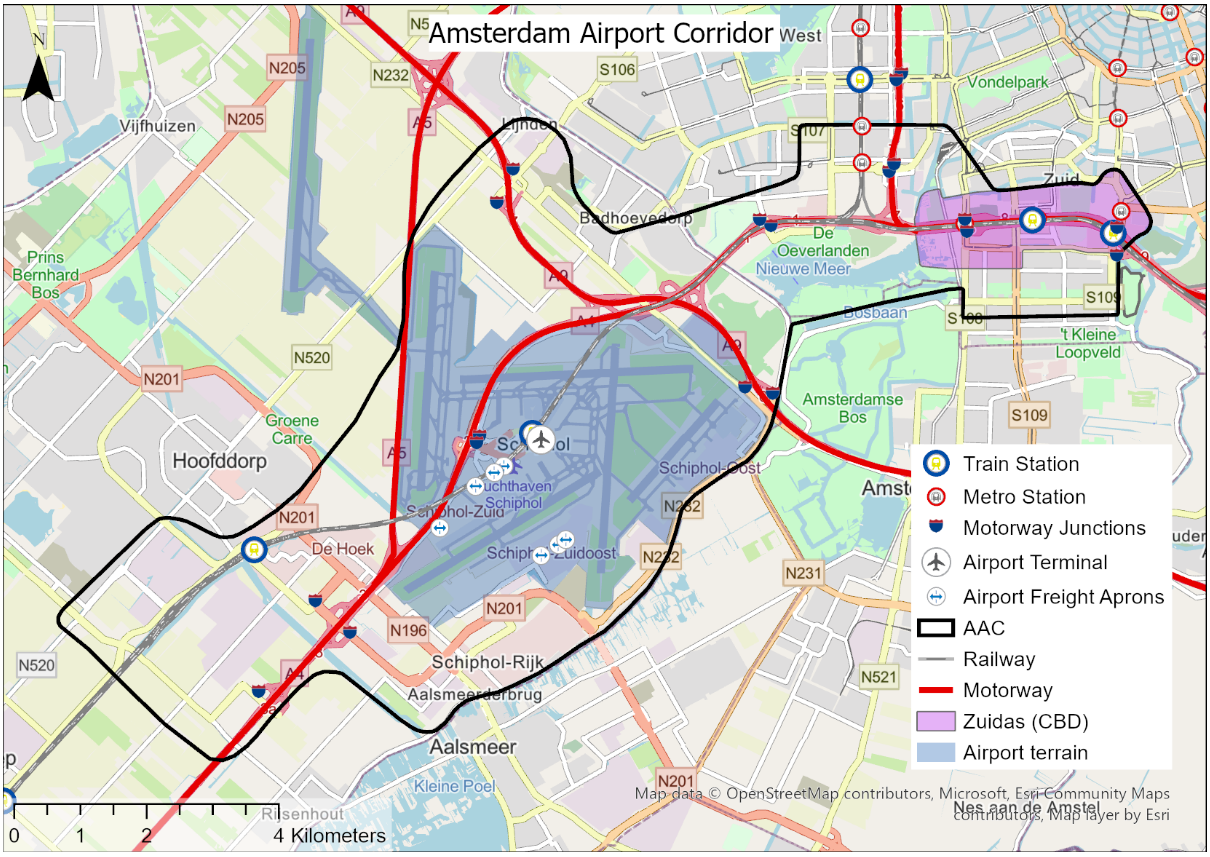
The influence of accessibility on company location choice in the Amsterdam airport corridor

An analysis of different modes of transport accessibility and their impact on four key sectors



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Abstract

This research paper aims to determine to what extent different modes of accessibility influence the location choice of companies in the Amsterdam airport corridor. Four different sectors determined to be of exceptional importance in the corridor are selected for analysis (advanced producer services, high tech, life sciences, and logistics), and four different types of accessibility are chosen (airport, train, metro, and motorway accessibility). Based upon relevant scientific literature, it is hypothesised that the location choice of knowledge centred companies (from the advanced producer services, high tech, and life sciences sectors) is positively influenced by public transport accessibility, while the location choice of companies in the logistics sector is positively influenced by motorway and airport accessibility. Company density maps are created and analysed, and a negative binomial regression analysis is executed, in attempt to answer the research question. Results show only partial confirmation for the expectation that knowledge centred companies prefer locations with high public transport accessibility, but fully confirm the expectation that logistics companies prefer locations with high airport and motorway accessibility.

1 Introduction

The opening of the 'Noord-Zuidlijn', the new metro line connecting the North of Amsterdam with the South of the city at Amsterdam Zuid station, took place on the 21st of July, 2018 (Parool, 2018) – a date repeatedly postponed since the originally intended opening in 2011. Years in the pipeline, the massive project was started by the municipality of Amsterdam in the 1990's, which was shrouded in controversy and delay from the very beginning. However, even before the official opening became fact, there was already talk of the possibilities of a future extension. Not long afterwards, seven parties consisting of regional governments (such as municipalities and the province) and transport providers (such as NS, KLM, and Schiphol Airport) came to an agreement, and substantiated their wish by collectively officially offering a sum of €1 billion to the minister for infrastructure in order to realise the extension, projected to cost €4 billion overall (ANP, 2020; Niemantsverdriet, 2020; NOS, 2020; Puylaert, 2020; AD, 2019). In the first half of 2021, it was announced that the Dutch National Growth Fund would contribute a further €1.5 billion to the project, half of what was hoped by the other contributing parties (Kok & Koops, 2021; Van Bekkum, 2021).

Earlier, the municipality of Haarlemmermeer (where Schiphol Airport is located), the Netherlands' national travellers association Rover, and Koninklijk Nederlands Vervoer (an employers' organisation in goods and passenger transport) had stated that a decision must be made quickly whether or not to extend the new metro line to Schiphol Airport, for fear of serious gridlock in the transport system in the Randstad (Eldering & Muller, 2018). The train tunnel passing under the airport is a well-known and severe bottleneck in the busy regional and national transport systems, and it is proposed that the extension of the Noord-Zuidlijn will free capacity in the tunnel by significantly decreasing regional train traffic (Puylaert, 2020). There are more reasons proposed in favour, which are mainly centred around economic benefits the extension could potentially have. Then-head of transport at the municipality of Amsterdam Sharon Dijksma said that the plan has the potential to generate up to 122.700 extra jobs, while others speak of a positive effect on the international business climate of Amsterdam (ANP, 2020; NOS, 2020).

However, there is also criticism positing that the area already has good accessibility, and the metro line extension is unnecessary. Moreover, whether extending the metro line has the desired effect remains to be seen, and is disputed by some. Researchers from the Dutch Central Planning Bureau have suggested an eventual extension of the train tunnel under Schiphol Airport is a likely future scenario regardless, potentially dismissing the congestion mitigation argument in favour of the metro line extension (Koops & Kruyswijk, 2021). Previous research also highlights that there are cheaper alternatives to light rail rapid transit, for instance those which make use of existing infrastructure (e.g. Ingvardson & Nielson, 2018).

Research of the Schiphol Area Development Company[1] indicates that accessibility in the Amsterdam airport corridor (AAC) – through the heart of which the proposed extension is routed – is an increasingly pressing issue for employers and employees alike, with the importance frequently being stressed (SADC, 2020). The respondents pronounced criticism of commuting time in recent years, which they said has increased rather than decreased. On that basis, and alongside findings suggesting that investors look increasingly toward locations with multimodal accessibility, SADC (2020) and other public sector parties (such as the Amsterdam municipality and the province) argue for an expansion of public transport which is purported to stop this trend of increasing commuting time. The mentioned parties also state the aim of contributing to a modal shift from the car to public transport, which releases pressure on the motorway network and is in line with sustainability goals.

[1] It should be noted that this is a party which is involved in the development of the AAC

Uncovering the relationship between different modes of accessibility and company location in this specific situation, is thus particularly relevant at the present moment, because it could play a role in assessing the merit and possible urgency of enhanced public transport accessibility. However, there is as yet no generalisable data to confirm or refute whether accessibility can be statistically proven to genuinely influence the location choice of firms in the AAC in a significant manner, and if so, which modes significantly influence what type of firms. The findings of SADC (2020) as mentioned above are based upon qualitative data: interviews of a sample of employers, employees, and investors in the AAC. One of the pitfalls of qualitative data is that reliably generalising sample results to draw conclusions on broader population is complicated, and not without controversy. Furthermore, this specific data represents the stated preference of respondents who all have an interest in improved public transport accessibility in the AAC. With quantitative data available comprising several descriptive variables for all firms in the corridor, research with the aim of filling this quantitative knowledge gap is not only necessary, but realistically attainable.

Moreover, in scientific literature there has recently been a more pronounced focus on the regional heterogeneity that inevitably exists at the subnational level. Recently, due attention has been paid to the subnational element within location choice in international business literature. This has resulted in for example various research papers (e.g. Zandiatashbar et al., 2019; Jiang et al., 2018; Huang & Wei, 2014) suggesting the need for further research on the relationship between knowledge-based firms and their local and regional transport infrastructure preferences.

While it has been widely illustrated that accessibility as a whole plays a vital role in firm location choice at the subnational level, there have not been many attempts to quantify the separate effects of different modes of accessibility. At the regional level, Verhetsel et al. (2015) analysed this for logistics firms in Flanders. At the metropolitan level, Jiang et al. (2018) performed an accessibility analysis of Japanese high-tech firms in Shanghai, and Ford et al. (2015) performed an accessibility study for Greater London. There are, however, as of yet no studies at the level of an airport corridor, which are distinct and unique spatial entities. For instance, in airport corridors there is a greater focus on internationally oriented businesses than elsewhere, and the geographies are unique in that they are almost always grouped around important transport axes. The present research aims to contribute to this avenue of scientific research, and to provide a modest supplement to the understanding of subnational location choice.

The conducted research detailed in this paper analyses the role of various modes of accessibility in the location choice of companies in the AAC. The AAC is well suited to such an analysis due to the aforementioned absence of location choice literature concerning an airport corridor, or an equivalent variant of spatial entity. While not directly concerning the specifics of the presented analysis, the globalised character of the area, and predominance of large companies and multinational enterprises (MNEs), ensures the relatedness to a large body of location choice literature. It adds to the growing but thus far incomplete body of scientific knowledge concerning firm location choice at the subnational level.

The present paper asks the question:

To what extent do different modes of accessibility influence company location choice in the Amsterdam airport corridor?

Four types of accessibility relevant to the AAC are included in the analysis: accessibility to the motorway network, accessibility to train stations, accessibility to metro stations, and accessibility to Schiphol Airport. Location choice will be represented by the company count per six-digit postcode area. It should be noted that the choice for regression analysis using models from the Poisson family necessitates the execution of multiple models – one for each sector – if a comparison between sectors is to be made. Therefore a selection was made of the most relevant sectors to the AAC, ultimately resulting in four sectors: advanced producer services (APS), high tech, life sciences, and logistics.

Company density maps per sector, and negative binomial regressions per sector, serve to provide information on the basis of which an answer to the research question is constructed. The density maps enable visual inspection of the company locations for each sector, and their orientation towards the relevant infrastructures. The regressions will point out if accessibility to each mode has a statistically significant effect on company location per sector, controlling for intra-sectoral clustering and highly urbanised locations.

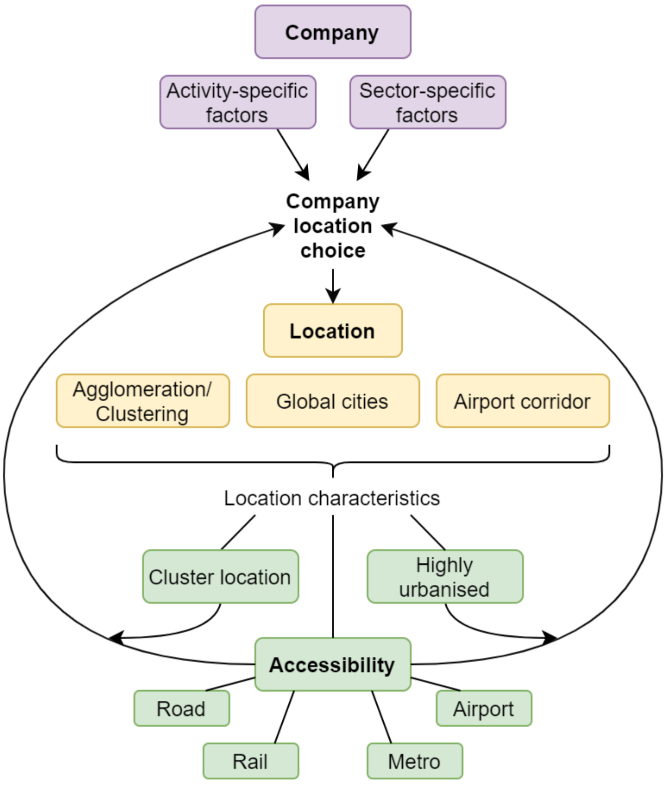
The structure of the research paper first leads to an exploration and review of relevant literature in the theoretical framework. Following this, the case of the AAC will be discussed, and then the data and methods for the research are systematically explained and motivated. Subsequently, the results of the research are presented, with the company density maps and the regression table displayed. Finally the results are evaluated, and placed in the context of current academic and societal debate, and certain recommendations are made.

2 Theoretical framework & literature review

Introduction

In this section, literature relevant to the research objective will be reviewed and a theoretical framework will be constructed. The first section will concern companies and their location choices, highlighting different scales of geographic analysis that determine the location choice of companies. At the supranational scale specifically, the influence of globalisation on location choice at the subnational level will be highlighted. At the subnational scale specifically, clusters and agglomeration economies, global cities, and airport corridors will be highlighted as spatial manifestations resulting from location preferences. Building upon the first section, the second section will discuss relevant literature about accessibility in particular, its close relationship with infrastructure, and its influence on the location choices of various different types of firms.

Figure 1 Conceptual model



In figure 1 a conceptual model visualises the key concepts that will be presented in the coming review of literature, and it illustrates how they connect to one another, and their relationship with the dependent variables (these will be discussed in the next section). Most importantly, it shows schematically how accessibility influences company location choice. It should be viewed as a general schematic overview to aid the interpretation of the interrelatedness of concepts, rather than an extensive model of all necessary theoretical concepts

2.1 Companies & location choice

Globalisation has radically altered economic dynamics and the role of geography and distance therein, but the world has not simply been flattened as Friedman (2005) suggested. With vast, historically inherited wealth disparities, dependency relationships between countries and continents at contrasting stages of development, and urbanisation advantages reinforcing wealth concentration in just a few metropolitan regions, if anything, the world has become *less* flat (Nijkamp, 2017; Krugman, 2011; Ghemawat, 2009; Stiglitz, 2007). Thus, the concept of location is more relevant than ever. This section will elaborate on the concept of location and the advantages certain locations have over others. It will explain the different scales at which location can be interpreted, the significance of location to companies, and the locational characteristics they typically value.

Acknowledging multiple scales of geographic analysis

While recognising that they share a common interest in economic activity which transcends national borders, there has recently been consensus between prominent economists and international business (IB) scholars (e.g. Arregle et al., 2016; Krugman, 2011) on the one hand, and prominent economic geography (EG) scholars (e.g. Beugelsdijk & Mudambi, 2013; Boschma & Frenken, 2011) on the other hand, that their respective fields have steadily diverged, developing different perspectives on the subject. IB-scholars have developed a sophisticated understanding of the economic organisation of companies worldwide, but lack the sophisticated spatial knowledge which sets apart their EG counterparts (Beugelsdijk & Mudambi, 2013). IB-scholars long concerned themselves with the country as the sole unit of geographic analysis; when analysing international economic activity, the country was by far the dominant scale at which material was approached.

In the light of globalisation however, radical changes in institutional and technological environments have reiterated the importance of assessing the concept of location at multiple geographic scales (Mudambi et al., 2018; Goerzen et al., 2013; Iammarino & McCann, 2013; Stiglitz, 2007). Where the national scale has in many cases become less relevant, globalisation has – perhaps somewhat paradoxically – rendered not only the macro but also the micro scale more relevant than ever. A heavily country-oriented approach neglects the micro scale, which is problematic because large intra-country differences often result in disparate subnational regions (Iammarino & McCann, 2013). It also fails to grasp that in a modern, globalised world, location at the supranational level can be very important in certain contexts where for example trade agreements and common markets are concerned, which also has ramifications on location at the subnational level.

Recently, two new streams of IB-scholars have emerged to focus on these different scales of analysis (Mudambi et al., 2018). One of these has focused on the importance of the subnational level, with a particular focus on global cities and geographic clusters (Da Cruz, 2020; Goerzen et al., 2013; Ma et al., 2013; Chan et al., 2010), and the other has demonstrated the importance of the supranational level in relation to international unions, organisations and treaties (Arregle et al., 2016; Qian et al., 2013; Rugman & Verbeke, 2007).

Mudambi et al. (2018) argue that it is prudent to integrate these different scales of geographic analysis to have a complete picture of the global economy and location choice. In this sense, the supranational, national, and subnational levels are complementary parts of a more holistic and integral approach, in which the differing considerations are often important to explain the location of companies. Their intertwined nature means that considerations from a global perspective can find their way into location choice considerations at the local level. The coming subsections will delve into the specifics of location choice at the subnational level, considering several relevant types of subnational geographies, and illustrating how inspection of the supranational (or global) scale is also necessary to determine different types of locational advantages at the subnational scale.

Global influences on company location choice

A combination of technological advancements, information technology (IT) innovations, and trade liberalisations has enabled the establishment of global production networks, and led to the global integration of knowledge and the push for the dispersion of activities. A new age of companies has dawned, in which MNEs account for an increasingly large portion of the world's economy (De Backer et al., 2019; OECD, 2018). Whilst local industries and suppliers can benefit from new knowledge and experience, firms can learn and absorb local knowledge, exploit new markets, and take advantage of efficiencies and cost savings enabled by locales (Ascani et al., 2020).

The influence of globalisation increasingly impacts company location choice because success in global sales and markets is often dependent upon large geographic scale (Mudambi et al., 2018). Indeed, most relevant data from large firms are presented at the regional level; most of the Fortune 500 companies have been found to do this (Mudambi et al., 2018; Rugman & Verbeke, 2004). Firms looking at a global scale prefer the selection of large markets, which are nowadays not only found at the national level, with common markets very much a part of global commerce.

These developments have led to a mass geographic separation of upstream and downstream activities, which fits into the new international division of labour concept. Upstream activities are now heavily concentrated in a minority of very influential, globally integrated areas in developed countries whereas downstream activities are typically located in less developed countries where production factors are cheap (Mudambi et al., 2018; Verbeke & Asmussen, 2016). This has had a hugely visible impact on the location choice of companies not just at the global scale but also the subnational scale, because these changes in the geographic dispersion of companies have led to fundamental changes in the nature and spatial manifestation of industrial agglomerations and clusters, and the establishment of new types of specialised geographic concentrations such as global cities and airport corridors.

Location choice at the subnational level

Mudambi et al. (2018, p.934) posit that *"MNEs zoom out to look for markets, and they zoom in to look for knowledge."* In doing so they capture both the importance of the subnational scale for upstream activities, and the relevance of global cities and airport corridors to downstream activities. Zooming out for markets implies the necessity of local nodes connected to a global network, thereby enabling the coordination of geographically dispersed activities. This legitimises the existence of global cities and airport corridors, and confirms that the supranational considerations have influence on subnational geographies. Zooming in for knowledge is necessary because of the characteristics of specialist, non-codifiable knowledge. This type of knowledge is sticky; it tends to be produced in a limited few places, and once the production cycle has commenced it is not easily removed (Balland & Rigby, 2017). It is attractive for companies because high-value, non-ubiquitous, complex, and tacit knowledge yields a competitive advantage if properly harnessed (Balland & Rigby, 2017; Asheim & Gertler, 2005).

As Iammarino & McCann (2006) and Glaeser (1998) argue, the costs involved in enabling adequate and frequent face-to-face contact in order to facilitate the transfer of such high quality knowledge and information, are the crucial driving forces behind the generation of cities and industrial clusters. This subsection will examine the three identified main subnational geographic entities relevant to this research. Agglomeration economies and industrial clusters will be discussed first, followed by global cities, and ultimately airport corridors.

Agglomeration economies and industry clusters

Agglomeration can be regarded broadly as the network of externalities produced by the concentration of companies and business operations. The school of thought concerning the agglomeration of businesses from the same industry stems from the seminal work of Marshall (1925). He contended that knowledge is generally industry-specific, and that companies benefit from co-location with their industry peers through agglomeration economies. This geographical clustering results in so-called Marshallian externalities: local specialised industry-specific labour markets; a local supply of specialised suppliers and customers; and, local knowledge spillovers. These externalities serve to make the agglomeration a self-reinforcing process, and benefit all the firms belonging to that industry cluster. The resulting inception and development of strong intra-industry connections in the clusters then serve to further complement and intensify the Marshallian externalities (Nielsen et al., 2017; Porter, 1998).

Porter (1990) produced a very influential work which, although initially focussed on nations, is certainly applicable to spatial agglomeration and clusters. According to Nielsen et al. (2017), Porter's diamond describes a broader set of location factors from which companies could profit, including: scale economics in demand for specific input markets; the sharing of market and technology information; the presence of demanding customers and intense competition necessitating productivity and innovation; and, the accessibility of higher quality infrastructure and other public goods, and localised externalities. This generally coincides with Malmberg's (1996) description of processes in agglomeration economies whereby links between firms, institutions and infrastructures lead to economies of scale and scope.

As posited in this subsection's introduction, specialist knowledge is sticky and therefore confined to locales, with a logical consequence of this being the spatial agglomeration of industries. Following on this premise, Mudambi et al. (2018) note that the *"focus of innovation systems is on narrow, very local geographic areas, the hotspots or so-called 'spikes' on the global knowledge map."* Reality illustrates the validity of this observation in the existence of the Silicon Valley high-tech IT cluster, the finance and banking cluster in the City of London, Boston's biotech cluster, (former) automobile clusters in Detroit and Southern Germany, the high-tech IT cluster in Eindhoven, and the aerospace cluster in Toulouse, to name but a few prominent examples. It should be noted that evidence suggests that knowledge centred companies such as those in the high tech and life sciences sectors benefit largely from the spillover effects resulting from industrial clustering, and that they tend to cluster proximate to universities because of knowledge spillovers (Burger et al., 2015; Kolympiris & Kalaitzandonakes, 2013).

There are however also reasons for certain companies to avoid locating in industrial clusters. Highly specialised and technically advanced firms with unique knowledge and capabilities are a possible example of the type of firm which could potentially be harmed more by such a location than they stand to gain. They are at risk of losing exclusive knowledge or capabilities to competitors through negative knowledge spillovers, and therefore also have a clear incentive not to locate in industrial clusters (Chung & Alcácer, 2005). This is in contrast to less technically advanced firms, who are much more inclined to locate in an industrial cluster, precisely because they stand to gain substantially from spillovers.

Global cities

The fact that specialist tacit knowledge is globally dispersed, coupled with the observation that it increasingly becomes integrated in global value chains, illustrates the importance of global cities (Mudambi et al., 2018). It follows that knowledge is location-specific, but the added value only comes to full fruition when integrated in a global network, meaning that global linkages are of critical importance and thus reserving an essential role for global cities in bridging the gap between location and organisation.

It has been well documented that global cities disproportionally attract MNEs (e.g. Chakravarty et al., 2021; Belderbos et al., 2020; Nielsen et al., 2017; Goerzen et al., 2013), with many referring to global cities as the command and control centres of the world's economy. They can be characterised by three key attributes, from which a plethora of advantages emerge: (1) the availability of a large and diverse pool of advanced producer services (APS) firms; (2) a cosmopolitan environment and the image of a high-status location; and (3) a high degree of connectedness to both local and global markets (Chakravarty et al., 2021; Goerzen et al., 2013).

Global cities are attractive to companies for numerous reasons (Chakravarty et al., 2021; Belderbos et al., 2020; Goerzen et al., 2013). They represent lucrative markets and business environments, characterised by low transaction costs, high business density, and large amounts of affluent consumers, expatriates, and tourists. Global cities also possess a higher quality labour force than elsewhere, because they have better job and education opportunities and are attractive places to live with a high quality of life. Moreover, many global city traits serve to reduce transaction costs. Furthermore, MNEs particularly are attracted to global cities because: the large pool of APS firms makes it easier for MNEs to start doing business there, and enables them to form relationships with local firms; they have stronger, more stable, and more business friendly institutions; and, they have a high degree of interconnectedness with local and global markets, with multiple infrastructures also reducing travel time and improving coordination possibilities in a geographically dispersed enterprise (Chakravarty et al., 2021; Belderbos et al., 2020). It reduces contextual (cultural, economic, and institutional) distance, which is the key source of costs for firms in a foreign country, and thus the choice for a global city minimises costs by minimising distance.

There are however also potential drawbacks to locating in a global city, and thus companies must carefully decide whether to locate in one because it is possible that the risks outweigh the advantages (Chakravarty et al., 2021). Global cities often have higher operating costs, a higher concentration of competitors, negative knowledge spillovers and a scarcity of certain production factors. Also, companies engaging in production activities or logistical operations could be less inclined to locate in a global city because of land prices and the protection of product knowledge. This is illustrated in the findings of Goerzen et al. (2013), where sales, distribution and information collection activities had a positive effect on global city location, whereas activities pertaining to global production networks, and product development and planning, had a negative effect. Belderbos et al. (2020) found that firms engaging in knowledge-intensive activities, as well as firms in non-knowledge-intensive services, sales and retail, all had significantly positive effects on the probability of firms locating in a global city as opposed to another place in the same country, with only logistics investments negatively associated with locating in a global city. Moreover, Castellani & Lavoratori (2019) found that R&D-related FDI was more likely to locate in global cities.

Airport corridors

Due to many developments in the world of aviation it has become necessary for airports to focus on nonaeronautical revenue to survive and thrive. The trend of liberalisation and privatisation of the aviation industry led to the advent of low-cost carriers, hub-and-spoke networks, and international alliances, opening up competition between airports while simultaneously the government support they previously relied on was limited (Peneda et al., 2011). Airports had to diversify, and gradually entered into the landside real estate business. Airports today have become centres of economic activity with several types of entertainment and commercial activities, such as shopping centres, hotels and restaurants, office centres and conference space (Chen & Kasarda, 2020; Peneda et al., 2011; Kasarda, 2006).

This process has led to the inception of concepts such as the airport city, airport region, airport corridor, and aerotropolis to describe the spatial manifestations of this diversification (Bouquet, 2018; Lindsay, 2011; Peneda et al., 2011; Van Wijk, 2008; Brueckner, 2003). The aerotropolis concept developed by Kasarda (1991; 2006) is all-encompassing and consists of all airport-related types of spatial development, describing a core of the airport city, embedded in an airport region housing an extensive mix of warehouses, e-fulfilment centres, logistics and distribution centres, industrial parks, office and business parks, free-trade zones, and hotel and entertainment districts. The airport corridor, first proposed by Schaafsma (2003), refers to the existence or development of such a region along a (public) transport infrastructure axis connecting airports (or airport cities) to the city proper. Real estate develops in a linear fashion along the axis, and is often planned (Peneda et al., 2011).

Airport corridors are often attractive because of their grouping around an easily accessible transport axis. Several researchers have demonstrated that a link exists between air passenger volume and demand, and employment in APS and the high tech sector, suggesting that these types of employment with increased reliance on face-to-face contact profit from close proximity to large hub airports – a proximity which is strengthened in an airport corridor (Bouquet, 2018; Alkaabi & Debbage, 2007; Brueckner, 2003; Debbage & Delk, 2001). An airport corridor location has advantages based on the possibility of reduced transport costs, and potential agglomeration advantages. Locations proximate to a global hub airport also serve to reduce distance as described by for example Belderbos et al. (2020). Moreover, within an airport corridor, companies active in transport and logistics, and aviation-related transport have a self-evident need to locate as close as possible to airports.

2.2 Accessibility and infrastructure

For a favourable location to be fully attractive, accessibility of that location is necessary – if not initially as a direct requirement – from a practical and operational perspective. Depending upon the product that is traded, a company will need the ability to broker access of goods, people (either employees or customers), or both, in varying degrees to their location if they are to engage in their business activities. This section will distil the theory concerning accessibility from a company location choice perspective, and the role of infrastructure in achieving this will be illustrated.

The fundamentals of accessibility

Although what is considered as accessibility can encompass varying degrees of specificity, in the context of land use and location choice the first basic definition to serve as a benchmark was coined by Hansen (1959) as *"the potential of opportunities for interaction."* The concept of accessibility is used to describe notions of opportunities available to people and firms enabling them to partake in activities they want to accomplish (Gutiérrez, 2001). In its most basic form it involves a combination of two elements: locations on a surface relative to suitable destinations, and the characteristics of the transport networks linking the points on said surface (Gutiérrez, 2001; Vickerman, 1974). In other words, accessibility is the ease with which activities van be reached from a certain place using certain modes of transport. According to Järv et al. (2018) the concept of accessibility fuses the key components of urban structure – people, mobility, and social activities – making a functional view of urban structures and processes possible.

Accessibility and infrastructure

Accessibility and infrastructure are two concepts which are intertwined with each other, as infrastructure is the physical manifestation which provides accessibility to places. The primary role of transport infrastructure is *"to provide people and businesses with access to other people and businesses so that they can physically engage in spatially and temporally distributed activities of all kinds,"* (Miller, 2018). It therefore logically follows that if accessibility is an important aspect in the location choice of companies, then the same is true for infrastructure. Accessibility enhancement at the local level is fundamental to improvements in the quality of services, reductions in transport and labour costs, and increases in productivity (Rodríguez-Pose et al., 2018; Vickerman, 2007). Adequate transport infrastructure to this end can solidify and boost economic growth, as has often been demonstrated (Rodríguez-Pose et al., 2018; Meersman & Nazemzadeh, 2017).

Generally, large infrastructure projects representing a substantial improvement of accessibility through public transport systems have a positive influence on urban development. This is illustrated for example by a rise in real estate prices, signalling that these areas are valued more and thus more attractive (Ingvardson & Nielsen, 2018; Munoz-Raskin, 2010; Martínez & Viegas, 2009; Brandt & Männig, 2008; Knaap et al., 2001). Research has also repeatedly shown that a link exists between transport infrastructure investment and improved economic performance, and a substantial body of evidence highlights the importance of transport infrastructure in city region competitiveness (e.g. Knowles & Ferbrache, 2016; Hensher et al., 2012; Ibeas et al., 2012; Knowles, 2012; Banister & Thurstain-Goodwin, 2011; Banister & Berechman, 2001). Most cities with successful post-industrial economies have been able to deliver significant investments in rail, and light rail infrastructure aimed at tackling road and rail bottlenecks, while simultaneously providing other benefits such as the enhancement or regeneration of CBD's, increase of employment, and improvement of the quality of the city environment (Knowles & Ferbrache, 2016; Banister & Thurstain-Goodwin, 2011; Cervero & Duncan, 2002). This ties in with the importance of efficiencies and a lack of accessibility constraints in ensuring the successful functioning of cities, and the achievement of economic growth. This is particularly the case for cities in developed countries where well-developed transport networks already exist, and the enhancement of accessibility and ultimately economic growth is far more likely to be attained through reductions in constraints such as congestion than by investing in completely new connections (Knowles & Ferbrache, 2016). In the United Kingdom for example, a government report determined that 89 percent of congestion was in urban areas, prompting the recommendation that the priority of transport infrastructure investment should lie with strategic projects focusing on existing urban areas experiencing congestion, key inter-urban corridors, and major international gateways (Eddington, 2006).

However, it is also evident that this is not always the case. When the threshold of necessary infrastructure is reached, it is uncertain what the precise impacts on economic growth will be (Rodríguez-Pose et al., 2018). It is clear that where adequate institutions are lacking, investments in infrastructure and thus the enhancement of accessibility are not synonymous with economic growth. One example is certain infrastructure investments in southern countries of the EU – where regional growth has historically been regarded as closely connected to, if not intertwined with, infrastructural development – which have resulted in costly undertakings that, while being a source of pride for decision makers and sometimes also the general population, ultimately proved unnecessary, as low usage and ridership figures show. Spain for example has multiple scarcely used airports, with some even being completely unused (Palet, 2014). The country also has the longest motorway network in the EU (and the third-largest in the world) by length, and the longest high-speed rail network in the EU, while both are significantly underused and can thus be characterised as white elephants (Albalate & Bel, 2012; Robinson & Torvik, 2005). Also, Portuguese decision makers were led by political desire to build the longest bridge in Europe, but it failed to alleviate congestion on another bridge as was intended because the bridge crossed from Lisbon to a less populated area instead of the area where congestion was worst (Bukowski, 2004; De Melo, 2000). As Rodríguez-Pose et al. (2018) put it, *"a choice for political and international visibility resulted in the construction of a bridge connecting Lisbon to a relatively lightly populated area, neglecting alternatives running parallel to the existing 25 de Abril bridge or between the city and the busy suburb of Barreiro in the south."* It is thus clear that ill-conceived, poorly-managed infrastructure projects borne from a questionable institutional environment can backfire severely, highlighting the importance of due diligence and an appropriate measure of scrutiny during the consideration and selection of future infrastructure projects.

Company accessibility preferences

From what has so far been considered in previous sections, it is clear that industry clusters, global cities, airport corridors, and companies in situ, require a location with good accessibility. Industry clusters must be well connected to the outside world in order to distribute their localised, specialist knowledge (Mudambi et al., 2018; Nielsen et al., 2017); global cities must preserve their strong linkages to maintain their function as intermediary between the local and the global (Chakravarty et al., 2021; Goerzen et al., 2013); airport corridors must sustain that which links their core business to their non- and extra-aeronautical satellite activities, dependent corridor-inhabiting businesses, and the city proper (Boquet, 2018; Peneda et al., 2011; Alkaabi & Debbage, 2007); and, companies individually must find a balance between minimising costs while maximising profit from location advantages (Goerzen et al., 2013; Dunning & Lundan, 2008).

Accessibility has been widely demonstrated to be a significant factor in determining company location choice, in several studies in different places with different foci and emphases. In more general research without distinction between companies from different sectors, it has been found that road and rail access have significant importance in the location choice of companies (Ahlfeldt, 2007; De Bok & Sanders, 2005). Overall, businesses depend mostly on automobiles worldwide, except for businesses located in CBDs where the majority of dependence is upon rail accessibility for employee commutes (Kawamura, 2004).

It has further emerged that the characteristics of the influence of accessibility on location choice are industry-specific, with different sectors having different accessibility requirements (Iseki & Eom, 2019; Verhetsel et al., 2015; Huang & Wei, 2014; Ala*ñ*ón-Pardo & Arauzo-Carod, 2013). Research conducted with a focus on companies from a specific sector have yielded results which provide evidence to this observation, with patterns visible confirming the existence of traits inherent to certain sectors. Research studying logistics company location (e.g. Holl & Mariotti, 2018; Verhetsel et al., 2015; Van Den Heuvel et al., 2013; Allen & Browne, 2010; Bowen, 2008), research studying APS-firms (e.g. Iseki & Eom, 2019; Song et al., 2010; Willigers et al., 2007), and research studying high tech and ICT-companies (e.g. Zandiatashbar et al., 2019; Jiang et al., 2018; Zandiatashbar & Hamidi, 2018; Atzema, 2001), all show different requirements for different types of firms.

Knowledge centred companies

While there are several conceivable divisions of different types of companies, for the purposes of this research the distinction of knowledge centred companies is deemed relevant as a type of umbrella term. Companies where the primary value-adding activity is knowledge related (which in this case is applicable to APS companies, high tech companies, and life sciences companies) can be observed in scientific literature to have similar accessibility preferences, despite specific dissimilarities at the sectoral level. Public transport accessibility is observed as an important accessibility preference for all such companies.

APS-firms appear to value public transport accessibility the most (Iseki & Eom, 2019; Song et al., 2010; Willigers et al., 2007). Iseki & Eom (2019) illustrate that finance, insurance, and real estate firms highly value locations in close proximity to metro stations, tending to cluster around them. Song et al. (2010) also demonstrated the positive influence of metro accessibility to various different types of APS-firms. Furthermore, Willigers et al. (2007) found that rail accessibility improvements have a positive effect on the location choice of offices.

High tech and ICT-firms are found to value locations with good public transport access (Zandiatashbar et al., 2019; Jiang et al., 2018; Zandiatashbar & Hamidi, 2018; Atzema, 2001). According to Zandiatashbar & Hamidi (2018) a high quality public transport system increases the attractivity of a location to high tech firms substantially, highlighting its stimulating effect on local innovation productivity, and suggesting that transport infrastructures can and should be used as enablers for knowledge-intensive and creative firms. Jiang et al. (2018) showed that the location choices of Japanese high-tech firms in Shanghai were significantly positively influenced by proximity to the airport, proximity to railway stations and proximity to metro stations. According to Zandiatashbar et al. (2019) the subgroup of IT-services firms in the U.S. place a high value on airport accessibility, whereas Burger et al. (2015) note that the location choice of life sciences companies is positively influenced by air accessibility.

Logistics companies

Transport and logistics firms for example are found to be highly urbanised and to value locations with good access to transport infrastructure, with extensive evidence showing that these types of firm place high value on locations with good motorway access (Holl & Mariotti, 2018; Verhetsel et al., 2015; Bowen, 2008). Holl & Mariotti (2018) find that logistics firms are more likely to locate near motorways than firms in manufacturing and business services. On the other hand, results on the influence of rail accessibility have been mixed. Verhetsel et al. (2015) found that accessibility to a major port is the most important accessibility preference for logistics companies in Flanders, eclipsing the also significant effect of road accessibility.

These accessibility preferences are attributable to the relationship between the core business of transport and logistics companies, and the necessary infrastructure to be able to adequately conduct their business: the most common way for such companies to transport goods is by road, air, and sea. This results in road and (air)port accessibility being highly valued by such companies.

2.3 Hypotheses

Based upon the available literature discussed in this section of the research paper, certain expectations have emerged pertaining to the results of this research in the AAC. This has led to the formulation of two hypotheses, which will be answered in the results section. Placed in the context of the AAC, it is reasonable to hypothesise that:

H1a: Knowledge centred company location choice is positively influenced by public transport accessibility

This is hypothesised because of the evidence demonstrated suggesting the proclivity of knowledge centred companies to locate in places with good rail and metro/light rail accessibility (e.g. Iseki & Eom, 2019; Zandiatashbar et al., 2019; Jiang et al., 2018; Song et al., 2010).

H1b: The magnitude of the positive influence of public transport accessibility on knowledge centred company location choice is higher for APS companies than for high tech and life sciences companies

This is because while it is clear that the majority of literature confirms that companies with highly specialised knowledge prefer locations with good public transport accessibility (e.g. Zandiatashbar et al., 2019; Jiang et al., 2018; Zandiatashbar & Hamidi, 2018; Huang & Wei, 2014; Atzema, 2001), it is clear that they also have incentives not to locate too close to a large number of direct competitors, in order to protect knowledge and other assets (e.g. Belderbos et al., 2020; Goerzen et al., 2013; Chung & Alcácer, 2005). Therefore it is expected that their location choices are more spread out. This contrasts with APS-companies, where such an incentive is absent because their knowledge is generally more ubiquitous, and the servicing character of the businesses entail that accessibility yields relatively more advantages.

H2: Logistics company location choice is positively influenced by airport and motorway accessibility

This is because of the evident preference of logistics companies to locate near a motorway (e.g. Holl & Mariotti, 2018; Verhetsel et al.,2015; Bowen, 2008), and also because logistics companies, in a region where there are major (air)ports, have been demonstrated to prefer locations with good accessibility to the respective (air)port (e.g. Verhetsel et al., 2015).

3 Case, data & methods

The AAC connects the city of Amsterdam and its CBD to the international hub that is Schiphol Airport. These geographic entities will briefly be described and explained in this section, before being linked to the theory presented previously. Subsequently, the data forming the basis for the research will be discussed, and its relevance and suitability assessed. Finally the choices concerning methods will be explained.

3.1 Case

Amsterdam is widely recognised as a global city, and it is thus embedded not only in its national and regional context but also in the corresponding global network (Diez-Pisonero et al., 2020; GaWC, 2020; Kearney, 2020). As a member state of the EU it is part of a stable bloc of wealthy countries, and has access to the European Common Market. As part of the Schengen Area it also profits from the free flow of people across the borders of participating member states. Schiphol Airport further connects Amsterdam to the rest of the world; according to the most recent reliable figures, it is the eleventh-busiest airport in the world by total passenger traffic, and the third-busiest in Europe (ACI, 2019). In terms of international passenger traffic, it is the third-busiest airport in the world. It is also a major airport for international air freight, being the fourteenth-busiest in the world in 2019. It is thus reasonable to assume that MNEs are very important in the AAC, considering the internationally oriented and globally connected location, the corresponding high price of land and real estate, the relative importance of MNEs in the overall Dutch economy, and the proclivity of large companies to settle on the Zuidas. The fact that The Netherlands sits sandwiched between markets (Germany, France, and the United Kingdom) far larger than itself further reinforces this assumption, as it would be difficult for the Dutch market to sustain large companies and MNEs on its own. Many non-European MNEs looking to expand to Europe may not otherwise consider locating in The Netherlands with larger national markets situated so close by. This global orientation stems at least in part from embedded historical reasons: Amsterdam has maintained a substantial, very internationally oriented stock exchange, with a heritage dating back to the 1700's when it was founded as the world's first, during the height of the VOC (Dutch East India Company).

This international focus of both The Netherlands and Amsterdam is reflected in various statistics. Table 1 below shows some statistics concerning foreign controlled companies in the Netherlands. Despite comprising just 1.2% of total companies in The Netherlands, foreign-owned companies account for almost 40% of total national turnover, just shy of one-third of total value added, more than 20 percent of employees, and approximately one-third of R&D expenditure. These statistics indicate the great importance of MNE's to the Dutch economy, especially considering that these figures only contain information on foreign-controlled firms and therefore do not account for Dutch MNEs, of which there are many.

Table 1 Economic indicators of foreign controlled companies in The Netherlands in 2018

Location of company control	**Turnover**		**Total value added**		**Employee totals**		**Total R&D-expenditure**	
	x €1.000.000	*% of total*	*x €1.000.000*	*% of total*	*x 1.000*	*% of total*	*x €1.000.000*	*% of total*
Total	1,644,839	100%	389,227	100%	5,195	100%	5,197	100%
Foreign	635,593	38.6%	116,977	30.1%	1,054	20.3%	1,709	32.9%
Domestic	1,009,246	61.4%	272,251	69.9%	4,141	79.7%	3,487	67.1%

Source: CBS (2020)

In modern times, it has become the primary benefactor of Brexit effects on the European stock markets, already displacing London as Europe's primary centre for trading in February 2021, just weeks after Brexit (Beunderman & Van Der Heijden, 2021; Stafford, 2021). Amsterdam has been able to capitalise largely because of its financial ecosystem. This consists of stable government, sophisticated and knowledgeable regulators, international orientation, the large presence of experienced and high quality APS-firms in the Zuidas (CBD), high quality transport and IT-infrastructure, a high degree of English language proficiency, and a favourable tax system (Beunderman & Van Der Heijden, 2021; Stafford et al., 2021).

The CBD of Amsterdam (Zuidas) has a large concentration of APS-firms (visible in table 2), due to the presence of many consulting, research, finance, information, and communication companies (Amsterdam Municipality, 2018). It further has a disproportionate share of large companies (50 or more employees). Whereas The Netherlands as a whole had a tiny share of large companies – just 0.2 percent in 2017 according to CBS (2021[1]) – the Zuidas had a 7 percent share of large companies (>250 employees) in that same year: a share 35 times the size of the Dutch average (Amsterdam Municipality, 2018). This indicates the high importance of large companies there, which is significant, and may explain why land and real estate is so expensive there.

Furthermore, Amsterdam has developed and prospered as a specialised, upstream location in the global production network. It is one of the few locations worldwide where certain specific highly specialised knowledge is concentrated. This is apparent in the recent rise of the high tech and life sciences sectors in Amsterdam for example. Moreover, the talent pool from which specialised companies can pick is diverse and exceptional, as various world university rankings indicate (QS, 2021; Times Higher Education, 2021).

Additionally, because of the size and connectedness of the airport, downstream activities are also very important, providing hinterland-servicing infrastructures as is evident from the extensive logistics sector in the immediate surrounding area of Schiphol Airport. Because of the global focus of downstream activities, the accommodating institutional framework within the EU, and the development of Schiphol Airport into one of the most important global and regional hub airports in the world, the Amsterdam area has been able to capitalise by becoming one of the major nodes brokering access to the EU common market in the global economic network. This has brought many logistics and transport firms to the area, as well as new avenues for APS-firms of which there is a massive concentration in the CBD.

3.2 Data

This research had the aim of determining the role of accessibility in company location choice in the AAC. As such, there were multiple ways possible to approach the research, because it is a question that can be researched from both a quantitative and a qualitative perspective. However, the choice was made to conduct quantitative research.

Quantitative research was selected because there was an extensive quantitative dataset available containing all companies in the AAC, as will be detailed in the following subsection. Conducting an objective analysis using all companies enables the drawing of general conclusions, which was preferable in this instance; it allows for the inclusion of all companies instead of a select group. When gathering and analysing qualitative data, there is always a risk associated with drawing conclusions; a sample is a minority, and on that basis it is difficult to draw conclusions for a whole population. With quantitative data this risk is removed, and the data is less influenced by circumstantial factors and therefore more objective.

Dataset

The dataset that was used in this research is a dataset compiled by the Schiphol Area Development Company, who have compiled a complete database of all companies in the AAC. The company data was obtained from the municipalities of Amsterdam and Haarlemmermeer, which are the two municipalities in which the corridor is situated.

For all companies, the dataset contains information on the following: company address; number of employees; company classification (based on the Dutch Standard Industry Classification, better known as SBI, which itself is based on EU and United Nations classification systems); further detailed categorisation in sectors; business district location; building information; and, various economic indicators such as turnover, production value, and total value added. The data obtained from the Haarlemmermeer Municipality is substantially richer, partly because the Haarlemmermeer municipality employs a dedicated data specialist, and partly due to privacy considerations on the part of the Amsterdam municipality leading them to withhold certain information. The Haarlemmermeer data also contains the following information: company name; detailed employment information such as full and part time employment distribution, employment distribution by gender, and employment status (direct employment or via an agency); and, Chamber of Commerce registration and branch numbers.

To prepare the dataset for the present research, various decisions and alterations were made. It was decided to disregard the extra variables because of the fact that data cannot be used if analysis is to be done for the whole corridor. The decision was also made to scale back the sectoral categorisation of companies to improve the clarity and validity of the GIS analysis and the statistical model. Table 2 shows the categorisation, with those in bold to be used in the current research. In appendix a, an overview is presented of what category contains which SBI-categories.

*Table 2 Sectors (**bold**: sectors of analysis)*

Sector	Count
Construction, Industry & Utilities	95
Retail & Wholesale	201
Logistics	**178**
Aerospace	22
Hospitality & Tourism	179
Arts, Culture & Media	45
High tech	**216**
Life Sciences	**33**
Public Services	119
Advanced Producer Services (APS)	**582**
General Services	139

Due to the type of regression (negative binomial with company count data as the dependent variable), models must be created separately for each sector. Thus the choice was made to scale back the number of sectors to be included in the analysis to those that are of exceptional importance or significance to the area, not least because it is not feasible to run eleven models. The choice was made to include all knowledge centred sectors as determined in the theoretical framework (APS, high tech, and life sciences), and also the logistics sector because of its massive influence on and presence in the airport corridor. Logistics is an important sector for obvious reasons relating to the airport corridor, but also because the Netherlands is consistently ranked as one of the top five countries in the world in logistics performance – the 2012-2018 World Bank Aggregated Logistics Performance Index (which aggregates the scores from several years in a six-year timespan) ranks it as the number 2 in the world (World Bank, 2018). As previously mentioned, the CBD contains a very substantial concentration of APS companies (of which financial services and business services are the most prominent), and is the life blood of the CBD according to figures from the official Zuidas information centre (Zuidas, 2021). High tech is a fast growing sector in the Amsterdam area, with international recognition, and already a sector with a major presence in both the CBD and the AAC as a whole (Pratty, 2020; Laskin, 2019). Lastly, concerning the Life Sciences sector, it is a specialised sector in which Amsterdam is recognised as one of Europe's leading regions (Le Deu & Da Silva, 2019; Terry, 2019; Philippidis, 2018; Kelly et al., 2015).

Finally, it was decided to remove all companies with less than five employees from the dataset. Removing entrepreneurs and very small businesses in this way ensures the validity of the research. Entrepreneurs and very small businesses make up a large majority of total businesses (CBS, 2021[2]), however the foundations for their location choices are very different – they are much more geographically bound to familiar locations, with location choice being far more dependent on personal roots, personal network and contextual familiarity (Verhetsel et al., 2014; Dahl & Sorenson, 2012). As Verhetsel et al. (2012) state, "*the location decision of large companies […] differs from the decision process of small companies. The latter are often located in geographical proximity to the residence of the companies' owners, so that the location of small companies is historically determined.*" Therefore their location choice is based much more upon subjective factors, and goes beyond the scope and goals of this research. Their inclusion would have risked skewing the data and having a detrimental effect on the model. Also, as a result of very liberal Dutch fiscal regulations, the Zuidas is a major worldwide hotspot for shell companies evading taxes elsewhere (Driessen, 2020; Beerentsen, 2019), and these companies would also have skewed the data if included because their location choice is based almost solely on fiscal considerations.

Variable selection

The review of relevant literature has shown that there are multiple factors which influence company location choice. The focus of this research was to assess the relative impact of the independent variables – the four modes of accessibility – on the dependent variable, location choice. Furthermore, aside from the independent variables, other factors that may influence company location choice were taken into account as control variables. Based on the literature review it was determined that in the context of the AAC, proximity to the city centre, proximity to the CBD, intra-industry agglomeration/clustering, and a highly urbanised location may have a significant effect on company location choice, and therefore these factors were included in the analysis. Table 3 below provides an overview of the different variables included in the analysis, and their names, measurements, and scales.

Table 3 Model variables

Variable type	Variable name	Measurement
Dependent variable	Location choice per PC6-area	Company count
Independent variables	Accessibility to Schiphol Airport	Euclidean distance
	Accessibility to train stations	Euclidean distance
	Accessibility to metro stations	Euclidean distance
	Accessibility to motorways	Euclidean distance
Control variables	Cluster location	Dummy
	Highly urbanised location	Dummy

After careful consideration, proximity to the CBD and proximity to the city centre were ultimately not selected to be incorporated into the analyses as control variables. Proximity to the city centre was found to have high multicollinearity with proximity to the CBD, and was therefore left out. Proximity to the CBD was initially included in the analyses, however due to complicated adverse effects on the model output it was ultimately disregarded.

Values for the four accessibility variables were calculated in ArcGIS using the 'Near' tool. This calculates the Euclidean distance from the central point of each PC6-area to the nearest location of the relevant infrastructure. Cluster locations were determined using the 'Calculate Density' tool in ArcGIS to create density maps (for a detailed, step-by-step description of the mapping process, see appendix b), and then using the resulting maps to assign cluster status to

PC6-areas based on location. Those located mostly or completely in a cluster were assigned the value 1, and those not located mostly or completely in a cluster were assigned the value 0. Highly urbanised location status was determined by using the CBS urbanisation categorisation. They assign each postcode area a value of 1-5 depending on address density, with 5 being the least urbanised and 1 the most urbanised. PC6-areas were determined to be highly urbanised if they were assigned the value 1 by CBS. All other values were assigned the value 0.

Table 4 shows the descriptive statistics for the variables. Because the dependent variable was company count per six-digit postcode area (of which there are 1878 in total), there were multiple models and thus multiple dependent variables, one for all companies and a further one each for the sectors of analysis. The cluster control variable was also unique for each model, with one for general clustering of all companies regardless of sector, and a further one for clustering in each of the separate sectors of analysis.

Table 4 Descriptive statistics for the variables

		Minimum	Maximum	Mean	Std. Deviation
Dependent variables	Total company count	0	99	0.96	4.517
	Count APS firms	0	51	0.31	2.201
	Count high tech firms	0	21	0.11	0.853
	Count life sciences firms	0	2	0.02	0.154
	Count logistics firms	0	12	0.10	0.602
Independent variables	Distance train station (km)	0	4.205	1.441	0.964
	Distance metro station (km)	0	13.672	2.945	3.702
	Distance motorway junction (km)	0	3.231	0.981	0.624
	Distance airport access point (km)	0	9.770	6.292	2.217
		0 (absolute)	**1 (absolute)**	**0 (%)**	**1 (%)**
Control variables	Cluster (all companies)	784	1093	41.8	58.2
	APS cluster	1799	79	95.8	4.2
	High tech cluster	1820	58	96.9	3.1
	Life sciences cluster	1862	16	99.1	0.9
	Logistics cluster	1812	66	96.5	3.5
	Highly urbanised	746	1132	39.7	60.3

3.3 Methods

GIS-analysis

The first step of the research was a GIS-analysis using ArcGIS Pro software. The goal of the analysis was to provide accessibility indicators for each company in the AAC. This was realised with the utilisation of mapping software to calculate the necessary indicators. Dutch six-digit postcode areas (PC6-areas) were used as reference points to spatially aggregate the data as a count per area, fit for application in a Poisson regression at a later stage. A detailed workflow of the steps taken to achieve this is provided as an appendix, and here follows a textual description of the process.

To import the company dataset into ArcGIS, the data was first prepared in such a way that it was easily compatible with the programme. It was then imported into ArcGIS and geocoded, resulting in a point data layer of all companies in the AAC. The point layer was split based upon sector, resulting in separate point layers for each sector, of which only those of the four sectors of analysis were kept.

The next step was to import all necessary external shapefiles to conduct the analysis: point layers with the location of Schiphol Airport, train stations, metro stations, and motorway junctions; and, polygon layers of the AAC, the six-digit postcode areas, and the CBD. The AAC polygon layer was used to show the area extent and to clip other layers, the six-digit postcode polygon layer was used to aggregate the data in for the analysis, and the CBD polygon layer was used to create the central point of the CBD.

The data output of the analysis was determined per PC6 area. The relevant distances for each area were calculated from the respective centroid to each nearest transport node. For the airport, the relevant facilities were determined to be specific per sector of analysis: for APS, High Tech, and Life Sciences firms the distance was calculated to the airport terminal, whereas for logistics firms the distance to the closest freight apron was calculated.

The GIS-analysis was also used for the creation of values for certain control variables. For the CBD proximity variable, a central point was calculated in the Zuidas shapefile, and the distance to it was calculated for each individual PC6 area. The choice was made to account for the influence of industrial clustering by means of a dummy variable, with a 1 indicating a cluster location and a 0 indicating a location outside a cluster. To accomplish this, company density maps were created for each sector, with which cluster status was assigned based upon the location of each company. Then cluster status was assigned to the PC6 areas for each different sector if one or more companies located within it had cluster status.

Finally, the end products were made and then exported from the programme. The density maps for each sector of analysis were produced as results output for visual inspection. Then ultimately the final table containing all relevant data per PC6 area was exported as an excel table. It included four different company count columns (one for each sector), five different columns with distances to the nearest relevant transport infrastructures (one each for distance to the nearest train station, metro station, motorway junction, airport terminal, and airport freight aapron), a column for distance to the CBD, and four columns reflecting the cluster status of each area (one for each sector).

Regression

In order to determine the influence of different modes of accessibility on the location choice of companies in the AAC, the complete table as finalised in the GIS-analysis was subjected to the application of a regression analysis using SPSS Statistics. The regression analyses were executed using the variables as displayed in table 3. To acquire results for different sectors, models were created separately for each, with the company count per PC6 area for each sector as dependent variable.

Table 5 Mean and variance per sector of analysis

Sector data	APS	High Tech	Life Sciences	Logistics
Mean	0.310	0.114	0.018	0.095
Variance	4.843	0.727	0.024	0.362

Preliminarily, it was determined that due to certain requirements being met a Poisson regression was the most relevant analysis. This was due to the fact that the dependent variable consisted of count data comprising nonnegative integers, and the inclusion of multiple independent and control variables based on a continuous or ordinal scale. However, an inspection of the variance and the mean revealed that the distribution of counts did not perfectly follow a Poisson distribution. As the descriptive statistics in table 5 illustrate, the variance was much higher than the mean of for all of the dependent variable company counts, suggesting a bad fit of the model due to overdispersion. The lambda parameter dictates that in the Poisson distribution, the variance must equal the mean ($\lambda = \mu = \sigma$).

Therefore, another type of regression was selected from the Poisson family. There are two alternative options for regressions with a dependent variable consisting of count data, with less strict requirements in a crucial aspect relevant to the current research. The assumption in a regular Poisson regression – that the variance equals the mean – does not apply to the quasi-Poisson model or the negative binomial model, thereby taking overdispersion into account. The difference between the two models is that with a quasi-Poisson model the variance is a linear function of the mean, whereas with a negative binomial model the variance is an exponential function of the mean. The negative binomial regression method was selected after testing of both types of models on the dataset indicated that it was a better fit for all sectors.

4 Results

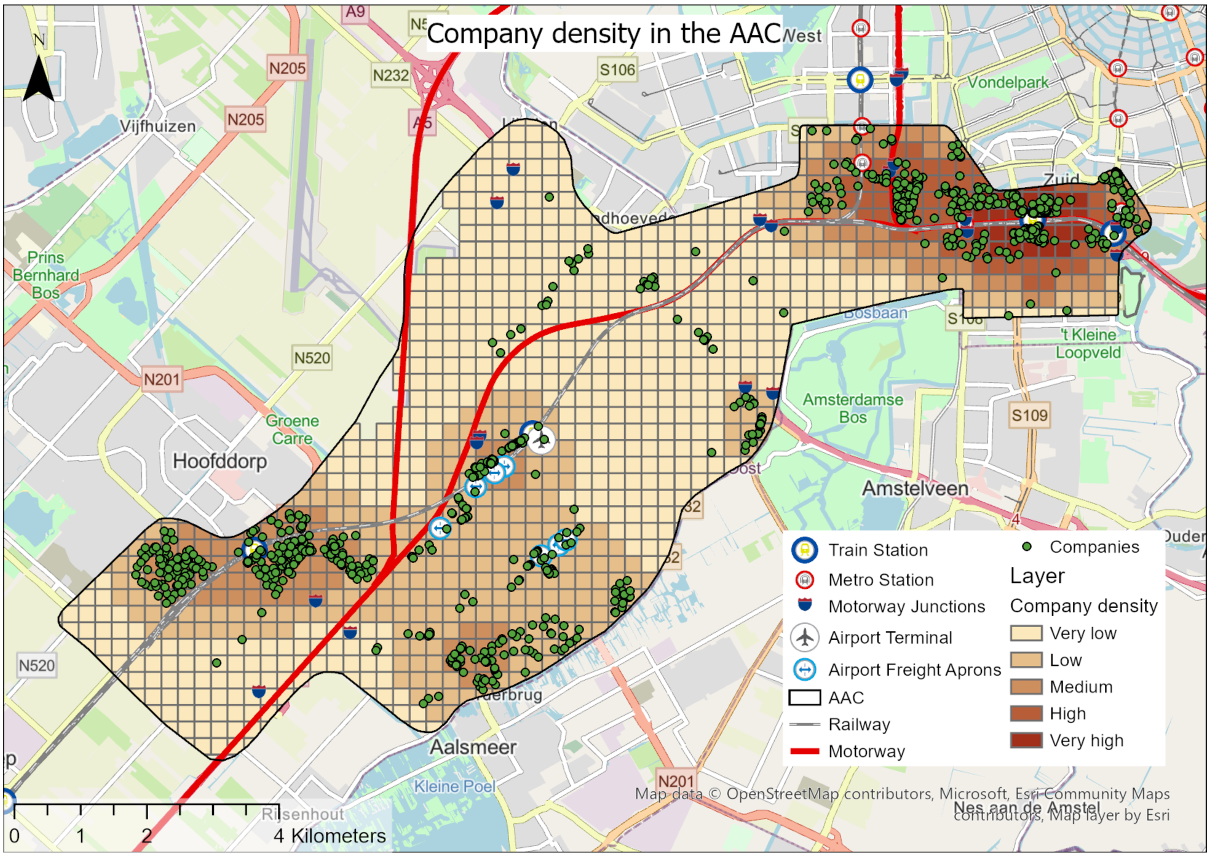
This chapter examines the results from both analyses. The density maps produced are interpreted first, after which the table with results from the regression models are interpreted. In due course the hypotheses are evaluated in the context of the results gathered from the data.

4.1 Density maps

Figures 2-6 below show the density maps produced for the present research. Figure 2 shows the density of all companies in the AAC, irrespective of sector, while figures 3-6 represent the company density of the four separate sectors of analysis: APS, high tech, life science, and logistics respectively. It is worth noting that the tool with which the density maps are produced works in such a manner that the density depicted is relative to the sector on which data it is based, and thus the number of companies in that sector.

Figure 2 demonstrates the sheer weight of the CBD concentration (top-right of the map). The company point data alone could draw one to the false conclusion that the agglomeration around Hoofddorp station (bottom-left of the map) rivals the CBD in magnitude, but the density map clearly disproves this. Nevertheless, there is significant agglomeration in a large area around Hoofddorp station, just as there is smaller area with significant agglomeration around both Schiphol Centre (middle of the map) and Schiphol Southeast (bottom-centre of the map).

Figure 2



What immediately becomes apparent regarding figures 3-5 is that the knowledge-centred companies display a company location pattern with significant similarities, which follow much the same pattern as the density clusters of all companies visible in figure 2. There is clustering activity at much the same locations for each: larger ones in the CBD and in the proximity of Hoofddorp station, and smaller ones at Schiphol Southeast and Schiphol Centre. Especially similar are the location patterns of companies in the APS and high tech sectors, visible in figures 3 and 4, with the life sciences sector (figure 5) being slightly anomalous, perhaps due to its much smaller company count.

Of the knowledge-centred companies, those in the APS sector are clustered most heavily in the CBD (or immediately proximate). There is some minor clustering of medium density surrounding Hoofddorp station, and lastly some scattered groups elsewhere. Companies in the high tech sector also have a major cluster of very high density in the CBD, albeit reaching farther westwards and thus not as concentrated directly inside the CBD when compared to APS companies. Instead, there is high density clustering of high tech companies surrounding Hoofddorp station, which has more weight than the medium density clustering of APS companies in the same place. Furthermore, there is also medium density clustering of high tech companies at Schiphol Southeast, also not present in the APS company density map. The pattern of life sciences companies' distribution is more divided than both than of APS companies and high tech companies, with two distinct clusters, one on the west side of the CBD and the other adjacent to Hoofddorp station. Finally there is also some scatter, but not of enough companies to appear substantial.

On the contrary, the density map of logistics companies (figure 6) displays a very distinct contrasting pattern. There is one considerably large cluster of very high density centred in Schiphol Southeast, stretching in high density all the way towards Hoofddorp station and then continuing further still in medium density past Hoofddorp station to the other side. Other than that there is nothing else of significance except some scatter. The larger spread of the logistics cluster could possibly be related to the larger amount of floor space those companies require, which results in more location spreading considering more concentrated clustering is likely not physically possible.

It can be deduced that the density maps largely support hypothesis 1a. The large majority of knowledge-centred companies visibly concentrate in locations around train and metro stations, which suggests that knowledge centred company location choice is indeed positively influenced by public transport accessibility. Hypothesis 1b also finds a modicum of support in the company density maps. The locations in and directly adjacent to the CBD have the most transport options, with multiple train stations, metro stations, and motorway junctions. Considering that the APS firms are most heavily concentrated there, and that the high tech and life sciences companies are spread out more (less concentrated in the best accessible area), it could be argued that there is support for the hypothesis, but that it is minor.

Hypothesis 2 seems to be partially confirmed by the density maps. The logistics companies are concentrated much closer to the airport when compared to knowledge-centred companies, especially considering the location of the freight aprons. However, the map does not confirm (or refute) a higher preference of logistics companies for locations with good motorway access when compared to knowledge-centred firms. Thus, a positive influence of airport accessibility on logistics company location choice seems evident from the map, but the same cannot be said for motorway accessibility.

4.2 Regression analyses

A negative binomial regression analysis was performed twice for each sector. One model was run consisting of the independent variables and the control variable, and a test for each was also performed solely including the independent variables. Models 1-4 display the latter, and models 5-8 the former. A further two models – one without (model B^1) and one with (model B^2) control

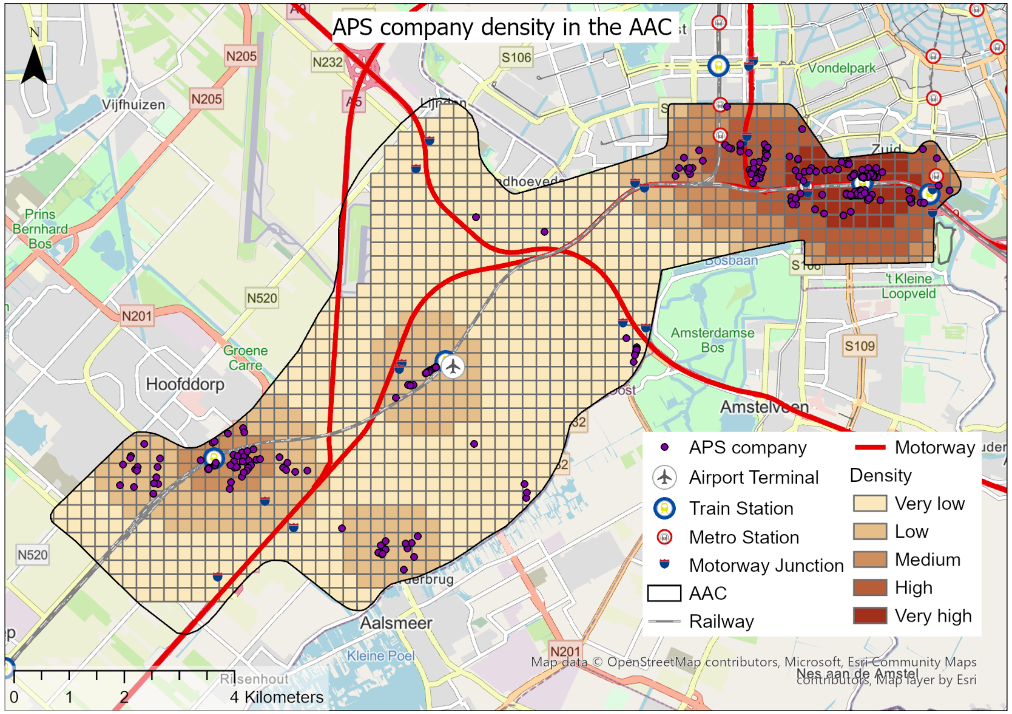


Fig. 3 ←

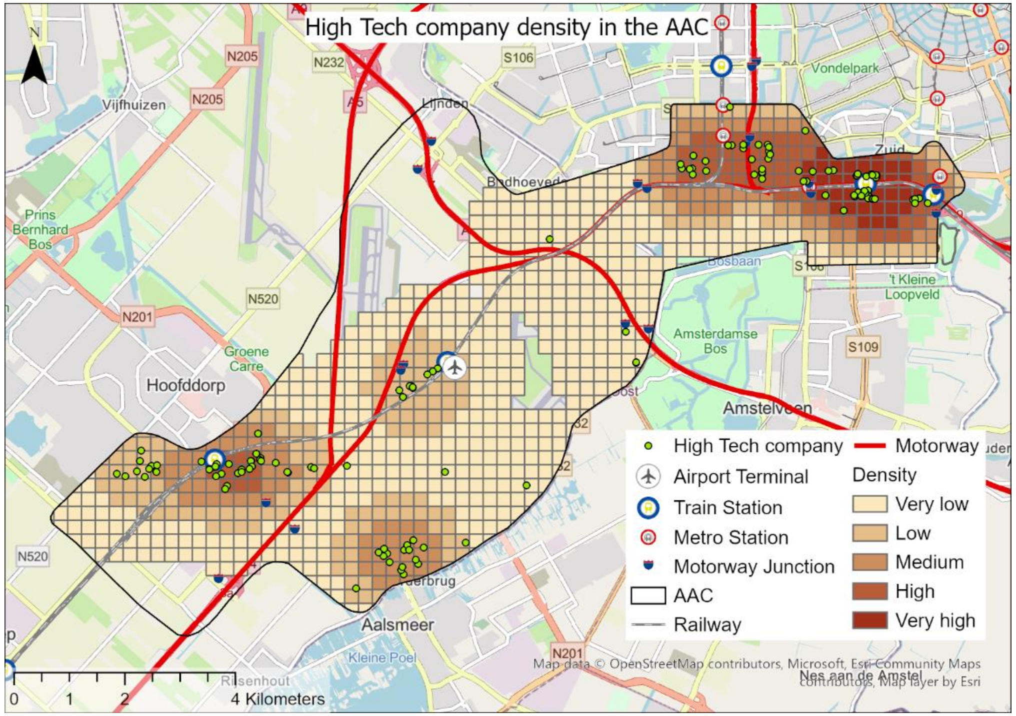


Fig. 4 →

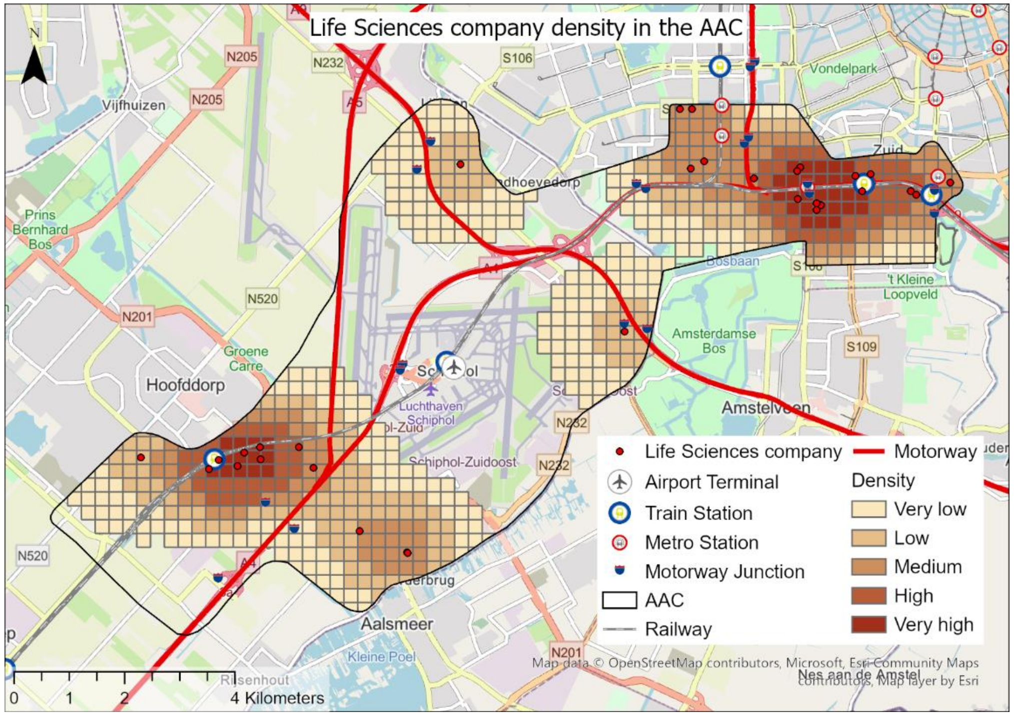


Fig. 5 ←

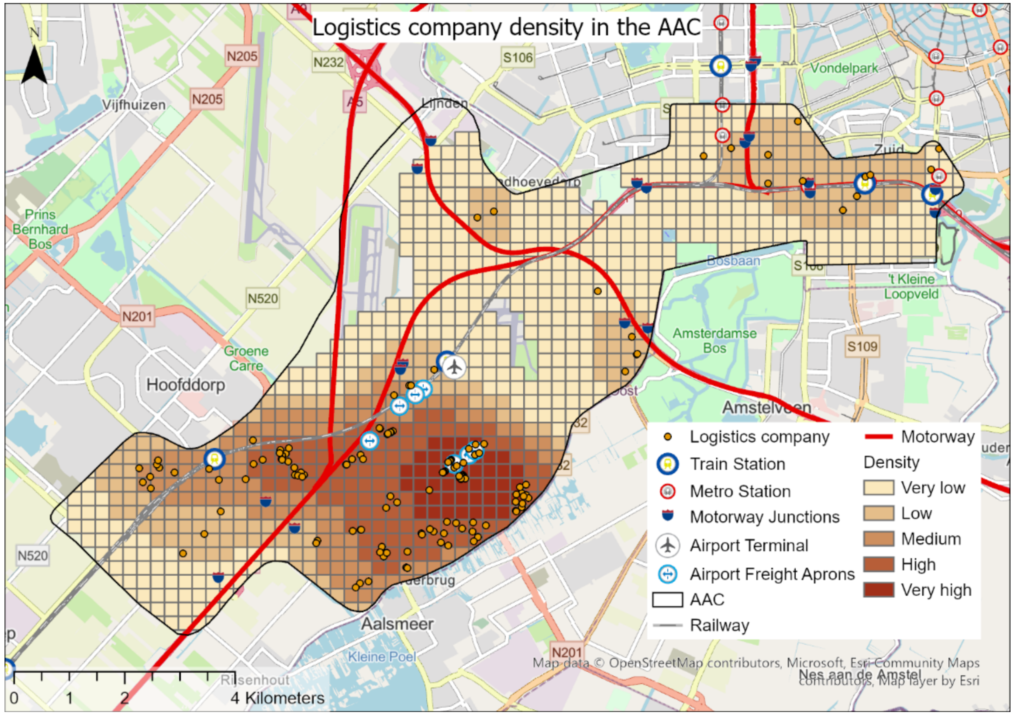


Fig. 6 →

Table 6 Regression results

	Independent variables only					Control variables included				
	(B[1]) $N_{all\ firms}$	(1) N_{APS}	(2) $N_{high\ tech}$	(3) $N_{life\ sciences}$	(4) $N_{logistics}$	(B[2]) $N_{all\ firms}$	(5) N_{APS}	(6) $N_{high\ tech}$	(7) $N_{life\ sciences}$	(8) $N_{logistics}$
Independent variables										
Distance nearest train station	-0.810*** (0.195)	-1.246*** (0.321)	-0.568* (0.239)	-0.466 (0.336)	-0.045 (0.119)	-0.624** (0.237)	-0.198 (0.234)	-0.656*** (0.148)	0.218 (0.520)	-0.109 (0.129)
Distance nearest metro station	0.038 (0.045)	-0.060 (0.060)	0.097 (0.053)	0.170** (0.065)	0.030 (0.053)	-0.006 (0.059)	0.122* (0.052)	-0.078 (0.048)	0.002 (0.153)	-0.074 (0.079)
Distance nearest motorway junction	-0.543* (0.270)	-0.730 (0.419)	-1.049** (0.362)	-1.796*** (0.523)	-0.030 (0.208)	-0.284 (0.312)	0.097 (0.297)	-0.093 (0.356)	-0.837 (0.530)	-0.392* (0.185)
Distance nearest airport access point	-0.343*** (0.048)	-0.303*** (0.080)	-0.155* (0.070)	-0.100 (0.070)	-0.683*** (0.075)	-0.493*** (0.079)	-0.455*** (0.119)	-0.436*** (0.137)	-0.084 (0.166)	-0.291*** (0.058)
Control variables										
Cluster location	–	–	–	–	–	1.717*** (0.268)	5.917*** (0.235)	5.511*** (0.282)	5.134*** (0.532)	4.486*** (0.416)
Highly urbanised	–	–	–	–	–	-0.141 (0.387)	0.680** (0.240)	-0.462 (0.418)	-0.609 (1.376)	-0.262 (0.548)
Pearson Chi² / df	9.011	7.302	4.326	1.319	2.410	8.150	1.051	0.864	1.087	0.983
AIC	4589.62	2316.88	1264.55	304.57	790.24	4350.89	1071.48	528.68	210.91	534.67
Likelihood ratio Chi²	58.70***	52.72***	30.31***	29.38***	180.81***	94.34***	1555.35***	1008.11***	125.44***	707.45***
Observations	1878	1878	1878	1878	1878	1878	1878	1878	1878	1878

Significance levels: * p<0.05; ** p<0.01; *** p<0.001

variables – were created using all companies regardless of sector, to function as benchmarks with which to compare results. Model B^1 serves in comparison to models 1-4, and model B^2 serves in comparison to models 5-8. All models are displayed in table 6.

The Pearson Chi-square/degrees of freedom (Pearson Chi^2 / df) values show that all models were a good fit for the data. The omnibus test comparing the fitted model to the intercept-only model was highly significant for all models ($p<0.001$), which is illustrated by the significance values of the Likelihood ratio Chi-square. When comparing each corresponding model before and after the inclusion of the control variables, it is clear from the Akaike's Information Criterion (AIC) values that in all instances the models with the inclusion of the control variable were a better fit when compared to the models without. This difference was substantial for all the models concerning the sectors of analyses, while the inclusion of control variables in the benchmark model B^2 resulted only in a minor improvement.

Model 1 shows that before the inclusion of the control variables, accessibility to a train station and accessibility of the airport were statistically significant predictors of APS company location choice in the AAC, the former having a stronger effect by a large margin. Compared to general company location choice in model B^1, it becomes clear that APS companies valued train accessibility significantly more than the average company in the AAC, while airport accessibility was valued about the same as the average company. Models 5 shows that after controlling for cluster locations and highly urbanised locations airport accessibility stayed significant, with a slight increase in magnitude. Comparison with model B^2 shows that this is again to approximately the same degree as the average company. However, train accessibility was no longer found to be significant. Furthermore, after introduction of the control variables APS companies were, to a very slight degree, significantly less likely to locate near a metro station. Cluster locations were found to be significantly more likely to attract APS companies than non-cluster locations by far, and comparison to model B^2 shows that APS companies were several times more likely to be located in a cluster than the average company. Finally, APS companies were found to have a significant preference for highly urbanised locations, unlike the average company.

Model 2 suggests that initially, high tech companies in the AAC had a statistically significant proclivity for locations proximate to multiple infrastructures, which was strongest for motorway junctions, about half as strong but still considerable for train stations, while they were found to have a mild preference for locations nearer the airport terminal. Comparison with model B^1 shows that the preference for motorway accessibility was twice as high for high tech firms than the average, and the preference for train and airport accessibility was slightly less than average. Model 6 illustrates however that after inclusion of the control variables, motorway junctions were no longer a significant predictor of high tech company location choice. It further shows that train station accessibility remained significant with a slight increase in effect magnitude, that there was a strong increase in the positive effect of proximity to the airport on high tech company location. Comparison with model B^2 shows that the accessibility preferences of high tech companies were found to be very similar to that of the average company, with metro and motorway accessibility being insignificant, and train and airport accessibility significant to approximately the same degree. Finally, model 6 shows that high tech companies in the AAC were found to value cluster locations highly, an effect also much stronger than the average company just as was the case for APS firms. Highly urbanised locations were not found to be of significant influence on the location choice of high tech companies, which is in line with the average company according to model B^2.

Model 3 shows that life sciences companies were found to strongly favour locations nearer to a motorway junction. It also shows that they were more likely to be located further from metro stations, but this is a comparatively minor effect. According to model B^1 the preference for motorway accessibility was several times higher than the average company. After the inclusion of the control variables in model 7, not a single mode of accessibility remained significant, the only significant predictor of life sciences company location being that of a cluster location. The effect was found to be large, and very similar in magnitude to those in models 5, 6, and 8.

Model 4 shows that initially only accessibility of airport freight aprons had a statistically significant effect on the location of logistics companies in the AAC. This effect was twice as high when compared to the average company according to model B[1]. After controlling for cluster locations and highly urbanised locations, model 8 shows a different picture. Aside from airport accessibility, motorway accessibility was also found to become statistically significant in the attraction of logistics firms. Again, as with the other sectors, logistics company location in the AAC was found to be significantly influenced by areas located in a cluster, to a large degree. As was the case with companies in general, highly urbanised locations were not significant predictors of logistics company location choice.

In summary, table 6 shows that better accessibility to the relevant airport infrastructures was found to have a significant positive effect on the location choice of companies from all sectors of analysis in the AAC, except life sciences, and that the effect was about the same as for companies in general. It also illustrates that the location choice of companies in the high tech sector was found to be positively influenced by train station accessibility, again to about the same degree as AAC companies in general. Motorway accessibility was found to have a significant positive effect only on the location choice of logistics companies, as opposed to both the other sectors and AAC companies in general. For the most part, metro accessibility was not found to have a significant effect on the location choice of companies in the AAC, with the exception of the APS sector where it had a very slight negative effect. APS companies were the only companies found to have a significant preference for highly urbanised locations, an effect also not observed with companies in general. Finally, it is clear that whether or not a location is located in a cluster has a large effect on the location choice of all analysed companies in the AAC. Cluster locations were much preferred over non-cluster locations, with the effect being of approximately equal magnitude for all sectors. Notably, this effect was several times stronger for the sectors of analysis than for companies in general.

Hypothesis 1a finds some support in these results, but cannot be confirmed by them. Metro accessibility was either insignificant, or significant with a very slight negative effect. Accessibility to train stations was a significant predictor of knowledge-centred company location choice in the AAC, except in the life sciences sector, however after the introduction of the control variables it became insignificant for APS companies. Thus, on the whole, there is not much concrete evidence that knowledge centred company location choice is positively influenced by public transport accessibility. Hypothesis 1b was initially confirmed in models 1-3, with train station accessibility significant to a much larger degree for APS companies than the other sectors, however the introduction of the control variables changed the picture substantially. Hypothesis 2 is definitely confirmed by the regression results. The location of logistics companies was indeed found to be significantly more likely in locations with better airport and motorway accessibility, signifying the positive influence of both on the location choice of logistics companies.

5 Conclusions

The goal of the present research was to find an answer to the question: *to what extent do different modes of accessibility influence company location choice in the AAC?* In the previous section, the results of the regression analysis illustrated that airport accessibility had a significant influence on the location choice of companies from all analysed sectors except life sciences, which held true after inclusion of the control variables. Train station accessibility was an important influence on the location choice of knowledge-centred firms, again excluding life sciences, until inclusion of the control variables rendered it no longer of significant influence on the location choice of APS companies. On the other hand, the density maps clearly illustrate that companies from all knowledge centred companies (APS, high tech, and life sciences) concentrate around train and metro stations. Motorway accessibility was found to significantly influence logistics company location choice in the regression analysis. Ultimately though, most prominent in the regression analysis were the results concerning cluster locations. These proved to have a large effect on company location choice in the AAC for all the sectors of analysis, though it is important to remember that because it is a dummy variable, the coefficient value is large compared to that of the continuous variables representing the change per kilometre distance. However, even after accounting for this, it remains a notable result.

Overall, the results of this research confirmed the majority of what was expected in hypothesis 1a. In the regression analysis, knowledge centred firms were confirmed to place more value on locations accessible by train, however the effect became insignificant for APS companies after inclusion of the control variables, and did not hold true for metro stations. The density maps however clearly show that these companies concentrate in locations surrounding public transport stations. The density maps further suggest that the regression results concerning metro accessibility could be insignificant because the metro stations are only present in Amsterdam, in and immediately proximate to the CBD, while there are also clusters located in Hoofddorp, and Schiphol Southeast to a lesser degree. Hypothesis 1b provided mixed results leaving the hypothesis unconfirmed. The density maps suggested that the knowledge-centred firms typically in possession of more highly specialised knowledge (e.g. high tech and life sciences companies) were indeed spread out a little more than APS firms, which certainly clustered more in the CBD. However, the results of the regression analysis did not support this. Logistics companies were confirmed to value both proximity to the airport and proximity to motorway junctions, both by the density maps and the regression analyses, confirming hypothesis 2.

Placing the results into perspective of prior academic literature, these results partially confirm observations in earlier work by for example Iseki & Eom (2019), Song et al. (2010), and Willigers et al. (2007), that APS firms value accessibility by public transport. Previous research by Zandiatashbar et al. (2019), Jiang et al. (2018), Zandiatashbar & Hamidi (2018), and Atzema (2001) indicated that this is also the case for high tech companies, something the results presented here also confirm. Interestingly, for high tech companies in the U.S., Zandiatashbar et al. (2019) and Zandiatashbar & Hamidi (2018) also demonstrated a preference for motorway accessibility, something that contrasts with the current research, and therefore may reflect disparities between the automotive culture and automobile reliance in the U.S. and the increased adoption of public transport in many European countries. Furthermore, prior research by for example Holl & Mariotti (2018), Verhetsel et al. (2015), and Bowen et al. (2008) indicating the significance of proximity to motorways and (air)ports for the locational preferences of logistics companies was also confirmed.

Discussion and implications

It is worth noting that all cluster locations in the AAC apparent in the density maps produced for this research corresponded spatially to the available commercial real estate in the area. This suggests that companies wishing to locate in the AAC are bound to the available commercial real estate appropriate for their needs. This leads to the conclusion that accessibility is important in company location choice to the extent that it is available in the locations where they can find commercial real estate that meets their requirements. These locations usually tend to well accessible though, especially in a place such as the AAC, and it is self-evident that companies do not choose to locate there without reason. In other words, companies follow location supply, but they do have significant demands of that location.

On another note, it has emerged that the life sciences sector is something of an anomaly. Whether or not it is the cause remains to be seen, but the number of companies in the AAC was small, and thus it is perhaps not as well suited to quantitative analysis. Especially for this sector, it is recommended to conduct qualitative analysis if further insight is to be gained into the location choices of life sciences companies in the AAC. For the other sectors, a more detailed view could be ascertained by doing the same for a sample of the total population.

The sectoral heterogeneity expected and observed in the results has relevant implications for policy makers and their considerations pertaining to infrastructure investment decisions. Different sectors have different needs, and this must be carefully considered during the decision making process. Investment in the motorway network may have many benefits for logistics companies, but could have much less benefits for companies from other sectors. Conversely, investment in public transport could yield substantial benefits for companies in the APS and high tech sectors for example, but much less for other types of companies.

Placing it in the context of the metro line extension, this research did not find a statistically significant positive effect of metro station accessibility. As indicated previously, this is possibly because of the stations' location in just a small part of the AAC, because those knowledge-centred companies located in and to the west of the CBD were observed on the maps to indeed be located near a metro station. Nevertheless, this does not provide an end to the discussion of the necessity of the extension, but it does confirm that there are also viable alternative options to consider, such as an increase in capacity of the Schiphol train tunnel, and a more frequent train service with an extra station between the airport and CBD.

Limitations

There are some notable limitations applicable to this research. In any research process choices have to be made which inevitably have consequences for the results, and this research is no different. Only train and metro accessibility were included in the research, while there are multiple bus routes throughout the AAC, and there are also trams in Amsterdam. Also, there were several other potential control variables considered which were ultimately discarded. Proximity to the city centre and proximity to the CBD were discarded because they are single point locations, while the location of the airport terminal is also a single point location. This would have resulted in a high degree of multicollinearity. Furthermore, options were explored to include the size of companies, but this would have become complex considering that it is a company attribute, while the dependent variable was not companies but the company count per PC6 area. Lasty, the chosen geographic area is relatively small, which may cause an inflation of importance of cluster locations. This is because there are not many alternative locations possible for companies to choose from. It may therefore be recommendable to expand the scope in later research to the greater Amsterdam area. Finally, it is worth noting that there are more sophisticated network analyses possible with ArcGIS than were used in this research. These are much more time and resource consuming, but may also yield more precise results. Due to time constraints these methods were not a viable possibility for this research, but this option could be explored in future research.

The data and the results themselves also had some limitations. It is important to mention that the results produced by the regression analysis in this research are correlations, which entails that causation is not proven. Concerning the data, an important limitation was the lack of the ability to determine whether or not a company was an MNE. This would certainly have been incorporated as a variable had it been available, and future research could yet attempt to attain this data. Lastly, the data used represented one year only, and thus developments over time were not analysed in this research. Future research could perhaps collect and make use of data spanning a time frame of multiple years, in order to be able to discern temporal developments.

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Appendix a – SBI conversion table

Categorisation	SBI letter	SBI subsectors	Names of sector includes, minus exceptions
Construction, industry & utilities	B	all	Mining of resources and minerals
	C	all *(exc. 18, 2120, 2660, 325)*	Industry *(exc. Press & media, Pharmaceuticals, Medical and dental instruments)*
	D	all	Utilities
	E	all	Water extraction and provision & waste water processing
	F	all	Construction
Retail & wholesale	G	all *(exc. 4646, 465)*	Retail, wholesale & automotive repairs *(exc. Pharmaceutical wholesale, Medical product wholesale)*
Logistics	H	all *(exc. 5110)*	Transport and logistics *(exc. Transport of people by air*)*
Aviation	H	5110	Transport of people by air*
Hospitality & tourism	I	all	Hospitality
	N	79, 8230	Tourism, Congresses & exhibitions
	R	932	General recreation (Theme parks, Circusses, Harbours etc.)
	S	9604	Saunas, spas etc.
Arts, culture & media	C	18	Press & media
	J	58-60 *(exc. 582)*	Publishing *(exc. Software publishing)*, Production and distribution of audio-visual media, Broadcasting
	M	742	Photography
	R	all *(exc. 932)*	Culture, sports, and recreation *(exc. General recreation)*
High tech	J	582, 61-63	Publishing of software, Telecommunications, IT-services
	G	465	Wholesale of ICT-products and apparatus
	M	72192, 7220	Technical R&D, General sciences R&D
Life sciences	C	2120, 2660, 325	Production of pharmaceuticals & pharmaceutical products, Production of medical and dental instruments
	G	4646	Wholesale of pharmaceutical, medical, and dental products
	M	7211, 72193	Biotechnology R&D, Health & nutritional R&D
	Q	86101, 86924	Academic medical centres, Medical laboratories
Public service	Q	all *(exc. 86101, 86924)*	Healthcare *(exc. Academic medical centres, Medical laboratories)*
	P	all	Education
	O	all	Government & governmental institutions and services
APS	K	all	Finance
	L	all	Real Estate
	M	all *exc. 72, 742, 75)*	Consultancy, research and other specialist business services
	N	8030	Investigative & detective work
Services (general)	M	75	Veterinary services
	N	all *(exc. 79, 8030, 8230)*	Rental and lease of mobile goods & general services (Employment services, Security, Facility management, Cleaning etc.) *(exc. Tourism, Investigative & detective work, Congresses & exhibitions)*
	S	all *(exc. 9604)*	Other services *(exc. Saunas and spas)*

*excluding 2 companies determined to be wrongly assigned to this sector: *Cargo Holland B.V.* & *DHL Global Forwarding*. These were manually assigned as 'H 5121 – Transport of cargo by air'

Appendix b – Mapping process workflow

- **Import of the company database**
  - Data fields modified
    - Special characters removed; ArcGIS only compatible with letters and underscores
  - Imported as table to ArcGIS Pro
  - Table geocoded using ArcGIS World Geocoding Service
    - 42 errors flagged with finding addresses; imprecise addresses or multiple matches
    - Errors manually relocated using Google Maps locations
      - Addresses and errors separated; new shapefile created excluding errors
      - New table made with only the error addresses
      - Table imported and geocoded, and addresses manually relocated using Google Maps locations
    - Resulting 2 shapefiles merged with Merge function to form one complete point data map with company locations
- **Import of externally sourced shapefiles (for variables)**
  - The basemap selected was the higher quality of the two options based on Open Street Map
  - Several data for variables were sourced via the online portal in ArcGIS Pro
    - Train stations: *data provided by Esri – based on data obtained from NS (Dutch Railways)*
      - A new layer was made using only the relevant stations in the Amsterdam area
    - Motorway junctions: *data from NWB (Dutch Road Archive) of Rijkswaterstaat (Directorate-General for Public Works and Water Management)*
      - Hectometre point data of all Dutch motorways, junctions, and main roads was obtained, including slip roads (for motorways)
      - For each junction, a manual selection was made of the point at the start of each slip road (on-ramp). A new layer was then made with the selection, and these points were used as the location of the motorway junctions
    - Schiphol Airport terminal location: *data provided by Esri*
    - Schiphol Airport freight apron locations: *data from Open Street Map and Google Maps Street View*
      - Entry locations for heavy goods vehicles to the airport freight aprons found using the former source, and visually confirmed using the latter
    - PC6 (six-digit postcode) areas: *data provided by Esri – based on data obtained from the BAG (Administration of Addresses and Buildings) of Kadaster (Dutch Cadastre)*
      - A new layer was made using only the relevant postcode areas in the AAC
  - Metro stations: *data from Amsterdam Municipality*
    - Downloaded csv-file with metro stations and tram stops and their corresponding latitude and longitude coordinates
    - Separated out metro stations from tram stops and made a new layer

        - Converted metro station latitude and longitude data to points using tool 'XY Table to Point'
            - 1 error with Amsterdam Zuid station
            - Solved by manually entering latitude and longitude coordinates from Google Maps into csv-file, and rerunning the tool
    - Central point of the CBD (Zuidas)
        - Zuidas: *made using data from the official Zuidas information platform*
            - A polygon shapefile of the Zuidas was created
            - Using the 'Feature to Point' tool, the centre point of the Zuidas was calculated
    - Urban density: *data provided by Esri – based on PC5 (five-digit postcode) area data from CBS (Central Bureau of Statistics)*
        - The most recent freely available PC5 dataset was used (the urban scale is not included in the PC6 data), which attaches relevant data to postcode areas
        - The CBS urban density scale (scale of 1-5, with 1 being the least urban and 5 being the most urban) was used.
- **Analysis**
    - For the PC6 areas layer, the distance from the centroid to each relevant infrastructure and the CBD was calculated using the 'Near' tool:
        - The infrastructures: the nearest train station, nearest metro station, nearest motorway junction, and the nearest relevant airport infrastructure (freight apron location for logistics companies, the terminal location for the other three company categories)
        - The centre point of the CBD (Zuidas)
    - For each company from each sector, it was determined whether it was located in a cluster or not
        - First, from the full company dataset separate point data layers were made for each sector of analysis (Logistics, Life Sciences, High Tech, APS)
        - The 'Calculate Density' tool was used to create a raster square density map for each sector
        - The output for each sector was split into 5 categories using the 'Natural Breaks (Jenks)' separations method. It was then visually interpreted, and for each sector it was determined that the top categories would be assigned cluster status.
        - Using the 'Join Attributes From Polygon' function, each point of each sector was assigned the density calculation of the raster square in which it is located.
        - Cluster status was digitised by using the 'Reclassify Field' tool to assign companies located inside one of the cluster the value '1' and those outside a cluster the value '0' based upon their respective values in the density column as mentioned in the previous bullet point.
    - Cluster status was then assigned to the PC6 areas separately for each sector of analysis. It was derived from the location of one or more cluster companies in the PC6 area. The 'Join Field' tool was used to achieve this.
    - Finally, using the 'Join Features' tool a company count per area was calculated for each different sector of analysis
    - Following this the datasets were exported using the 'Table To Excel' tool

- **Import of additional externally sourced shapefiles as supporting layers in the creation of end product maps**
    - Roads: *data from NWB (Dutch Road Archive) of Rijkswaterstaat (Directorate-General for Public Works and Water Management)*
        - Line data was imported and then clipped to show only the motorways in the Amsterdam region
    - Railways: *data from BGT (Registration of Large-Scale Topography) of the Dutch government*
        - Line data was clipped to show only train lines in the Amsterdam region, and only those owned by ProRail (as rails from other owners are not train lines but light rail)
- **Other preparatory work for the creation of end product maps**
    - To create visually attractive maps containing only relevant data, the AAC shapefile was used to clip other data layers, e.g. the density raster maps

Appendix c – Density maps: large view

Figure A1

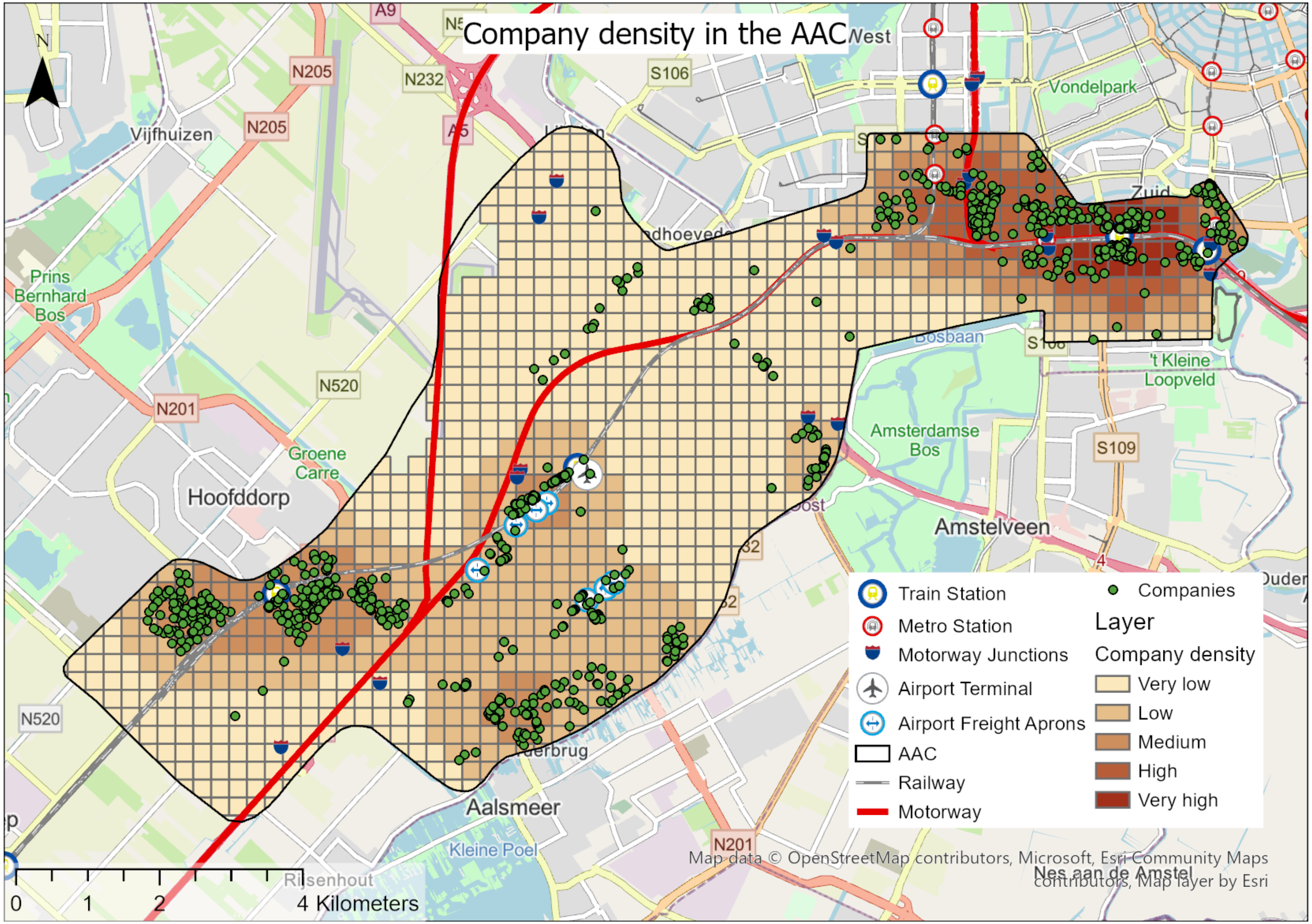


Figure A2

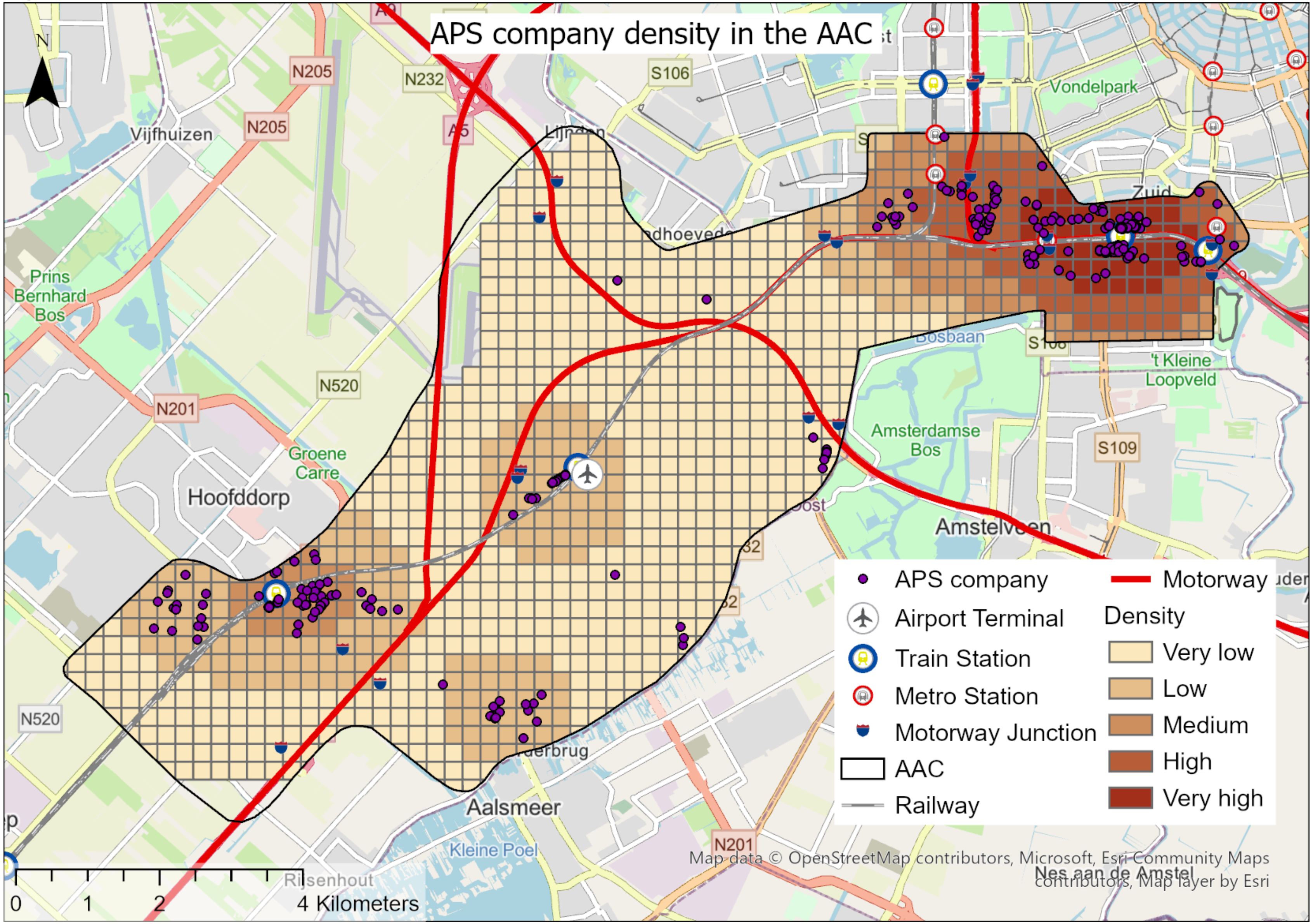

APS company density in the AAC
N
APS company
Airport Terminal
Train Station
Metro Station
Motorway Junction
AAC
Railway
Motorway
Density
Very low
Low
Medium
High
Very high
0
1
2
4 Kilometers
Map data © OpenStreetMap contributors, Microsoft, Esri Community Maps contributors, Map layer by Esri
Vijfhuizen
Hoofddorp
Aalsmeer
Amstelveen
Vondelpark
Amsterdamse Bos
Prins Bernhard Bos
Groene Carre
Kleine Poel
Rijsenhout
Nes aan de Amstel
't Kleine Loopveld
Bosbaan
N205
N232
N520
N201
S106
S109
A5

Figure A3

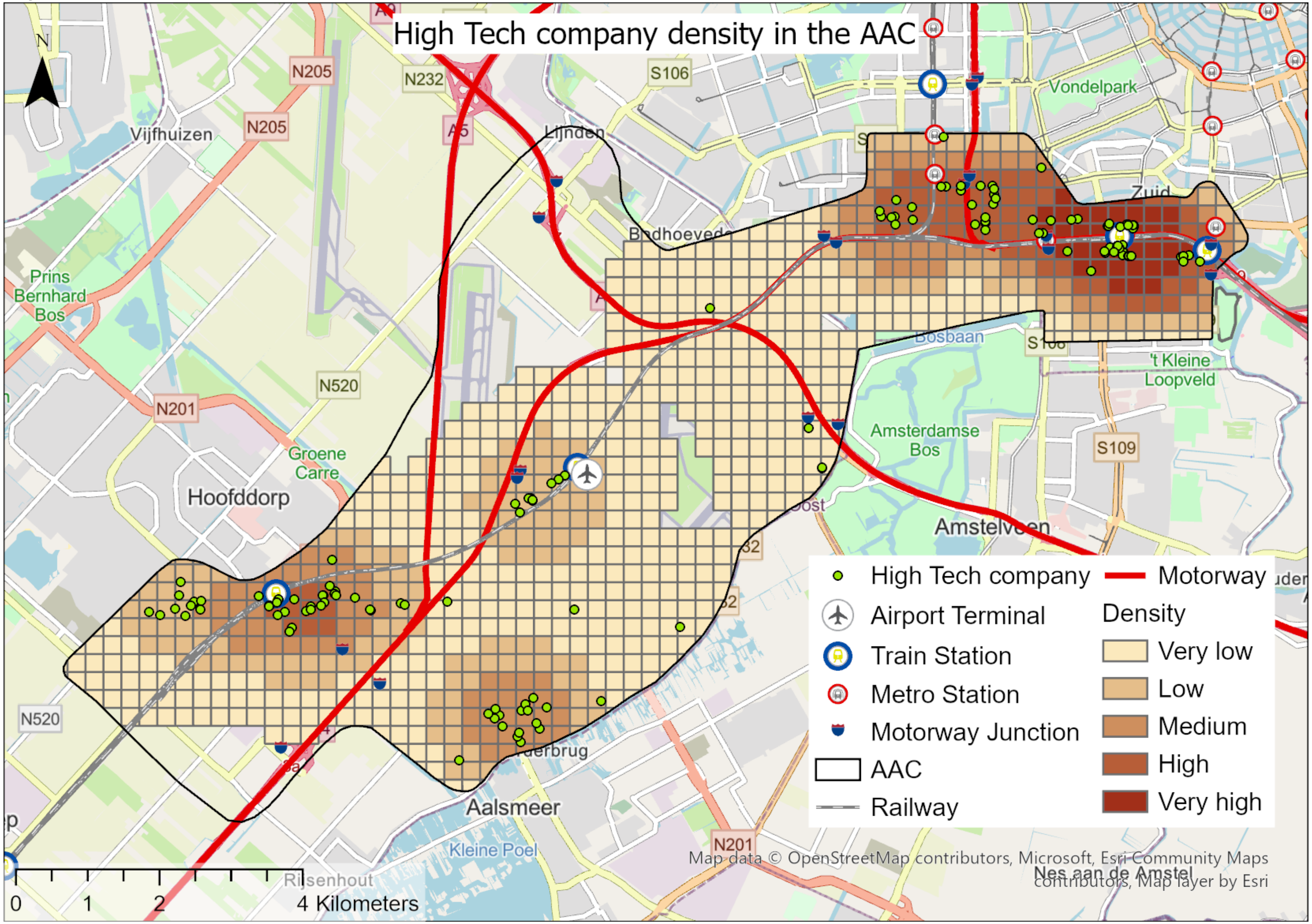

High Tech company density in the AAC
N
N205
N232
S106
Vondelpark
Vijfhuizen
N205
A5
Lijnden
Prins
Bernhard
Bos
Badhoevedorp
Zuid
Bosbaan
't Kleine
Loopveld
N520
N201
Amsterdamse
Bos
S109
Groene
Carre
Hoofddorp
Amstelveen
N520
Aalsmeer
Kleine Poel
N201
Rijsenhout
0
1
2
4 Kilometers
Map data © OpenStreetMap contributors, Microsoft, Esri Community Maps contributors, Map layer by Esri
High Tech company
Airport Terminal
Train Station
Metro Station
Motorway Junction
AAC
Railway
Motorway
Density
Very low
Low
Medium
High
Very high

Figure A4

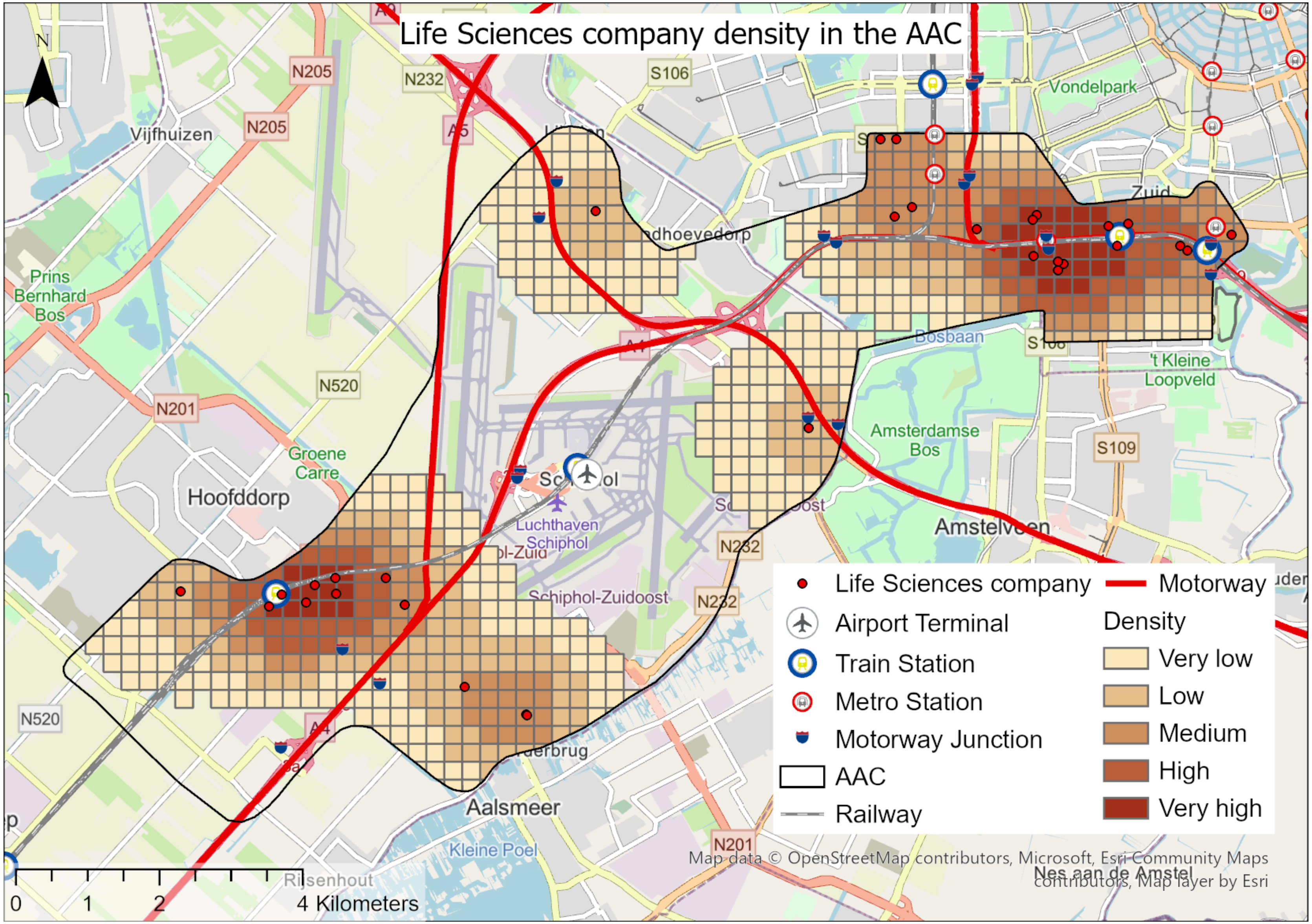
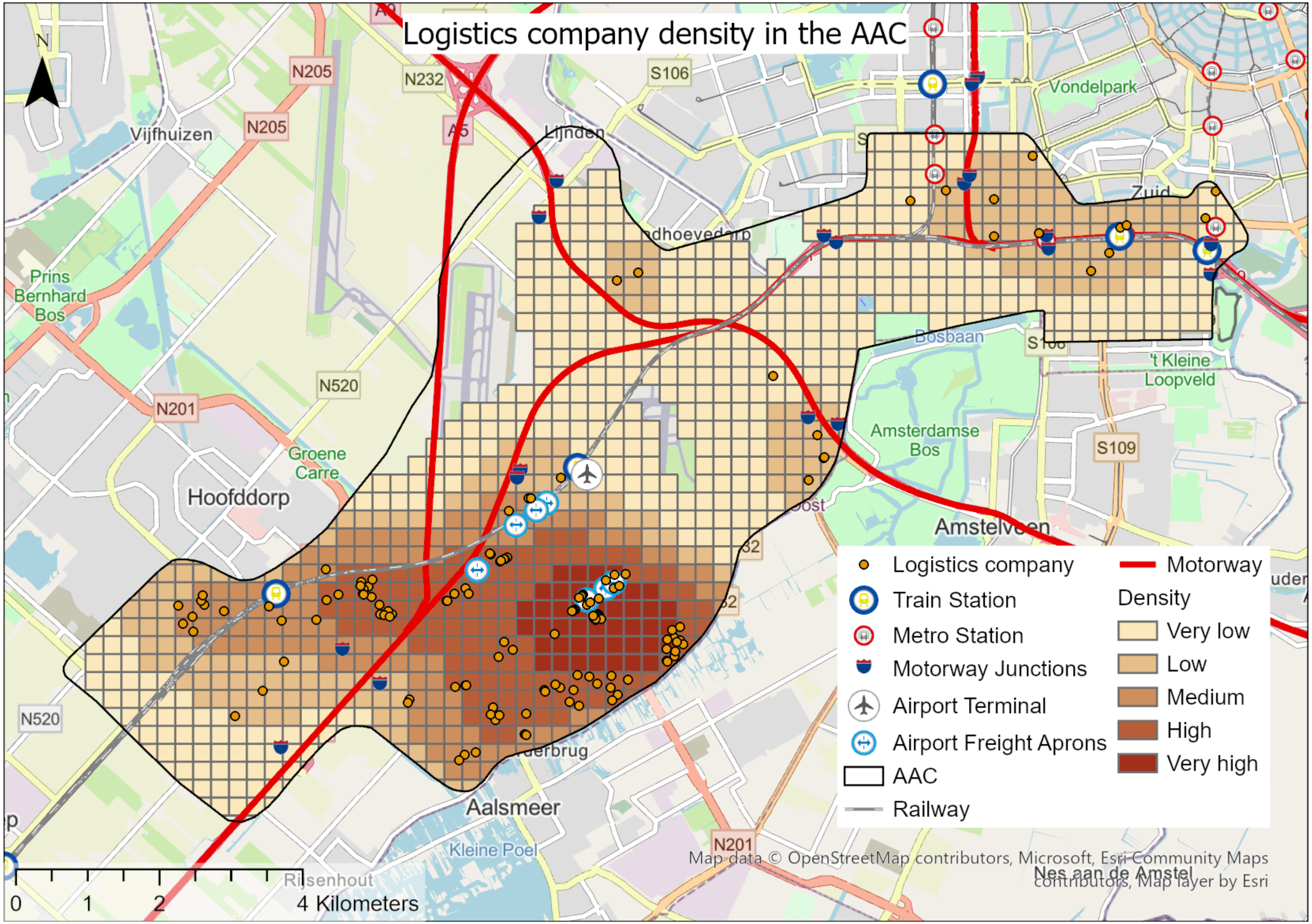

Life Sciences company density in the AAC
N
Life Sciences company
Motorway
Airport Terminal
Density
Train Station
Very low
Metro Station
Low
Motorway Junction
Medium
High
AAC
Very high
Railway
0
1
2
4 Kilometers
Map data © OpenStreetMap contributors, Microsoft, Esri Community Maps contributors, Map layer by Esri
Vijfhuizen
Hoofddorp
Aalsmeer
Amstelveen
Vondelpark
Amsterdamse Bos
Bosbaan
Luchthaven Schiphol
Schiphol-Zuidoost
Kleine Poel
Prins Bernhard Bos
Groene Carre
't Kleine Loopveld
N205
N232
N520
N201
S106
S109
A5
A4

Figure A5


Logistics company density in the AAC
N
Logistics company
Train Station
Metro Station
Motorway Junctions
Airport Terminal
Airport Freight Aprons
AAC
Railway
Motorway
Density
Very low
Low
Medium
High
Very high
0
1
2
4 Kilometers
Map data © OpenStreetMap contributors, Microsoft, Esri Community Maps contributors, Map layer by Esri
Vijfhuizen
Hoofddorp
Prins Bernhard Bos
Groene Carre
Vondelpark
Bosbaan
Amsterdamse Bos
't Kleine Loopveld
Amstelveen
Aalsmeer
Kleine Poel
Rijsenhout
Nes aan de Amstel
N205
N232
S106
N520
N201
S109