Master thesis for the MSc Urban Governance

Rotterdam, the Netherlands, August 2022

Boxes, boom and benefits?

— identifying effects of XXL distribution centres on regional economies in the Netherlands

Word count: 17,328

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Summary

This work provides a first economic identifying analysis on the effects of the introduction of very large distribution centers (XXL DCs) to regional economies in the East-Southeast Freight Corridor of the Netherlands, the logistic hub of the country and "Gateway to Europe". Detailed geolocation data on the prevalence of XXL DCs and comprehensive Dutch employment data have been used to estimate through a difference-in-differences (DiD) approach whether indirect employment benefits can be causally linked to the introduction of XXL DCs as predicted by theory on place-based policies and agglomeration economy. Furthermore, in exploration of a more systemic perspective, it has been examined whether a causal influence on local economic diversity in terms of sector variety and balance can be detected.

We find that XXL DCs do not have causally identifiable indirect employment effects for the regions of introduction both at the Corop level (NUTS 3), a statistical division that denotes coherent local labor market regions, and the municipal level. For effects on sector diversity, applied models did return statistically significant results indicating rebalancing effects of XXL DCs on the municipal level. Upon more succinct analysis and contextual discussion of the estimators, this can be deemed however at most a curious correlation, albeit one counterintuitive to narratives of XXL DCs as harbingers of monotony and alienation, inviting further research. For the moment unobserved variables and underlining trends remain more plausible explanators.

The results entail several implications for the governance and policy surrounding XXL DC attraction, subsidization, and construction. For one, they put the leniency of local governments towards the alleged economic benefits more strongly into question. Furthermore, we advocate in light of our findings for a complementary rescaling of steering processes to both national and municipal level, as well as for bolder forms of interactive governance in the face of highlighted epistemic uncertainty.

Keywords

Distribution centres, logistics, local economy, place-based policy, difference-in-differences

Acknowledgements

The present work would not have been possible without the love and support of my parents, my brother, and the many exceptional friends I'm humbled to have. (You know who you are.) I also want to thank my supervisor and his colleagues for their support and guidance throughout the thesis process and specifically for their unpretentiousness and genuine and generous curiosity for discussing research ideas. This will leave a lasting impression on me. In these times of several crises, including a recent pandemic, I moreover want to express my heartfelt gratitude and recognition to the many workers that are sustaining essential services and infrastructure every day - despite this often not being acknowledged fairly in our current economic system - and more generally to all the people who care.

Abbreviations

COROP	Coördinatiecommissie Regionaal Onderzoeksprogramma (Coordination Commission Regional Research Programme, regional division in the Netherlands for statistical purposes)
DC	Distribution centre
DESEFC	Dutch East-Southeast Freight Corridor
DiD	Difference-in-differences
EU	European Union
IHS	Institute for Housing and Urban Development Studies
OECD	Organisation for Economic Co-operation and Developmen
MAUP	Modifiable Area Unit Problem
SUTVA	Stable Unit Treatment Value Assumption

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Chapter 1: Introduction

The Netherlands, soil conquered from the sea, densely populated, effectively used, yet always scarce and precarious. Not only that the sea might return through climate change (Katsman et al., 2011; Kulp & Strauss, 2019) or because of soil depletion through intensive industrial agriculture (Galloway et al., 2021; Van Damme et al., 2021), but also because the landscape is more and more scattered and filled with boxes of tremendous size: XXL distribution centres (DC)[1] with a footprint of 40,000 square metres, more than seven football fields.

They are the most recent upgrade of what is powering the "Gateway to Europe", a large logistics corridor between Rotterdam and the border to Germany that links central Europe with a globalized economy. But is the alleged wealth creation worth the price paid? This work will contribute to answering this question in economic identifying terms.

1.1. Background

Very large distribution centres are an increasingly relevant feature of many spatio-economic landscapes in the world. Their emergence can be traced back to the 80s and parallels the network conditions of interconnected, globalized societies (Castells, 2010). E-commerce has certainly provided an additional boost, one that has been furthered through the pandemic shock around Covid19 (Beckers et al., 2021; Gao et al., 2020; Guthrie et al., 2021). It is a peculiar development in that it is not only escalating and progressing existing dynamics, not just an addition to the economic system as we know it, but transformative of it. To put it in the imagery of urban environments: It is not only adding new shops in the streets but replacing and absorbing them, giving ground to the ubiquitous warning of "dying city centres" and changing the way space is used. While being physically placed mostly in the hinterland outside of cities, DCs can thus nevertheless entail strong implications for urban and regional spatiality.

In the United States, Amazon and its fulfilment centres are arguably already one of the most influential shapers of the (unequal) spatio-economic landscape of the country at large (MacGillis, 2021). But also in the Netherlands, an increasing "boxification" (verdozing) has been happening, embedded in the grander spatial policy narrative of making and sustaining the

[1] Throughout this work "very large boxes" and "XXL DCs" as well as combinations thereof will be used interchangeably unless otherwise indicated.

country's status as a "Gateway to Europe" (Nefs et al., 2022). The logistics industry is estimated to make up about 10% of the Dutch economy and rising **(Onstein et al., 2016)**. Many local governments and municipalities have been actively trying to attract DCs with the intention of fostering economic growth in the region (Nefs et al., 2022). Moreover, the size of the DCs got increasingly bigger, tripling since the 1980s in the corridor between the German border and Rotterdam (Nefs & Daamen, 2022). On the other hand, more and more concerns arise regarding their economic and social impacts beyond immediate gains and comfort but also because of already concrete negative externalities such as congestion, environmental pollution or landscape transformation (Apicella & Hildebrandt, 2019; de Carvalho, Nayara Louise Alves et al., 2019; Nefs, 2022; Torbianelli, 2009). In the face of such a transformative phenomenon in logistics developments and given that many of its underlining drivers can be expected to remain present, questions around how governance shall position itself vis-a-vis this development and how it could steer and manage it become ever more important. A sensible policy position and evaluation will need to examine the effects of very large distribution centres on regional economies more closely and comprehensively.

1.2. Problem statement

Increasingly, the alleged promise of very large DCs enabling regional economic growth in the Netherlands is countered by concerns over environmental problems (Li et al., 2008), sector and work transformation (Benvegnù et al., 2018; Benvegnù et al., 2022; Jaffee & Bensman, 2016) and landscape alteration – echoed in the Netherlands by the derogative term for this development as a "boxification" (Cooiman & Arnoudse, 2022). Do alleged economic gains offset these disadvantages? To advance this discussion, it is urgent to gain a deeper and possibly identifying understanding of the economic impact of large-scale DCs, especially as these logistic developments are often actively induced through local governance and policy. With this aspiration, the present work hopes to contribute to a more transparent and succinct weighting of the costs and benefits surrounding this influential development in regional economies.

1.3. Relevance of the research topic

Despite their increasing physical presence in the Netherlands and beyond, the issue around very large DCs has only recently become a topic of research (Nefs et al., 2022). Works have been focusing on spatial analysis (Jaller et al., 2017; Nefs & Daamen, 2022; Sopha et al., 2016; Warffemius, 2007) or on tracing the policy narratives and argumentations that preceded their appearance (Nefs et al., 2022; Stevens, 2021). More economic identifying works on the issue of XXL DCs and their effects on regional economies have, to the best of the author's knowledge, not yet been undertaken. This is especially curious when considering two things. One, like outlined previously, logistic developments seem to be a strong factor in reshaping contemporary spatiality. Two, identification issues have generally regained interest in the research on regional growth and development and, more broadly, economic geography (McCann & Van Oort, 2019). The latter is underlined not least by Nobel Prizes of Economics in recent years being awarded to contributors of advancements in this type of research, namely to David Card, Joshua Angrist and Guido Imbens in 2021 "for their methodological contributions to the analysis of causal relationships" (Royal Swedish Academy of Sciences, 2021) and Abhijit Banerjee, Esther Duflo and Michael Kremer in 2019 experimental methodological approaches in global poverty alleviation. An increasing availability of data bases in combination with advancements in methodology have renewed the hope to continuously improve answers on key causal questions even in the fuzzier social and economic realm outside the laboratory and to the benefit of society.

As such an approach differs from the research paths taken on the issue so far, it can be an important complementary, yet alone under the importance of including several disciplines and approaches in the face of the complexity of issues (Storper, 2011). A desirability of further empirical assessment methods for distribution centres in the Dutch context is also stated specifically in Nefs & Daamen (2022).

Moreover, an economic identifying analysis can help substantiate more straightforwardly future governance and policy discussions and decisions around distribution centres, something of help especially considering that some municipalities can be deemed insufficiently informed and caught in races "to the bottom in terms of land price and quality criteria" (Nefs & Daamen, 2022).

1.4. Research Objectives

The objective of this research is twofold. On the one hand it aims to provide precise estimates of the economic effects of the introduction of very large DCs to their surrounding regional economies, in order to contribute to a more economically identifying ex-post analysis of policy. On the other hand, this quantitative approach shall be reflected upon and positioned within the diverse approaches of researching the issue and, more specifically, attempt to link it to research on governance practice. As such, this research design entails a profoundly interdisciplinary ambition that aims to bridge an often-notorious gap between quantitative and qualitative perspectives. To do so, the following research question is formulated:

What are economically identifiable effects of XXL distribution centres on regional economies in the Dutch East-Southeast freight corridor?

This overarching research question will be supported by the following sub-questions:

a) What model can sensibly aspire to test for causal inferences in the present scenario?

b) What are the indirect employment effects of the introduction of large-scale distribution centres to certain areas?

c) What are the effects on sector diversity of the introduction of large-scale distribution centres to certain areas?

d) What implications do the answers to above questions hold for the governance and policymaking around very large DCs?

The next chapter will provide a theoretical framework for the governance around XXL DC instalment on the one hand, and urban and regional economics on the other hand, as well as on the two selected identifiers of economic effects in this work. This will in turn inform in chapter three the conceptual model of the designated variables in this research and the methodological choice (sub-question a), as well as the concrete hypotheses to above research questions b) and c) and the quantitative models to be tested against. Chapter four will present and analyse the

results, provide a discussion of the findings, and relate them to implications for the governance and policymaking around XXL DCs (sub-question d). Lastly, conclusions are formulated in chapter five.

Chapter 2: Theoretical framework

The theoretical framework of this work is subdivided in two parts, whereby the first will outline what we know from the literature about the governance around instalments of very large DCs and on the macro-level what applicable theories and debates exist around the governance of urban and regional economics more broadly. The second part will then give brief theoretical background on two selected identifiers of economic effects, namely (i) agglomeration externalities in terms of employment and (ii) sector diversity which will serve as the dependent variables in our research design and whose precise operationalizations as applicable to our research case will follow in chapter three.

2.1 The governance around very large DCs and regional economies

In the first section the aim is to link the governance dynamics of a specific policy phenomenon, the emergence of very large DCs, with the broader governance of and research on urban and regional economies. It is composed of three parts. First, we will outline what is known so far about the peculiar modes of governance that surround instalments of very large DCs. This will then be contextualized in the broader debate between spatially neutral and place-based policies as means for developing regional economies, which will lead to the theoretical input around agglomeration economies, the idea that size and clustering do matter and can yield synergies and beneficial externalities in the aggregate for a regional economy - a hope also undergirding the emergence of very large DCs.

2.1.1 Governance around very large DCs

"Governance" is an ever more widely used concept in the social sciences since the 1990s and yet it remains contested on what meaning it entails (Zürn, 2008). According to Holtkamp (2007) it can be subdivided into an analytical, descriptive, and normative conceptualization. The analytical perspective focuses "governance" as a way of interpreting "political and societal

coordination increasingly as the interaction of hierarchy, networks of politics and market" to (Holtkamp, 2007). Descriptive perspectives contextualize this in time and suggest that governance is the result of a progression following paradigms of rather hierarchic, narrow and traditional public administration, and new public management (Osborne, 2006) (Sørensen, 2006). Lastly, it is normatively invoked ("Good Governance") as a standard and ambition towards which political and corporate coordination should orient itself (Rothstein, 2012). All three have in common that they emphasise the significance of multi-stakeholder contexts in steering, and for the public side a pluralist understanding of the state and administrations beyond former traditional means of government which were characterized by established and formalized transaction and decision-making processes and clear functional division (Osborne, 2006). Governance is located and practiced not in and by silos but encompasses all of them as a coordinating and often reciprocal process. Many scholars put a strong emphasis on the network properties governance as a concept ought to express: "'Governance' means there is no one centre but multiple centres; there is no sovereign authority because networks have considerable autonomy" (Rhodes, 1997). Others retort that for many issues a centralized steering capacity has in fact not receded (Kjaer, 2011) or that the governance concept fundamentally doesn't describe anything new (Colebatch, 2009; Offe, 2009) and conclude that, if any, the analytical use of the concept is most applicable.

Unless otherwise specified, this work will follow this position and apply the analytical conceptualization of governance. It will not be used as a superordinate category, with which it would risk to just be a synonym of social order at large (Risse, 2008), but as a counter-concept to hierarchical modes of government.

More so than the alternatives, we deem this use to allow for linking the findings of our economic identifying analysis with a discussion of how the present governance mode around XXL DCs is facilitative of the empirical results of our study and reflect on how it might incorporate them in the future.

Before we can examine the governance of XXL DCs more closely, let us briefly get on a common page on the definition of distribution centres, the most concrete object of interest in this research. We will follow Higgins et al (2012) in understanding a distribution centre as "a single large warehouse or cluster of warehouses dedicated to the rapid movement of goods" (Higgins et al., 2012). XXL distribution centres are then defined as all those whose footprint is larger than 40,000 square meters (Nefs, 2022a), the equivalent of about 7 football fields. In any case, the multi-layered processes around the decision for and construction of XXL DCs in the Netherlands, involving numerous stakeholders, can be clearly subsumed under the analytical

governance concept. While empirical insight into the detailed roles of numerous stakeholders is still lacking, (Nefs & Daamen, 2022) note the involvement and influence of several tiers of government planning, internationalized developers, investors, operators and, to yet lower extent, civil society. Typical to the logistic sector in the Netherlands are also interest groups (Nefs et al., 2022). Moreover, often semi-public agencies are involved which have been found to conflate entrepreneurial goals with political ones (Raimbault et al., 2016) and are generally placed further away from democratic accountability, thereby bearing witness to the characteristic blurred lines of governance processes. Based on a number of interviews with various stakeholders, (Nefs & Daamen, 2022) find that local and regional government on the one hand, and logistics operators, investors and developers on the other hand are perceived as the two groups of primary influence. For the steering input from the public side two directions can be categorized, with either clusters planned on the national level, embedded in European freight corridors (outside-in development) or emerging from existing dynamics and concentrations with stimulation from local government up till potential subsequent designation as nationally relevant hubs (inside-out development) (Nefs & Daamen, 2022). The private sector relates to this in a mixed way. One the one hand, several horizontal arrangements with the public side are observed, such as the so-called "sector plans" that aim to foster matching between employers and employees in a Dutch logistics labour market under shortage, e.g. in Limburg and Venlo (van der Weg, 2018). Triple-helix networks involving logistics operators with DCs have been identified in seven Dutch horticulture Greenport regions (Geerling-Eiff et al., 2017) and (De Langen & Chouly, 2004) illustrate how access building to the hinterlands for maritime logistics – and, by extension, distribution centres – face collective action problems which can be overcome only by effective governance through coalition-building. Such requirements collide, however, with the fact that developments of very large DCs often follow the logic of global and fast-paced real-estate markets (Nefs & Daamen, 2022) and related speculation. Therewith involved actors of higher anonymity and easier exit options are presumably harder to bring under the umbrella of coordinative governance processes. In addition to that, two other systematically diverging dynamics seem to occur. One is information and skill asymmetries, especially between investors or developers and local governments linking to classical principal-agent problems and which leads to the curious situation that municipalities, despite assumed to be influential through land-use plans (Woudsma, 2012) don't consider themselves as such (Nefs & Daamen, 2022). The other is a seemingly "high level of corporate pan-European standardization" such (Nefs & Daamen, 2022) contrasting diverse modes and positions on the government side including slower transaction. Against this

background it is perhaps no wonder that on the public side, too, bias prevails towards economic advantages (Yuan, 2019) even without succinct empirical backing, and despite a plethora of other complex issues and ambitions, such as circularity, net-zero carbon emission goals or landscape transformation which themselves ascertain that processes around the emergence of XXL DCs will continue to often be modes of governance.

2.1.2 Spatially neutral vs place-based policies

The question of how to foster regional development and economic growth from a policy perspective is largely divided in two schools of thought. Spatially neutral approaches on the one hand and place-based approaches on the other are separated by "profoundly different understandings of the role played by institutions, governance, and urban hierarchies in influencing historical processes of development" (Barca et al., 2012). Both positions have advocates in powerful policy circles, leading to diametrically opposite policy recommendations in reports of organizations such as the World Bank, the European Commission, or the OECD (Barca et al., 2012).

Space-neutral approaches consider institutions and market mechanisms to be the only relevant factors for regional development (Barca et al., 2012). Efficiency gains have primacy and, per definition, asymmetries and inequalities between regions are irrelevant for questions of productive allocation. Rather, the latter should be alleviated ex post through compensations which can be sourced from welfare gains precisely achieved thanks to productive and allocative efficiency first. Proper institutions and market mechanisms are seen to be the sole important ingredients for an eventual convergence towards optimal spatial distribution of economic dynamics. Policy examples reflecting this perspective are for example national welfare transfers and tax credits (Neumark & Simpson, 2015) or the stimulation checks paid in many countries during the Covid19 pandemic, all irrespective of recipients' location. A very tangible illustration of this perspective is Edward Glaeser's argument that the intended budget to be spent on rebuilding New Orleans' infrastructure after Hurricane Katrina in 2011 would be put to better use by handing it out to residents in direct checks, allowing them to individualize their coping with the catastrophe for example through self-made choices of relocation, home-ownership or sending children to college, facilitating a more efficient and precise steering of resources (Glaeser, 2011).

Place-based approaches on the other hand contend that often local context does matter, and policies should be nuanced respectively. Broadly, their policies can be defined as (actively)

trying “to reallocate economic activity across areas within a jurisdiction or stimulate activity in very specific areas within a jurisdiction” (Neumark & Simpson, 2015). A subdivision can be made between direct and indirect place-based policies whereby the former attempt to create stimulus in situ, e.g., through special economic zones, and the latter intend to incentivize people to move to more economically dynamic areas in order to reduce spatial mismatch (Neumark & Simpson, 2015).

Place-based theory advances several arguments against the spatially neutral position. One is that many transaction- and social costs that arise from space-neutral policies, e.g., in the relocation of people to urban centres, are relatively unknown and not sufficiently accounted for. This explains how in many cases people’s locational choices are much stickier than what the rational-choice-assumptions of many economists would predict (Banerjee & Duflo, 2019). Moreover, it is often unique characteristics of locations that bear and sustain competitive advantages or let the isomorphic policy coat tailored by space-neutral approaches fail (Barca et al., 2012). Another argument addresses the fundamental issue of knowledge in policy and maintains that a complementary arrangement of the knowledge of local elites and new knowledge and ideas from exogenous factors specifically can enable a growth out of underdevelopment traps (Barca, 2009). More generally it is maintained that integrated, regionally specified policies can indeed create and stimulate local development and spill overs for larger aggregate growth. However, the overarching question for any such place-based policy remains whether their interventions have come at a cost to other areas with for example clouding-out dynamics at play.

The relevance of place-based approaches in any case has resurfaced recently with political developments that Rodríguez-Pose coined to be “the revenge of places that don’t matter” (Rodríguez-Pose, 2018), namely the rise of populisms in left-behind hinterlands such as East Germany or North Britain and the need to find answers to this phenomenon also through from the realm of economics and policy.

In practice of course a clear division between these two theoretical perspectives can be rarely upheld. The competition between port cities in Europe is a case in point. Several natural and historical circumstances have narrowed down the group of very large ports in central Europe to Antwerp, Rotterdam, Bremen and Hamburg, echoing the prediction of spatially neutral perspectives, as this “shortlist” arguably emerged through natural geographic advantages and supporting institutional frameworks. On the other hand, many of these ports experienced frequently place-based and place-specific interventions, for example through publicly backed expansion and construction projects such as the widening of the deltas and riverbeds (Dekker

et al., 2003; Grossmann, 2008). Against the background of postindustrial challenges, cultural clusters are another example of place-based interventions that not only support existing competitiveness but shall enable transition (Mommaas, 2004). However, with mixed evidence regarding their success on both sides, the necessity persists to put policies from both schools of thought, spatially neutral or place-based, under continuous scrutiny.

Conceptually, it is important to note that "policy", like governance, is a rather subject-less notion, i.e., it remains unvocal on specific actor constellations. While indeed for public policy government decision-making is a necessary condition, it is not sufficient for the overall policy since "there are often many types of actions and interventions that are consistent with achieving or at least potentially achieving particular outcomes" (Stewart, 2014).

Against this framework then the emergence of XXL distribution centres can be subsumed as instances of direct place-based policies. This is most obvious in contexts of the aforementioned outside-in or inside-out developments where considerable initiative comes from government tiers and areas are specifically designated for enhancements through very large DCs. But even in cases where initial locational choice is determined by market side only, the realization of projects of the size of very large DCs almost per definition includes involvement and negotiation with public stakeholders, since its dimensions make greenfield developments unlikely (Nefs & Daamen, 2022) and land, planning and accessibility need to be negotiated for with the government.

But more concretely, how is instalment of XXL DCs rationalized as beneficial to the regional economy, especially beyond a perspective of relative gains ("win-lose"), at the expense of other places in the region that could have attracted them? Typical arguments revolve around the assumed efficiency and synergy effects of agglomeration externalities (Neumark & Simpson, 2015) detailed in the next section.

2.1.3 Agglomeration economies

Literature in urban and regional economics maintains that agglomeration or clustering yields economic effects on its own. City size is associated with disproportionally larger growth, a doubling in size is observed to return more than double in GDP, income, and patents (Bettencourt et al., 2010; Bettencourt & Lobo, 2016). This is assumed to be because of numerous microfoundations summarized in the triad of "sharing, matching and learning" (Duranton & Puga, 2004). For example, larger and more qualitative labour pools in

agglomerations entail more matching opportunities between jobseekers and employers or easier because shared access for suppliers and manufacturers, lower costs for material input and an easier distribution to a more proximate population (Rosenthal & Strange, 2004). Several types of physical proximities, such as the cognitive, organizational or institutional one, likely reduce transaction costs and enhance flows of knowledge, leading to more innovation (Boschma, 2005). Previous research showed that this applies also to the logistics sector (Van den Heuvel, Frank P et al., 2014). In the concrete case of very large DCs exemplary externalities could be an induced stronger demand for specialized maintenance or cleaning services, or related sectors like agrofood or manufacturing benefiting from elevated accessibility and throughput for their value chains. Even more specifically a phenomenon relating to distribution centres is the fact that many large e-commerce platforms offer retailers through comprehensive fulfilment services a full externalization of logistics, thus "onramping" ad-hoc many individual sellers (Grewal et al., 2004; Rodrigue, 2020). Other dynamics and trends pointing to presumably more disruptive and radical innovation in the logistics sector, and which could provide spill over effects are supply-chain-as-a-service (Leukel et al., 2011) or blockchain applications (Hackius & Petersen, 2017; Tijan et al., 2019) which could leverage the "learning" conditions of clusters. In this respect it is interesting that some authors note that even for the attraction of venture capital local proximity may be an important factor. (Zhang, 2007) observes this for example for the Silicon Valley region, but (Fritsch & Schilder, 2008) contest it with regard to venture capital investments in Germany.

2.2 Identifiers of economic effects

The first step of our theoretical framework in the previous section has established more generally the assumption that place-based policies can locally create and sustain agglomeration economies and that this applies to very large DCs as well. However, how can economic agglomeration effects and gains be more concretely conceptualized and identified? This work suggests two major dependent variables that could be influenced by the introduction of very large DCs through clustering: Indirect employment gains (i) and sector diversity (ii).

2.2.1 Second- and third-order employment changes

In most economic schools of thought, labour is one of the most important, if not the most fundamental endowment of an economy. As such it is almost a natural first identifier of economic effects to be considered. It also continues to be a very favourable metric in marketing economic policies as politicians seek to present employment benefits to their constituency. On the microeconomic level of firm's growth as well, employment is next to sales the most common criterion used for growth determination (Janssen, 2009).

A potential examination of changes in the patterns of employment after the introduction of very large DCs in a region can be subdivided in three categories. First there is direct employment benefits through the locating of the XXL DCs as employers themselves. Several particularities however apply in the employment dynamics for this industry. For one, they continue to grow and thereby absorb a lot of low-educated manual labour with some suggesting that these characteristics have even flattening and converging potential, uplifting hitherto unemployed or otherwise people left out of the labour market (Sheffi, 2012). Contrary to that, however, it needs also to be considered that these jobs are especially vulnerable to automation (Yuan, 2019) and that in the Dutch labor market the pool of such employees largely relies on migrant labour from Eastern Europe (Nefs et al., 2022) once again underlining the supraregional dimension the subject entails. Furthermore, with increasing footprint of distribution centres employment numbers seem to decrease at the margin[2] , another form of rationalization of work force.

Against the theoretical background of agglomeration externalities mentioned above, however, employment changes beyond these direct effects are of higher interest for the present work. Such indirect employment effects can be subdivided into a second and third order level (if we name the direct employment effects those of first order level). The second order employment effects are assumed to be happening in the supply chains and related sectors such as agrofood or manufacturing, to which the XXL DCs are linked. Referring back to (Duranton & Puga, 2004)'s triad of sharing, matching and learning, this is because suppliers have better access to their clients, or related industries ample opportunities to reciprocally exchange and further their knowledge. Spill overs are assumed to be larger in related sectors, in relative terms, then in the aggregate. Beyond that, third order aggregate regional employment benefits deserve attention. They can stem from new entrepreneurship or innovation through the knowledge exchange of

[2] This was confirmed during exploratory data analysis of the geolocation data from Nefs (2022).

unrelated sectors (Jacobs externalities) but also through induced economic trends in the local economy along the lines of demand-side theories, e.g. through the proverbial increased spending and consumption that takes place by the new workforce locally and which can create virtuous circles.

2.2.2 Sector diversity

While employment dynamics in terms of number of employments in different reference frames can be seen as a rather straightforward identifier for economic growth, the complex conditions of interrelated economies and societal issues require increasingly also the adoption of more systemic perspectives (Hynes et al., 2020; Storper, 2011). To inquire into potential influences of the prevalence of XXL DCs on the economic diversity of the reference unit is one such perspective. Tracing and understanding how the stimulation of one sector changes the constitution of all the sectors in an economy relates to the assumption that the logistics industry, of which XXL DCs are prime embodiments, is transformative of a wide array of aspects in society (Bullinger, 2015). It is also a sensible perspective in regard to the networked conditions that were highlighted above for both the physical sense, i.e. XXL DCs as nodes in a web of global logistics, and the ideational sense when outlining the governance around XXL DC instalments and its networked properties.

If employment levels are indicative of unidimensional developments (increase or decrease of units), examining sector diversity can be the complementary, providing an insight into more aspects of the assumed agglomeration externalities and into "thicker" developments that are perhaps changing the character of the economy overall.

Generally, literature assumes that higher diversity in sector composition is a desirable faculty, as it is often associated with economic development (Davies & Tonts, 2010). Another increasingly relevant argument in volatile and crisis-prone times is that of resilience. Economies of higher sector diversity are found to be better in absorbing shocks and bounce back (Brown & Greenbaum, 2017; Davies & Tonts, 2010; Di Caro, 2017; Xiao & Drucker, 2013). Frenken et al. (2017) confirmed this assumption specifically for the Netherlands in that they found that unrelated variety on the level of broad sector categories dampens unemployment growth.

But how can economic diversity be conceptualized? Unfortunately, literature proposes an array of differing conceptualizations (Wagner, 2000). Van Dam (2019) suggests three dimensions

that are constitutive of it: Variety, balance, and disparity. Variety describes the number of different (sector) units in an economy or a system, in other words the "ontology" of a system. Balance describes the weight or the share of each of these units from the total. Disparity is an expression of the (intrinsic) difference between units. The stylized example in fig. 1 below illustrates this more clearly. Economy A with its four sectors has a higher number of variety than economy B with only three sectors. But it has also a lower disparity than Economy B, expressed by the fact that all of its sectors are "blue" rather than from different colours. Economy A is also less balanced, with sector three having a visibly dominant share. Note, however, that balance is also directly and negatively influenced by the total number of varieties and not only by its distribution. In two systems where both have one unit dominating with a 99% share, the one with the smaller total number of units will be considered more balanced than the other.

As to the potential specific effects of logistics stimulation and more concretely the introduction of XXL DCs on the diversity of economies there is not yet much empirical literature. The threat of e-commerce to offline retail seems to be a widely accepted truism and its consequences visible in inner-city centres (Just & Plößl, 2021). But "McDonaldization", i.e., a homogenization of city centres and economies occurred also prior to the ascent of e-commerce (Ritzer, 2008; Ritzer & Miles, 2019). When goods are bought increasingly virtually instead of in stationary arrangements this is detrimental to stationary retail, but does it necessarily have to decrease overall economic diversity? It is conceivable that it likewise onboards more producers to platforms and gives them access to wider economies which could mean a net gain in diversity. On the other hand, (Lee & Hosanagar, 2019) have found that recommender systems in online shopping supress sales diversity over time. More generally concerns over monopolistic tendencies and influences of online platforms, for which XXL DCs are physical expressions more often than not, are mounting (Gawer & Srnicek, 2021).

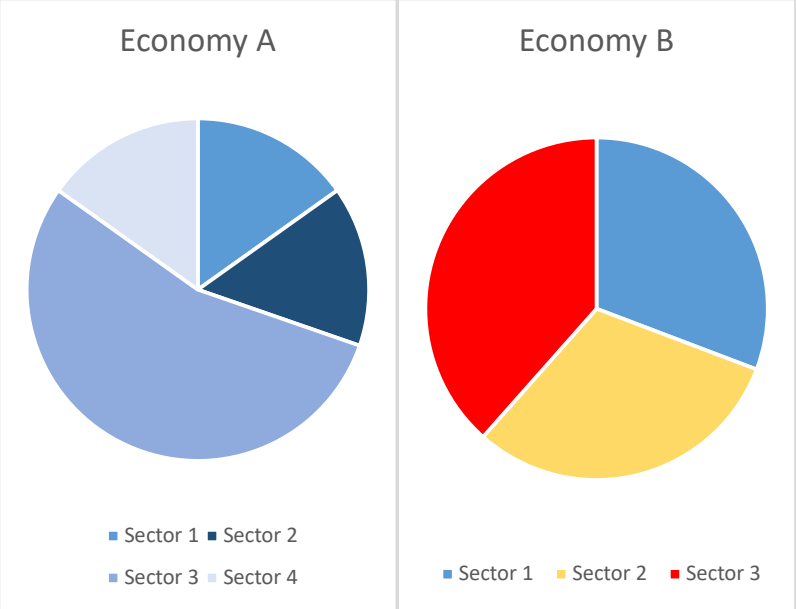

Figure 1 - Stylized example of two economies and their diversity

Chapter 3: Research design

In this chapter on the research design of this work we will first present the conceptual model synthesized from the theoretical framework. Thereafter we will briefly motivate our case selection before outlining our methodological choice for a quantitative analysis through a difference-in-differences (DiD) approach. The ensuing operationalizations of the independent and dependent variables will also guide towards the built up of the actual models to be tested for DiD estimators. The chapter will end with highlighting a few of the limitations the taken methodological approach entails before the following chapter will present the results and engage in analysis and discussion of them.

3.1 Conceptual model

This chapter will build a conceptual model from the theoretical framework outlined in the previous chapter. To begin with, the following 3 propositions summarize selected economic dynamics as predicted by literature and are the reference for hypotheses to be quantitatively tested:

P_1: Regional units with treatment, i.e. place-based policies and the introduction of very large distribution centres, experience ceteris paribus higher agglomeration externalities in terms of employment on the aggregate level than those without treatment.

P_2: Regional units with treatment experience higher net agglomeration externalities in terms of employment on the value-chain level than those without treatment.

P_3: Regional units with treatment experience lower sector diversity than those without treatment.

The independent variables are place-based policies (V_{i0}) from local governance effecting the instalment of very large DCs in assigned areas (V_{i1}). This causes direct and indirect employment gains through agglomeration externalities, with assumed positive employment gains on the value-chain level ($V_{d1.1}$) and on the aggregate level of the regional unit ($V_{d1.2}$). Furthermore, V_{i1} changes the sector composition of the local economy in that it reduces sector diversity (V_{d2}). A schematic illustration of this can be found below in figure 2.

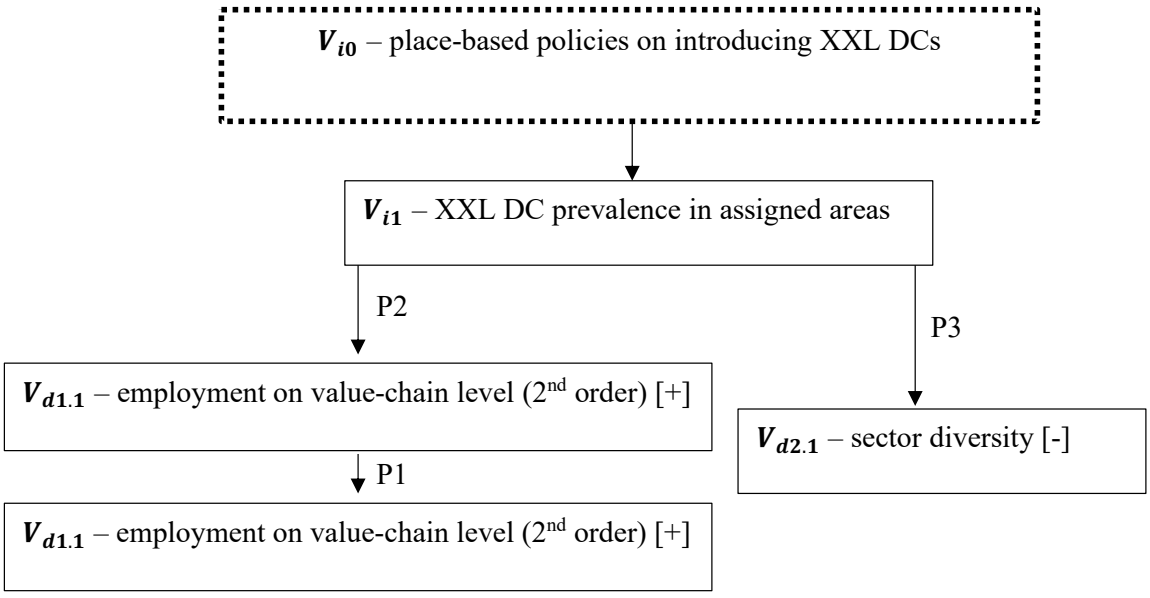

Figure 2 - Schematic illustration of the present work's conceptual model

3.2 Case selection

Several reasons have motivated the selection of the Dutch East-Southeast Freight corridor (fig. 3), situated between Rotterdam, the largest port of Europe, and Germany, as an interesting case for testing the abovementioned conceptual model and the present work's research questions.

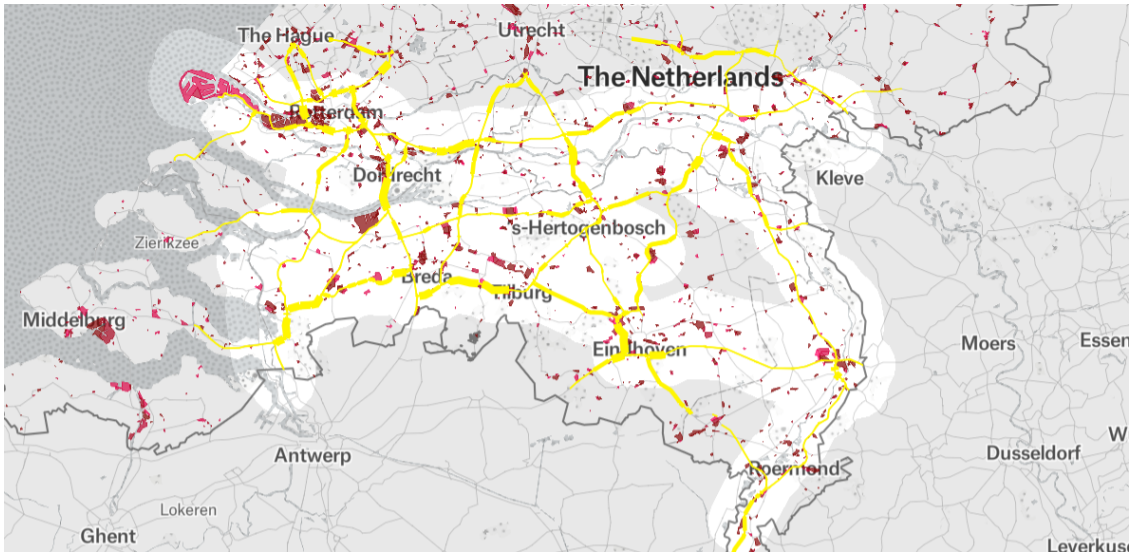

Figure 3 - Dutch East-Southeast Freight Corridor (highlighted in white), from "Landscapes of trade" (Nefs, 2021)

First, as the "Gateway to Europe" narrative already invokes, the corridor bears a strong local, but also supraregional relevance. It is strongly embedded in the Schengen area of the EU and has linkages to the Chinese Belt and Road initiative, e.g. through a third rail terminal in Venlo (Nefs & Daamen, 2022). Global and local economic dynamics are at interplay. Second, compared to other countries (Hesse, 2020), in the Netherlands the emergence of very large DCs is still seemingly not passed its peak but further expanding, all in a comparatively dense and relatively developed geography. Figure 4 below gives an overview of the cumulative prevalence of very large XXL DCs over the last two decades and the steep curve in recent years indicates further acceleration. As such this case is arguably at the forefront of future developments and its examination can hold lessons to inform remaining contingencies elsewhere. Third, the corridor suggests a certain homogeneity among the compared regional units which undergirds prospective claims inferred from statistical comparison ceteris paribus.

Fourth, the necessary detailed data for the operationalization of the variables of the conceptual model are readily available (more details in the section on operationalizations

further below), not least thanks to a recent meticulous compilation of geolocational data of the logistics complex in the Netherlands (Nefs, 2021). This leads to the fifth reason, the fact that this case is being the focus of latest research from other disciplinary perspectives (Nefs & Daamen, 2022) (Nefs et al., 2022) on which the present works' approach can then built on for a complementary, wider, and diverse analysis that includes discussion of economic identification.

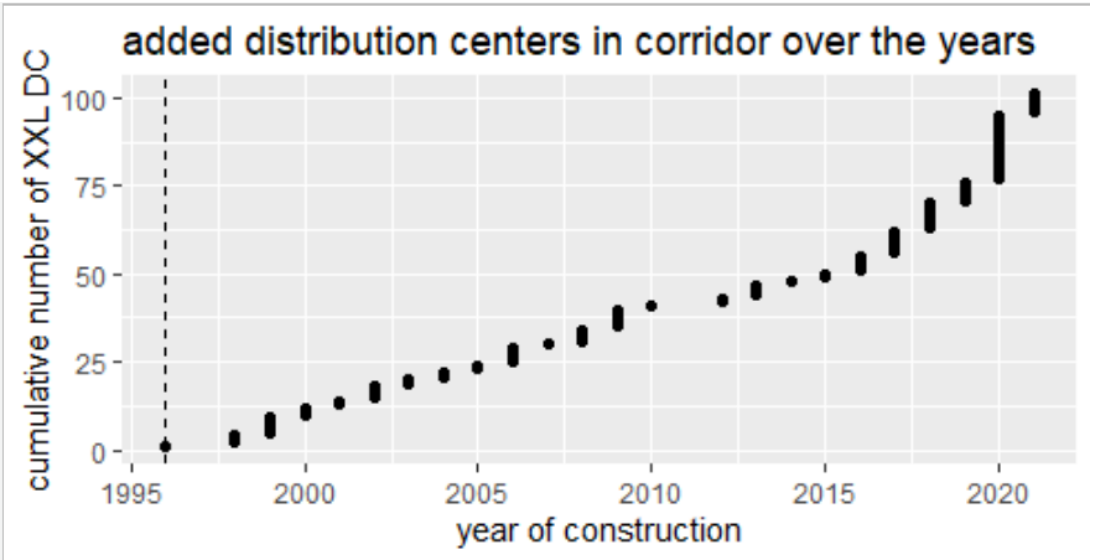

Figure 4 - Cumulative number of XXL DCs in DESEFC over time

3.3 Methodology: A difference-in-differences approach

A renewed interest in place-based policies for regional development as outlined above also puts the need for the application of quantitative evaluations back in focus, especially in the context of a general trend back towards economic identifying research. To measure the success of policies, or more generally to establish causal relationships, a common orientation is to seek for counterfactual scenarios as comparators. In the context of regional development, with its many layers and interfering dynamics, such counterfactuals can seldomly be neatly encountered or actively built like in the "scientific gold standard" of randomized controlled trials (RCT)[3]. Therefore, observational studies are common choice (Cerqua & Pellegrini, 2019) whose design can come close to RCT characteristics.

From among these, the present study makes the methodological choice of a difference-in-

[3] A notable example of applications of RCTs in development economics is the work from Banerjee, Duflo and Kremer (Banerjee et al., 2016).

differences (DiD) approach, which is "one of the most used approaches for evaluating local policies" (Cerqua & Pellegrini, 2019). In its classical version, two groups are observed over two periods of time. No group is exposed to any treatment in the first time period, but one group receives treatment in the second time period, while the other remains untreated and can serve as a control group (Imbens & Wooldridge, 2009). The changes over time in the non-treated group are subtracted from the changes over time in the treated group and thus yield an estimator of the treatment effect. The double differencing, between the groups and between the periods (pre- and post-treatment) cancels out potential confounding variables and biases so that the treatment can be understood as endogenously adopted (see Timothy, Besley & Case, 2000; Athey & Imbens 2006). For a stylized example of this see fig. 5.

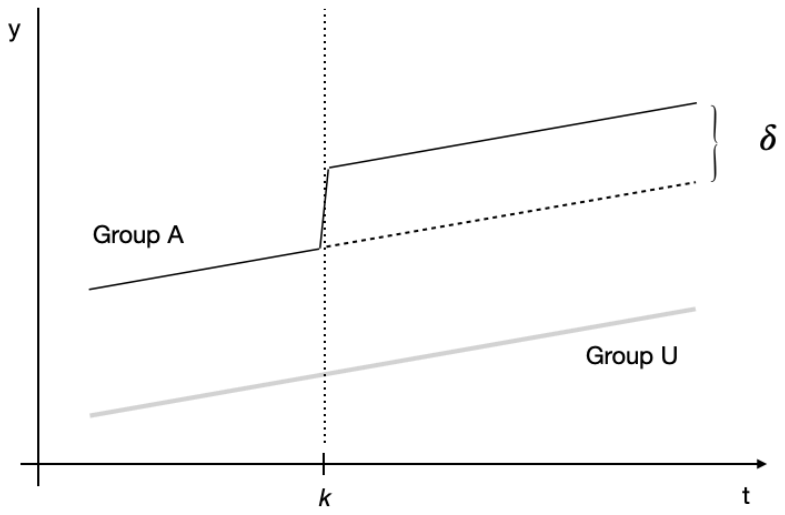

Figure 5 - Stylized example of a classic difference-in-differences set-up

In the "standard model", the DiD estimate can be formalized mathematically as follows (per Imbens & Woolridge, 2009: 67). The outcomes $y_i(0)$ for an individual (unit) i in a group G_i if there is no treatment is written as

$$y_i(0) = \alpha_i + \beta * T_i + \gamma * G_i + \varepsilon_{it}$$

where α, β and γ are unknown parameters, amongst which α represents a constant term, β is the coefficient of the influence of time T_i and γ is the coefficient of a group-specific, time-independent component G_i and ε_{it} is the representation of an unobservable variable to formally

complete the equation. From this follows that treatment $y_i(1)$ can be in combination with the outcome equation for no treatment $y_i(0)$ written as follows

$$y_i(1) = y_i(0) + \delta$$

where δ represents the DiD estimator, the treatment effect, composed from the subtraction of the expected outcome of $y_i(0)$ pre- and post-treatment period from the expected outcome of $y_i(1)$ pre- and post-treatment period. A form for regressions according to the Ordinary Least Squares (OLS) method is per Imbens & Woolridge (2009: 67) then

$$y_i = \alpha_i + \beta * T_i + \gamma * G_i + \delta D_{it} + \varepsilon_{it} \quad (1)$$

with D_{it} (deviating notation from the author) expressing the interaction of the time indicators and group indicators ($T_i * G_i$). The resulting format is essentially one of two-way-fixed effects (TWFE) regression models with interaction.

Beyond such formalizations DiD models have to make additional fundamental assumptions or account for their deviations. One such is the Stable Unit Trend Assumption (SUTVA), which postulates that the composition of treated and untreated groups is stable over time and that a unit's outcome does not affect treatment status of another unit (Rubin, 1978). With reference to the stylized example in fig. 5, a violation of SUTVA would mean that the line post-treatment e.g. fluctuates and doesn't remain constant because of spill overs and influences of the other group. It is then easy to see how this would introduce bias to the DiD estimator δ. Precisely for regional policies, yet alone those who seek out spill over effects like the agglomeration externalities examined in this research, a strict SUTVA is however difficult to uphold, as usually no walls prevent effects to end at the doorstep of another unit. Using "aggregated geographical areas" which largely embed potential spill overs (Cerqua & Pellegrini, 2019), in combination with argumentative justifications and sensible judgement in the interpretation of estimators, are common ways for remediation. Below sections on operationalizations will specify this for our case.

Additionally, two more central conditions are presented in the literature as particular sources of bias, and which should be possibly prevented. First, the assigning of treatment should not be based on temporary shocks that are affecting certain areas momentarily, because reverting

back to the mean biases the estimator upwardly (Ashenfelter, 1978; Cerqua & Pellegrini, 2019). In the case and time period of the present study, temporary shocks have not been the reason for treatment assignment. (The pandemic shock of Covid19 would also not fall under this category because, albeit temporarily, it would have had affected arguably all units in the sample equally.) Second, the DiD approach builds on an underlying parallel trend assumption, i.e. that "without the treatment, the trends of the outcomes relative to the treated group and the control group would have stayed unchanged" (Cerqua & Pellegrini, 2019), and whose suggestion necessitates careful scrutiny. In reference to above formalization (1) it is the question of how to maintain that ε_i, the error term, is not correlated to the equation's other variables. In applied research common methods to support parallel trend assumptions are tests on pre-treatment trends of the dependent and possible control variables. If trends between groups prior to treatment deviate too strongly from each other a heterogeneity can be assumed, undermining the parallel trend assumption and in turn defeating the purpose of modeling the untreated group as a control. However, in many cases conventional pre-trend testing has been shown to be either underpowered to detect parallel trends or their conditionality performing even worse than biased estimates unconditional on pre-trend testing (Roth, 2019). Kahn-Lang & Lang (Kahn-Lang & Lang, 2020) point out on a more fundamental level that parallel trends prior to the treatment period are at best "suggestive of counterfactual trends" in the second time period, but neither a necessary nor sufficient condition to prove them. This should encourage to make cases for parallel trends and non-confoundedness in a comprehensive way as is also expressed by Roth: "Bringing economic knowledge to bear on how parallel trends may be violated, and thus the plausibility of these assumptions, will yield stronger, more credible inferences than relying on the statistical significance of pre-trends tests alone" (2019: 31).

Beyond these discussions on the "standard model", continuous research and theoretical advancements in recent years have highlighted further theoretical and practical challenges for the DiD approach. These will be outlined in more detail through the operationalizations below as they are pertinent to our case.

A last general methodological concern not only of DiD approaches but of any spatial research the problem of choosing level of observation, or what is called in other terms the Modifiable Area Unit Problem (MAUP). What it summarizes is the fact that many common reference units for spatial analysis, such as municipalities or provinces are rarely constituted based on objectifiable criteria only but contain historical and administrative noise (Bertinelli & Decrop, 2005). Given that there is usually a large number of possibilities how spatial units can be

summarized into bigger units, compiled data sets and ensuing results might be inconsistent (Wong, 2004). Note that MAUP can relate to SUTVA (and not only because of the similarly long acronym) in that the choice or modification of reference areas can tune down potential interferences among units. More generally it is important to bear in mind that the very choice of spatial units might bring unwanted confounding variables into the research design. The chosen level of observation for the present case will be justified below in the operationalizations.

3.4 Operationalization and DiD modelling

This section will provide a detailed operationalization of the variables from the conceptual model and thereby also naturally discuss how the challenges to the DiD approach mentioned in the previous section apply to our research case and can be accounted for, leading to the build-up of the in total 10 DiD models to test for the propositions P_1- P_3 from the beginning of this chapter.

3.4.1 The treatment: Place-based policies for the instalment of very large DCs

For causal inference, the treatment in the DiD-design should be "substantial, sudden and well-measured" (Angrist, 2022). It should be uniform and clearly identifiable in both time and place, also from an applied perspective. In common applications of DiD it is quite evident how the treatments satisfy these conditions. In Card & Kruerger's (Card & Krueger, 1993) by now classic minimum wage study, for example, the treatment was a state-wide raise of minimum wage in New Jersey in 1992 compared to "untreated" neighbouring Pennsylvania. Other DiD research designs exploit natural experiments, such as disasters of earthquakes or flooding (Di Pietro, 2018), or sudden social crisis, such as the advent of the Vietnamese Boat People to the US (Parsons & Vézina, 2018).

In the present study the modelling of a difference-in-differences scenario is not as straightforward. While in the abovementioned "typical applications" of DiD, treatment is usually top-down and uniform at the same time, in this work's case it is the result of a near synchronous emergence of multiple governance processes and therefore has arguably different

characteristics. To try to couple thus *governance* – in its analytical sense, not as a superordinate category (see 2.1.1 above) – with an econometric method that is more prone to be used in contexts of hierarchical "non-governance" or exogenous shocks can also be seen as an innovative and explorative contribution of the present study.

Against this background, the operationalization and DiD-modelling of the independent variables V_{i0} and V_{i1} as the "treatment" for our DiD research design needs to account for several challenges. First, place-based policy is in our case very broadly defined because "there is still limited empirical knowledge on the role of the various stakeholders, as well as the legal-financial arrangements and regulations that shape their transactions" (Nefs & Daamen, 2022). While a detailed tracing of the decision-making process and identification of formal decision moments, in order to operationalize place-based policies may be possible, it is not deemed a reasonable approach for the present study, for both theoretical and practical reasons. Practically, it would overwhelm the scope of this study, not least because the author is not a native Dutch speaker. Theoretically, it is problematic that the thereby revealed place-based policies and their interaction with V_{i1} (XXL DC instalment) would likely lack sufficient uniformity. In one case, formal decision for area designation and the actual instalment of very large boxes could be only a few months apart and the process be very straightforward, in another case it could be tedious and last many years. Additionally, informal and untransparent aspects of the decision-making process are likely influential as well, and even formal decisions are reversible or subject to change, for example through appeals. In some cases, a place-based policy might have been decided on but no tangible steps for implementation are recorded yet. All this would introduce several sources of additional noise to be accounted for in subsequent interactions with the dependent variables. It would also put arguably too much emphasis on the different governance processes, rather than on the appearance of XXL DCs as outcomes of place-based policies, while this study's conceptual model approaches the issue from the other side: It aspires an identification of the outcome's effects and seeks to inform and provide implications back to the governance process afterwards.

Contrary to that, choosing the actual construction of XXL DCs as the treatment event comes closest to the abovementioned criteria for causal inference. Effectively, therefore, V_{i0} and V_{i1} will be conflated into one variable. This can be justified not least considering that the scale of very large DCs of minimum 40,000 sqm requires involvement of public administration and policy almost by definition, especially in a relatively dense geographical area like the Netherlands. Like mentioned above, their very size makes brownfield developments highly

unlikely (Flämig & Hesse in Nefs & Daamen, 2022) which means that the public side is either in the role of seller of land, or at least has considerable leverage in planning approval.

The next decision to make for operationalization is the spatial unit of analysis. Which geographical units shall be compared with each other? The present work will opt mainly for the COROP level which is situated between the provincial level and the municipal level in the Netherlands and corresponds to level 3 of the "nomenclature of territorial units for statistics" (NUTS 3) in the European Union. The dependent variables of this study revolve around employment and the labour market, and the size of COROP regions represents reasonable commuting time which is suggestive of a coherent labour market region. Consequently, the COROP level is "regarded as the most relevant unit of analysis in agglomeration research" (Frenken et al., 2007a). Our case region, the Dutch East-Southeast Freight Corridor, contains 17 of a total 40 of these COROP units (Nefs, 2022). While we deem this to be the best unit of analysis, models on the municipal level will also be included as a complementary check for the robustness of results.

Like previously mentioned, Geodata for Dutch distribution centres until 2021 are provided through latest work of Nefs (2021). Fig. 7 and fig. 8 below show the prevalence of very large DCs in the Dutch East-Southeast Freight corridor on both the COROP and the municipal level as sourced from these Geodata.

For the COROP level we see that COROP units 13, 14, 28 and 32 qualify as the non-treated group as they don't have any XXL DC instalments. (In the case of COROP 32 we neglect the one construction, as it happened in 2021 and its effects thus aren't relevant for our available timeframe ranging until 2021 as well.) Furthermore, the second vertical dashed line from the left indicates that COROP units 15, 27, 29, 33, 34, 36 and 37 have approximately the year 2000 as the common first treatment timing. COROP 33, 34, 37 are the regions West-Noord-Brabant, Midden-Noord-Brabant and Noord-Limburg, respectively, who will be singled out in one model as they are the COROP units that most clearly had strong place-based policies stimulating the logistic sector and very large DCs, also through the designation from the national level as nodes in the "Gateway to Europe" policy narrative (Nefs et al., 2022). COROP 30, 38 and 39 have 2005 as the first year of treatment, as also indicated by the vertical dashed lines in the middle. COROP units 16 and 35 are discarded from the sample because their first treatment lies prior to or at the beginning of the timeline of the employment data starting in 1996 ($V_{d1.1}$ and $V_{d1.2}$) and thus wouldn't allow for a pre-treatment period to be compared. Additionally, a total of three distribution centres that were categorized as very large and built

in the 60s and 70s were discarded from our sample as outliers that could neither be captured by the timeline of the data on our dependent variables, nor is it arguably influential on the dynamics this study tries to examine two decades later. Identified treatment timing is 2000 and 2005 as per the vertical dashed lines in fig. 7. For the sake of simplicity this includes constructions in the years immediately around those cut-offs as potential gains from further specification or otherwise potential bias are deemed negligible in this case.

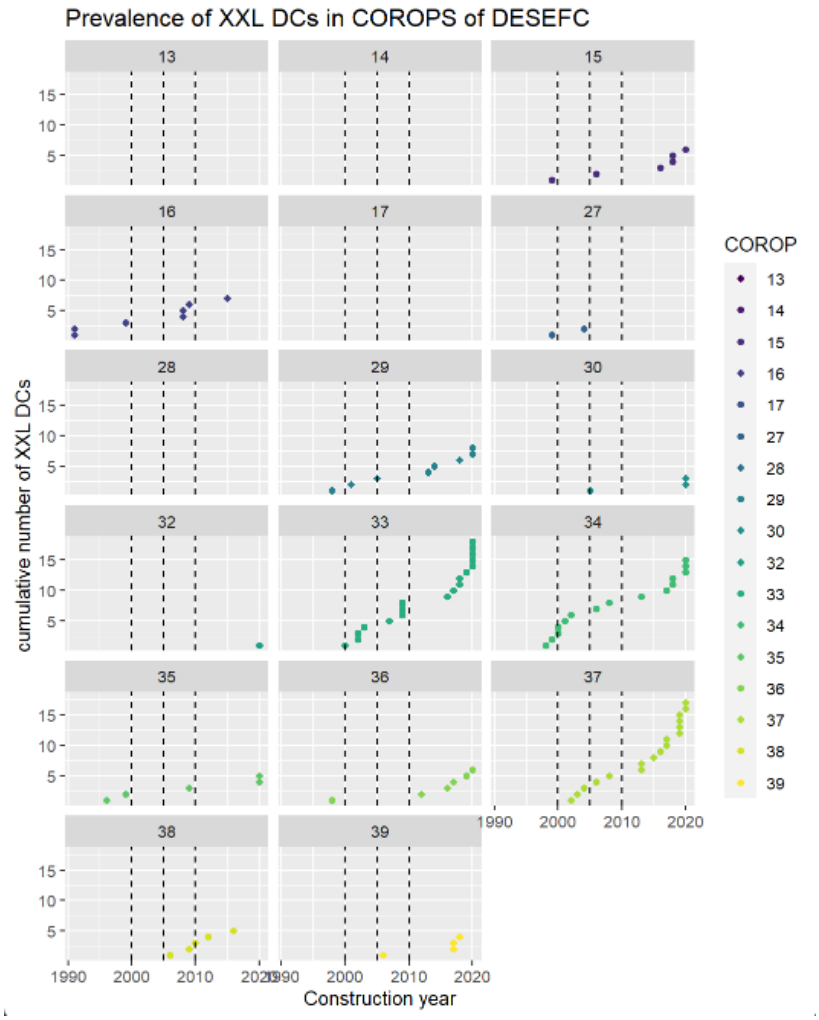

Figure 6 - Prevalence of XXL DCs on the Corop level in the DESEFC

For the municipal level fig. 8 shows only municipalities with at least one existing XXL DC in the time period 1996-2017 in alignment with the availability of data on the dependent variable for this level of observation. The municipal level provides also a slightly more uniform situation in treatment intensity. Identified moments of treatment are 2000, 2005 and 2008 as

per the vertical dashed lines. Control groups for municipalities have been matched according to population size in five different categories. A table with a detailed overview of this categorization can be found in the appendix. Municipalities 828, 848 and 1674 are discarded from the sample because their treatment occurs at the very end of the available time frame and therefore no post-treatment period can be analyzed. Municipalities 599, 772 and 855 were discarded because no comparable non-treated municipality exists in the DESEFC. 1960 and 1963 are the results of municipal mergers after the timeline of the data set of LISA at the municipal level and their observation values have been retrospectively reconstructed by the author.

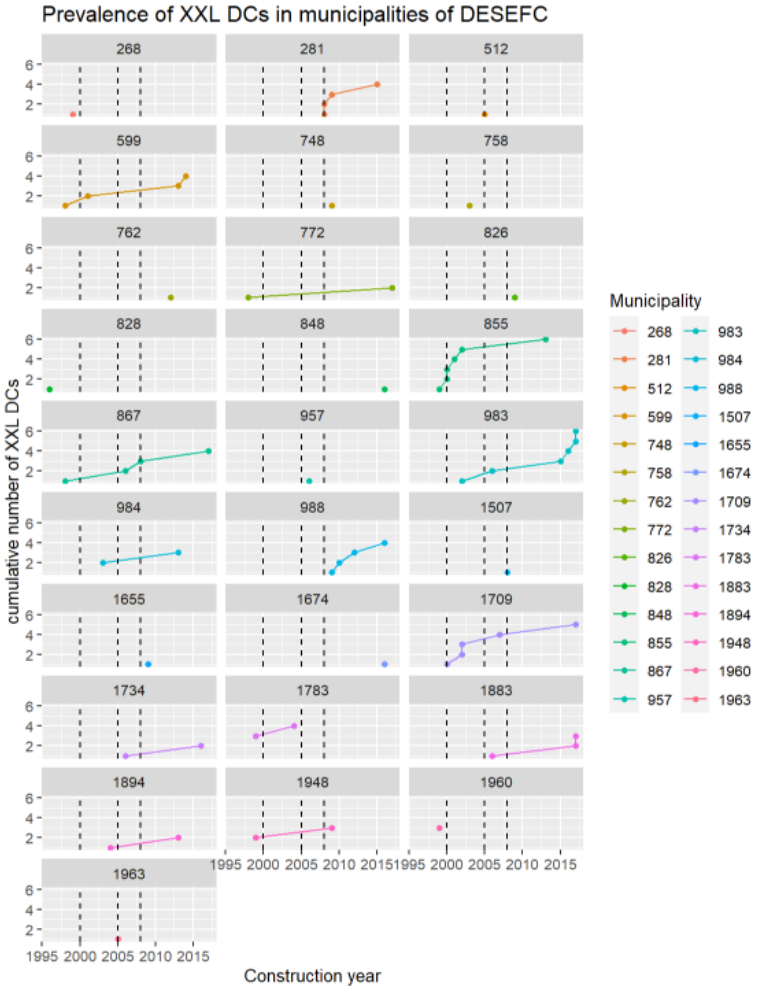

Figure 7 - Prevalence of XXL DCs in municipalities of the DESEFC

In closest alignment with the DiD standard scenario (1) this allows for the first concrete models for calculation. As a baseline in the classical two-by-two difference-in-differences sense the first treatment cohort will be compared to never treated units throughout the timeline for both

the aggregate (Model C1a) and the value-chain level (Model C1b). The same goes for matched municipalities (Model M1a and M1b).

Model code	Model name	Description
C1a	Corop baseline aggregate	2x2 DiD with treated and untreated Corops, t= 2000, aggregate level
C1b	Corop baseline value chain	2x2 DiD with treated and untreated Corops, t=2000, value chain level
M1a	Municipality baseline aggregate, .45, .55, .75, .120, .200	2x2 DiD treated & untreated municipalities, t = 1999, 2005 & 2008, aggregate employment effects, 5 categories
M1b	Municipality baseline value chain, .45, .55, .75, .120, .200	2x2 DiD treated & untreated municipalities, t = 1999, 2005 & 2008, value chain employment effects, 5 categories

A summary table of all models used in this study can be found in the appendix.

Above overviews of the prevalence of XXL DCs (fig. 7 and fig. 8), our treatments in this DiD research design, indicate however also two challenging diversions from the standard model: There is in fact a varying treatment "intensity", i.e., some regions have received more XXL DCs over time than others, and there is more than one treatment period and thus differing treatment groups.

Treatment intensity in our case can differ across two dimensions. It can be operationalized as the overall number of XXL DCs per regional unit, as a discrete variation of treatment intensity, or as the size of XXL DCs and thus a continuous treatment intensity variation. Imbens & Woolridge (2009:72 ff.) offer a summarized account of different ways to include treatment intensity for each of these dimensions. We deem incorporating continuous treatment intensity as per footprint of the DCs in the mathematical model an overspecification for the present study. It would also have to include the complicated fact that direct employment seems to decrease at the margin. Instead, we will account for the varying number of XXL boxes for the independent variable in a simplified way: Models C2a & C2b single out specifically the "high-intensity group" of COROPs 33, 34, and 37.

Model code	Model name	Description
C2a	Corop intense aggregate	Singling out 33, 34, 37 against untreated Corops on aggregate level
C2b	Corop intense value chain	Singling out 33, 34, 37 against untreated Corops on value chain level

In a more nuanced way, continuous treatment intensity will be however also indirectly accounted for through the operationalization of the dependent variable $\boldsymbol{V_{d1.1}}$ (see next section for details). Note that many studies in the past haven't controlled for treatment intensity at all but counted only the first instance of treatment in binary manner (e.g. Bailey & Goodman-Bacon, 2015).

Lastly, variation in treatment timing adds several fundamental theoretical problems for the DiD methodology. Figure 9 shows a stylized example of such a scenario. The usual approach used to be a simple extrapolation of the classical form (1) to a two-way-fixed-effects scenario where the varying treatment groups are separated (Callaway & Sant'Anna, 2021) as follows:

$$y_{i,t} = \alpha_i + \beta_t + \sum_{k=-K}^{-2} \gamma_k^{lead} D_{i,t}^k + \sum_{l=0}^{L} \gamma_k^{lag} D_{i,t}^k + \varepsilon_{it} \qquad (2)$$

where $D_{i,t}^k = 1\{t - G_i = k\}$ is a dummy variable entailing the proportion of treatment period vis-à-vis the first treated group.

In recent years, several authors have formulated theoretical criticism for this approach and showed that it introduces severe biases to the estimates, at times even up to the wrong sign (e.g. Athey & Imbens, 2022; Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021; Sun & Abraham, 2021). While we do not have space to expand on the argumentations in detail here, it suffices to say that the root causes of estimator biases are heterogeneities in the effects between various treatment groups and in the strong assumptions of stable treatment effects over time. The comparability between early and late treated group entails elevated difficulty.

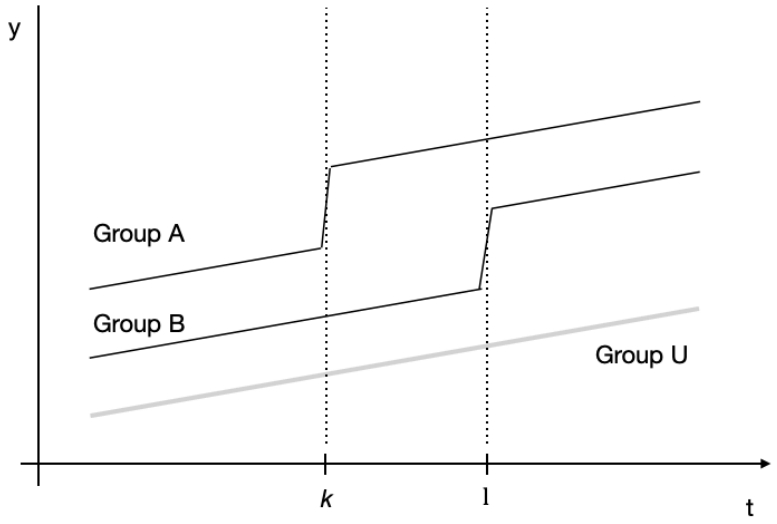

Figure 8 - Stylized DiD scenario with variation in treatment timing

To account for these recent advancements we will follow in our model also a recent contribution from Goodman-Bacon (2021) suggesting a more "precise" method. In essence, it pursues a disaggregation of the overall scenario with varying treatment timing into all the applicable 2x2 components and apply a weighting to them before reaggregation. For better understanding a stylized disaggregation of a DiD-scenario with three groups and two treatment moments, k and l, is presented in fig. X as per Goodman-Bacon (2021).

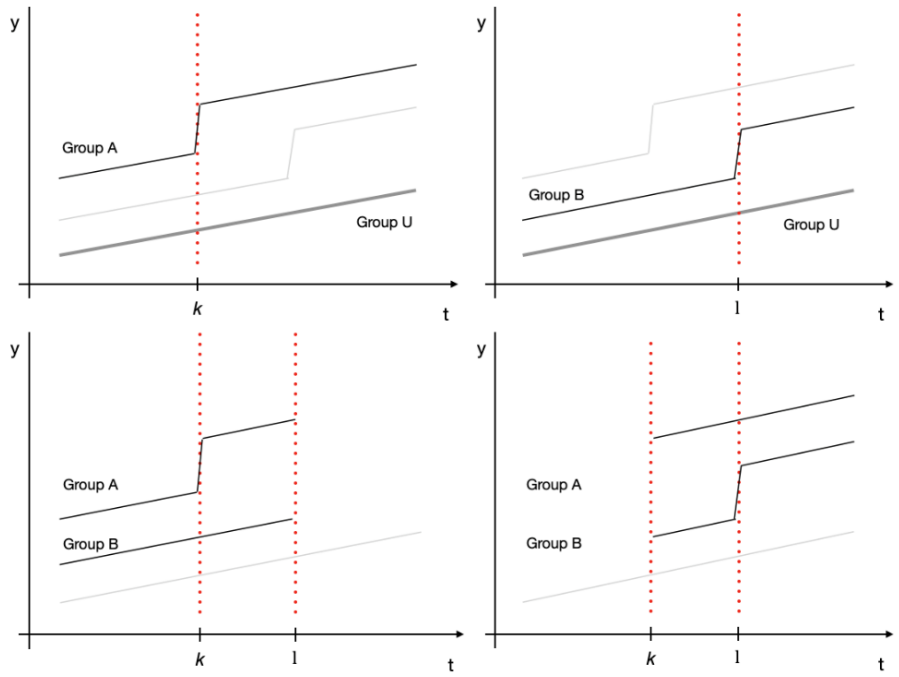

Figure 9 - Decomposition of DiD scenario with variation in treatment timing as per Goodman-Bacon (2021)

Goodman-Bacon suggests to weight each of these two-by-two DiD scenarios in relation to share of treatment time, share of group size and variance of treatment dummies and we will follow his notation here in full as per Goodman-Bacon (2021).

The beginning is again a TWFE linear regression model like in (1) with

$$y_{it} = \alpha_i + \alpha_t + \hat{\beta}^{DD} D_{it} + \varepsilon_{it}$$

where $\hat{\beta}^{D}DD_{it}$ signifies the weighted sum of all possible two-by-two estimators. With a theorem that by now is known as the Bacon Decomposition it is proven that the decomposability into the following parts applies (see also fig. X) when reconstructing a multi-treatment-timing setting with

$$\hat{\beta}^{DD} = s_{kU}\hat{\beta}^{DD}_{kU} + s_{lU}\hat{\beta}^{DD}_{lU} + [s^{k}_{kl}\hat{\beta}^{DD,k}_{kl} + s^{l}_{kl}\hat{\beta}^{DD,l}_{kl}] \quad (3)$$

whereby each s represents the weighting coefficient of the decomposed DiD estimator, k denotes the early treatment group, l the late treatment group and U the untreated. With three

differing components[4] the weighting coefficients can be calculated as follows:

$$s_{kU} = \frac{(n_k + n_U)^2 n_{kU}(1 - n_{kU})\overline{D}_k(1 - \overline{D}_k)}{\hat{V}^D} \tag{4}$$

$$s_{kl}^k = \frac{\left((n_k + n_l)(1 - \overline{D}_l)\right)^2 n_{kl}(1 - n_{kl})\frac{\overline{D}_k - \overline{D}_l}{1 - \overline{D}_l}\frac{1 - \overline{D}_k}{1 - \overline{D}_l}}{\hat{V}^D} \tag{5}$$

$$s_{kl}^l = \frac{\left((n_k + n_l)(1 - \overline{D}_k)\right)^2 n_{kl}(1 - n_{kl})\frac{\overline{D}_l}{\overline{D}_k}\frac{\overline{D}_k - \overline{D}_l}{\overline{D}_k}}{\hat{V}^D} \tag{6}$$

whereby n denote the share of group size in the sample, $\overline{D}$ is treatment share of total time (specified by group) and $\hat{V}^D$ is the variance of total fixed-effects dummy variables (for details see Goodman-Bacon (2021)). Table 2 provides the calculated results[5] for these variables and the weighting coefficients.

Table 1 - Calculated variables for the Bacon Decomposition

	n	$\overline{D}$	$\hat{V}^D$	s	
k	0.467	0.85	0.0534	s_{kU}	0.371
l	0.2	0.65		s_{lU}	0.284
U	0.333	.		s_{kl}^k	0.183
				s_{kl}^l	0.227

With these parameters we can then calculate the comprehensive models C3a and C3b on the Corop level[6].

[4] s_{lU} is calculated with the same equation like s_{kU} although the paper doesn't single it out again specifically.

[5] With the Bacon Decomposition still being a rather recent advancement, it is not yet fully established in all common statistical programs. The calculations for this research where therefore done to quite some extent "manually".

[6] For the municipal level this comprehensive modeling per Bacon Decomposition was deemed a disproportionate overspecification in this work given that in most time periods only one unit is treated. Nevertheless, the same method would apply.

Model code	Model name	Description
C3a	Corop comprehensive aggregate	Comprehensive model for aggregate level per Bacon Decomposition, varying treatment times
C3b	Corop comprehensive value chain	Comprehensive model for value chain level per Bacon Decomposition, varying treatment times

With this "skeleton" of our DiD models and the operationalization of our independent variable we can then move on to the operationalizations of the independent variables.

3.4.2 Employment dynamics

The operationalization of employment dynamics is in large parts externalized to the secondary source of the LISA data set with a timeline from 1996 to 2021. The therewidth drawn employment is counted per person in full-time equivalents and aggregated into both COROP and municipal level through data transformations. To make regional units from the same category comparable to each other despite differing population sizes the change rate of employment in percentage decimals was chosen instead of the absolute change in employment numbers as the concrete outcome (y-value) for employment dynamic in the equation. Since the other two variables, group category and time were discrete, standardization was not undertaken.

A challenge arising from the conceptual model was to isolate the assumed 2nd and 3rd order indirect effects stemming from agglomeration externalities, from the rather trivial direct employment effects, i.e. jobs that are created through the XXL DCs themselves. This was done by subtracting the known employment figures per XXL DC from the aggregate employment numbers. For XXL DCs where no data on employment was available the mean employment number from all XXL DCs in the DESEFC was applied in order to not diminish sample size. This isolation also accounts indirectly for treatment intensity because a regional unit that received several very large boxes over time has to "overcompensate" for the thereby higher subtracted number of direct employment effects through stronger synergies and agglomeration

effects in alignment with theoretical predictions.

Another task for operationalization was to define related sectors and sub-sectors to be grouped for indirect effects on the value-chain - or 2nd order - level. Absent any systematic definitions to rely on, this was done in broader terms by the author in assessing the SBI08 nomenclature of economic sectors in the Netherlands (CBS, 2021) in combination with common suggestions made in the literature. As such, identified related sectors were agrofood and manufacturing (Nefs & Daamen, 2022), retail and wholesale (Chhetri et al., 2014) as well as "Transport and storage" (H), and "Renting and leasing of tangible goods and other business support services (N)". Occasionally, only a selection of sub-sectors was included in the value-chain grouping for further specification. This was guided by the reasoning that XXL DCs are assumed to be positioned more towards the smaller-scale end-customer side of the value chain which means that they are storing processed and manufactured goods of limited size and higher quantity, rather than primary materials such as steel or larger manufactured goods such as cars or ships whose industries are likely to operate their own more autonomous distribution systems. In this respect a stylized example of an entity on the value chain level benefiting from agglomeration economies with XXL DCs could be a one-person retailer of small goods. She elevates her sales numbers through the more proximate and larger storage facilities and employs new tracking methods over the blockchain which are more likely to be found around recent state-of-the art XXL DC instalments.

Generally, the inclusion of sectors to the value chain level was done in broader rather than over specifying terms. In total the thereby identified 2nd order employment population on the value chain level made up about one third of total aggregate employment in regional units. An overview of all the sectors and subsectors selected to be part of the examination of value chain effects can be found in the appendix.

In regard to substantiating the parallel trend assumption, we will refrain from complicated statistical pre-trend testing absent data availability on possible control and instrumental variables but also in reference to the caution brought forward by Roth (Roth, 2019) mentioned previously (section 3.3). Figure 11 shows the change rates in employment prior to treatment years 2000 and 2005 (vertical dashed lines) for untreated Corop units on the left and treated Corop units on the right. We can see that the direction of change and the overall pattern broadly align. Additionally, our case region comprising of the DESEFC supports the case of a certain homogeneity. To this we may add more generally as supportive facts the high population density in the Netherlands, as well as the relatively compact size of our geographic area under investigation – about one-seventh of New Jersey and Pennsylvania in Card & Krueger's (1993)

classic minimum-wage study!

Nonetheless potential confounders and alternative explanators will of course be reflected upon in the discussion of our results.

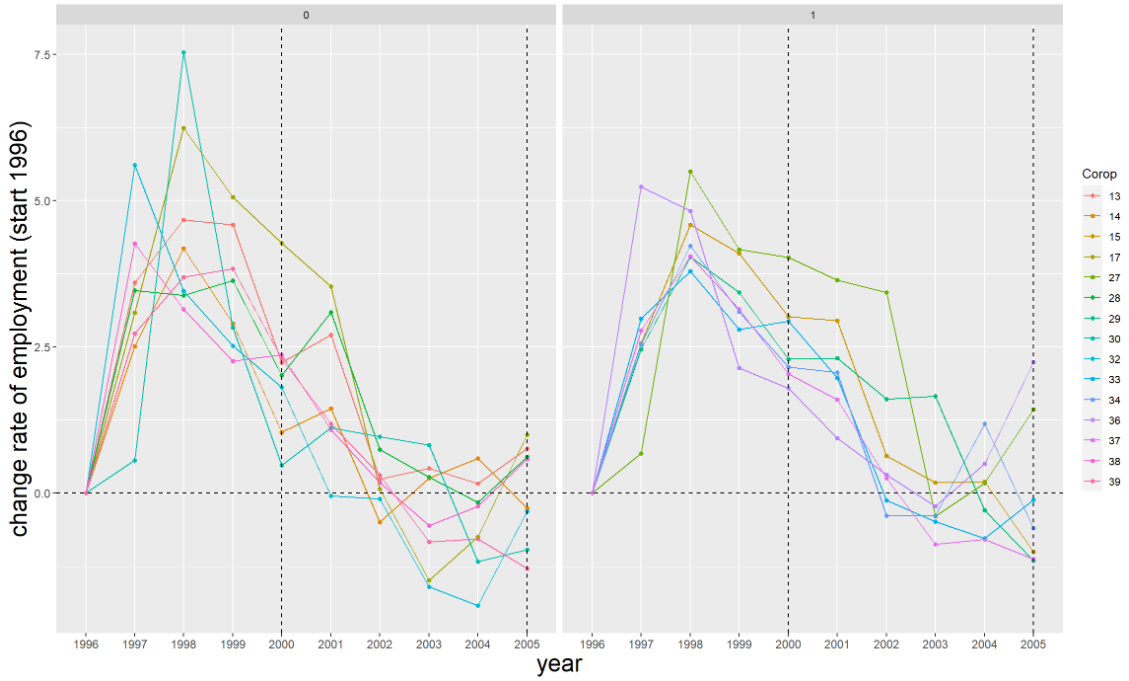

Figure 10 - Change rates of employment in DESEFC for both treatment and control group prior to treatment

3.4.3 Sector diversity

The theoretical introduction on conceptualizing economic diversity as presented in section 2.2.2 equally needs adaptation and operationalization to our case and context. First, the question of the level of analysis arises. In the Netherlands sector classifications (SBI08) are available from the broadest two-digit level (20 categories) to the most detailed 5-digit level (934 different categories existing in our sample). Frenken et al. (2007b) have shown "that the choice of sector aggregation is not trivial". This work, however, will abstain from a fine-grained examination of diversity at high-digit levels and of related variety as this would go beyond its scope. An analysis of related variety would consequently have to integrate specifically XXL boxes to related sectors and entities – a problem into which we have already run in the previous section, and which would require succinct conceptualization and indexing at this level of detail. Moreover, even a general analysis of related variety, without sub-categorizing for XXL DC value chains, would necessitate additional data, such as the Los-

index employed in Frenken et al. (2007).

For the needs of the present study, we will thus opt for an analysis on the two-digit level. It is the category which has been shown to be associated with resilience in the past (Frenken et al., 2007), precisely the systemic characteristic we are most interested in here because it introduces a complementary aspect to the focus on employment growth.

From among the three different dimensions of systemic diversity, i.e. variety, balance and disparity (van Dam, 2019), this work will only operationalize sector diversity along the dimension of balance in the regression model. This is because variety was observed to be constant on the two-digit level for every COROP and municipality in the data set. While at times minuscule – some two-digit sectors in a Corop employed at times only 17 people – employment is consistently recorded across all 21 sectors. Disparity, on the other hand, is much more complicated to operationalize. To approximate the "inherent difference" between two sectors requires a detailed account of their features where disparity could then be computed in terms of overlap between these features. Again, practically, and theoretically, this would require additional work and data.

Balance, on the contrary, is computable with greater ease from the available data, at least if calculated by entropy. The underlining understanding when employing the entropy measure is that not only unrelated variety, as per portfolio-theory, but equiproportionality of it is desirable in a system (Wagner, 2000). The applicable formula for sector diversity is then calculated with the following log share formula[7]:

$$D = \sum_{g=1}^{G} S_g \, log_2 \left(\frac{1}{S_g}\right) \tag{7}$$

where S is the share of a given sector g from the total of sectors G.

The isolation of indirect contributions from direct contributions is not pursued for the examination of sector diversity since this dependent variable is about providing insight into systemic dynamics and consolidations rather than further qualifying a unidimensional variable like employment numbers.

[7] The debate and refinements on mathematical formulas to calculate diversity is ongoing and several alternatives exists (Dissart, 2003; Wagner, 2000). Economics draws here often from insights in research on ecology.

In regard to parallel trend assumption, all arguments made in 3.4.2 apply equally. Figure 12 visualizes again trends in entropy on the Corop and municipal level (for larger municipalities) prior to treatment times 2000 and 2005. The compression through the logarithmic function makes interpretation more difficult, but the pattern of pre-trends is markedly more variate which should make us more cautious for any results to be received from the DiD estimator.

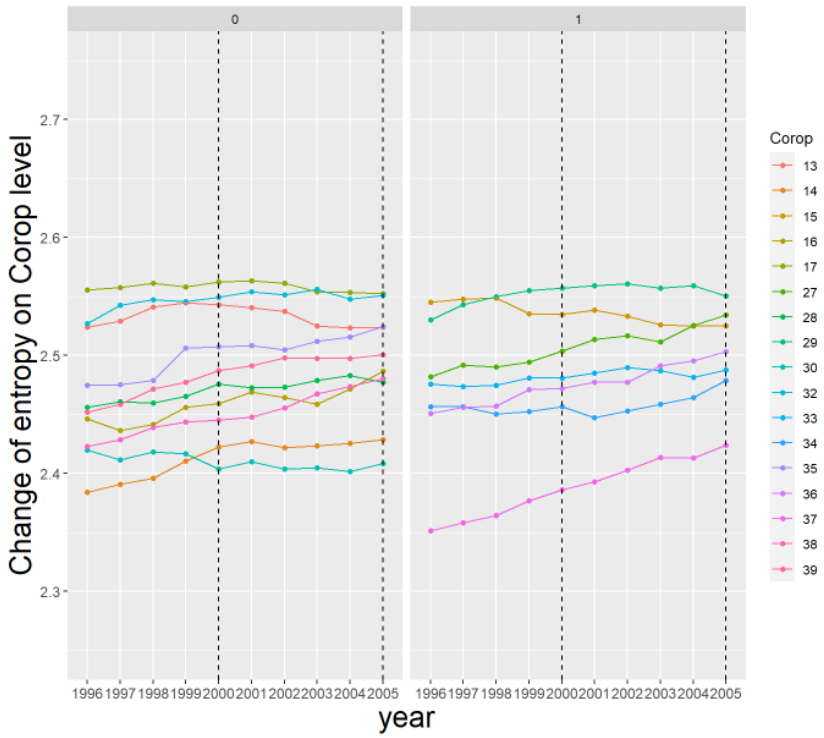

Figure 11 - Sector diversity trends pre-treatment on Corop level

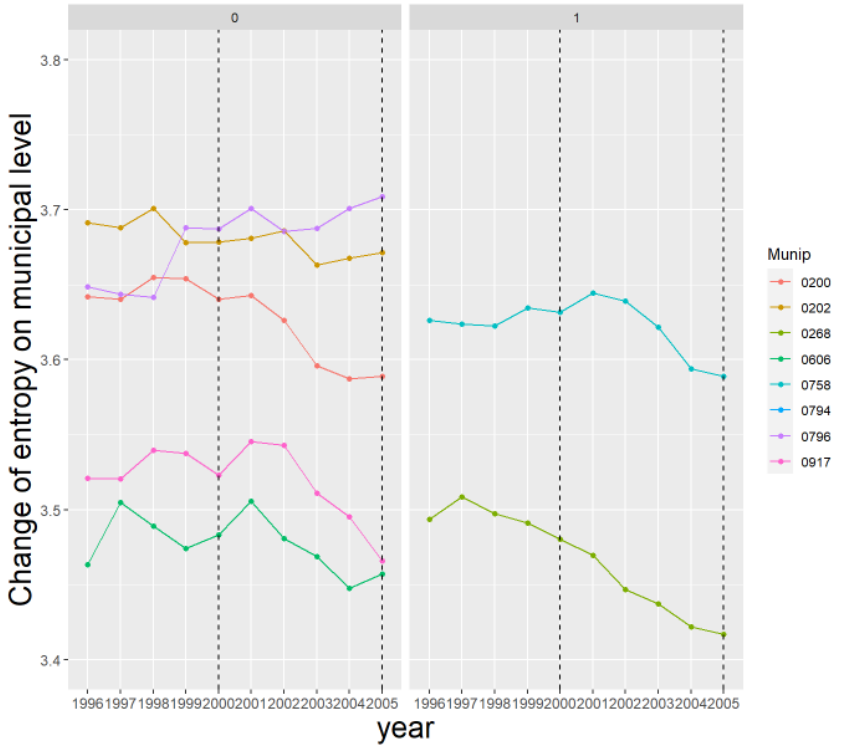

Figure 12 - Sector diversity pre-trends on municipal level for larger grouped municipalities

3.5 Data collection and program used

This work is drawing from secondary data for its research. Longitudinal data on the geolocation and construction moments as the identifiers of treatment are provided by Nefs (2022). Detailed data on employment for both COROP and municipal level, as well as per sector is sourced from the LiSA data set, kindly made available by Prof. Frank van Oort (Erasmus University Rotterdam). Population figures are sourced from the Dutch Central Agency for Statistics (CBS, Centraal Bureau voor de Statistiek). Exploratory data analysis and statistical calculations were done with the program R. Scripts of the code can be made available upon request to the author and in compliance with the licences of all secondary sources.

3.6 Limitations

Next to the usual caveats several limitations apply to this research. For one, with a total of 108 XXL DCs in the DESEFC and only 17 examined COROP regions as well as 74 municipalities, sample sizes are relatively small.
Moreover, the timeline that can be applied in the present work is not capturing the considerable acceleration of XXL DC instalments throughout the years of the Covid19 pandemic in 2020 and 2021. Follow-up research in that regard but also with wider geographic scope would be highly desirable (although conditions for a DiD research design become increasingly difficult with dwindling untreated groups).
Lastly, on a broader theoretical note, a usual limitation of quantitative economic research is that possible focus is often strongly guided by the availability of data. Only what has been recorded through established and often path-dependent "epistemic infrastructures" can be seen and researched. It is no secret that economics, its epistemics and its data gathering continues all too often to be focused on pecuniary terms only, instead of broader and more holistic metrics of wellbeing and development (Giannetti et al., 2015).

Chapter 4: Results, analysis and discussion

This chapter presents the results of the previously introduced models analyses them and offers brief contextual discussions per dependent variable. Then follows a broader discussion of the implications of these results for the future governance around XXL DCs.

4.1 Results and analysis

First dependent variable: Employment dynamics

Table 3 provides an overview of the core statistical results of the models C1a to C3b, that is the employment dynamics on the Corop level. Throughout all models, the sign of the DiD estimator is positive, which would correspond to indeed additional rates of indirect

employment dynamics for both value chain and aggregate levels. However, the results are far from significant. We see large standard errors and corresponding p-values mostly even closer to one than to zero. The implicit null hypothesis in relation to propositions P_1 and P_2, namely that Corop units with XXL DC treatment experience *no* agglomeration externalities on the aggregate or value chain level, clearly cannot be rejected. The baseline model comparing the first cohort of treated with the non-treated has the highest estimator with the value-chain level (C1b) being higher than the aggregate level. In case of significance, this would have been plausible with our conceptual model and theoretical framework and the intuition that aggregate effects follow value-chain effects. The singling out of the "intensely treated" Corops in C2a and C2b returns – counter to expectation – smaller DiD estimands and with value chain effects smaller than aggregate effects, again, however, far from any significance. If significance were to be the case, the smaller estimate size could have pointed to perhaps reduced "marginal returns" on agglomeration effects.

Interestingly, with increasing "precision", i.e. the weighting as per Bacon Decomposition, the DiD estimand seems to be getting smaller and is in the comprehensive model only at 0.128 percentage points for the aggregate level.

Table 3 - Dependent variable employment dynamics at Corop level

	C1a	C1b	C2a	C2b	C3a	C3b
time	-2.046*** [0.000]	-2.883*** [0.000]	-2.046*** [0.000]	-2.883*** [0.000]	-1.424° [0.09]	-1.562 [0.283]
	(0.391)	(0.559)	(0.401)	(0.570)	(0.428)	(0.499)
group	-0.332 [0.481]	-0.445 [0.502]	-0.494 [0.414]	-0.137 [0.871]	-0.347 [0.538]	-0.247 [0.37]
	(0.471)	(0.662)	(0.603)	(0.841)	(0.519)	(0.591)
did	0.331 [0.518]	0.506 [0.490]	0.277 [0.673]	0.181 [0.846]	0.128 [0.618]	0.208 [0.665]
	(0.512)	(0.732)	(0.656)	(0.930)	(0.615)	(0.717)
No. Obs.	312	264	208	176	312	264
R2	0.150	0.167	0.160	0.185	0.126	0.143
R2 Adj.	0.142	0.157	0.148	0.171	0.111	0.126

Notes: Significant at the ***0.001, **0.01, *0.05 and °0.1 levels. Standard errors are in round parentheses, exact p-values in squared parentheses.

Clearly significant is the negative effect of time, the first fixed variable indicating the time trend on the control group throughout pre- and post-treatment period, except in the comprehensive models C3a and C3b. Results of the second dummy variable, differences between groups prior to treatment (γ in equation (1) of section 3.3) returned consistently negative signs but also with no significance levels. Low R^2-values throughout suggest that none of the models explain occurring variance very well and thus explanatory power must be estimated low.

In sum the results for the Corop level suggest that no indirect economic effects to XXL DCs in the panel data are traceable. Three potential reasons come to mind. From an econometrical perspective the relatively small sample size and generally the fact that interaction terms are underpowered vis-à-vis the main effects that constitute them (Rogers, 2002) render detection difficult. From an economic perspective, the scale of the treatments might be yet too small, in case of which including the years around the pandemic catalyst in future research could be of interest. Both these issues could potentially be addressed by extending the sample size and scope of the area of interest (e.g. to the border region in Germany and Belgium) although this might entail trade-offs on heterogeneity and other potentially confounding variables. Lastly, as expressed with the rejection of the null hypothesis already, the possibility remains that XXL DCs just don't cause much cluster externalities at all or that rationalisation of labour evens out any gains through synergy and agglomeration. Despite their current mediatic presence, other factors are seemingly much more relevant for short- and medium-term regional economic performance.

Table 4 gives an overview of the results on the municipal level (models M1a & M1b). Here a few DiD estimands are significant at the most moderate 0.1 level. Notably this is the case for the municipalities of population size higher between 45 and 55,000 (category 2); 55 to 75,000 (category 3) and 75 to 120,000 (category 4); respectively. Direction of signs, however, is not coherent. Municipalities of population size 55 to 75,000, treated in 2008, have gained in our model 3.8 percentage points in employment through the treatment on the value chain level (M1b.75), municipalities of category 2 have lost a high 3.8 percentage points and municipalities of category 4 have lost again comparatively high 2.2 percentage points (rounded numbers compared to table). In combination with very small sample sizes (ranging from n=19

Table 4 - Summary of dependent variable employment dynamics on municipal level

	M1a.45	M1b.45	M1a.55	M1b.55	M1a.75	M1b.75	M1a.120	M1b.120	M1a.200	M1b.200
time	-0.024 [0.951]	-0.603 [0.280]	0.072 [0.905]	0.595 [0.469]	-0.187 [0.720]	-0.331 [0.612]	0.957 [0.179]	3.060** [0.007]	-2.581*** [0.000]	-1.321 [0.342]
	(0.389)	(0.558)	(0.605)	(0.821)	(0.520)	(0.650)	(0.705)	(1.110)	(0.654)	(1.381)
group	0.751 [0.315]	2.421* [0.025]	0.114 [0.898]	1.156 [0.339]	-1.214 [0.164]	-2.437* [0.026]	-0.573 [0.401]	-0.036 [0.973]	-0.187 [0.856]	0.184 [0.932]
	(0.747)	(1.071)	(0.888)	(1.205)	(0.866)	(1.081)	(0.677)	(1.067)	(1.025)	(2.163)
did	-1.045 [0.438]	-1.976 [0.307]	-1.639 [0.307]	-3.833° [0.079]	0.990 [0.528]	3.806° [0.053]	-2.156° [0.082]	-3.193 [0.101]	0.219 [0.847]	-2.060 [0.392]
	(1.346)	(1.931)	(1.600)	(2.172)	(1.561)	(1.949)	(1.221)	(1.923)	(1.133)	(2.391)
No. Obs.	312	312	182	182	117	117	78	78	66	66
R2	0.004	0.023	0.008	0.017	0.018	0.049	0.099	0.108	0.263	0.096
R2 Adj.	-0.006	0.013	-0.009	0.001	-0.009	0.024	0.062	0.071	0.227	0.052

Notes: Significant at the ***0.001, **0.01, *0.05 and °0.1 levels. Standard errors are in round parentheses, exact p-values in squared parentheses.

Table 5 - Summary of dependent variable economic diversity on both Corop and municipal level

	CD1	MD1.45.05	MD1.45.08	MD1.55.05	MD1.55.08	MD1.75.05	MD1.75.08	MD1.120.05	MD1.120.08	MD1.200.00	MD1.200.05
time	0.013 [0.308]	0.032** [0.003]	0.004 [0.624]	0.030 [0.137]	0.025 [0.202]	0.050*** [0.000]	0.050*** [0.000]	-0.027 [0.126]	-0.032° [0.052]	0.003 [0.830]	0.007 [0.504]
	(0.012)	(0.011)	(0.007)	(0.020)	(0.020)	(0.012)	(0.012)	(0.017)	(0.016)	(0.015)	(0.010)
group	0.000 [0.985]	-0.116*** [0.000]	0.011 [0.404]	-0.036 [0.383]	-0.044 [0.359]	-0.006 [0.793]	-0.052** [0.005]	-0.293*** [0.000]	-0.072** [0.004]	-0.167*** [0.000]	-0.037* [0.017]
	(0.014)	(0.027)	(0.014)	(0.041)	(0.048)	(0.024)	(0.018)	(0.030)	(0.025)	(0.027)	(0.015)
did	0.003 [0.861]	0.104** [0.004]	0.056** [0.006]	0.026 [0.629]	0.165* [0.021]	-0.038 [0.220]	-0.026 [0.280]	0.242*** [0.000]	-0.007 [0.843]	-0.114*** [0.000]	-0.036° [0.066]
	(0.018)	(0.036)	(0.020)	(0.053)	(0.071)	(0.031)	(0.024)	(0.038)	(0.036)	(0.030)	(0.019)
No. Obs.	150	508	528	305	283	154	176	110	110	88	88
R2	0.017	0.065	0.042	0.014	0.035	0.127	0.233	0.497	0.175	0.862	0.324
R2 Adj.	-0.003	0.059	0.037	0.004	0.025	0.110	0.220	0.483	0.152	0.857	0.300

Notes: Significant at the ***0.001, **0.01, *0.05 and °0.1 levels. Standard errors are in round parentheses, exact p-values in squared parentheses.

to n=5 for higher categories), further diminished through population size matching, this incoherence of direction should make us very sceptical in the interpretation. The very size of both the estimator and the standard values add to this impression. Larger estimate size in general could be expected from a smaller size of unit of spatial reference that is the municipality. Under the plausible assumption that second and third order effects will first cascade through the immediately proximate municipality, it will only later and in lower size scale and be detectable on the Corop level. This could be the case also for the negative directions, i.e., reductions in employment levels. Because the subtraction of direct employment was done in absolute numbers in our operationalization of the isolation of indirect effects negative direction theoretically weighs in relatively stronger. Practically this is implausible, however, since direct employment in XXL DCs nowhere made up an excessive amount of local employment and also because almost no single municipality had high treatment intensity of multiple boxes. If scale was truly driving the estimate size up this should apply to smaller municipalities as well, something not visible in the results. Unless a minimum threshold population size is necessary to punctuate equilibria and trigger agglomeration effects, or at least considerably furthers them (Van Oort, 2007), and does so specifically between the given ranges, the argument of spatial scale should not be given relevance to this level of nuance here. Some municipality-specific heterogeneity as an unobserved driver in the background is much more likely. In the case of M1b.75 this could be for example the fact that treated "Hoeksche Waard" (code 1963) has the dynamic logistic nodes of Rotterdam and Dordrecht in its immediate vicinity. The fact that it resulted from a municipal merger in 2019 (which was applied retrospectively to the panel data by the author) could be another indicator of heterogeneities stemming from the former municipalities constituting it. Moreover, such idiosyncrasies could also explain the sign change vis-à-vis the other significant estimates. Notable is also the varying pattern regarding the fixed variables. Contrary to the Corop level, the negative time trend for the untreated is significant only for large municipalities of population size 150 to 200,000 on the aggregate level (M1a.200). The coefficient size here matches the one seen for the Corop level. This may be reflective of a generally higher economic dynamism in larger cities and a general macroeconomic profile in the Netherlands skewed towards larger corporations in larger cities (Chong et al., 2019) thus contributing relatively stronger to aggregate estimates. As another deviating pattern for M1b.120 the time trend variable is positive at the value chain level at significance-level 0.01, something not observed in any model at the Corop level. Again, the by now common general caution notwithstanding, it may indicate a specifically positive economic dynamic on the value chain level for this

municipal size between the largest and medium-to-small sized cities. This can indeed be plausible for this specific range of size, given that many larger municipalities have more alternatives for growth in other sectors and smaller municipalities might partially self-sort in that they are not as interesting for major logistics developments, e.g. through a slightly bigger difference to major transportation routes or smaller labour pools. At least theoretically it is conceivable that municipalities of category 4 from a sweet spot in this regard in the frame of a more general consolidation. Importantly, this has to be deemed independent of the treatment of XXL boxes with the DiD estimator not being significant. Again, small R^2-values in all models suggest that none are good explanators of variance in the panel and thus explanatory power cannot be assumed.

Like for the Corop level thus the results suggest that (almost) no indirect economic effects to XXL DCs in the panel data are detectable with the abovementioned explanations for the Corop level applying equally. However, given that the municipal level returned some significant results, and in reference to MAUP, it might be sensible to reconsider the scale of focus. A larger sample of municipalities in the wider region of Central Europe (or even beyond), matched by comprehensive propensity scores could be one alley of improvement of the research design. An alternative option could be to abandon pre-defined administrative area units altogether and opt for computed spatial units with introduced thresholds of distance from XXL boxes.

Second dependent variable: Sector diversity

Table 5 shows the results for the second dependent variable (ii), sector diversity. Given that the values for entropy are logarithmic, interpretation of the size of estimators is much more difficult than with many continuous linear variables. For orientation, note that maximum theoretical entropy value in our case at the two-digit level if all 21 sectors were distributed evenly would be 4.392 (see equation (7) in chapter three). Otherwise, it shall suffice to interpret estimator size relative to values of other models' results and with the general directions of influence, i.e. a positive sign indicating an increase in balance and a negative sign indicating a decrease in balance. We can see that several more strongly significant DiD estimates appear, but only on the municipal level. For smaller municipalities of up to 45,000 inhabitants (category 1) and municipalities of up to 55,000 inhabitants (category 2), increases in balances through treatment are reported at the 0.01 level of significance. A positive effect is also shown

at the highest 0.001-significance level for municipalities of population size 75 to 120,000 in the DESEFC and has the highest value, but only for the cohort treated in 2005, not the one treated in 2008. With equally strong statistical significance, municipal category 5 (population 150 to 200,000) returns a negative effect of treatment time 1999. Moreover, relatively high R2-values (0.862 for MD1.200.00, for example) suggest statistically high explanatory power for variance in the sample.

However, already the look to the other two fixed variables in the model relativizes this impression. Municipal category 3 is the only one where a strong significance of a fixed term (in this case time-trend positive at 0.001-level) doesn't "collide" with the significant values of the interaction term. For all other did-estimators at significance level 0.01 and above, the group variable denoting differences between groups prior to treatment shows to be an equally strong or stronger predictor, a clear violation of parallel trends assumption. If we add to this several other aspects not directly reflected in the results matrix, causal inference must be deemed prohibitive. First, direction of signs and significance are again not coherent across municipal sizes and treatment timing. To make plausible inference of effects at staggered timing, e.g., with positive balancing effects first for large municipalities in 1999 and then for smaller municipalities in 2005, is in direct conflict and further undermines SUTVA. In other words, if we want to explain varying patterns in treatment effects across timing in hierarchization of different municipal categories we thereby introduce the assumption of inference between units, a severe source of bias in the estimate as described before. Second, given our results on the first dependant variable, where treatment effects for employment couldn't be detected, it seems rather implausible that suddenly on a systemic level they come to play – even though for measurements of sector diversity direct employment effects were included. This becomes even clearer if we look – as an additional "robustness check" direct employment numbers per single box was examined more closely. In the case of MD1.200, the unit with treatment time in 2005 has substantially lower significance levels with employment numbers more or less on par. Even more unsettling is the situation for municipal category 4 (MD120). While units with treatment time in 2005 returned a strong significance level of 0.001, the unit treated in 2008 didn't show any significance level at all – despite having higher direct employment from the XXL DCs than the earlier treated cohort! Third, pre-trends in general were much more mixed, another suggestive indicator of violation of parallel trend assumption also for after moments of treatment. However, one must also take into account that pre-trends and parallel trends in general are *inherently* more difficult to maintain for sensitive and more volatile measures such

as entropy and the complex dynamics that lie behind it. While their non-linear properties could in theory explain relationships and effect sizes that under linear assumptions would seem unreasonable, causal inference in general is rendered through that more elusive almost by definition. In plain words, entropy is just overall noisier.

For the sake of a more extended discussion let us however return to the significant results of the DiD estimators and take them only at face value for a moment. An increase in balance for a local economy through introduction of very large boxes would run counter to the assumptions derived from the theoretical framework and would also be certainly counterintuitive to popular narratives that associate boxification and, more generally, e-commerce with looming monotony. Nevertheless, it could indeed be conceivable that specifically smaller and bigger municipalities experience a rebalancing of their sectors through the introduction of XXL DCs. In smaller municipalities they could have activated some sectors or at least halted a broad decline that would leave "sectors of last resort" standing even without their active growth or absorption. For larger municipalities a scenario could occur where strong specialization in one sector is just evened out by a stimulus in logistics. Note that balance through the calculation and subsequent aggregation of entropies is agnostic towards baselines in this setting. What we mean by this is that for both cases, a) rising dominance and absorption of logistics and related sectors through XXL DCs, and b) reduced dominance because of endogenous effects within other sectors and thus overall sector constellation changing on several other ends, independently of XXL DC introduction; higher balance levels would be recorded for a unit. In simpler terms, a region can get more balanced because it was unbalanced through treatment, or because the treatment stimulates several sectors at the same time.

Additionally, we have to bear in mind that a more balanced diversity in and of itself, albeit associated with more resilience, can be the result of otherwise undesirable dynamics. For example, a healthy but specialized local economy might have received an involuntary rebalancing through a painstaking shock and included layoff for a large group of workers. In fact, the criticism can be made much more fundamentally, as literature has questioned in the past the a priori preference for equiproportionality implicit in the entropy measure. Wasylenko and Erickson (1978) for example pointed out that very specialized regions as per entropy perspective were often also those enjoying relative economic stability. On the other hand, this argument rests on an arguably idiosyncratic timeline of prosperity through specialization, namely the decades post second world war or from a wider angle the centuries since the industrial revolution. Several scholars of economic history maintain that this window is to be considered rather an exception than the rule (Philippon, 2022; Vonyó, 2008) and a seemingly

higher frequency of crises in the economic systems and beyond give leeway to a stronger emphasis on balance to say the least.

Another important point to make is that a certain circularity of categorizations may fail to fully grasp paradigmatic changes. For example, precarious workers of platform economies, such as couriers for postal services, drivers of urban food delivery services or taxi drivers for mobility platforms will be recorded and grouped in different sectors (G, H and I on the two-digit level of SBI08, respectively) while their applied skillset and labour is strikingly similar. In entropy terms we might thus receive results that are not reflective of tectonic shifts in the economy but seemingly balanced.

From a research perspective this strengthens the argument to more prominently include other dimensions of diversity, notably variety at more detailed levels, but also the application of disparity although this dimension is the one that is likely most "data hungry" and entails trade-offs with ease of knowledge transaction and risks of overspecification.

Lastly, one should not underestimate, also in economic and econometric research the lived reality of people to which ever more abstract categorizations and labels for industries, sectors and professions could seem like detached and illusionary markers of diversity while monotony, alienation and urban anonymity seems to escalate along the classic lines of Tönnies' observations on "Gesellschaft" (Tönnies, 2012).

Let us summarize again at the end of this section the result for both dependent variables in the scientifically most rigorous terms of critical rationalism: For all three of our propositions P_1, P_2, P_3 , made in section 3.1 above, the null hypothesis of introduction of XXL distribution centres having no effect on the dependent variables, could not be rejected. Signs of the predicted relationships were consistently confirmed for the Corop level, namely employment gains on the value-chain and aggregate level, but much more mixed for the municipal level. Regarding sector diversity in terms of systemic balance, most signs ran counter to the predicted relationship, i.e., that presence of very large boxes will absorb other sectors and reduce diversity in the regional unit. However, the recorded results of significance were relativized both through further analysis of the results matrix but also under additional robustness checks and discussions of plausibility. Absent the identification of covariates and other explanators an association remains, however. Overall, considerable uncertainty regarding bias in the estimates prevails and needs to be accounted for in future research.

4.2 Discussion and implications for governance and policy

From a slightly less rigorously scientific perspective, the substantiated "non-findings" in the previous section carry important implications for the governance and policy around very large distribution centres. The most obvious one is that the often-invoked narratives and rationalizations in place-based policies, of XXL boxes as portents of sustainable jobs and stimuli for the local economy, must be put much more into question. That even for the most proximate municipal level effects were not detectable, underlines the impression of a strong delocalization of the value-creation and gains created from XXL boxes. The often-observed leniency of local governments towards alleged economic benefits (Flämig & Hesse, 2011; Stevens, 2021; Yuan, 2019) is not justified.

In this sense the results of this work invite public decisionmakers and regional planners to reassess their weighting of the costs and benefits in supporting XXL DC constructions. Naturally, this is easier said than done: Many scholars criticize the governance concept for its obscuring of subject-centred power relationships or outright blindness to power (Christodoulidis, 2019; Swyngedouw, 2005; Vollmer et al., 2021). Contrary to that, public decisionmakers and aldermen are of course very well aware of their power interests, focused on securing their roles and orient initiatives or decisions also on their legislative periods. Studies on blame avoidance theory show empirically how this tilts decisionmakers towards misallocation of funds or delay necessary reforms as long as services are momentarily high performing (George et al., 2016; Nielsen & Baekgaard, 2015). It is easy to see how this can apply to the governance around XXL boxes as well. Therefore, public servants alone will have difficulty in changing course on the weighting of gains and pains against the background of a for the moment still seemingly successful "Gateway to Europe" narrative that has become a "rigid spatial planning story", continuously focused on higher trade volume (Nefs et al., 2022).

Still, our substantiated absence of evidence for locally beneficial, non-trivial stimuli on the labour market can and should alter the bargaining power of negotiators and, more concretely, the "pricing" of projects and land sales. This is necessary especially for smaller local governments. Bigger cities seem to weigh in already more assertively conditions to interested parties, e.g., when offering only shortened periods for writing off or applying additional criteria of socioeconomic relevance in the selection of projects (Nefs & Daamen, 2022). With profits in Dutch logistics real estate development "comparable per sqm to the London office market" (Nefs & Daamen, 2022), more possibilities for capture of public welfare

gain need to be explored.

In this respect local and national government can make further use of traditional levers like regulation and building codes. Considering collective action problems on behalf of corporations but also municipalities, which are often caught in the already mentioned "races to the bottom" to attract logistics developments, this will have to include a partial "rescaling" (Brenner, 2003) of government levels, this time back to the national level as well. A fitting example in this regard – and a rather straightforward policy measure – could be to make solar panel instalments mandatory nationally for buildings beyond a certain roof size. The European Commission has already made a move in this regard with a time horizon of 2025 in the framework of its REPowerEU Plan (European Commission, 2022) and the Netherlands seem to follow at present (NOS, 2022). It is however also telling that it wasn't until a crisis like the war in Ukraine happened that such policy initiatives seem to materialize.

Linking back to the analytical governance concept that was applied in this work, this first line of implications can be summarised as "less governance and more assertive *government*" for the concrete transactions and negotiations of XXL DC construction. A second line of implications builds on the fact that the present study has highlighted epistemic uncertainty around XXL DCs. We continue to know little about their actual dynamics and effects on regional but also macro economies. Even rigorous statistical methods may perhaps be able to reveal only so much. This is altered by the fact that very large boxes are directly linked to a globalized complex system of logistics. The epistemes and heuristics to navigate this situation clearly differ among stakeholders. For private investors, they can most often be broken down to the central currency of business administration, monetary profit. The public and civic side on the other hand must take into account many more wants, needs, conditions and agendas. Instead of bemoaning this, it should be embraced. Many possibilities exist to further tap into the opportunities of interactive governance "the complex process through which a plurality of social and political actors with diverging interests interact in order to formulate, promote, and achieve common objectives by means of mobilizing, exchanging, and deploying a range of ideas, rules, and resources" (Torfing et al., 2012).

Concretely, this could achieve several improvements. For one, early and inclusive fora and participation processes can provide democratic anchorage and important impulses to adapt the abovementioned skewed weighting of costs and benefits. It can "back up" public servants in negotiations or at all move them out of the abovementioned inertia of blame-avoidance. Importantly, this shouldn't mean to just remain at the lower rungs of the "ladder of citizen participation" (Arnstein, 1969). Often notorious citizen consultations without real impacts or

alterations in steering can end up being detrimental to trust (Ianniello et al., 2019). Instead, more binding forms of citizen participation should be genuinely considered as well. Not only that they can diffuse and pacify conflicts in the public discourse, but they are also at times shown to improve the efficiency and effectiveness of public administration and local governments (Asatryan & De Witte, 2015; Oh et al., 2019), despite many public servants in the Netherlands still holding sceptical attitudes toward it (Blijleven & van Hulst, 2021). Specifically for the steering of place-based policies on XXL boxes, it should be notable that direct democracy institutions have been able to alter the interaction between developers and interest groups in the community and, perhaps in view of the delocalization of XXL DC profits and benefits even more importantly, open the door for compensations to locals (Gerber & Phillips, 2004). Against this background, it can be deemed regrettable from both a research and a governance perspective that a solicited referendum in Tilburg on a logistics development eventually has not materialized (Nefs, 2022).

Naturally, all these implications highlight especially for local governments the need for further capacity building and resources. This leads to ongoing discussions about the right budgeting levels for the various tiers of government (something we will not engage in here) but should also refresh the focus on resource dependence theory" (Hillman et al., 2009). If we affirm that the organizations pertaining to local governance, including the municipality, are "embedded in their environments and depend on external resources to operate and survive" (Biermann & Harsch, 2017), interactive governance can be helpful in mobilizing resources like knowledge, creativity, time or material, in order to bridge the constantly observed asymmetries towards private actors (Nefs & Daamen, 2022). In this sense a second and still often overlooked implication is resource mobilization and exchange for local governments specifically *inter pares*, that is supraregional municipal networks. Bulkeley et al. (2003) have shown how these have been important drivers in environmental governance and a focalisation of the logistics-transport nexus could plausibly be another important subject matter.

The last line of implications is also deriving from the epistemic uncertainty established above but points us more towards coping with the complex environment instead of attempting to steer it. We need to repeat here that the stakes are high with XXL distribution centres, not only in their literal sense of the sheer size they occupy, or the investment volumes concerned, but also because they are superstructures lasting several decades. Apart from the discussion of how much they represent a clouding-out of resources and other potential growth- and development paths for their regional economies at this very moment, what to do with them when they are unused, empty but still a present reality? Given that already some contemporary big box

developments are speculative in nature (Nefs & Daamen, 2022), this is not a hypothetical question. The “Quelle Areal” in Nürnberg, Germany, former logistics centre of a catalogue selling giant, is a famous warning sign. Stretching around an area of 250,000 sqm, it has been standing empty for more than a decade in the suburb of a secondary city after the insolvency of its owner and finding suitable investment alternative uses was a painstakingly difficult process (Bosch, 2016). A perspective of interactive governance should anticipate this and nourish community-based initiatives and placemaking initiatives also in anticipation of new uses. From an urban planning perspective, more innovative ways to insist on modularity through building codes should be explored (Ling et al., 2021; Salingaros & Tejada, 2001). Adaptability is key.

Lastly, given that XXL DCs are frontiers of two potentially disruptive future technologies, robotics and blockchain, they should be understood as the early ecosystems for piloting and understanding paradigmatic changes in government and governance. The fact that the means of “classic economic analysis” could barely capture their dynamics and effects is echoing this. Excessive automation will make the need for innovation in both policy and (tax) regimes more and more salient (Kovacev, 2020; Prettner & Strulik, 2020). Network governance approaches can facilitate the necessary innovation through large-scale legislation and providing resources for experiments (Hartley, 2005). Research on governance might benefit from further reception of actor-network theory (Latour, 2007) to elucidate how these technologies themselves might alter our ways of doing governance.

Chapter 5: Conclusions

This research aspired to shed more light on the economic effects of the appearance of XXL distribution centres (DC) on regional economies in the Netherlands. A difference-in-differences (DiD) approach comparing regional units where boxes emerged with units that did not have them over a longitudinal time frame was pursued as a means for identifying analysis. While this methodological choice was in line with renewed interest in research of causal inference in economics, it entailed in the application to the context of XXL DC instalments also exploratory and innovative elements. Contrary to most other treatments in typical DiD research design, treatment was not top-down and uniform or delivered through an exogenous shock like natural disasters, but the result of near-synchronous emergence through governance processes and place-based policies. Ensuing challenges, such as variations in treatment timing and intensity, were accounted for, amongst others, through the application of the Bacon Decomposition (Goodman-Bacon, 2021). Dependent variables that were investigated and which were assumed to be influenced by the presence of XXL DCs were (i) indirect employment dynamics and (ii) sector diversity. For employment dynamics the assumption was that agglomeration externalities lead to additional identifiable employment growth through "sharing, matching and learning" (Duranton & Puga, 2004) on both the value-chain level of related economic sectors, and the aggregate level of the total economy of the regional unit observed. Sector diversity, in this work defined predominantly as the entropic balance of sector proportions, was assumed to be influenced negatively by XXL DC appearance.

With regard to employment dynamics, no strongly significant results were found. Sporadically significant results ($p < 0.1$) were detected for a few municipalities, albeit with incoherent direction of signs. Upon analysis and discussion, we concluded that heterogenous and unobserved underlining trends seem to be more plausible explanators for these. Furthermore, the very scale of XXL DCs in the panel data might have been yet too small for detection as an interaction term, something that might change when future research can take into account the "second wave" of instalments of XXL boxes during the pandemic of Covid19 which served as a catalyst for further e-commerce growth. Several adaptations for future research designs were

proposed. All this notwithstanding the possibility that XXL DCs simply do not cause much agglomeration externalities, counter to our theoretical framework, remains a serious possibility. Their linkages to the emerging platform economy and engagement in potentially tectonic shifts in economic organization at large warrant perhaps conceptualizations that are much more focused on rentier mechanisms and arising new forms of economic dependencies or distribution of surplus, aspects underexposed in this work.

For the second dependent variable of sector diversity, some strongly significant DiD estimators results ($p < 0.001$) were found which reported mostly positive effects on sector diversity in terms of balance. This ran counter to the assumptions derived from the theoretical framework. However, upon further analysis of the results matrix, discussions of plausibility and contextualization with the results for the first dependent variable, the suggested effects were deemed far from sufficiently robust. Unobserved variables or background noise through the complexity of the entropy measure seem to be more realistic explanations. Nonetheless, the detected relationship offers reason for further investigation and again first recommendations for future research designs were made.

The substantiated absence of evidence for positive economic externalities to the regional economies of their surroundings puts the consistent skewness of local governments towards narratives of economic growth and benefits through the attraction of XXL DCs more strongly into question. We advocate that this holds three strokes of implications for future governance processes around very large logistics boxes.

First, current assessments of benefits and disadvantages on behalf of the government side need to be reconsidered. With the presumption of localized positive economic effects not holding well in empirical investigation, room is opened for different “pricing” of projects. Traditional leverages of regulation and building codes need to be exploited more, including a partial rescaling back to upper levels of government.

Second, overall, we confirmed profound epistemic uncertainty around the effects and consequences of the spatial and local economic decisions around XXL DCs. If we add to this their time horizon of several decades as well as the web of complexity to which very large boxes are necessarily linked with through globalized logistics, this calls for a more meaningful inclusion of various stakeholders, and a much more comprehensive incorporation and mobilization of local knowledge, needs and wants. Notably, this also means to not shy away from more binding forms of citizen participation in the preparation and planning process for XXL DC developments.

Third, also in view of epistemic uncertainty, a governance perspective needs to embrace and

nourish already now community-based initiatives and experimental projects in awareness that some XXL DC structures may be long-time present in substance but not in originally intended use. Embracing adaptability and modularity is a sensible way of facing unpredictable and volatile futures. In the same sense, network governance should foster innovation in its own area and expect new challenges to its own modes of steering, through technologies, for which XXL DCs might very well be the main vessel of introduction to our social environments.

From both a perspective of research, and a perspective of urban and regional governance, it should be our strong interest to "open up" these very large boxes to more examination and broader societal engagement, to secure that they are indeed meaningful and enriching nodes to our networked but also future-prone economies.

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Appendices

Appendix A – Overview of employed DiD models

Model code	Model name	Description
C1a	Corop baseline aggregate	2x2 DiD with treated and untreated Corops, treatment year 2000, aggregate level
C1b	Corop baseline value chain	2x2 DiD with treated and untreated Corops, treatment year 2000, value chain level
C2a	Corop intense aggregate	Singling out 33, 34, 37 against untreated Corops on aggregate level

C2b	Corop intense value chain	Singling out 33, 34, 37 against untreated Corops on value chain level
C3a	Corop comprehensive aggregate	Comprehensive model for aggregate level per Bacon Decomposition, varying treatment times
C3b	Corop comprehensive value chain	Comprehensive model for value chain level per Bacon Decomposition, varying treatment times
M1a	Municipality baseline aggregate, .45, .55, .75, .120, .200	2x2 DiD treated & untreated municipalities, t = 1999, 2005 & 2008, aggregate employment effects, 5 categories
M1b	Municipality baseline value chain, .45, .55, .75, .120, .200	2x2 DiD treated & untreated municipalities, t = 1999, 2005 & 2008, value chain employment effects, 5 categories
CD1	Corop diversity baseline	Baseline 2x2 DiD, treated vs untreated, treatment time 2000
MD1	Municipality diversity baseline, .45, .55, .75, .120, .200	Baseline 2x2 DiD, treated vs untreated, treatment times 2000, 2005 and 2008

Appendix B – Sectors considered to be linked on the value chain level to XXL DCs (operationalization of 2nd order employment effects in 3.4.2)

Code	Title
A	**Agriculture, forestry and fishing**
01	Agriculture and related service activities
011	*Growing of non-perennial crops*
012	*Growing of perennial crops*
013	*Growing of bulbs and plants trees for ornamental purposes*
014	*Animal production*
015	*Mixed farming*
016	*Support activities for agriculture and post-harvest crop activities*
02	Forestry and logging
03	Fishing and aquaculture

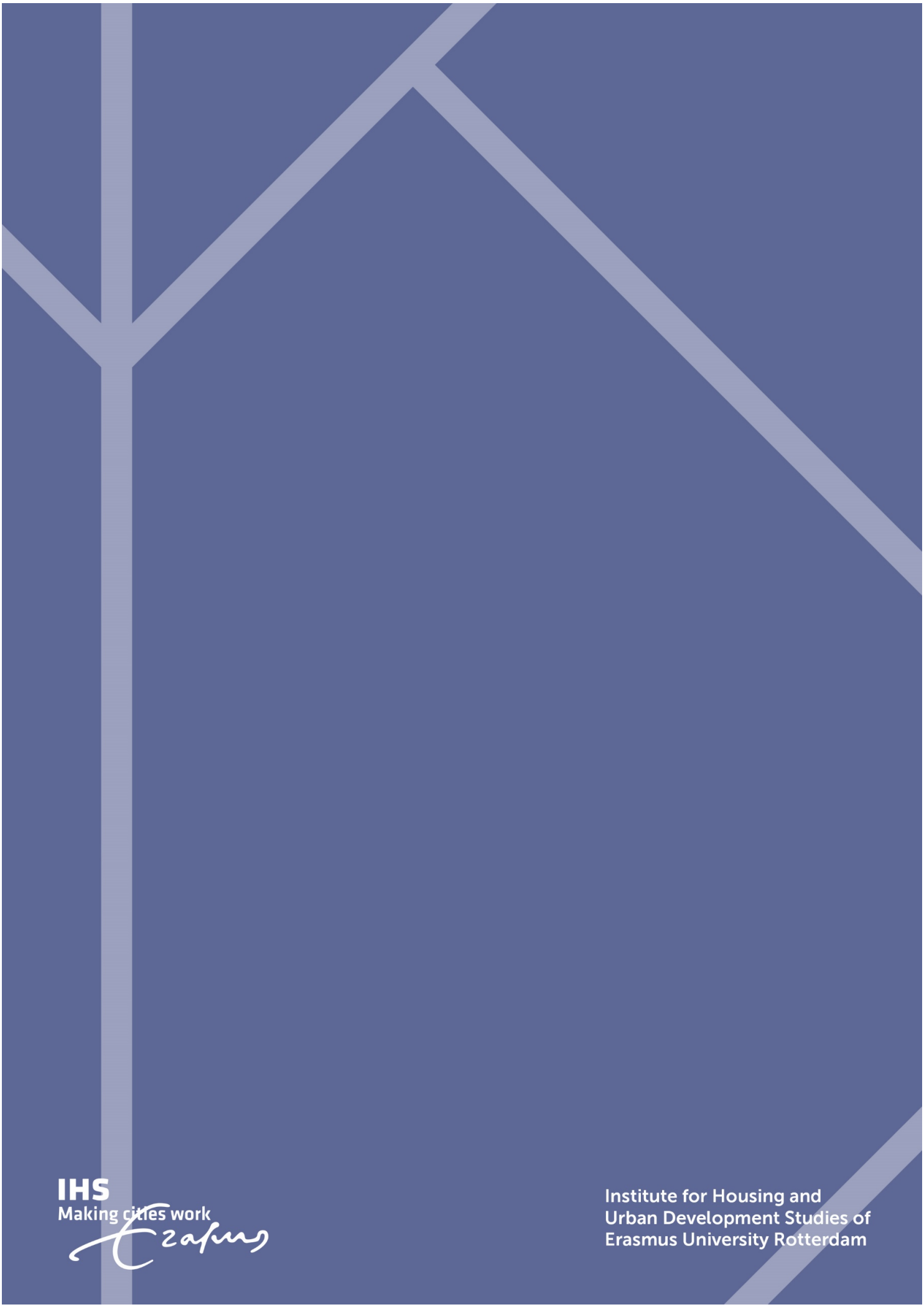
C		**Manufacturing**
10		Manufacture of food products
11		Manufacture of beverages
12		Manufacture of tobacco products
13		Manufacture of textiles
14		Manufacture of wearing apparel
15		Manufacture of leather, products of leather and footwear
16		Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17		Manufacture of paper and paper products
18		Printing and reproduction of recorded media
20		Manufacture of chemicals and chemical products
21		Manufacture of basic pharmaceutical products and pharmaceutical preparations
22		Manufacture of rubber and plastic products
23		Manufacture of other non-metallic mineral products
25		Manufacture of fabricated metal products except machinery and equipment
26		Manufacture of computers, electronic and optical products
27		Manufacture of electrical equipment
31		Manufacture of furniture
32		Manufacture of other products n.e.c.
G		**Wholesale and retail trade; repair of motor vehicles and motorcycles**
46		Wholesale trade (no motor vehicles and motorcycles)
47		Retail trade (not in motor vehicles)
H		**Transport and storage**
49		Land transport
	492	*Freight rail transport*
	494	*Freight transport by road*
	502	*Sea and coastal water transport*
	504	*Inland freight water transport*
	512	*Freight air transport*
52		Warehousing and support activities for transportation
53		Postal and courier services
N		**Renting and leasing of tangible goods and other business support services**
80		Security and investigation
	802	*Security systems service activities*
81		Facility management

Notes: Three-digit sectors in italics specify the applicable groups within two-digit sectors, otherwise all are chosen

Appendix C – Categorical matching of municipalities per population size

Treatment time	1999	2005	2008	untreated		
Category 1,						
population up to 45,000	1709**	512	281*	232	624	1876
		984	1507	262	757	1901
			1655	267	777	
				275	882	
				289	1507	
				296	1509	
				299	1525	
				353	1640	
				530	1771	
				556	1859	
Category 2,						
population 45 to 55,000	1960	867	826	243	1705	
		988	988	301	1892	
		1734		321	1924	
				489		
				597		
				632		
				797		
				861		
				928		
				1581		
Category 3,						
population 55 to 75,000		957	748	222	1991	
			826	502		
				513		
				603		
				622		
				1621		
				1926		
				1931		
				1959		
				1961		
Category 4,						
population 75 to 120,000	983	1883	1948	606		
		1963		794		
				917		
				1930		
				1982		

Treatment time	1999	2005	2008	untreated
Category 5, population 150 to 200,000		268	758	200 202 796


IHS
Making cities work
Erasmus
Institute for Housing and
Urban Development Studies of
Erasmus University Rotterdam