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TRANSIT ORIENTED DEVELOPMENT (TOD)

A Literature Review

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Foreword

*Integrating transport and land use planning can promote the use of public transport (and active modes of transport) and make an important contribution to the sustainability of cities.*While transit-oriented development (TOD) can be found in many cities around the world there are many others where it is not. In these cities, opportunities to access and use public transport are limited. The importance of TOD to the success of public transport, and a need to understand how to deliver it, is the key justification for this research.

The report has been produced in the context of the K2 funded project *Transit Oriented Development (TOD) in the early stages of planning processes – improved tools for navigating collaborative complexities and private sector rationalities*. The purpose of the project is to identify innovative ways to promote TOD in the early stages of planning processes. The project is being carried out by a research group from Molde University College (Prof. Tom Rye), Lund Technical University (Dr. Fredrik Pettersson-Löfstedt) and Malmö University (Dr. Lina Olsson and Associate Prof. Robert Hrelja)

Linköping, November, 2020.

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Summary

The report presents an international literature review on Transit Oriented Development (TOD) research carried out in order to frame the research problem and gaps for a research project that is to be carried out largely in the Swedish context.

The literature searches of peer-reviewed articles, literature reviews, and conference papers were carried out in the bibliographic databases Google Scholar, Scopus and Web of Science based on keywords selected by the project team.

The report presents definitions of TOD, the application of the TOD concept in semi-peripheral, peripheral and rural areas, the role of the private sector in delivering TOD, as well as best practice examples, including enabling processual planning factors, barriers and outcomes. It then identifies research gaps that are related to the above topics. Based on the findings of the literature review, the report suggests an outline for future research.

TOD definitions
TOD is typically defined as an approach to transport and land use planning that makes walking, cycling, and transit use convenient and desirable, and that maximizes the efficiency of existing public transit services by focusing development around public transit stations and stops. The review also illustrates that there is a lack of studies that try to define TOD in low density or semi-rural contexts; nor are there studies that explicitly focus on non-metropolitan contexts. In addition, the review of the literature makes it clear that the majority of studies relate to rail based public transport, with few bus-based examples.

Lessons for Delivering Transit-Oriented Development
An important prerequisite for TOD is that its delivery requires the involvement of many actors: national railroad authorities, organisations involved in land development around transport infrastructure, such as private developers, local authorities, and private companies contracted to provide transit services. A complex set of relationships can make TOD challenging. Complex governance structures are among the most often reported barriers to TOD. One example of this is how there in many countries is a lack of statutory regional planning and in some countries any form of regional planning organization. Related to the above, there may sometimes be competition between central and peripheral municipalities in a metropolitan area. Additionally, there is a rather vague definition of the TOD concept and therefore poor understanding of it in the development industry, so it is perceived by many developers as risky. This perception of risk is compounded by the multi-party multi-actor context of TOD sites; there are in reality frequently additional development costs as TOD sites are often under complex ownership.

In many cases, the enablers of TOD are found to be the converse of the barriers: a) strong state intervention, b) powerful plans, c) public ownership of land and public development of housing and public transport, d) coordinated by powerful and well resourced local or regional government.

Outcomes. What have TOD projects delivered and how have their successes or failures been judged?

Success can be judged in many different ways, although in general the private development industry will judge TOD success in directly financial terms whilst public sector actors have a very wide set of expectations and outcomes that they seek. The review shows that: a) there is good evidence from North America that TOD focused on public transport nodes results in lower levels of car use, somewhat higher levels of public transport use and much higher levels of walking than in conventional suburban neighbourhoods, b) there is mixed evidence of the effect of TOD (in its North American version at least) on gentrification, c) there is clear evidence that land values increase in TOD areas around stations due to their increased accessibility and the greater number of amenities offered in the area, d) it is also clear that buyers and renters in North American TOD areas are willing to pay more to live in an area of greater walkability. Finally, all outcomes are seen as difficult to deliver but particular outcome-related challenges include achieving a mix of uses, delivering TOD at a regional scale, reconciling density and a liveable environment, and accommodating parking and ensuring a good enough level of public transport service to make the development attractive to invest in. In terms of (planning) processes, the largest challenge is always found to be that of coordinating a large number of actors.

Research gaps and outline of required research

A considerable number of research gaps emerge from this review. How TOD is defined by different actors and in different spatial, country and institutional contexts is not well understood. Coupled to this, it is not clear whether the development industry has a shared definition of TOD nor how aware the industry as a whole is of the concept. More work is also required to understand how for example developers perceive risks of TOD.

Site-level design specifications for TOD are mainly informed by US preferences. It is unlikely that 'made in the USA' TOD design guidelines can be applied in their entirety to other contexts due to institutional differences and traditions. More research in therefore needed on TOD planning and implementation in the European context and on geographical contexts characterised by medium or low densities of population and activities. The variations between contexts and the multiplicity of actors involved requires an understanding of TOD as diverse; and this also implies the need for a systematic comparison of cases so that general and specific explanations in determining outcomes can be better understood. Research has not looked at specifically how particular planning processes have a greater likelihood of producing particular outcomes. The 'processual planning dimensions' underlying TOD projects at the local scale, and the obstacles and levers to TOD implementation, particularly with regard to governance at the local level, have not been researched in detail in the European context outside the Netherlands. Nor is the role of regional governance in supporting TOD to bring about TOD at a regional level well understood.

1. Introduction

Adjusting and developing the urban built environment to better support sustainable transport is one of the key challenges for urban planning today. It is clear from previous research that land-use has a strong influence on how people travel (Bertolini, 1999; Naess et al., 2018). It is also clear that integration of land-use planning and transport planning has been key to the success of cities that have increased the use of public transport, walking and cycling and reduced car transportation (see e.g. Bertolini and LeClercq, 2003; Buehler et al., 2018). These changes are results of strategic efforts to apply the concept of Transit Oriented Development (TOD) as a planning and development principle for densifying built environments around public transportation nodes and along public transit corridors.

Parallel to the growing popularity of planning for urban growth around public transportation systems, research on TOD concepts and similar planning and development concepts have proliferated. In the TOD literature European cities, such as Stockholm and Copenhagen are often mentioned as an inspiration for the development of TOD (e.g. Cervero, 1998; Knowles, 2012; Paulsson, 2020) These cities are often (and rightly so!) held in high regard among TOD researchers for their proven ability to achieve a close integration between land-use and (rail based) public transport. However, to some degree there may be a tendency to overestimate the proliferation of TOD as an established planning practice in the Scandinavian context, at least when considering a wider national perspective including areas outside the urban areas of the capital cities. In Sweden previous research has for instance found that regional-wide approaches to implementing TOD in the region of Skåne were associated with difficulties concerning factors such as how to define what counts as a public transport accessible development location, how to define what counts as high quality public transport, and how to define key concepts such as density (Pettersson and Frisk, 2016).

A survey by Hansson et al. (2018) based on answers from 194 of 290 Swedish municipalities consolidated these findings. This study showed that larger and denser (and hence more ‘urban’) municipalities work more with integrating public transport and land-use planning, while these issues are much less in focus in smaller and less densely populated municipalities, often peripherally or semi-peripherally located in functional regions. Striving for larger labour markets, and providing better access between regional urban cores, and their concentration of economic activity, from the regional hinterlands has been at the core of Swedish policy making for decades. A key idea in such policy strategies is the possibility to combine increased regional mobility with the goal of achieving sustainable transport; this is of course conditioned on increasing the use of public transport (Pettersson, 2013). Hence, broadening the scope of TOD approaches to include also less densely populated areas located outside the immediate urban, regional cores, is a key concern for policy.

This report has been produced as a part of a research project on the delivery of TOD in semi-peripheral and peripheral areas in Sweden’s three largest metropolitan regions –

Stockholm, Västra Götaland and Skåne. While Västra Götaland and Skåne have promoted polycentric urban development structured around public transport systems, the Stockholm region has a longer tradition of planning for TOD. TOD planning has clearly contributed to increase public transport use, walking and cycling in dense urban areas, but a remaining challenge is to create development patterns which support these modes of transportation in more sparsely populated areas. Such areas do not only exist in rural regions, but also in semi-peripheral and peripheral areas of metropolitan regions. In addition to this particular geographical focus, the research project moreover focusses on three specific aspects of TOD planning: I) early stage TOD planning processes, and II) the role and influence of property developers and investors in governance for TOD, III) the outcomes – both intended and unintended – of TOD.

1.1. Purpose, research questions and methodology

The purpose of this report is three-fold: firstly, to provide a literature review of existing research; secondly, to identify research gaps in the literature; and thirdly, to suggest areas of future research which is relevant to the Swedish context. The literature was designed and structured around the following research questions:

1. How does the literature conceptualize TOD as a planning and development concept?
2. What definitions of TOD are presented in the literature?
3. What research has been done on TOD in semi-peripheral and peripheral areas, including low-density areas in metropolitan regions, and what conclusions do they draw?
4. What studies have been made on early stage TOD planning processes? What best practice processes and tools used to make TOD happen, including barriers, enablers and challenges are identified in the literature?
5. What are outcomes of best practice examples of TOD, including some of the unintended outcomes related to gentrification and equity?
6. What studies have been made on the role of the private sector in delivering TOD and how market-related factors affect the conditions for delivering TOD? What conclusions do these studies draw?

The literature review has been carried out through a combination of a semi-systematic and systematic review process (Snyder, 2019). While the search for literature addressing research questions 1, 2, and 4 – 5 has been semi-systematic, the search for literature addressing research question 3 has been done through a systematic search process. The motivation for using a semi-systematic search for literature covering research questions 1,2 and 4-5 is that the number of publications covering these topics is large and the purpose was not therefore to undertake a review covering all literature. Instead a strategic selection was made. Publications were not excluded due to age, but for the sake of focusing on the most up to date knowledge on TOD the majority of the included publications were published over the past ten years. For the semi-systematic literature search, we have used Google Scholar, Scopus and Web of Science . ‘Transit Oriented Development’ was used as a principal search term in combination with the search terms ‘planning processes’, ‘best practice’, for research question 4), ‘outcomes’, ‘barriers’, ‘enablers’, ‘gentrification’, ‘displacement’, and ‘equity’ for research question 5), and

'developers', 'lenders', 'creditors', 'financing' and 'funding' for research question 6). For the semi-systematic search qualitative judgement based on each paper's abstract was then used to assess which papers were relevant to our study. Those papers citing the relevant papers were also searched and used when also judged relevant in a similar way.

Research question 3 addresses a topic that we assumed to be less covered in the TOD research. To test this hypothesis, we carried a systematic search of literature on TOD in semi-peripheral and peripheral areas, including low-density areas in metropolitan regions. A search using LUB Search (the Lund University library search engine) and Scopus was made using the search words 'public transport', 'transit oriented development' and 'low density'. The query resulted in 40 academic publications and all were reviewed.

Much of the research on TOD is – due to the geographic spread of the term – focused on examples in Australia and North America. The term TOD is used lesser in other parts of the world, where we find a range of other terms - due to linguistic variety - describing more or less similar planning and development principles as those captured by the concept TOD. In Sweden, for instance, the term '*stationsnära utveckling'* (Eng. station-adjacent development) is used to promote development of polycentric city regions, which support transportation by public transit by expanding regional public transport networks and concentrating urban growth around station nodes (e.g. Region Skåne, 2019). We acknowledge the existence of this variety of related TOD related terms, but have – for the sake of limiting the scope of the literature review and for the sake of using consistent search criteria – chosen to focus the search on literature published in English. The limit of this approach is that we have not systematically covered literature published in other languages and that deal with the same or similar planning and development concepts as that described by the term TOD. Cases studied in the included literature, however, are geographically spread and to not only include examples from Australia and North America, where the term TOD is most widely used.

1.2. Outline of the report

In Chapter 2, TOD literature addressing questions 1), 2) and 3) is presented. It covers universal and relational definitions of TOD and the distinction between them. In addition, it discusses what a regional approach to TOD is and how TOD can be defined a 'regional building block' (Dittmar and Poticha, 2004). The chapter also covers universal and relational definitions of TOD and the distinction between them. As the literature suggests, TOD needs to be defined in relation to its urban and regional context. Thus, in this definition there is no minimum density in dwellings per hectare below which a development cannot under any circumstances be defined as TOD. The density needs instead to be considered in the context of that specific development, or TOD policy.

Chapter 3 presents an overview of TOD literature addressing questions 3) – 6) and focusing on actors, processes, results and impacts of TOD, as well as barriers and enablers to its implementation. Finally, Chapter 4 identifies research gaps found through the literature review.

2. Definitions of Transit-Oriented Development

2.1. Universal, relational and regional definitions of TOD

TOD is typically defined as an approach to transport and land use planning '... that makes walking, cycling, and transit use convenient and desirable, and that maximizes the efficiency of existing public transit services by focusing development around public transit stations, stops, and exchanges.' (Thomas and Bertolini, 2017: p. 140, Lee et al., 2019). However, according to a review by Ibraeva et al. (2020) there are several different ways to conceptualise TOD. Many studies have focussed on the three Ds of the concept, density, diversity, design, (e.g. Cervero and Kockelman, 1997). *Density* means to increase the number of units per hectare compared to typical development densities; *diversity* refers to the need to increase the mix of uses in a development; and *design* refers to urban design and street layout that make walking, cycling and public transport use attractive and efficient. Ewing and Cervero (2010) add another two Ds: *distance to transit*, and *destination accessibility*. A similar approach is found in Kamruzzaman et al., (2014) whose framework for measuring the level of TOD includes public transport accessibility level, net residential density, net employment density, land use mix, intersection density, and cul-de-sac density. As illustrated by the brief examples provided here there are not only different ways of conceptualising TOD, but the different ways of conceptualising TOD also influences research design regarding methods and models. While this can be considered normal for any research topic generating a lot of interest, it does make it challenging to get an overview of the existing knowledge. In this chapter we will therefore focus on definitions of TOD, as well as definitions of various key components of the concept found in the literature.

To begin with, Bertolini et al. 2012 (p. 47) make a distinction between those who understand TOD based on *universal models and definitions* (Calthorpe, 1993; Rogers, 1997; Hall and Ward 1998), and those who apply a diversity of more flexible approaches and definitions (Cervero, 2004, and Curtis, 2012), here referred to as *relational definitions*.

According to most definitions, TOD is a form of development that takes place at public transport nodes, intended to raise development densities to generate more public transport patronage. A relational understanding of TOD means viewing the concept as a broader spatial planning policy approach that tries to create a built environment that is generally more supportive to public transport, cycling and walking. Examples of relational approaches include Thomas and Bertolini (2017) who argue that TOD should be viewed as a regional approach, not station-by-station; and Curtis (2012), who views the European approach to spatial planning as inherently transit-oriented in the majority of situations, in

contrast to the situation in North America or Australasia where wholly car-focused spatial planning is the norm and thus station-area TOD an exception.

In the sections below, which presents various approaches of defining and measuring TOD, we discuss both universal definitions as well as relational ones.

2.2. Walking distance and catchment area definitions

Walking distance to a station is a quantitative indicator often used, but distances vary between different studies. Ginn (2009) argues that there appears to be a common agreement that a TOD is delimited to a 400 – 600 m radius from a public transport station. Similarly, Calthorpe (1993), who is often cited as having established the concept of TOD in planning literature, defined primary areas as located within 600 m (2000-foot) from a station. In Copenhagen the 'station proximity principle', which is a key concept for operationalizing the integration of public transport and land use planning (which has been on the planning agenda since the 1947 Finger Plan (Knowles, 2012)), defines the catchment area as 600 m around train stations (e.g. Haartoft-Nielsen, 2002). Here it should be noted that the 'station proximity principle' as a planning concept only applies to rail stations (Pettersson and Sørensen, 2019).

However, other sources, such as Vale (2015) develop a concept they refer to as the pedestrian shed ratio, which is defined as the proportion of walkable area inside a 700-m buffer from a station. Bolleter and Ramalho (2020) write that TOD precincts are areas within an 800 m, 10-minute walk from a public transport hub, while Cervero and Dai (2014) defined stations impact zones for the Bogota Bus Rapid Transit (BRT) as 1000 m. Lee, Choi and Leem, (2016) introduce the concept of bicycle TOD as a complement to conventional, pedestrian shed approaches to TOD. According to their review of previous research including bicycle access could increase the geographical catchment areas of public transport stations in the range of 1,6 km up to 10 km. For time based definitions of how long people were willing to bike they also found a variation ranging from 7 minutes up to 25 minutes.

Both definitions of pedestrian, and bicycle catchment areas vary considerably. For pedestrian catchment areas the most generous definition is 2,5 times wider than the strictest one. For bicycle catchment areas the most generous definition is suggesting that people are willing to bike a distance almost 10 times longer than according to the strictest definition. We can only speculate about the reasons for these differences, but it seems reasonable to assume that a number of contextual factors influence a wide range of outcomes in different parts of the world. This probably includes factors such as geography and topography, weather and climate, pedestrian and biking infrastructure and facilities, general traffic conditions, as well as cultural preferences and views on walking and biking as transport modes.

A seemingly less studied aspect concerns catchment areas by car for stations with park and ride facilities. Hansson et al. (forthcoming) studied car access trips to rural train stations and found that the average distance was 8 km.

2.3. Universal density definitions

Density is another indicator frequently used to define TOD areas. Calthorpe (1993) argued that a lower threshold for residential zones outside of the primary areas should remain in the range of 25–62 units per hectare. Cervero and Dai (2014) use floor-area-ratio (FAR), and argue for 'the wedding cake style' approach to development with high densities directly adjacent to stations, and where building heights systematically taper with distance from BRT corridors.

However when one looks at actual densities achieved in North American TOD neighbourhoods, these are quite low by European standards. For example, Litman (2020) cites 30 residential units per hectare as typical 'mixed medium density' in a North American TOD. Ratner and Goetz (2013) present densities for 'major urban centre' TOD in Denver, USA, at around 24 households per hectare of primarily residential land. Cervero, Ferrell and Murphy (2002) cite typical densities between 43 and 70 dwellings per hectare. In comparison, TOD sites in Europe described by ITDP (2015), all of which lie outside city centres, densities vary between 30 and 100 units per hectare; whilst in the UK, single family detached and semi-detached housing – not normally designed, nor considered to be, public transport-oriented - achieves densities of 20-30 units per hectare. This would suggest that North American TOD may often achieve lower density than standard low to medium density housing in Europe, and that some housing that by European standards is low density could be considered to be of a TOD level of density in North America.

With reference to TOD in areas of differing development densities, Nigro et al., (2019, p.111) write that '… very few studies on land use and public transport integration focus explicitly on geographical contexts characterised by medium or low densities of population and activities…'. A problem with this is that in low density areas (small cities, towns, suburbs, rural areas, and low-density areas in metropolitan areas) access to stations are often made by other modes than walking (e.g. biking, car, other forms of public transport). Therefore, the walkshed approaches to TOD described above are not likely to be relevant in low-density contexts. Nigro et al. (2019) reviewed 24 studies referred to in Kamruzzaman et al. (2014) and Lyu et al. (2016) but could not find any studies that explicitly focused on non-metropolitan contexts, or studies that considered links between transport nodes and wider catchment areas.

2.4. Relational density definitions

As we have seen the TOD literature and the conception of what counts as medium and low densities typically refer to urban and regional land use structures characterising metropolitan areas in North America and Australia. According to Litman (2020), North American city suburbs are developed typically at a density of 10 dwellings per hectare or even less. These are densities that one would find on the edge of villages in Europe.

This contrast is developed by Wandl, (2019) who argue that there are major differences in the development of urban and regional settlement patterns between the US and Europe,

which could be one part of the explanation to why the conceptualisation of TOD in the literature is difficult to adapt to a European context. Wandl (2019) points out that a key difference between Europe and the US is that until recently the population in US suburbs grew at the expense of city centres; while in Europe this conflict between centre and periphery in metropolitan areas has not been as pronounced. Wandl (2019), p. 91 further describe differences the following way:

> In the US the urban pattern is related with sprawl, in the sense of low density, car dependent, monofunctional residential development. In Europe, the urban pattern has followed the form of territories-in-between, mixed open and urban land of varying density, intersected by infrastructure including public transport. In Europe urban development has tended to be less monofunctional with mixed uses, especially at the regional scale.

In other words, TOD, even if it is not called that, is a more typical planning approach across regions in Europe, whereas in North America it marks a very significant departure from typical land use patterns (territories-in-between is a concept developed to better match the prevailing land use structures characterised by being neither fully urban, nor rural).

Wandl (2019) argue that another contrast between North America and Europe is that while many metropolitan areas in Europe have experienced considerable population growth, this growth has been more evenly distributed within the metropolitan areas. While population has increased in many major cities, it has also increased in many small and medium sized cities. Population has also increased both in city centres as well as in more peripheral areas.

On a general level, the patterns described by Wandl (2019) do correspond quite well to the development in Sweden (Statistics Sweden, 2015). However, many rural regions, for instance in the north of Sweden, have experienced decreases in population for several decades (Statistics Sweden, 2018). An important point made by Wandl (2019) is that currently, up to 50 % of Europeans live in small and medium sized cities and what they refer to as ‘territories-in-between’.

One possible consequence of these different development dynamics is that North American and Australasian studies of TOD may generate results that are hard to translate to a European context characterised by different urban and regional structures. One illustration of this is that Nigro et al. (2019), who searched for literature on TOD in DEGURBA[1] class towns and suburbs, could not find many studies. Further, it can

[1] The Degree of urbanisation (DEGURBA) is a classification that indicates the character of an area. The latest update of the classification is based on 2011 population grid and the 2014 Local Administrative Units (LAU) boundaries. The next major update will be based on 2020 Census results. Based on the share of local population living in urban clusters and in urban centres, it classifies Local Administrative Units level 2 (LAU2 or communes) into three types of area: Cities (densely populated areas) Towns and suburbs (intermediate density areas) Rural areas (thinly populated areas). See https://www.eea.europa.eu/data-and-maps/data/external/degree-of-urbanisation-degurba for full details.

probably be argued that many relevant potential case studies of TOD in Sweden would fall under the DEGURBA category *Rural areas*, which means that it is even more unlikely that relevant research has been carried out.

2.5. TOD as a planning concept

There is also a range of conceptualisations of TOD concerning the role it is intended to play in urban and regional planning. One way to describe this range is to distinguish between Transit *Oriented* Development and Transit *Adjacent* Development (TAD). According to Cervero et al. (2002) and Hale (2014), TAD can be defined as a development which lacks functional connectivity to the public transport system due to, for example, the land-use composition, means of station access, or design of development areas. In other words, TAD signifies types of development in proximity to stations but with limited integration of land use- and transport planning.

Ibraeva et al. (2020) notes many similarities between TOD and older ideas and visionary ideals in urban planning, such as the Garden city, or Satellite cities (Howard, 1902), and the Linear city. TOD is also closely linked to more current planning ideals such as Smart growth and New urbanism (Knowles, 2012). A core idea in such ideas about urban planning is to develop walkable and liveable settlements. Moving between different parts of the city is made easy through access to public transport, but at the same time the emphasis on place also means that settlements should be self-contained, and that movement within settlements can be facilitated by non-motorized transport modes.

Calthorpe (1993) proposed that TOD should rest on the principles of a primary area in the immediate proximity of the station where major commercial and employment areas should be located, and where the public space should ensure neighborhood vitality. Cervero and Dai, (2014) also express similar ideas about vertical mixing of uses within buildings. They suggest the location of high rise buildings next to the public transport node, where the first two floors of buildings are for retail use, above the retail facilities office spaces are built, and on top of the office spaces housing units are provided.

Calthorpe's (1993) ideas of a primary area also include a residential zone with high densities close to stations, and then a successive decrease in densities towards the perimeter of the primary area. In the secondary TOD area, which according to Calthorpe should be no more than one US mile (1,6 km) from the core zone, low-density housing, park areas, schools and other facilities for local community could be located. The street network should facilitate easy access between the primary and secondary TOD areas, especially by bicycle, and the stations should have park-and-ride lots. In addition Cervero and Kockelman (1997) also emphasise the importance of street and neighbourhood level designs that contribute to 'de-generate' car trips and the need to have access to a car in order to maintain accessibility to jobs and other societal functions. Such design features could include placing car parks at the rear of retail facilities, while the main entrance is only accessible for pedestrians and cyclists, and to make sure that bike lanes and pedestrian walkways feel safe and have sufficient weather proofing (e.g. shade, or protection from rain and wind).

Common to all the authors discussed above is that they approach TOD as a planning concept applied to ramp up the three Ds (density, diversity and design) at a local level, and at individual development sites typically situated in an urban, or metropolitan context. Another approach is to highlight the regional importance of TOD, describing it as 'an approach to station area projects which reaches further than single-locations, and aims at the re-centering of entire urban regions around transport by rail and away from the car' (Bertolini et al. 2012, p. 335). As Staricco and Brovarone (2018) point out, such regional approaches to TOD are bound to include station areas in minor suburbs, small towns or in rural areas where the principles for local TOD outlined above may be less relevant because of lower densities – that is, at least if the ideals of the three Ds are considered as undivisible and as a package concept. It is for instance unlikely that ideas about pedestrian oriented vertically mixed, high density developments are suitable for rural area stations. On the other hand design features as station accessibility by bike, and park and ride facilities may be highly relevant in such contexts.

Authors such as Mees (2010) and Dodson et al. (2011), have argued that the role of urban density is often overestimated in explaining differences in public transport use. Their work shows that cities with similar levels of density display very different levels of public transport use. They argue that the specificities of urban structures, and the relative attractiveness of public transport is not considered enough. This argument is clearly relevant to TOD. The detailed design of the public transport system, and the quality and level of accessibility provided by public transport in a TOD are essential to its effectiveness.

2.6. Transit-oriented Development as an a spatial strategy for economic development

Besides being a concept for creating more sustainable and livable urban environments, TOD is also seen as a spatial planning strategy for promoting economic development, at two geographic scales, according to the literature. At the regional scale, the economic potential of TOD is expressed in national and regional spatial development policies promoting the formation of polycentric, and public transport-oriented, city-regions. By concentrating jobs and economic activities around public transport nodes, which are linked to form integrated urban systems, TOD is seen as a crucial building block for shaping high performing urban agglomeration economies (eg. Hall and Pain, 2006; Salat and Ollivier, 2017).

At the local scale, the economic development potential of TOD is reflected in policies advocating the development of station areas to create attractive urban neighborhoods as places to live, work, consume, as well as invest in. Such policies have generated many initiatives for station area developments across Europe, especially those with inter-urban high-speed links, which are regarded as important for both local and regional economic development (Bertolini et al., 2012). One explanation for this is that in a globalizing and increasingly 'footloose' economy, firms, individuals and households do not locate in spatially diffused, but in spatially selective, patterns. In a world of increasing spatial mobility, transportation nodes become strategic locations since these are "the places

where the still much valued ‘face to face’ exchanges of the knowledge economy and ‘shoulder to shoulder’ experiences of the leisure economy” takes place (Bertolini et al., 2012, p. 34). Thus, while car-oriented suburbanisation was central to 20th Century industrial economy, TOD is seen as an urban development concept more suited to post-industrial, service-based economies.

It is much more typical both in the professional and the scientific literature to see TOD related to rail based than bus based public transport, but this may be the result of the discourse around rail based public transport (including tram/Light Rail) rather than because rail is necessarily more effective at attracting trips from car. There is a literature covering the political tendency to choose Light Rail options before Bus Rapid Transit options due to the perceived greater potential of Light Rail to contribute to boost local and regional economies through branding and place making (Ferbrache and Knowles, 2017; Olesen, 2014; Olesen and Lassen, 2016). There is also some research which suggest that the political preference for Light Rail has led to overestimations of the socio-economic benefits of Light Rail (Bottoms, 2003; Pickrell, 1992). This may help to explain why TOD is so much more identified with rail-based than bus-based public transport.

2.7. Summary

As a planning and development concept, TOD firstly aim to both reduce the need for transport, and to increase the modal shares of public transport, cycling and walking at the expense of transportation by car. Secondly, TOD seeks to generate more livable neighbourhoods with high urban design quality. Thirdly, TOD is understood to be a driver of, or even a tool, for economic development.

Overall, then, the definition from Thomas and Bertolini, 2017: p. 140 (see section 2.1) appears to summarise how most authors in the literature define TOD, although there are a smaller number of authors who take a more context-specific approach to its definition.

This review also illustrates that there is a lack of studies that try to define TOD in low density or semi-rural contexts – this may be because most TOD studies are from North America and Australasia where in such contexts high quality walking infrastructure, which is fundamental to station-focused TOD, and high quality rural public transport, are much less common than compared to many European countries. Nor are there studies that explicitly focus on non-metropolitan contexts, or studies that considered links between transport nodes and wider catchment areas.

In addition, our review of the literature makes it clear that the majority of studies relate to rail based public transport, with few bus-based examples. Where bus-based TOD is discussed, it is usually in the form of Bus Rapid Transit (BRT).

3. Lessons for Delivering Transit-Oriented Development

An important prerequisite for TOD is that the delivery of TOD requires the involvement of many actors: national and/or regional public transport authorities, organisations involved in land development around transport infrastructure, e.g., private developers, local authorities, and private companies contracted to provide transit services. This complex set of relationships can make TOD challenging because of organizational fragmentation between regional and local authorities on the one hand, and between public sector actors and private sector actors on the other (see e.g. Curtis, 2012; Hakaart and Morrissey, 2014; Hrelja, 2015; Pettersson and Frisk, 2016). In what follows, we will first describe what previous research has to say about what characterizes 'successful' TOD processes and actor relations in TOD planning and delivery. We will then discuss the role of private sector companies in particular. The motivation for this is that the logics of economic development strongly influence property development and therefore the shape and location of urban development. Any research in this topic area must, therefore, consider the role and motivations of property developers in relation to that of regional and local government.

3.1. What characterizes TOD processes?

There are several papers focusing on the local scale and the '*processual dimensions*' underlying TOD projects at the local scale, the obstacles and levers to TOD, particularly with regard to governance at the local level. The latter are regularly mentioned in various studies but are claimed by, for example, Scherrer (2019) to be generally under-documented, particularly in terms of *procedural dimensions and the instruments it entails*: 'In fact, research on TOD has rarely examined the connection between how the project is carried out (the actors and the processes involved) at different stages (from planning to implementation) and local urban planning (professional practice and urbanism)' according to Scherrer (2019). Understanding TOD implementation processes in general requires, according to Scherrer (2019, p. 478), 'an in-depth analysis of every stage of a given project: the collective construction of problems and challenges to overcome (their content and evolution throughout the project); problem-solving methods put forth by the system of actors/stakeholders involved (mobilized, existing or new processes and instruments); final urban planning choices (inter-scale and intersectoral conciliation of challenges) and their substantive (change in urban forms) and procedural (collective learning) effects'. A 'successful' TOD process could then be said to foster 'TOD implementation through a well-integrated urban project that is as best adapted to the context as possible' (Scherrer 2019).

In several studies of TOD implementation processes, and of factors acting as barriers, researchers such as Thomas *et al* (2018) refer to these as either formal or informal factors or *institutions*. For example, Scherrer 2019 makes a distinction between 'barriers encountered during projects of a formal nature (related to institutions and the legal frameworks of urban actions) and those of an informal nature (related to lifestyle, experiences, or the opinions of stakeholders)', while Tan, Tan et al. 2014a, in an analysis of cases of successful TOD implementation, hypothesize that a deliberate shift occurred in the *institutional* context through the introduction of incentives to overcome implementation barriers. They developed a conceptual model 'proposing the relationship between formal and informal barriers in a vicious cycle as well as the lifting of those barriers through a virtuous cycle of mutually reinforcing formal and informal incentives is applied'. Building on North (1995), Tan et al. (2014a, p.35) define formal barriers as factors that 'allude to the efficiency and competency of regulatory and legislative frameworks, availability and distribution of funding as well as physical and technical blockages experienced. Informal barriers are those caused by political and cultural, and institutional and territorial deterrents. Informal barriers deal with issues of framing, perception, politics, acceptability and awareness within the planning profession'.

Institutional change has, according to Tan et al. (2014b), to do with the use of formal incentives (measures within formal institutions targeting barriers through enforcement or remunerations, such as: financial compensation, legal instruments and organisational restructuring. Informal incentives are measures that inspire stakeholders to overcome barriers with the promise of social or moral rewards) that shift planning processes from a vicious to a virtuous cycle. Thomas and Bertolini (2017) define critical success factors in TOD implementation as political stability at the national level, relationships between actors in the region, interdisciplinary teams used to implement TOD, and public participation. Several of the success factors can be said to be 'informal institutional' factors. For example, when it comes to actor relationships Thomas and Bertolini (2017) conclude that very good relationships between municipal actors, at a regional scale, and actors willing to experiment with new policies, practices, and tools are important success factors. Finally, Thomas and Bertolini (2014), in a Dutch case study, find "that land use and transportation planners seem to be familiar with TOD concepts and ideas, but less familiar with 'softer' transferable lessons that consistently play a role in successful TOD implementation, such as good actor relationships, the support of the national government, the need for a multi-disciplinary approach and active public engagement".

This short review shows how the concept institutions is used in previous TOD research to analyse implementation processes and how formal and informal arenas influence how a TOD project is carried out (the actors and the processes involved) at different stages (from planning to implementation). Judging by previous research, there is a research gap, about the '*processual dimensions*' underlying TOD projects at the local scale, the obstacles and levers to TOD implementation, particularly with regard to governance at the local level. Previous research also indicates a particular need to understand the *informal* institutional success factors better, and the implications of the *interactions* between formal and informal institutions for the TOD implementation processes.

The formal institutional factors which in previous research have been reported to be of significance, such as legal frameworks, should be of potential importance for any TOD

implementation processes within a specific country. On the other hand, it can be assumed that the importance of the informal factors will differ between different TOD projects. The informal institutional factors that have been claimed to be significant in the success or failure of TOD, such as the collective construction of problems, relationships between actors in the region, interdisciplinary teams used to implement TOD, public participation, actors' willingness to experiment with new policies, practices etc. are all context dependent. Additionally, as already said, the interaction of formal and informal institutional factors is, judging by previous research, of importance to how well TOD implementation processes work.

3.2. Market factors and market actors

Property developers and investors constitute, as already mentioned, a category of key actors involved in the planning and implementation of TOD. The role they take differs across geographical contexts. In countries where urban development is more steered by market forces and private sector actors, for instance Japan, developers and investors take a more leading role than in countries such as, for example, Singapore, where government planning largely determines conditions for urban development (Bertolini et al., 2012; Chorus, 2009).

3.2.1. Developer perceptions of and attitudes to TOD

There are a number of publications which discuss developer attitudes to, involvement in and experience of TOD, based on experience in Australia, Canada and the US. The key findings of these publications are as follows:

Developers often perceive TOD to be expensive and risky. The expense comes from the need to create higher quality urban environments and to build at higher densities. Vertical mixed-use development especially entails higher development costs, this is because vertical mixed-use development requires unique solutions for which standard cost models are more difficult to apply (Venner and Ecola, 2007). The risk comes from the complexities and interdependencies of the relationships that are required for TOD to function (James, 2009; Feldman et al., 2012; Utter, 2009).

Developers perceive TOD to be something of a niche market, and not of mass appeal to investors and the public. They perceive the market for TOD to be limited largely to those sectors of the public who seek a more vibrant local neighbourhood than a conventional suburban life; and for those who live in subsidized housing and who therefore, for income reasons, depend more on public transport (Guthrie and Fan, 2016; Feldman et al., 2012). However, over recent years consumer interest of TOD has grown, and there is a subsequent growing interest for TOD among developers too in the US (Loukaitou-Sideris, 2010; Venner and Ecola, 2007).

Developers perceive and/or experience a great number of barriers to the implementation of TOD. It is not clear from the articles reviewed to what extent these barriers are only perceived rather than actually experienced; and which of the barriers are

the most important. Renne (2009, p. 267) lists a number of obstacles to developers' willingness to engage in TOD: "1) A back door location; 2) Missing density gradients; 3) Inaccessible station locations; 4) Pedestrian unfriendly station locations; 5) Lack of an urban design framework for the station area; 6) Landscape of deprivation and the 'broken window syndrome'; 7) High land costs (land cost paradox); 8) Regulatory barriers; 9) Lack of institutional commitment: 10) Absence of critical mass; 11) Lack of community involvement and participation". Many of these are echoed by Pojani and Stead (2014) in the Dutch context. Meanwhile, Utter (2009) adds the uncertainty of the long term planning system and the difficulty of land acquisition to this list of barriers; and Guthrie and Fan (2014) note the lack of good public transport access as a significant barrier. In the US context, TOD developers have experienced significant financial obstacles, since loans for TOD are more difficult to attain, and interest rates are usually higher for TOD projects than for conventional suburban development projects (Venner and Ecola, 2007).

How developers believe barriers can be overcome and their risks reduced. Previous research posits a number of possible ways to overcome the barriers listed previously, although it is not clear whether these suggestions are those of developers, of the authors themselves, or a mixture of the two. Suggestions include:

- a public-private funding mechanism is key to 'make TOD happen' (James, 2009; Newman, 2009).
- relaxations of statutory planning law may be needed, that is, the privatisation of land-use regulation (James, 2009). However, he also proposes that TOD can be more effectively implemented if the public transport infrastructure planner takes on the role of property developer (as in Japan or in London before WW2).
- Guthrie and Fan (2016) noted that government incentives such as density bonuses and funding were key factors contributing to the delivery of affordable housing in TOD.

Feldman et al. (2014) produced an extensive paper on developer attitudes to TOD in the Montreal region in Canada, and these amplify the points made in the review above, so their results are presented here in more detail. Studies in the US suggest that there is a latent demand for TOD, which is hindered by supply-side barriers. This is the first study on supply-side factors conducted in Canada. Looking at the Montreal metropolitan region two obstacles relating to the regional spatial policy were identified: 1) suburban municipalities possibilities to ask for an exception from restrictions to build on greenfield land, 2) the tendency of the regional transit authority 'to view suburban train stations as opportunities for park-and-ride lots rather than integrating development projects creates additional impediments to TOD' (p.30).

The same paper also presents results from an interview study on developer's perceptions on the conditions for TOD. The authors depart the types of supply-side barriers - fiscal/financial, political, organizational and structural - that Cervero et al. (2002) identified. To these, the authors add another category: regulatory barriers. The authors did not find significant organizational barriers.

Regarding regulatory barriers, they did not identify any specific to TOD. Nevertheless, developers expressed frustration with governmental regulation of development. The authors argue that developers generally wish to work with as little regulation as possible.

Thus it is ‘difficult to distinguish [developers'] complaints of abusive use of regulation from complaints resulting from a simple desire to escape all forms of regulation’ (p. 33). The interview results suggest that developers mostly had an understanding of the necessity of regulatory measures, for instance, environmental impact assessments, but wished for speedier processes.

Regarding financial barriers to developers’ engagement in TOD, interviewees generally observed that developers who engage in TOD are ”very healthy financially” and also well equipped to plan for TOD projects. Small developers rarely have the financial independence required to engage in TOD. Among political barriers, public opposition was identified as a major obstacle, but this factor was not unique to TOD, rather affecting all types of development. The developers saw that if the municipality and the developer worked together to communicate a common vision, then public objection would be less of a barrier. Political will was seen as especially crucial for the success of more innovative projects such as TOD.

Of all supply-side barriers, the structural barriers were regarded as the most significant. Three structural barriers were identified: ”land scarcity; absence of good sites near transport; and poor supply of transit”. Regarding land scarcity, in the Montreal region, most land outside the protected agricultural zone was understood to have environmental constraints. Developers thought that few suburban sites near transit were of 'good quality' and available for development or redevelopment. High land prices and soil contamination near transit nodes were also identified as barriers. Limited opportunity to increase the capacity of existing infrastructure in some places was also regarded as a barrier. The authors conclude that, despite perceived land scarcity, the pressure for densification and thus TOD is relatively low.

One further barrier, which the authors found to be fundamental, was a general lack, among developers, of understanding of the TOD concept. One reason for this could be that they have not been ‘previously exposed to the concept by another actor, such as a municipal planning department’ (p. 37). This came to expression also through the general inability of the developers to reflect on availability of development land around transit stations. The study also ‘revealed a few attributes that distinguish the type of developer that can create a TOD: vision, willingness to take risks, patience, and ability to work in partnership with the municipality’ (p. 38) – but the authors did not encounter many instances of developers with these characteristics.

The authors finally emphasise that the public sector needs to address the three top structural barriers, but the ‘willingness to intervene directly to address these top three barriers is not currently apparent, despite the promotion of the TOD concept in various municipal and regional planning documents’ (p. 40).

3.2.2. Lender attitudes to TOD

The investors, i.e. the lenders, who fund the developers who build TOD are a group of actors whose attitudes are extremely important for its success, but who may have different perceptions from developers themselves. In their overview of lenders attitudes towards TOD, Venner and Ecola (2007) found that lenders showed more scepticism towards

lending to TOD compared to conventional suburban development. They argue that this may be partly due to lenders' lack of experience with lending to TOD. However, one more tangible reason that they found was that lenders saw more difficulties in underwriting[2] and trading "TOD products" on the secondary market. Actors trading loans for real estate products on the secondary market strongly favour product standardization and product conformity. TOD products were often understood as unique, or non-conforming, products and this affects how they are underwritten. Loans for TOD development projects may - due to the unique design, unique land-use mix, and more complex construction processes - be viewed as more difficult to sell on the secondary market. This, in turn, may be a factor which makes lenders reluctant to accept loans for TOD. Venner and Ecola also found that vertical land-use mix was regarded more difficult than horizontal land use mix by lenders. Horizontal land use mix, which allows every project to be traded separately, was found to be conforming with existing underwriting standards while vertical land use mixing was not. The authors also found that developers are increasingly required to adopt cost and risk management systems which can be subject to bank oversight. These systems may contribute to better risk control which improves chances of attaining loans. They also note that investors have noted that TOD has become more valuable among consumers and this may be a factor which change their attitudes towards TOD.

Pojani and Stead (2014) note that the investment climate for TOD in the Netherlands changed markedly after the 2008 financial crisis, but development in more accessible locations remained more desirable and commanded higher rents than in less accessible locations. They also argue that investment in TOD after 2008 became less strategic and more small scale than it had been in the previous decade. Many authors note that the relatively risky nature of TOD, as something unusual, may deter investors.

3.3. Demand for TOD

Does TOD just add to the total development in a municipality and in other parts of the municipality, low density sprawl continues; or does TOD really substitute for that low density sprawl? The limited evidence on this question indicates that development that is badged as TOD is sufficiently 'niche' in most contexts that its region wide impacts are negligible and that it adds to rather than substituting for development, except in Southeast Asian cities and unusual cities such as Stockholm that have pursued TOD for many years with strong framework conditions supporting it. This would suggest that in many regions, demand for TOD forms a small portion of the overall development demand.

Emphasising the relation between demand and supply, Feldman et al. (2012) also identify demand as a supply barrier. Developers displayed a scepticism around the likeliness of baby boomers desiring to leave their suburban homes for denser areas. These perceptions could be indications since 'the subjective perceptions of developers provide a preliminary

[2] Underwriting is the practice of determining whether a borrower, or an investment, is worthy of credit or not.

indication of demand-side factors from the perspective of the sole actors directly involved in both the supply and demand side of real estate development' (p. 38). Importantly, the authors also found that developers emphasised that selling TOD was not simply about selling 'square feet', but selling a particular lifestyle.

Pojani and Stead (2014b) note that in the Netherlands, new suburban TOD office locations like Sloterdijk and Bilmeer in peripheral Amsterdam are not that sought after because they do not provide a mix of uses, in spite of being very accessible from new mainline railway stations that are also local public transport nodes. However, this is partly because people do not want to live in such places so they become mono-functional – the high use of the bike in the Netherlands to access stations means that immediate walking proximity to stations is less important than in other countries. These locations according to the authors become relegated to second-tier back-office type functions.

Noland et al. (2017) interviewed residents of existing New Jersey TOD developments as well as planning professionals and developers involved in their creation. An issue for residents was traffic attracted to the businesses in the area and to the station itself which they perceived as threat to its liveability. They also wanted local shopping opportunities but at the same time admitted that they did not shop enough locally to support those opportunities (driving instead to larger suburban shops) so if there were businesses open to customers at these locations, they tended to be bars and restaurants – in effect, they demanded a liveable walkable neighbourhood to live in, but not necessarily to patronize local businesses.

3.4. Tools for delivering TOD

Hood's (1986) fourfold categorisation of policy tools is used to structure this review. They are: (i) Authority (regulatory tools); (ii) Treasury (fiscal tools); (iii) Nodality (information tools); and (iv) Organisation (agencies, services, amenities or facilities which governments provide directly).

3.4.1. Authority tools

Policy and legal regulation are mechanisms controlled by the public sector through the use of which TOD can be encouraged or mandated. Examples of policy tools include:

Elements (such as policies and standards) within land use plans, at least in some jurisdictions where they are applied with flexibility rather than as codes to be followed to the letter. This means that the plan has a statutory basis in law, but it is not something that must be followed absolutely strictly (as in the UK or Irish planning system, for example). Clearly a land use plan can be of strong support to TOD where it includes policies such as densification in general but especially around public transport nodes, discouragement of development in locations poorly served by public transport, and provision of street networks conducive to cycling, walking and public transport.

Parking standards for new development is another authority tool. It is clear that developments provided with less off-street parking have lower car dependence and higher use of alternative modes (ITDP, 2015). In some jurisdictions, parking standards are policies applied with some flexibility and so they can be made more restrictive to support TOD by effectively freeing up land for development that would otherwise have to be used for parking, and by reducing the build cost of higher density development by reducing the number of parking spaces that have to be built (see Arrington and Cervero, 2008).

However, in some jurisdictions the two examples above are better seen as legal mechanisms, in that some types of land use plan must be followed strictly (a detailed plan for the detailed development of a specific neighbourhood in a German city, for example) and parking standards are defined strictly in law. In these situations it may be problematic to bring about transit-oriented development: the very well-known example of the Freiburg Vauban development has restricted parking supply but the mechanism to deliver this is complex and required committed actors to persevere in having it finally approved at Federal State level (ITDP, 2015).

3.4.2. Fiscal tools (see also section 3.4.5 below)

Clearly government can facilitate TOD by subsidizing it in some way, either directly through payments to agencies or developers, or indirectly through changing taxation or charging regimes or by assuming certain development costs more normally assumed by developers (see for example Dumbaugh, 2004, for a case in which a public transport authority bore the costs of ground rehabilitation and servicing at a TOD site).

3.4.3. Nodality tools

The examples in this section so far are all what North (1990) might refer to as formal institutions in that they are founded in law, and form part of the formal rules of the planning context in which TOD occurs. However, more informal institutions may also constitute examples of the policy tools that can be used to support TOD. For example, non-statutory (advisory) regional plans have no legal basis in many jurisdictions but may nonetheless be developed in order to structure discussion and ultimately consensus between actors about the need for TOD (Renne, 2008; Hess and Lombardi, 2004). Changes in regulatory or legal structures will be increased in their effectiveness if implemented in tandem with awareness raising measures to increase the acceptability of public transport (Tan et al., 2014a). These same authors also point out how the formal and the informal enablers of TOD can be mutually reinforcing.

Informal forums to structure collaboration between the actors involved in TOD (municipalities and regional public transport authorities, for example) are another example of policy tools to encourage and support TOD, as is the creation of a shared understanding that policy should realise TOD, and the reasons for it - what Hrelja (2015, p. 1) calls ‘discourses and rationales concerning transport and the urban development of which public transport forms part’.

Tan et al. (2014b) very usefully categorise policy tools - which they call ‘incentives’ for TOD - into four categories, using three metropolitan areas as empirical examples of these

tools, and demonstrating the mutually reinforcing relationship between the informal and formal. An example of one category is the *Legal – socio-cultural*, which they define as the use of new cultural/behavioural concepts such as the liveable city to change the nature of legal instruments such as statutory land use plans to support TOD. Whilst their typology can be criticised, it supports the informal/formal distinction made by other authors and gives a wide range of examples of policy tools.

3.4.4. Organisation tools

Other policies that might support aspects of TOD are for example those where services are provided more locally to make access to them by cycling, walking and public transport more feasible by keeping travel distances low. Decisions on where to locate new medical facilities can have major ramifications for public transport access and policies *could* be adopted by medical authorities to consider how to locate their new buildings to make them accessible by public transport.

3.4.5. Tools for financing TOD

In the literature, the term value capture (LVC) is often used to describe and discuss the economic benefits of TOD. One is the potential of TOD to reduce household expenditures for transportation. Dittmar and Poticha (2004) argues that since transportation costs constitute a major expenditure in car-dependent cities and regions, TOD could entail substantial economic value capture for households. As Newman (2009) and Chorus (2009) explain, concentrating development around public transport systems instead of around cars as the principal means of transportation contribute to create private wealth since car ownership will be reduced. This, in turn, can generate positive local economic development, since the extra available household wealth can be spent on locally produced goods and services. It should be pointed out that the property value increment generated by improved accessibility may however erase such household gains.

The other is the potential of capturing value from the higher rents and property values, with which (successful) TOD is associated. Results from numerous econometric studies have shown that rents and property prices generally increase in areas where rail-based accessibility is improved (e.g. McMillen and McDonald, 2004; Mohammad et al., 2013; Smith et al., 2010). In the best practice literature, rent and property price premiums which are anticipated to result from the concentration of development and economic activities around public transport nodes and corridors, are generally regarded as a positive feature of TOD (eg. Newman, 2009; Salat and Ollivier, 2017). One reason is that this indicates an effective consumer demand for TOD (Utter, 2009). Another reason is that the expectations of premiums are a critical driver for property developers and investors, who are key deliverers of TOD, to embrace the concept (James, 2009; Renne, 2009).

The issue of value capture raises the question of who are, and who should, be the beneficiaries of property value uplifts associated with TOD. Dittmar and Poticha (2004) take a clear normative standpoint and argue that accruing the value which may be captured through reduced transportation costs to households or the community should be one of the key objectives of TOD.

Partnering between public and private actors to provide for new public transport is becoming increasingly common. The growing popularity of applying LVC to finance new public transport and other transport infrastructure is a part of this development. The literature on land value capture for public transport is extensive. LVC is regarded as a promising mechanism for TOD, since it builds on merging transport planning with regulatory land-use planning, and public landownership, for instance through joint development. General conclusions from this research are:

- Applying LVC to finance public transport creates incentives to develop densely since the revenue from property uplifts will be larger; LVC is unevenly applied
- LVC is best applied in places with strong property markets, i.e. large and growing cities
- The Hong Kong model (Rail Plus Property) is seen as a prime example of how LVC can help delivering TOD successfully
- There is a risk for decision-makers to start manipulating property and land markets
- Joint development requires that arrangements for LVC is made case by case, which increases transaction costs
- There is a risk of suboptimization of land-use mixes due to the incentives to maximize land values

3.5. Barriers to and enablers of TOD

Section 3.1 of the report, above, considered processes as barriers to and enablers of TOD and emphasised the role of formal and informal institutions as the setting for these processes. Here we discuss more concrete examples of barriers and enablers, but these have to be viewed within the institutional context within which they take place, and so the lessons of Section 3.1 should be borne in mind. In addition, Section 3.2 discussed developer attitudes and there is some overlap between those and the barriers and enablers discussed here.

The first major barrier to (but, if supportive, also enabler of) TOD identified by many authors is **governance** (clearly something that is strongly related to institutions, formal and informal). This manifests itself in a number of ways. Dorsey and Mulder (2013) and Mu and de Jong (2016) both highlight the complexity of the actor relations within TOD and the tensions and conflicts that this can cause, slowing the TOD process. They therefore advocate a stronger coordinating governance approach – 'coordinative integration' in the words of Mu and de Jong (2016:55) - to build common understandings of goals and motivations between the actors within a network governance framework.

Other authors, such as Papa (2019) – who considers the Greater London area – and Staricco and Brovarone (2018) – who look at northern Italy, wish to see a more regional approach to planning governance. The former author sees a coordination discontinuity between the strong TOD policies within Greater London, but much weaker ones in the surrounding municipalities, in spite of their being a single travel area. In the Italian case, the authors argue that a regional approach to TOD can facilitate it by being more flexible than a site by site approach, and by stimulating the creation of two way flows along public transport corridors. They also argue that a more flexible collaborative rather than

codified/prescriptive approach to translating the regional policy into action within local plans is most effective, pointing to their Dutch case as one that was more successful than their Italian case. Thomas and Bertolini (2014) also highlight the importance of a regional land use planning organisation as an enabler to TOD.

The importance of a regional approach and strong governance at the city region level is also emphasized by Pojani and Stead (2018) in their study of the history of TOD in Amsterdam, Vienna and Stockholm. They identify these cities' relatively interventionist, social democratic governments over many years as key to their success in TOD. However, the TOD approach did not necessarily spread beyond the city municipality in all these cases - the example of Amsterdam is one where surrounding suburban municipalities took a different approach.

On the other hand weak governance can undermine TOD: Feldman et al. (2012) point to the example in Montreal of how municipalities can apply to take land out of the regional green belt, contributing to sprawl and reducing demand for development near public transport.

A second barrier mentioned by many authors is related to the **availability and nature of sites for TOD** close to public transport nodes. This issue plays out in several ways. Authors note the complexity of assembling sites due to multiple landowners, and the lack of transparency of costs due to this complexity (Papa, 2019; Staricco and Brovarone, 2018). Costs also increase due to the need to decontaminate brownfield land around stations. A more 'straightforward' barrier is the basic lack of suitable sites, something which is highlighted by Feldman et al. (2012) in relation to Montreal and also by Boarnet and Compin (2006) in relation to the San Diego trolley (LRT).The latter point out that in order to make new public transport investment viable it is built in areas that are already at quite high density, by definition therefore in areas with a lack of suitable sites. On the other hand, Hess and Lombardi (2004) argue that new urban rail and light rail is built where there is a corridor available, not necessarily close to higher density land uses, and that therefore the economic case for greater land use densification at stations does not exist, due to the constraints that engineering and land use place on route choice. Finally Feldman et al. (2012) note that the public transport authority may have more focus on finding new park and ride sites at stations rather than facilitating TOD, which further reduces the availability of suitable locations.

Linked to the availability of sites is the issue of **existing land use patterns.** Niles and Nielson (1999a, 1999b) make much of this in the US context, pointing out that, at least at that time, for shopping and leisure land uses in particular, businesses were seeking out large scale low density sites that simply could not be served by public transport. In addition they demonstrate that such sites, by 'virtue' of their low densities, very much limit the walk-in catchment on which TOD depends (in societies with low cycle use). Thus they argue that it is problematic in the North American context for TOD to be any more than a niche land use, simply because there is so much low density development in existence that it locks in car dependence. This point is also echoed by Lee, Choi and Leem (2014), although they use it to then build an argument for improving cycling access to stations in North American cities, in order to widen catchments. Pojani and Stead (2014) also note that the reliance on bicycle rather than walk as a station access mode in the

Netherlands militates against station areas as locations for residential land use (because people can live further from the station but still get there quickly), making them mono-functional and therefore less attractive to higher-end employment uses.

A fourth key barrier is the (perceived) **low quality of public transport**, mentioned by many authors, with Niles and Neilson (1999a, 1999b) as one example. This appears to be less of an issue in the European context although it was seen to occur in the so-called VINEX high density suburban residential locations in the Netherlands, which were designed to be transit-oriented but where, due to lack of coordination between the various authorities responsible, public transport often arrived after the flats had been built (Pojani and Stead, 2014).

3.6. Summary of barriers and enablers to TOD

It should be borne in mind that many of these barriers have been studied primarily in the North American and Australasian context, but those studies from Europe that have looked at barriers to the development of TOD at public transport nodes, on the North American model, have identified similar barriers and enablers. There is an absence of studies on the barriers and enablers to the creation of public transport supportive environments at a broader spatial scale. It should be noted that barriers and enablers to TOD from the developer perspective are also discussed in the section above on developer views, but are summarised here for completeness. An important point regarding barriers is made by Tan et al. (2014a page 657) when they say that 'In the literature, barriers have been presented as independent and context-generic, rather than as interrelated and context-specific, as in our approach, identification and analysis'.

Barriers

- The governance structures for TOD at specific sites are often overly complex, and no one organisation takes the lead. Sometimes the management of TOD sits is in the hands of different private sector organisations (as in the Netherlands, for example).
- A lack of statutory regional planning and sometimes any form of regional planning organisation makes a coordinated regional approach to TOD (and therefore significant impact on regional travel patterns) more difficult to achieve.
- Related to the above, there may sometimes be competition between central and peripheral municipalities in a metropolitan area such as Amsterdam, where peripheral municipalities may wish not to be identified with a land use policy that is seen primarily as that of the central municipality.
- Perception or actual lack of high quality public transport – the public transport service arrives too late at new sites, or is highly radial so does not cater for orbital trips that are an important aspect of regional mobility. This may be compounded by a public transport authority that is not itself that concerned about TOD, preferring to pursue park and ride around suburban stations instead.

In relation to the development industry:

- There is a rather vague definition of TOD concept and therefore poor understanding of it, so it is perceived by many developers as risky (so especially at times of economic crisis they are reluctant to do it).
- This perception of risk is compounded by the multi-party multi-actor context of TOD sites; there are in reality frequently additional development costs as TOD sites are often under complex ownership and on contaminated brownfield land.
- It only appeals, or thought to appeal, to a certain market segment of home renters and owners.
- A real mix of uses is difficult to attract at many sites.

Enablers

In many cases, the enablers of TOD are found to be the converse of the barriers. However, building on this, Pojani and Stead (2018) highlight Stockholm – for example, the area of Vällingby - as a very good example of these TOD enablers working well in concert: strong state intervention, powerful plans, public ownership of land and public development of housing and public transport coordinated by powerful and well resourced local or regional government. In addition, the literature identifies the following as enablers:

- Land use planners and transport planners who understand and talk to each other.
- Powerful national rail operators can in some cases be effective lobbyists for TOD, when they see the business case in terms of value uplift for their landholdings and/or additional passenger revenue.
- Visionary developers.

Finally, Curtis et al. (2009) identify the need for these enablers of TOD to be in place for a long time and for there to be a consistency in policy over many years for the policy to have the greatest chance of success.

3.6.1. Barriers to and enablers of TOD compared to barriers and enablers to planning for higher density and mixed use development well-served by public transport

Earlier in this report when discussing definitions of TOD it was explained that the term is normally used to refer to specific developments in locations close to public transport nodes, especially stations and LRT stops. However, it was also noted that in Europe in particular there is a tradition of attempting to plan land use more generally in a way that supports the use of sustainable modes of transport, by increasing densities and mixing land uses. It is important to reflect on the degree to which the literature shows that the barriers to delivering this type of integrated transport land use planning are similar to those to delivering location-specific TOD. Te Brommelstroet and Bertolini (2010, p 86) summarises the former as follows:

> A wide variety of barriers block such early integration, for example: distinctive budgets, different procedures, weak/contradictory incentives for cooperation, reluctant departmental culture or the lack of efficient management mechanisms... Beside these institutional barriers there are large substantive differences between the domains of land use and transport planning in: planning objects (places vs. networks/flows); tools and instruments (e.g., spatial GIS vs. mathematical transport models); operational modes (holistic visioning vs. optimizing problem solving); and educational carriers [*sic*]. Hence, the two professions speak different professional languages…

Tennoy (2010) sees institutional barriers as factors that block development of a common understanding of integration of land use and transport at early stages in the planning process. Papa et al (2016) note similar barriers in the adoption and use of Accessibility Instruments as a support system for the integration of transport and land use planning, whilst Hrelja (2015) notes that if there is no clear discourse or rationale supporting the integration of land use and transport planning then such integration is unlikely to occur, regardless of the 'steering culture' of the context within integration is attempted. Indeed, many countries face similar problems in achieving integrated public transport and land use planning as a result of fragmented areas of responsibility and conflicting interests among key actors (Hrelja et al. 2020). Therefore, the institutional barriers to TOD and to wider integration of transport and land use planning appear to be very similar, but in addition there are barriers specific to the implementation of TOD such as its vague definition, complex land ownership patterns and securing sufficient public transport service at the specific station/stop.

3.7. Outcomes: What have TOD projects delivered and how have their successes or failures been judged?

3.7.1. Density and modal split outcomes

Research in North America has demonstrated with a reasonable level of certainty that TOD with densities typically 2–5 times higher than standard low density suburban development is associated with very different travel patterns among the people who live and work in the TOD. Litman (2019) summarises this work well, pointing to rates of vehicle trip generation and vehicle kilometres travelled typically a third of those in 'conventional' non-TOD. Public transport ridership is higher in TOD than in conventional suburbs, but the most significant difference is in levels of walking, due to the mix of uses and walkability found in TODs. This is quite well summed-up in the experience of Portland, Oregon, in Table 1, below (from Litman, 2019 – his Table 6).

Table 1. Land Use Impacts on Vehicle Ownership and Travel (Portland 2009)

Land Use Type	Auto Ownership	Daily VMT	Mode Split				
	Per Household	Per Capita	Auto	Walk	Transit	Bike	Other
Good transit/Mixed use	0.93	9.8	58%	27%	12%	1.9%	1.5%
Good transit only	1.50	13.3	74%	15%	7.9%	1.4%	1.1%
Remainder of county	1.74	17.3	82%	10%	3.5%	1.6%	3.7%
Remainder of region	1.93	21.8	87%	6.1%	1.2%	0.8%	4.0%

Arrington and Cervero (2008)'s results also support those of Litman (2019). They note that a commuter living in a TOD area is 2 to 5 times more likely than other commuters in the region to travel by public transport, with public transport mode share for these residents for commute trips varying from 5% to near 50%, depending essentially on the range of job opportunities accessible by public transport for each commuter - thus not only is the fact that they are living in a TOD important, but how well that TOD is linked by public transport to the job and other opportunities available is also critical. Arrington and Cervero also highlight the importance of parking restrictions in the TOD in delivering a less car-based mode share.

Niles and Nelson (1999a) say that at the time of writing their paper (now of course some time ago), there was little evidence that at a regional level TOD investment and planning could be seen to have had any effect on **regional** modal split. They further argued that in order to be judged successful, it has to have an effect on a regional scale by reducing congestion; and it has to be economically beneficial. This implies that a few individual TOD developments here and there is not really a definition of success - a wider approach to TOD is necessary (as exhibited in entire European cities such as Stockholm, Amsterdam and Vienna, as explained by Pojani and Stead (2019). Niles and Nelson (*op cit*) further (p. 3) present this table to set out a number of criteria by which TOD success can be judged at local and regional level:

Table 2. Factors determining the success of TOD (from Niles and Nelson, 1999:3)

Factor	Station-area success	Regional success
Number of TODs (and station areas)		X
Transit quality	X	X
Transit technology		X
Street pattern	X	X
Station-area parking	X	X
Employment and housing density	X	X
Commercial mix	X	X
Retail siting criteria		X
Regional market structure		X
Consumer activity patterns		X
Travel behavior/trip chaining		X
Zoning flexibility		X
Resident reactions	X	X
Housing type preference/life style and life stage		X
Self-selection in residential choice	X	X
Government policies		X

3.7.2. Counteracting sprawl and car-dependency

As noted by Niles and Nielsen, isolated individual TODs will not of themselves counteract sprawl and car-dependency. Although many US urban areas have pursued TOD around their public transport stops and stations over the past 20 years, the scale of this has been insufficient to counteract sprawl at the wider regional level, and it has increased in all areas except Portland, Oregon, as has car use as a proportion of trips. Portland appears to be an exception to the rule for a number of reasons (Sullivan and Yeh, 2014). It pursues TOD at the stops on its extensive light rail network, but probably more importantly it has the most interventionist land use planning system of any US metropolitan region, with limits on where land can be developed, which increases densities. At the same time its state department of transportation has a strong role in the land use planning system, ensuring that all new development is accessible by a range of modes. Thus TOD is just one of a number of measures used to better integrate land use and (public) transport at the city region level in Portland. This appears to have been important also in those European cities with very positive public transport and active travel mode shares, such as Vienna and Stockholm; and also in Canadian cities such as Toronto and, increasingly, Vancouver. The conclusion is that TOD as a site-specific development strategy alone is insufficient to combat sprawl and car dependency at a city region scale; instead, a coordinated package of measures has to be delivered.

In terms of TOD being used to counteract sprawl and increase densities in relation to public transport nodes in more rural areas, the literature review was unable to unearth any relevant publications.

3.7.3. Community outcomes and gentrification risks

Noland et al. (2017) also report their finding that planning professionals view TOD success in many ways: improved quality of life, improved walkability, more sustainable modal split, less household income spent on transport, and reduction in environmental impacts. Several of them, and developers, talked about using TOD to create 'community' in currently suburban locations which in turn would attract the knowledge economy young professionals that they want. They also hope for job creation due to a mix of uses and better accessibility to jobs for those without cars. Also they aspire to increased long term local tax income due to increased population; and reduced servicing costs for things like rubbish collection because people live more densely.

Padeiro et al. (2019) undertook a systematic review of the impacts of TOD on gentrification and found no conclusive evidence that there is an impact – rather, gentrification in TOD sites is context/characteristic specific and not directly related to public transport availability. Lund (2006) surveyed TOD residents to understand what had been important in their decision to move there. Housing quality, price and residential amenity were all more important than access to public transport, and for some in LA region, access to roads was more important than access to public transport. However, public transport use was significantly higher, perhaps unsurprisingly, among those residents who moved there because proximity to public transport was important to them.

On the other hand, a systematic review of the socio-economic characteristics of populations living and working around 600 Light Rail Transit (LRT) stations in 12 US cities found some clear associations between the most 'successful' LRT stations - in terms of jobs and housing density, transit use and mix of uses - and positive socio-economic outcomes, as well as lower car use. For example, at these 'successful' stations, car use was significantly lower, obesity rates lower and household spending on housing and transport (in total) lower than at the majority of stations, located in lower density areas. This study by Appleyard et al. (2019) did not however establish the causality of these relationships, that is, whether the most 'successful' stations were located in areas that already had positive socio-economic outcomes, or whether they caused them - or possibly accentuated - already-existing differences. Similar results were reported by Zuk (2015) on the low levels of new low cost housing close to public transport.

In summary then there is mixed evidence of the effect of TOD (on the North American model at least) on gentrification. Positive socio-economic outcomes are sought by those planning and promoting TOD and it appears that it is associated with these outcomes, but it is less clear as to whether it contributes to improving them.

3.7.4. Economic outcomes

There is clear evidence that land values increase in TOD areas around stations due to their increased accessibility and the greater number of amenities offered in the area (Appleyard, 2019; Higgins and Kanaroglu, 2016, 2018;). It is also clear that buyers and renters in North American TOD areas are willing to pay more to live in an area of greater walkability (Li et al., 2015). Pojani and Stead (2014) also note that local governments in the Netherlands see TOD as a way of maintaining both accessibility and housing

affordability whilst creating economically attractive 'knowledge economy' nodes – Eindhoven and Arnhem/Nijmegen are examples. The combination of accessibility and attractive urban environment found in "successful" TOD lifts land values, but the degree to which this occurs is highly context specific. Appleyard et al., (2019) put only 15% of the more than 600 US LRT stations for which they had data into this category, demonstrating that the label TOD alone is not sufficient to deliver positive economic outcomes.

3.7.5. Summary of outcomes

In summary, success is judged in many different ways, although in general the private development industry will judge TOD success in directly financial terms (increased rent or profit per square metre of development) with some expectation of wider economic development benefits, whilst public sector actors have a very wide set of expectations and outcomes that they seek, which in turn will influence the way in which they participate in the process of TOD planning. There is evidence that the public sector does not fully understand the motivations of their private sector counterparts in relation to TOD.

There is good evidence from North America that TOD focused on public transport nodes results in lower levels of car use, somewhat higher levels of public transport use and much higher levels of walking than in conventional suburban neighbourhoods.

4. Research gaps

The literature review has identified the following research gap related to the research questions presented in Chapter 1:

Research gaps relating to how TOD is definied and conceptualised (research question 1 – 3)

Over time, relational definitions are preferred to universal ones. Most conceptualisations of TOD originate from the US and Australian contexts, and thus need to be adapted when applied in other parts of the world where dense development is more the norm. How this adaptation may be delivered, and how TOD is currently defined by different actors and in different spatial, country and institutional contexts, is not well understood. For example, in cities is densification around public transport nodes key to TOD, while in small towns can TOD be understood as ensuring that development is served by and close to public transport? Furthermore, the literature review reveals that there is a tendency in the TOD literature to view European planning as transit oriented by default. Specific research gaps include the following. The research gaps have been grouped into coherent themes that emerge from the overall list:

Definitions

- There is a lack of studies that look into how TOD may be defined and applied in low density and rural contexts. For instance, there is no research on TOD in smaller towns and suburbs and rural areas.
- Coupled to the point above, it is not clear whether the development industry has a shared definition of TOD nor how aware the industry as a whole is of the concept.

TOD content and site-level design

- Site-level design specifications for TOD are mainly informed by US preferences (because a great deal of research on TOD is done in the US context). Thomas et al. (2018) conclude that it is unlikely that 'made in the USA' TOD design guidelines can be applied in their entirety to other contexts due to cultural differences.
- Also at a practical level, it is not clear whether TOD always includes measures to restrain car use and car ownership in developments - although the available research shows that where these measures are included, car use is lower.
- The vast majority of the literature makes an almost unwritten assumption that TOD has to be served by rail or LRT. There is little literature on BRT and bus.

Research gaps relating to planning processes as well as best practice outcomes (research question 4 – 5):

Processes

- Research has not looked specifically at how particular planning processes have a greater likelihood of producing particular outcomes.
- The 'processual dimensions' underlying TOD projects at the local scale, and the obstacles and levers to TOD implementation, particularly with regard to governance at the local level, have not been researched in detail in the European context outside the Netherlands.
- How different actors' perceptions and expectations of the outcomes of TOD influence their participation in TOD planning processes is little-researched in the literature.

Institutional issues

- There is a need to better understand informal institutional success factors, and the implications of the interactions between formal and informal institutions for the TOD implementation process.
- The literature implies that new formal and/or informal institutions can aid the TOD implementation process but the processes that lead to the formation of such institutions have not been researched.
- The implications of the interactions between formal and informal institutions for the TOD implementation process have not been researched in detail.

Local and regional governance of TOD

- The relationship between major city municipalities' policy and practice on TOD compared to that of the smaller municipalities that border on them has not been extensively researched, yet may be important for securing an effective regional approach to TOD.
- More generally, the role of regional governance in supporting TOD to bring about TOD at a regional level is not well understood.

Research gaps on the role of the private sector in delivering TOD (research question 6):

Land Value Capture and financialization

- Land Value Capture is seen as a very promising tool for TOD, but more research scrutinizing the consequences of applying this model in different contexts is needed.
- So far there is little research which specifically deals with the financialization of public transport in relation to land development.

Property market actors

- Property markets and development sectors work differently in different contexts. The variations between contexts and the multiplicity of actors involved requires an understanding of TOD as diverse; and this also implies the need for a systematic comparison of cases so that general and specific explanations in determining outcomes can be better understood.

- More work is required to understand whether the risks of TOD to developers are so high that it can only be delivered in favourable market conditions?

Public transport as a trigger for new development

- Over recent years there are a number of publications indicating that public transport planning is becoming property-led; more research on this trend is needed.
- Qualitative studies on the role of Light Rail in triggering property development are required.
- What residents and prospective residents think of TOD is not well-researched in the European context.

4.1. Next steps for future research

Clearly this review of the literature has revealed a large number of research gaps, not all of which can be addressed by the research project of which it is a part, due to resource limitations and the original scope of the project, which focuses on early stages in the planning process. As a result of the literature review identifying a lack of TOD related research relating to lower density and more peripheral areas, the research team has decided to make this, as well as TOD planning processes, a focus of the project, since such areas are particularly relevant to the Scandinavian context. The project will proceed to explore these issues in relation to a number of case studies in Sweden and abroad, and using a document review and interview-based method.

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