leads to the conclusion that Berlin is suitable for using pick-up points as an alternative delivery location (Leerkamp et al. 2021).

Following Suzhou's consistent bundling approach and using Berlin's existing infrastructure (number, capacity and spatial distribution of the pick-up points), around 26% of the mileage could be saved[13].

Comparing the two countries in terms of vehicle usage remains complicated. These results do not only depend on the different vehicle classifications, but also on the avialble data Even if differentiated data on vehicle fleet use were available for Suzhou, similar numbers for Berlin would have to be derived from the available figures at national level. However, the vehicles used to handle the last mile are

13 More insights on the modeling of last mile can be found in Leerkmap et al. 2021.

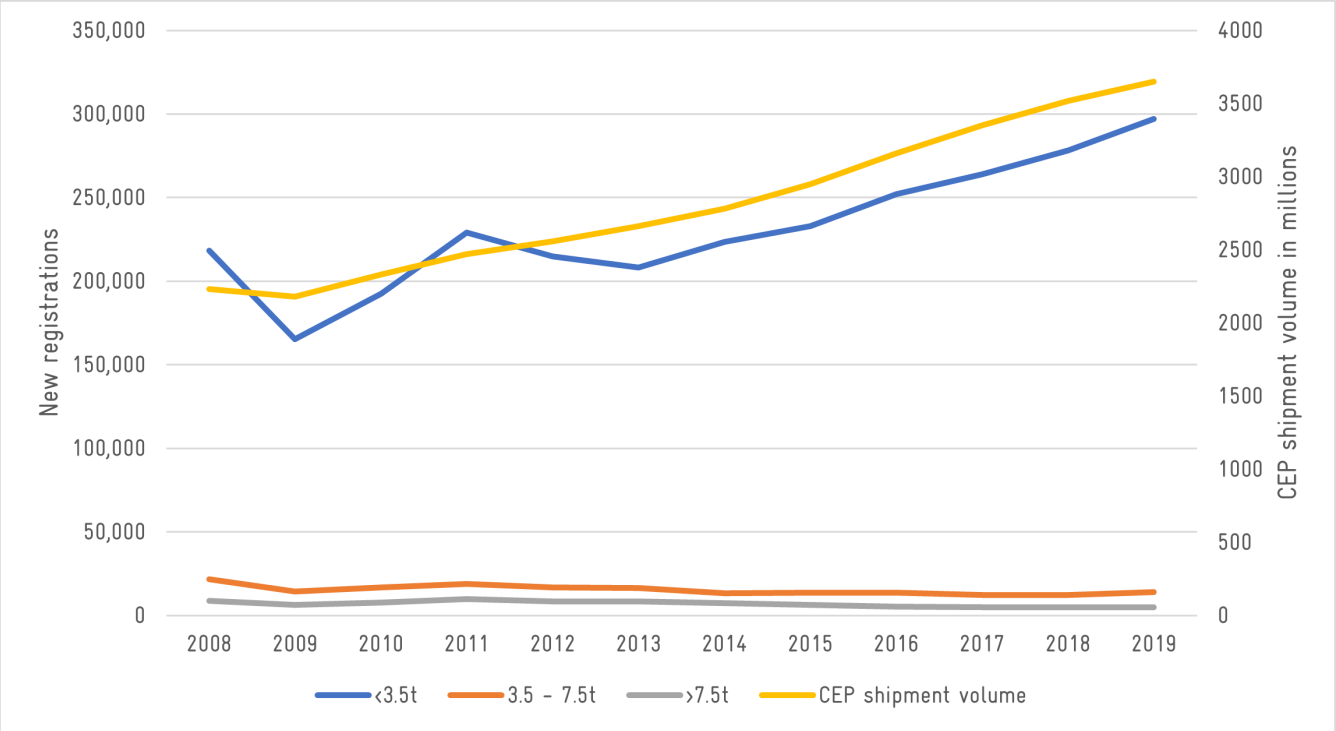

Figure 19: Development of registration figures for commercial vehicles and shipment volumes in the CEP sector in Germany. Figure from Leerkamp et al. 2020

employed for other uses and require a deeper analysis. Estimates suggest that the number of delivery vehicles in the 100 largest cities in the world will increase by up to 36% by the year 2030 (World Economic Forum 2020). A comparison of the growth both in parcel volumes and the commercial vehicle fleet in Germany leads to the conclusion that parcel delivery can be identified as a driver of the growth of light commercial vehicles, as depicted in Figure 19.

Even though studies show that not all light commercial vehicles are used for freight transport, Allen et al. (2018) conclude that around 34% of the light goods vehicles are used for this purpose.

In China, individual stages of the transport process are carried out by differentiated vehicle segments. Parcel delivery enterprises use three vehicle classes throughout their transport chain: Heavy-duty trucks are used for transport between the region-level sorting centres and the prefecture-level sorting centres, light commercial vehicles carry deliveries to parcel stations. The final delivery to the end customer is made with the electrically powered tricycles and other micro vehicles. The vehicle segments in Germany are similar for transports over longer distances. However, most deliveries on the last mile in Germany are made with lightweight commercial vehicles (up to 7.5 tons gross vehicle weight).

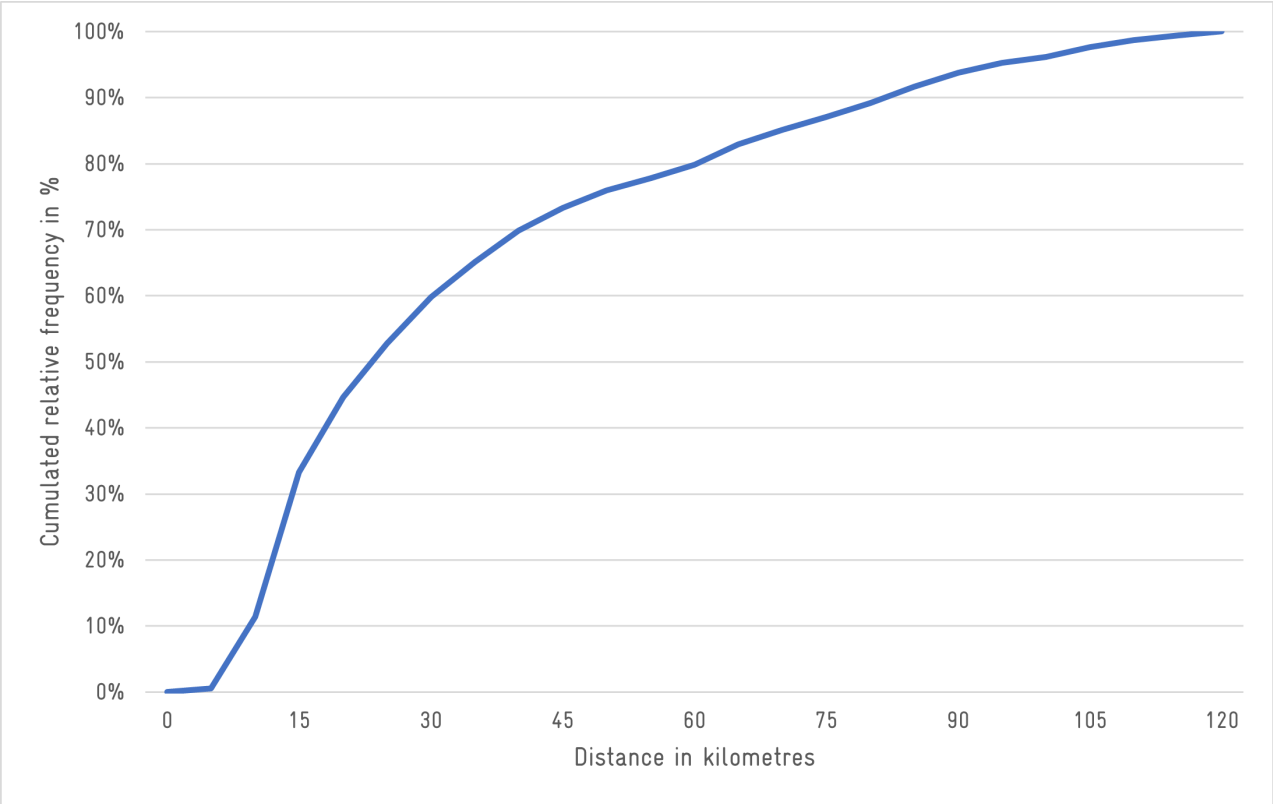

Figure 20: Frequently distribution of tour lengths of the modelled base scenario in Berlin, Own figure

According to the absolute numbers for both cities, Suzhou has around 53,000 motorized delivery vehicles, around 4,300 of them are electric. There are no such differentiated figures for Berlin. The new IWVK mentions an approximation of around 2,500 delivery vehicles that are used for the last mile and are predominantly diesel-powered (Senate Department for the Environment, Transport and Climate Protection 2021). Considering the short tour lengths of last mile delivery (shown in Figure 20), the electrification of the last mile vehicle would be a feasbile measure.

From the GIS modelling of the last mile in Berlin, conclusions can be drawn about the respective tour lengths of the base scenario. Figure 23 shows the cumulative frequency distribution of tour lengths in Berlin, the longest tour being around 120 km. A market survey by Krauß (2020) shows that the average range of available electric delivery vehicles is around 226 km. Even the lowest driving range of 120 km out of the delivery vehicles examined would still be sufficient to cover 99% (cp. Figure 20) of all calculated tours in the base scenario in Berlin. According to this, electrification of the last mile should be accelerated in Germany.

3.6 Comparison and Assessment of the Sustainability and Efficiency of Current Parcel Delivery Structures

Climate-relevant carbon dioxide from the parcel logistics sector is produced primarily through the combustion of fossil fuels in vehicles. Therefore, transport has the highest importance in the following considerations. The combustion of one litre of truck diesel produces around 2.65 kg of CO_2. A loaded truck (40 ton gross vehicle weight) consumes approx. 35 litres per 100 km (Kranke et al. 2011).

Common methods for calculating vehicle GHG emissions usually use constant conversion factors, which makes it easy to determine approximate values. Due to the stratified network of parcel delivery operations (e. g. main leg, last mile) and the lack of data, the calculation of emission factors per parcel, on the other hand, is complex. If production-side emissions such as the manufacture of the product or the production of the packaging are internalised, the complexity will increase further. In addition to the widely different stages in the delivery process (pre-run, main leg and last mile), parcels may be transported along a global transport chain, within one country or even only city-wide.

To measure actual GHG emissions attributed to one parcel in a comprehensive manner, the following steps would have to be factored in[14]:

- the distribution of distances between the shippers (if necessary, also a distribution of driving distances between the manufacturer of the product and the warehouse of the shipper) and the parcel sorting centres,
- the distribution of transport shares by mode for the distances covered, as described above,
    - for road vehicles, distributions of gross vehicle weight (GVW) and load levels for the vehicles used,
- the distance distribution between the higher-level sorting centres and the last parcel sorting centre before delivery (first mile),

14 The following list only considers transport-related emissions. A more comprehensive description of the entire process chain can be found at Zimmermann et al. 2020.

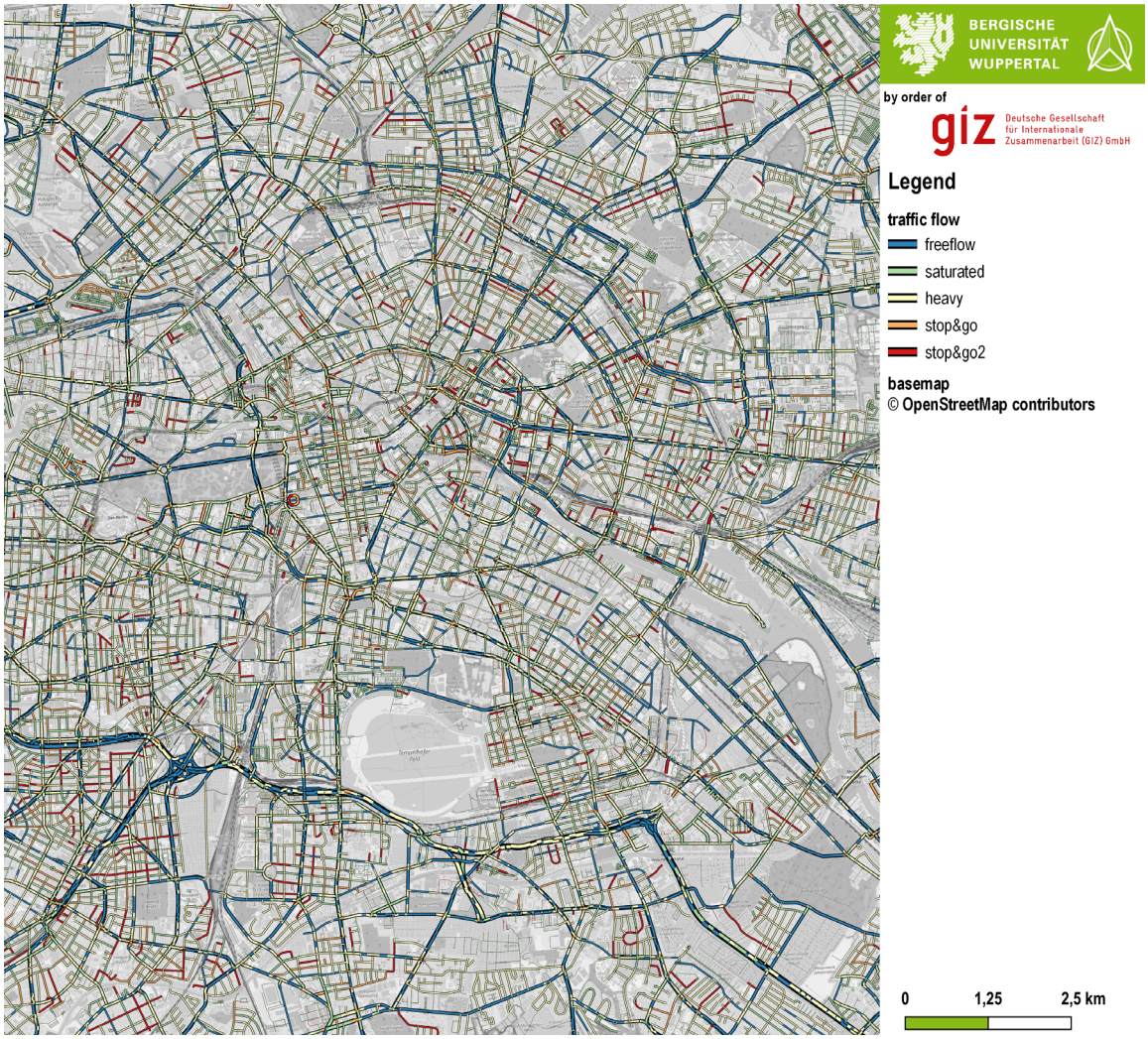

Figure 21: FCD-based traffic situations in the network model, Figure from Leerkamp et al. 2021

- distributions of GVW and the load levels for the vehicles used.

For China, shares of parcels by different driving distances (international vs. national, for example) are available. Therefore, a transport-related emission value of 235 grammes (g) of CO_2 per parcel can be calculated for Suzhou, which considers the shares of the parcels by travel distances. Furthermore, information about the modal split in parcel transport in China is available for the year 2018. Around 85% of shipments were handled by road, 10% by air and 5% by rail. In addition, the shares of shipments delivered intercity (75%), intracity (23%) or international (2%) are also known (Kang et al. 2021). The 235 g CO_2 per parcel coincide with the calculation results of Kang et al. (2021).

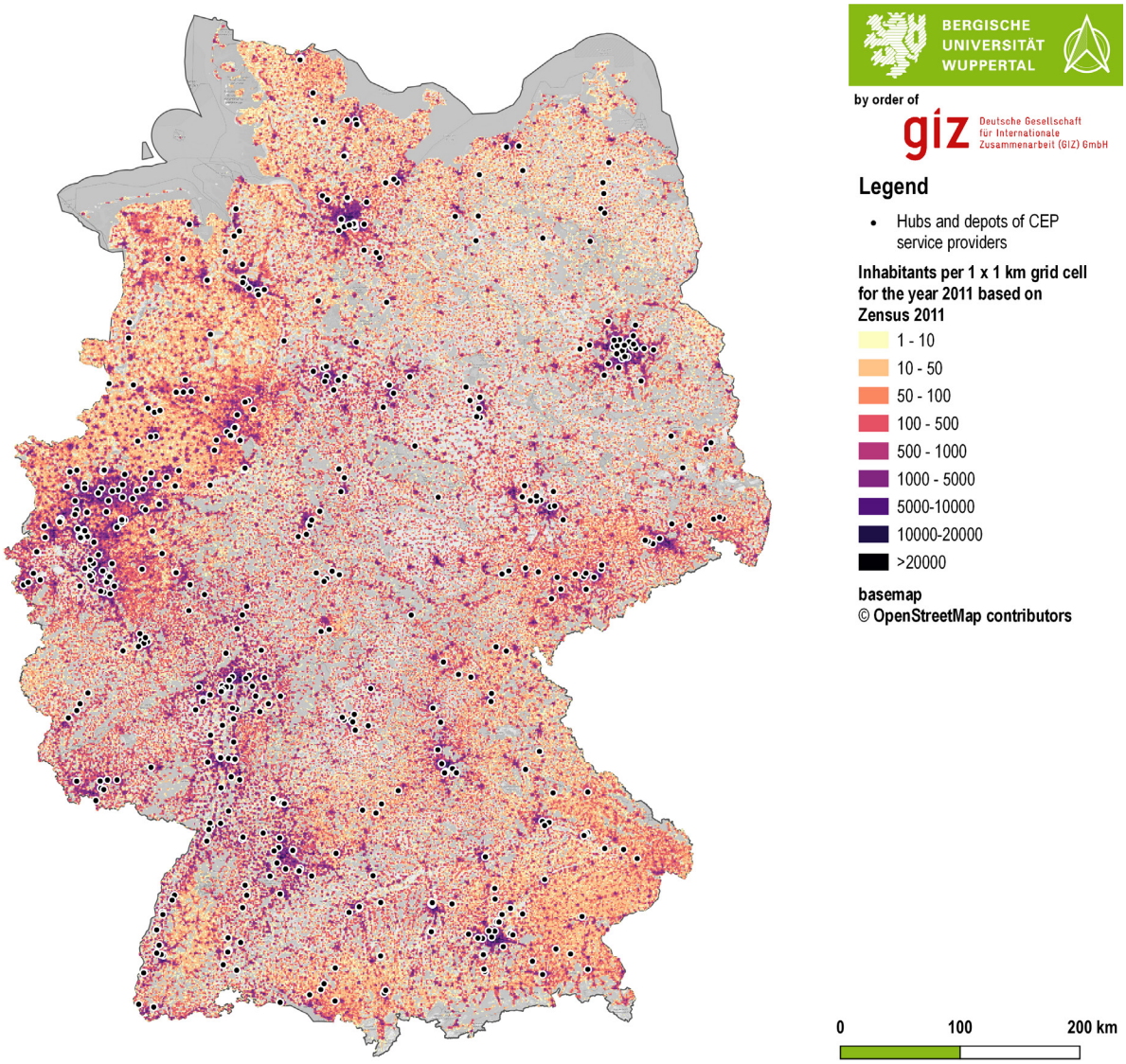

Figure 22: Hubs and depots used to calculate the average distance travelled by CEP service providers. Own figure

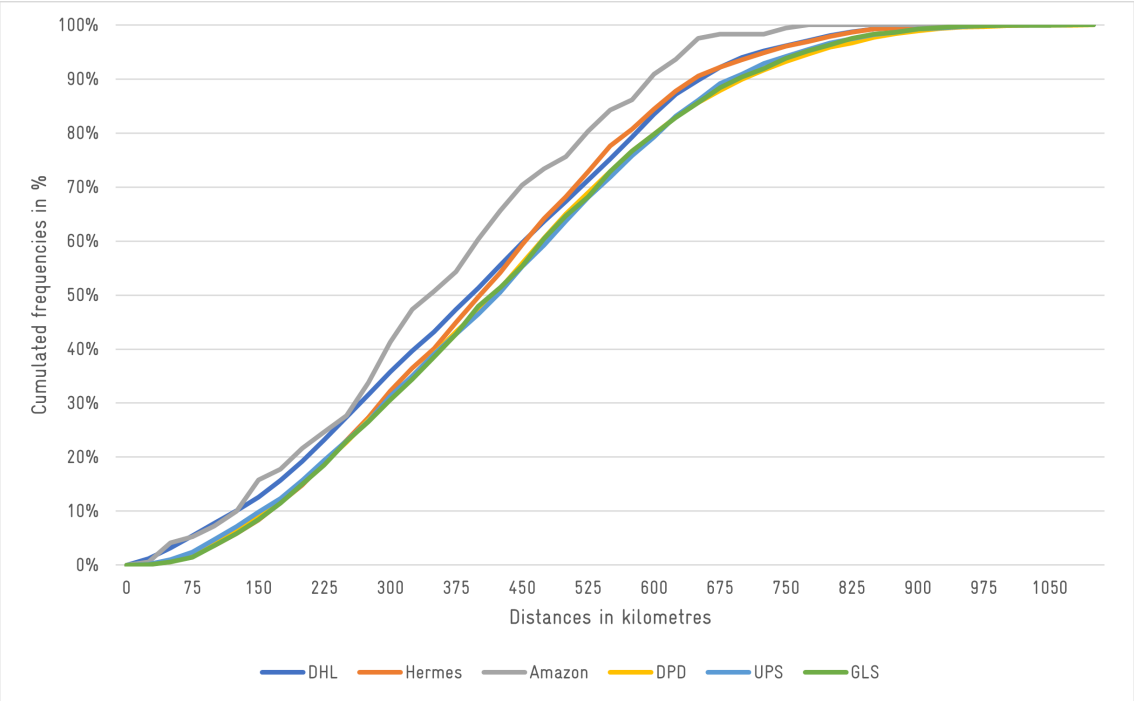

Figure 23: Cumulative frequency distribution of the travel tours between the hubs of the CEP service providers. Own figure

There are no officially reported values for Germany in general and for Berlin in particular. A review of studies shows that often, only specific emission values for the last mile are reported (cf. the comparison of key values from the literature by Zimmermann et al. (2020), who report a range of 181-390 g CO_2 per parcel). Another recent study, which makes no distinction between the transport-side transport processes (first mile vs. last mile), concludes that 184 g of CO_2 can be attributed to each parcel (SESAM GmbH 2020). The values identified in the studies can be used as a reference point for the calculation methodology used in this study, which is outlined below.

To obtain an approximate value for Berlin, a simple calculation based on the allocation of the transport-side emissions proportionally to the parcels is used. GIS-based modelling of the delivery routes and the network model, parameterised with Floating Car Data (FCD), allow the GHG emissions to be calculated for a representative day in Berlin, for all delivery routes. For each edge in the network model, FCD can be used to determine an average drivable speed as a function of time, which is used to form a ratio of average drivable speed to permissible speed. From the ratio value average drivable speed/permissible speed per network edge, a traffic condition can be deri-

ved from the HBEFA[15], which is used as the basis for calculating emissions.

From that, an average of around 32.366 g CO_2 per parcel can be determined for the last mile in Berlin (Leerkamp et al. 2021). To be able to map the traffic-related emissions of the first mile, a trip distance distribution is necessary. Through a literature analysis, no values can be found for Germany that describe the transport between parcel sorting centres. Annual transport distances for mail and parcels[16] are available from the KBA's data collection. For 2020, an average distance of around 208 km is reported for all transport sectors. However, this number does not allow any differentiation with regard to the stage of the parcel transportation network (Kraftfahrtbundesamt (KBA) 2021).

To obtain an estimate of the average route distance between the parcel sorting centres in the main run, a matrix is constructed which considers every possible relation between the parcel centres ("hubs and depots", as depicted in Figure 22), differentiated by parcel delivery enterprises. Using an FCD-based network, actual travel times and distances can be determined.

Figure 23 shows the cumulative frequency distributions of the routes distance between all depots and parcel centres of the CEP companies. If one also includes the map of the spatial distribution of the hubs and depots (Figure 22), it can be concluded that they are in similar locations, mostly in proximity to population centres and transport facilities.

Since only Amazon can be identified as an outlier in the distribution of routes distance, the median and average values of six larges CEP service providers can still be convincing. Nevertheless, it should be emphasised that this rough calculation does not directly account for shipment volumes transports even further back in the transport process (e. g. parcel collection or international shipments), as only one country-wide transport between sorting

15 HBEFA is a database for emission factors for road traffic. Emission factors are differentiated according to different spatial references, traffic situations, road types and longitudinal gradients.
16 Division 15 in the Classification system for transport statistics (NST 2007) as defined by the United Nations Economic Commission for Europe.

Table 4: Median and average route distances between the hubs of the CEP service providers

CEP Service Provider	median [km]	average [km]	maximum routes distance [km]
Amazon	346.516	353.775	760.573
DHL	391.692	393.468	1,011.982
DPD	418.163	423.351	1,085.481
GLS	416.453	423.728	1,053.681
Hermes	401.542	405.608	1,027.40
ups	421.205	422.118	1,061.877
All CEP service providers	398.718	401.769	1,085.481

centres is considered in this model of the main run.[17]

Table 4 compares the individual values of the parcel companies. The average and median values for all service providers are used to calculate emissions.

In addition to the distribution of routes distance and the emission-specific consumption of the trucks, a consideration of the payload is crucial, which is expressed in the form of the maximum possible number of parcels. From the literature it is known that an average parcel has a volume of about 0.06 m³. If one estimates that a truck with a GVW of 40 tonens has a payload of approx. 100 m³, approx. 1,666 parcels can be transported per truck and trip. Using these parameters, the CO_2 emissions per parcel can now be roughly calculated for Berlin, which is shown in the following equation.

$$\frac{0.35\ l * 2.65\ kg\ CO_2\ * 401.769\ km}{1{,}666\ parcels} + 0.032366\ kg\ CO_2$$

$$= 0.256\ kg\ CO_2\ per\ parcel$$

17 See Figure 24 for an overview of the modelled trannsport processes.

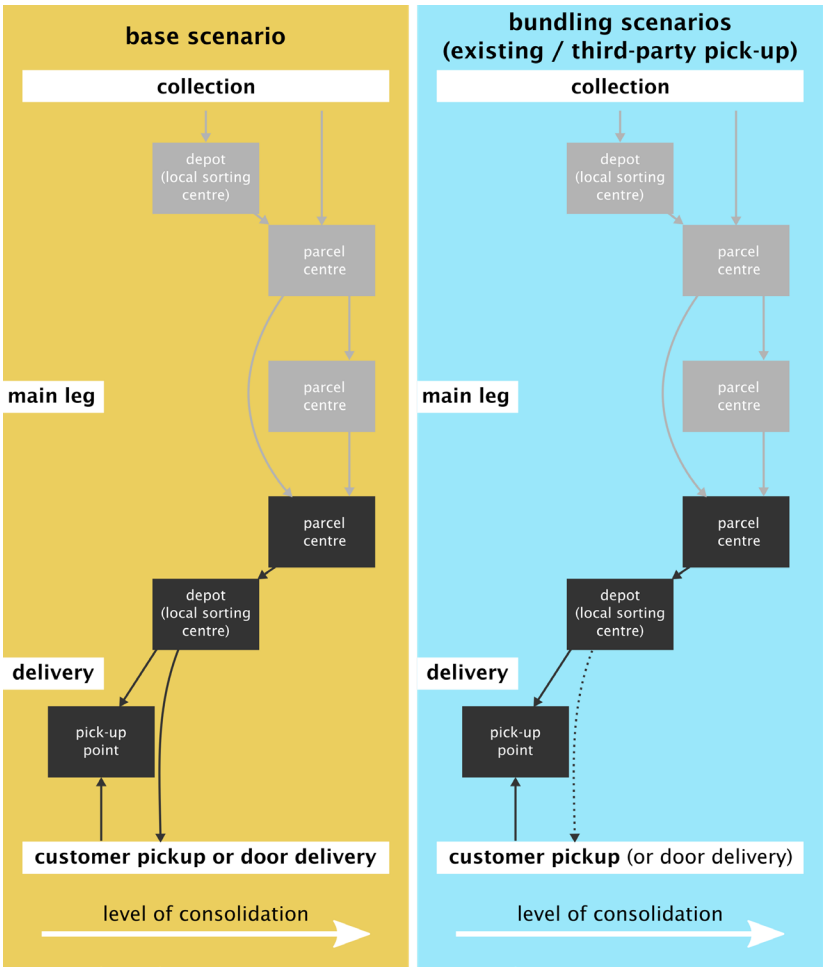

Figure 24: Modelled parts of the parcel delivery network (black). Own figure

Using this function, approximately 256 g of CO_2 per parcel can be calculated for Berlin.

The calculation method used here can only provide an approximation to reality. As the previous considerations showed, the complexity of actual emissions is significantly greater. However, since the method ultimately depends only on the trip distance and the load of the vehicle (parcels per vehicle), a variation can easily be undertaken. The special feature of the calculation method is the possibility to illustrate the slight differentiation between first and last mile. The GIS-based modelling of the last mile in Berlin makes it possible to report average GHG emissions per parcel.

Zimmermann et al. (2020) conclude in their literature analysis that the shares of the last mile are significantly higher than in the present calculation. For the first mile they illustrate that the mode of transport is decisive. As no information is available on the modal distribution for Germany, this effect cannot be taken into account. Zimmermann et al. (2020) also show that the emission shares (first mile vs. last mile) vary depending on first mile transport mode. If road transport is used, 60% of GHG emissions will accrue from the last mile. For parcels shipped overseas, the last mile can account to as little as 14% of the emissions per parcel. The emissions calculation carried out in the previous study, finds that the emission shares are only around 13% on the last mile. Due to the GIS-based modelling, which considers the spatial distribution of the depot locations of the CEP service providers, it can be assumed that the reported average value per parcel for Berlin is more accurate than the emission values or shares mentioned in Zimmermann et al. (2020).

The average emission values per parcel of the modelled scenarios in Berlin are shown in Table 5.

The fact that KoMoDo emits the same amount of GHG per parcel (rounded) emphasises once again that only an area-wide implementation of micro-depots can lead to the desired savings effects. The mileage savings of the other two scenarios are also reflected in the overall average values. Both the joint delivery approach (Suzhou) and the optimal utilisation

Table 5: Average GHG emissions per parcel differntiated by the modelled scenarios on the last mile

Scenario	CO_2 emissions per parcel in grammes
base scenario	32.366
third-party parcel stations	20.013
bundling at existing pick-up points	19.264
KoMoDo	32.366

of the already existing pick-up points can lead to considerable savings per parcel, which again illustrates the savings potential of bundling approaches.

If the values for the cities are compared, it becomes clear that Suzhou emits less CO_2 per parcel on average than Germany or Berlin. If the fact that the parcel routes distances in China are longer than in Germany due to the size of the country is also included, it can be assumed that the low emission value per parcel derives, among other factors, from more efficient handling of the last mile in Suzhou. The emissions generated by the last mile account for around one tenth of total GHG emission, which illustrates remaining inefficiencies in the usual delivery in Germany.

4 Comparative Overview of Findings and Transferable Results

Urban parcel logistics is the result of national as well as subnational frameworks, set both by private stakeholders (mainly the delivery enterprises themselves) and government institutions.

Between China and Germany, many factors influence the design of measures for urban parcel deliveries:

- Government oversight and involvement in the parcel delivery market is higher in China, with a central government body and multiple organisations fostering communication. In Germany, relevant organisations focus more on representing their shared interests to other stakeholders. Planning documents in China hold more regulatory power and set specific rules and standards for the parcel delivery sector, whereas Germany regulates its parcel delivery only indirectly, mainly by awarding subsidies.
- Parcel volumes in the urbanised areas in China are higher than in Germany, both per capita and in total, even though disposable income is smaller in China. This discrepancy can be mainly attributed to consumer preferences. The rise in volumes is expected to continue in both countries, albeit at a reduced rate. Main growth drivers will be perishables and convenience goods.
- The parcel delivery market is less mature and more oligopolistic in China. The government incentivises cooperation, as do private actors, mainly the online retail giants. German parcel delivery is dominated by one enterprise, DHL.
- Due to the different expanses of China and Germany, the main leg of parcel delivery networks is organised in different ways. Chinese parcel delivery networks use hierarchical sorting centres, sometimes jointly, while every service provider in Germany has their own network of transhipping facilities, with similar spatial structures.

For municipalities, the sphere of action is determined by national frameworks for urban spatial planning: In Germany, lower levels of government have a higher degree of autonomy and can influence superordinate plans (mutual feedback principle). In China, a similar decentralised and specialised planning structure was adapted, but municipalities are dependent on higher-level approval for their planning.

In their municipal planning, Suzhou addresses parcel delivery issues directly, while Berlin's planning documents have a more integrated approach. The focus of Suzhou's measures lies on promoting cooperation and setting standards. This facilitates bundled deliveries, as does the city structure, with a high number of high-rise buildings.

Combining these preliminary considerations to derive approaches for action, two interesting aspects from Suzhou can be recommended for Berlin: Parcel stations as implemented in Suzhou (operated by third parties and pick-up-points at central places like compounds and schools) lead to strong bundling effects, which can be seen in the model results for the implementation in Berlin. This requires intensified efforts at the conceptual level to promote cross-company cooperation. In Suzhou, this is actively taken up in concepts and supported by the city at the measure level through the promotion of jointly used facilities. The model results for the KoMoDo project in Berlin support the hypothesis that only a large-scale implementation of jointly operated parcel stations or depots can lead to city-wide savings effects.

Figure 25 illustrates a possible design of the third-party parcel stations approach in Berlin. Parcel stations operated at central points in the city, which enable both customer pick-up and environmentally friendly delivery with cargo bikes (micro-depots) for parcels of all CEP providers, can be an effective measure that is also easy to implement.

If 85% of Berlin's inhabitants were able to access a pick-up point within 10 minutes by foot, high revenue effects could be expected in the B2C segment. In the B2B market, bundling on the recipient's side is also a proven concept in Germany.

Furthermore, Berlin could follow Suzhou's compounds bundling approach by making

Figure 25: A possible solution for parcel stations in Berlin based on the dense pick-up network in China. Own figure

more intensive use of the already well-developed and available infrastructure of pick-up points. In summary, a consistent implementation of the bundling concept from Suzhou can be identified as the most important recommendation for action.

For Suzhou, it can be said that the integrated approach in Berlin from a freight transport planning perspective, which considers the stakeholder orientation of freight transport, can be a useful extension of the already existing planning approaches. Surveys in Germany (see Leerkamp (2021), among others) show that the parcel market only plays a minor role when it comes to mileage in cities. The IWVK in Berlin actively addresses this circumstance and develops measures that also affect other relevant segments of urban freight transport. Yet, as the studies at hand focus on parcel delivery, the extent to which similar strategies are used in Suzhou is out of scope of the present comparison.

5 Summary

5.1 Regulatory and political conditions on national level

Government oversight is stronger and more centralised in China, where it permeates all kinds of relevant organisations. In contrast, the German parcel delivery sector is characterised by a plethora of stakeholders, both on the governments and the NGOs sides. Planning and goalsetting are carried out on all governmental levels both in China and in Germany, while lower levels in Germany have more self-government rights.

This approach also applies to subsidies, the main measure of governmental planning in the German parcel delivery sector, which can be distributed to municipal governments as well as private companies. In contrast, planning documents in China hold more regulatory power and set specific rules and standards for the parcel delivery sector. Germany regulates its parcel delivery only indirectly, with laws and standards also applying to other sectors. Private parcel delivery companies in Germany thus have more autonomy. Some have pledged to reduce their environmental impact independently and without government involvement.

The development goals concerning the parcel delivery sector differ between China and Germany. Both countries have recently adopted legislation addressing packaging waste.

5.2 Comparison of Developments in E-commerce and Parcel Delivery Markets

E-commerce is a growing market both in Germany and China. By total numbers, online sales in China are a much bigger and faster-growing market, although disposable incomes and internet penetration rates in Germany are higher. Also facilitated by a more accepting consumer mindset, online retail is more popular in China than in Germany, where brick-and-mortar retail is expected to remain dominant in the near future. The COVID-19 pandemic has demonstrated a lasting growth boost for online retail, which is projected to grow even further, especially in the FMCG segment.

The growth of online retail reflects in growing volumes of parcel deliveries but increases even faster than e-commerce revenue in China. Per capita, the volumes are on a similar level, though a direct comparison of shipments to consumers is difficult. Regionally, parcel delivery activity is centred in the most urbanised areas of each country. In line with the growth of online retail, shipment volumes are also expected to rise.

Parcel delivery markets in China and Germany are dominated by a handful of big enterprises, mostly (China) or completely (Germany) privately owned and organised. Market concentration is very high in both countries, but struc-

tured differently, with Germany being more monopolistic and China oligopolistic. The delivery enterprises employ vehicle fleets mostly powered by fossil fuels, except for last mile delivery vehicles, some of which use alternative fuels. Fleet sizes are hard to compare, as definitions and statistical classifications differ.

5.3 Comparison of the Key Facts and Characteristics of the Cities

Suzhou and Berlin display a similar population density in the most urbanised areas, but in general, the municipality of Suzhou is much bigger and includes smaller regional centres and rural areas. The population in both cities is rising steadily.

Economically, both cities are major centres in their respective countries, Berlin being of higher importance nationally. Per capita, its economic output is higher than Suzhou's, and its residents have about double the disposable income.

Both Suzhou and Berlin have a stratified road network fitted for their demand. Mobility behaviour of urban populations is similar, but urban residents in Suzhou use private motorised transport more often than Berlin residents, where public transit is more popular. On average, residents are less mobile in Suzhou by number of trips alone. Data on trip length was not given.

Parcel delivery networks are structured differently in Berlin and Suzhou, mainly in the way higher-level sorting centres are connected and shared between companies. The delivery process displays a lot of similarities: Last mile delivery networks are heavily dependent on subcontractors and agencies and can include both door deliveries and deliveries to pick-up points, where customers can retrieve their parcels. Last mile delivery is carried out with micro mobility devices in China, while German delivery companies use heavier vehicles overall.

5.4 Comparison of Citywide Logistics Strategies and Plans

The shape of Chinese spatial planning (urban and rural planning) has changed considerably in recent decades. The creation of the MNR has contributed to the fact that China for the first time has a spatial planning system divided into subsystems, similar to Germany. In parallel, higher-level plans in China formulate goals and serve as a basis for lower planning levels, which derive recommendations for action from them. In Germany, however, the mutual feedback principle is an institutionalised mechanism that functions in both directions of the planning logic. At the municipal level, Suzhou targets parcel delivery with special development concepts. Similar parcel delivery concepts do not exist for Berlin, where

the plans (e. g. the IWVK) are integrated and cross-segmental.

5.5 Citywide Measures in Urban Logistics

Between both cities, the scope of measures differs greatly. While the measures in Berlin take on a transport planning perspective (focus in infrastructure, e. g. designation of loading zones), they follow a regulatory policy character in Suzhou. They focus more on strengthening cooperation between stakeholders, like the bundling of shipments on the last mile or data sharing. Municipal measures are usually derived from higher-level policies and concepts.

5.6 Comparison of Relevant Economic Factors for Logistics

For Germany in general and for Berlin in particular, there is hardly any officially reported data that would allow a quantitative comparison of logistics revenues in its entirety, but for Germany it is known that the revenues per shipment were falling for years. The decrease is explained by structural changes in the market. This is primarily caused by the stronger growth of the B2C segment and also reflects the market and price pressure in the CEP segment. For the development of the average price per shipment, a drop can be seen which, in addition to the development of digital technologies, led to a more efficient handling of the parcel market, which can also be explained by a more dynamic market development due to the rising e-commerce market demand. In addition, an increase in competitive pressure can also be observed for Suzhou as in Germany.

5.7 Comparative Analysis and Display of Similarities and Differences in Spatial Structures

The shipment volume per capita differs considerably for both cities. In Suzhou, around 161 parcels are delivered per capita per year, compared to 41 in Berlin. The spatial distribution of parcel stations (pick-up points) is not straightforward, as the values shown for Suzhou do not consider the distribution of inhabited areas. Comparing the coverage in the simplest way, the accessibility of parcel stations in Berlin is almost twice as high. A comparison of the mileage of the delivery tours between the two cities is not possible due to a lack of data. However, when one of Suzhou‘s typical delivery concepts is applied to Berlin, large savings can be observed in comparison to the modelled German base scenario. These positive effects only exist when bundling concepts, like third-party parcel stations, are applied area-wide in Berlin.

5.8 Comparison and Assessment of the Sustainability and Efficiency of Current Parcel Delivery Structures

In this chapter, too, only an approximate comparison is possible, as only Suzhou can show detailed data regarding the average GHG emissions of a parcel. Common methods for calculating vehicle GHG emissions usually use constant conversion factors, which makes it easy to determine approximate values. The calculation of emission factors per parcel, on the other hand, is complex. This is due to the production structure of CEP logistics (e. g. first mile, last mile) and the lack of data. If production-side emissions such as the manufacture of the product or the production of the packages are internalised, the complexity increases significantly. In China, shares are available on the modes of transport used in the production process as well as the distances covered by the parcels. Similar values are not available for Germany. A transport-related emission value in CO_2 per g of 235 g of CO_2 per parcel can be calculated for Suzhou, which considers the shares of the parcels in the travel distances. In order to have a comparative value for Germany, a function is developed which depends on the number of parcels per 40-tons-truck and the trip distance. Based on the modelling of the last mile in Berlin, emission values are available with a high spatial resolution, which are used for the calculation. Using the simplified function, approximately 256 grammes of CO_2 per parcel can be calculated for Berlin. It becomes clear that Suzhou emits less CO_2 per parcel on average than Germany or Berlin. If one also includes the fact that the parcel routes distance in China are longer than in Germany due to the size of the country, it can be assumed that the low emission value per parcel results, among other things, from the more efficient handling of the last mile in Suzhou.

5.9 Comparative Overview of Similarities and Differences between China and Germany

The comparison of parcel delivery markets at national and city levels between the two countries has shown that there is a wealth of differences and similarities, which can, nevertheless, be the basis for mutual learning and improvements. For Berlin, city-wide bundling of deliveries can be of particular interest. In particular, the creation of an area-wide joint parcel station network can help to ensure that the last mile can be handled more sustainably. For Suzhou, the integrative approach implemented in Berlin can be helpful because the parcel market is only a sub-segment of urban freight transport and studies in Germany and Europe have shown that the mileage of parcel deliveries in cities must be considered in the larger urban transport context.

6 Recommendations

For actors, a number of recommendations can be derived from this study. The recommendations for municipalities and enterprises apply both to Germany and China. Important points for different stakeholders are listed below:

National actors

- As this study shows, the data basis on parcel deliveries in Germany is still limited. Thorough monitoring of parcel delivery enterprises could bring more insights about parcel delivery processes and what could be improved, as well as exposing possible violations of labour law or other regulations.
- The governance approach to rely mainly on subsidies to influence the parcel delivery market seems to not yield the desired results in lowering overall GHG emissions. More binding regulations could lead to faster adaption of sustainable practices.

Municipal actors

- Municipalities can influence parcel delivery activities in many ways. However, it is important to note that these deliveries only make up for a small percentage in freight transport and traffic-related emissions. Any planning carried out should thus use an integrated approach and use more than one set of measures, as formulated in Berlin's Integrated Concept for Commercial Transportation.
- To actually influence the impacts of parcel delivery, small-scale projects that only exist for a limited time have only limited impact. Measures should be implemented city-wide and as long as possible.
- Cooperation between parcel delivery companies can be facilitated by municipal actors, for example by securing land for cooperation projects or by promoting or even operating third party parcel stations as a public service.
- Some city structures can be seen as opportunities for bundling, for example areas with many high-rise buildings or central locations in transport networks.

Enterprises

- By power of the current legislation in Germany, private enterprises have a high level of policy discretion. As the model calculations showed, parcel delivery enterprises could already carry out their last mile delivery with all-electric vehicles.
- Cooperation between delivery enterprises is an important factor for reducing negative impacts. Delivery enterprises should see this as an opportunity and their responsibility to reduce traffic-related emissions, both for marketing and corporate social responsibility purposes. Existing or new trade organisations in Germany could be used to coordinate cooperation projects.

- A commitment to bundling should also be made by the shippers. E-Commerce enterprises can also actively partake in more efficient delivery practices, for example by operating their own third party parcel stations.

7 Conclusion

This study compares the current state of the last mile organisation for parcel deliveries in Germany and China, with a focus on Berlin and Suzhou as case studies.

First, the comparative study has shown that there are significant differences between Germany and China on a national level concerning the handling of the parcel market. This results from the different political systems of both countries. China shows stronger centralisation tendencies, which are reflected in a strong permeation of different relevant policy fields of the parcel market. Germany, in contrast, is much more diversely organised; with a plethora of different governmental and private sector organisations influencing the parcel delivery market. This is shown in the fact that there are no officially reported statistics concerning parcel deliveries in Germany, only figures published by industry associations in Germany. The high centralisation in China is also reflected in the more binding planning documents, which are often specific to parcel delivery and more regulatory than similar German plans. Moreover, in Germany, these often concern all segments of (urban) freight transport. For efficient and sustainable practices, no specific planning documents for parcel delivery are necessary, but it is advisable that representative studies or surveys of the parcel delivery market are carried out at different spatial levels in Germany. The establishment of a solid data basis should be initiated primarily at the national level. The usual funding in Germany often contains the same city logistics measures. In this context, emission savings assessments of these measures, such as the promotion of micro-depots, is oftentimes inexistent, whilst many projects do not go beyond a pilot phase. A comprehensive, systematic, and scientific evaluation of existing funding guidelines is therefore desirable.

Above all, the comparison at municipal level has shown that both cities set different priorities in their scopes of action. The proactive and cross-company bundling promoted in Suzhou both through the city structure and on the part of the administration can be a model for the German parcel delivery market. The model calculations support the thesis

that the alternative last mile delivery concepts, like the third-party parcel stations, can reduce mileage, especially on access roads. In order to achieve this, cooperative parcel stations could be set up at intersections of public transport and major road networks. Furthermore, it can be stated that only city-wide implementation of delivery concepts can lead to significant improvements, as opposed to small-scale local pilots.

The measures presented are not automatically applicable to every municipality; rather, city logistics measures must be developed according to the local frameworks and structures for each case. The support of all stakeholders, especially on national level, is crucial to the success of comprehensive improvements for parcel deliveries. Municipalities should try to do their part and actively support the development of alternative last mile delivery concepts.

A coordinated effort to improve parcel deliveries can lead to positive effects in this specific segment of sustainable urban logistics. Meanwhile, it should also be ensured that in urban freight transport concepts, all relevant segments of urban logistics are addressed, as parcel deliveries only play a small role in urban traffic in its entity.

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