EVALUATION OF EFFICIENCY OF INFRASTRUCTURE MANAGEMENT AT THE PROVINCIAL LEVEL

Can the way to efficient road-management be found?

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MASTER THESIS BUSINESS ADMINISTRATION

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JUNE 2023

COLOPHON

MANAGEMENT
BMS

DATE
June 2023

PROJECT
Master thesis Business Administration

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ABSTRACT

Introduction
Infrastructural networks enable mobility and movement of people and goods. The management of these networks usually is a responsibility of governments. In the Netherlands this management is executed at all levels of government; the national, the provincial and the local level. Developing and maintaining these networks is a costly endeavor. In the Dutch context these costs are financed through the tax-system.

Problem statement
In this research an attempt is made to measure the efficiency of infrastructural management. The principal-agent theorem is used as a broader framework. In this theorem, it is questioned to what extent a principal is able to control an executing agent; often used in the relation between shareholders and executive boards. In this case, governments are the acting agent on behalf of the people as principal. Management of infrastructural networks is very costly, and the principal should be able to assess whether the agent is acting efficiently. The academic value of this research is in a contribution to the literature on measurement of governmental performance.

Theoretical background
First, a literature study is done in order to find out what ways there are to assess efficiency in the public sector and to what extent this is applicable to infrastructure management. First, the way performance of public sector organization can be measured is researched. Nine methods are found, of which the method where outputs are weighed to costs is found most effective for the aim of this thesis. An advantage of this method is that it uses available indicators, and it focusses on tangible factors. Other methods, for example, use intangible factors such as user-appreciation. Thereafter, the way this method is used in earlier research to infrastructure management will be shown. Several international studies have researched performance of infrastructure management. A common problem in these researches is the availability of data, differences in indicators. Research also show that local circumstances vary too much to make general comparisons; therefore local circumstances should always be taken into consideration. In the literature, a method is found in which the efficiency can be measured in the Dutch context at the local municipal level. In this thesis, this method will be applied to a case study, the province Overijssel.

Methodology
This research uses an elaborated cost function. In an ordinary cost weighed output function, costs are directly related to outputs in order to measure efficiency. In this research, local influencing factors such as soil quality and density are added to this cost function. By using these, an efficiency factor has been found. Based on this data, the province Overijssel is less efficient than the average of all Dutch municipalities. However, when taking the intensity of road usage (i.e. the number of vehicles that use infrastructure on a daily base), the province seems to have lower costs than municipalities.

Conclusion, discussion and recommendations
Based on this research, it can be concluded that efficiency measurement is possible, but that local circumstances (both in fysical circumstances and organizational circumstances vary a lot. A model as used in this research can be used to compare more provinces. Furthermore, the way public expenditure and control is organized in the Netherlands, with detailed accounting principles, makes it possible to create an obligatory measurement framework. By doing so, best practices of managing agencies can be used in order to control agents and to create common good. The available theories on infrastructure management, such as the infrastructural life cycle and Asset Management provide useful frameworks for a general method.

1. INTRODUCTION

Creating and maintaining an infrastructural network is of high importance for economic and societal development and considered one of the pillars for competitiveness by the World Economic Forum (Schwab, 2019). In most cases, such networks are planned, designed and maintained by or under supervision of public authorities such as municipalities, provinces or governments. They do so in order to enhance societal and economic welfare.

Altogether, regional governments in the Netherlands are spending 5 billion euros per year on developing and maintaining a network of roads, canals, bridges, locks and supportive assets. Pressure on this spending is increasing. Firstly because the state of key elements in infrastructure is ageing and therefore deteriorating (Bleijenberg, 2017). The collapse of the Morandi-bridge in Genoa, Italy, in august 2018, can be seen as the worst example of this ageing infrastructure (Calvi et al, 2019). Secondly, changes in demography and climate change (Maring and Blauw, 2017) result in higher costs because existing networks, designed for example for less traffic and less water discharge capacity have to deal with higher traffic flows and to be made suitable for extreme weather conditions. For these reasons and for reasons of good organizational performance, debate on the right allocation of infrastructure spending is very relevant. Comparison of different managing agencies can highlight differences and might lead to insights on effectiveness.

Furthermore, since the funding of this effort lies in public, tax payer money, citizens have an interest in knowing whether management is done in an efficient way. In short, a principal-agent problem is at hand, where the managing agent is found in the civil service, acting on behalf of the principal, which can be found in the regional parliament as elected by the citizens. But the question at hand is whether the principal has insight in how the agent performs (Andersen et al, 2008). This thesis will develop this question for the provincial context.

A first question is what definition of efficiency is being used. This thesis will build further upon research on public sector productivity and comparisons of productivity. In earlier research, when a public agency uses less inputs (usually money) with a comparable output (usually services which are free of charge, such as public safety, infrastructure, schools) then it is generally expected to be more efficient (Atkinson, 2006). Such benchmarks are used to look deeper into the way public agencies are organized. This will be further explained in the theoretical chapter.

A major benchmarking research to control for efficiency in management of infrastructure in the Netherlands was performed by Niaounakis and Van Heezik in 2017. They focused on the spending for infrastructure by decentral authorities in the Netherlands. They took several influencing factors (such as density and soil use) into account in order to compare financial investments with the produced output. This way to compare input to outputs was, based on their analysis of methods, the best option to measure efficiency of infrastructure management. This method is also in line with recent reports by the World Bank (Somani, 2021) and the Organisation for Economic Co-operation and Development (OECD; Dunleavy, 2017) on public sector productivity measurement. This will be further developed in the theoretical chapter.

However, although Niaounakis and Van Heezik aimed to include all decentral authorities (all municipalities and provinces), they were not able to include the twelve Dutch provinces in their research (Niaounakis and Van Heezik, 2017). The reason for this inability was simple: unavailability of data. Despite having Generally Accepted Accounting Principles (in the case of Dutch public agencies this works via the 'Budget and Accountability Decree for provinces and municipalities' (Besluit Begroting en Verantwoording provincies en gemeenten, hereafter BBV)), large differences in accounting exist between provincial organizations. Different provinces appeared to have different ways of managing infrastructure and different accounting methods, which disenabled the authors to research the provinces.

Hereafter, no follow-up research has been published. Therefore, the question of efficiency in spending of infrastructural resources at the provincial level in the Netherlands still remains unanswered. The goal of this thesis is to examine to what extent such measurement is possible at the provincial level, what problems there are with measuring it and how this can be overcome.

The research question for this thesis is the following:
To what extent can efficiency of infrastructural management at the provincial level in the Netherlands be measured?

In order to answer this question, the methodology as designed by Niaounakis and Van Heezik (2017) will be applied to the context of the Dutch province of Overijssel. This involves answering the following subquestions:

- How can efficiency of infrastructural expenditure be defined and measured?
- How does the province Overijssel perform towards the benchmark as given by Niaounakis and Van Heezik (2017)?
- How could provinces organize their (financial) reporting in order to enhance benchmarking?

The first question will be developed in the theoretical chapter, whereafter the methodology will be explained. Thereafter it will be applied to the case study of Overijssel. Together, this will give an impression whether the efficiency of infrastructure management in Overijssel can be measured and how this could be improved and done in other provinces.

Next to this, in 2017 the province of Overijssel got a certification for the ISO 55000 standard of Asset Management. This is becoming the major standard for managing infrastructural agencies. Since the introduction of the ISO standards in 2014, no analysis of its impact has been conducted, despite academic calls to do so and great promises on the benefits of such a system. By attempting to assess this system in Overijssel it might be found whether implementing such a quality system has had an impact on financial performance.

This thesis will contribute to the debate as started in the Netherlands by Niaounakis and Van Heezik (2017) and add the provincial level to the scope. Ultimately, this can lead to an addition in accounting principles for governmental organizations with regard to their spending on infrastructure. This will be beneficial since having a model by which provinces can report on their (financial) performance will enhance the drivers for efficient infrastructure management. Furthermore, it will lead to a greater ability of the principal to control the agent, important for both public and private organizations.

It is expected that small adjustments to the BBV will enable benchmarking of infrastructural spending at the provincial level. This will contribute to greater control by the principal over the agent. Furthermore, the thesis will provide insights into the limitations to current research on all facets of infrastructural spending and the chances that are offered by general accounting principles and methods like ISO 55000 Asset Management.

This introduction will be followed by a literature review chapter where the concepts will be explained based on recent literature. Also, recent empirical studies on infrastructure management will be discussed. Thereafter, a methodological chapter will follow in which the method of measuring efficiency of infrastructure management will be explained. The next chapter will show the results of applying the method to the province of Overijssel. Thereafter, these results will be discussed in order to present a conclusion to the main question. Limitations to the research will be explained. Finally, recommendations for the provincial management, the BBV and future research will be given.

2. THEORETICAL FRAMEWORK

2.1 INFRASTRUCTURE MANAGEMENT

Creating and maintaining an infrastructural network is of high importance for societies. It has an effect on the distribution of wealth through a country and creates abilities for companies and citizens to thrive (Gibson and Rioja, 2017). Unreliable infrastructural networks have a disastrous impact on society (De Bruijne, 2006). In the Netherlands, infrastructural networks are the responsibility of public authorities. At different levels of government, national, provincial and local, authorities take care of a network of roads, waterways and supportive constructions such as bridges and locks. Table 1 shows the size of the infrastructural acreage at the diverse levels in the Netherlands. It shows that the largest part of acreage is under control of local authorities. The acreage of all provinces together is larger than the acreage at the national level.

Table 1: size of infrastructural networks at diverse levels in the Netherlands in 2018

	TOTAL [1]	**LOCAL**[2]	**PROVINCIAL**	**NATIONAL**
	km	km	km	km
ROADS (CBS-1, 2021)	139,587	126,458	7,745	5,384
WATERWAYS (CBS-2, 2021)	6,297	1,484	1,487	2,728

2.1.1 Challenges in managing infrastructure

Managing infrastructure is interdisciplinary in nature (Duivenvoorden et al, 2021). Geological, technical, organizational, financial and engineering aspects all need to be taken into account in integral management. Challenges are as diverse, and also related to recent developments such as climate change, scarcity of resources, circular economy and an increasing pressure on land use due to growing populations and mobility.

Although infrastructure is an interdisciplinary subject to manage, Duivenvoorden et al (2021) show how research to infrastructure is rather sectoral than integral. The authors stipulate how this leads to a knowledge gap on the borders of the sectors. Available research is often focused only on parts, often from an engineering or contracting perspective (Wolters and Van den Berg, 2015). Engineering studies are usually focusing on the design of infrastructure, rather than the management of infrastructure. The studies on contracting focus on a choice within managing infrastructure, mostly manifested in outsourcing such as performance-based contracting (PBC). Little research exists that integrates the diverse aspects of infrastructural management.

2.1.2 Phases in infrastructural management

Giglio et al (2018) use Figure 1 to show the diverse phases of the infrastructure life cycle. In the Planning phase, first thoughts about new infrastructure are articulated and worked out to the first plans. The subsequent Development phase works these plans out to specific plans which are ready to be constructed. Thereafter in the phase of Operation, sometimes called construction phase, the assets are being build. The Maintenance phase is quite clear, in this phase small maintenance is needed in order to keep it functioning. During the lifecycle, usually at least one Preservation phase finds place. During the Preservation phase a construction is almost entirely renewed, as if it was new. Finally, in the Disposal phase, the asset is removed because it is either replaced by new infrastructure of is no longer needed,

Giglio et al argue that the responsibility for infrastructure can be organized differently in different phases. In the Netherlands, the responsibility in all these phases, from planning to disposal, lies at the public authorities. It also entails the responsibility for traffic safety during the operation phase and consecutive maintenance operations.

[1] Total is not the sum of the three levels; there are also roads and waterways in private or unknown property
[2] Local includes infrastructural management of both municipalities and sub-local waterauthorities

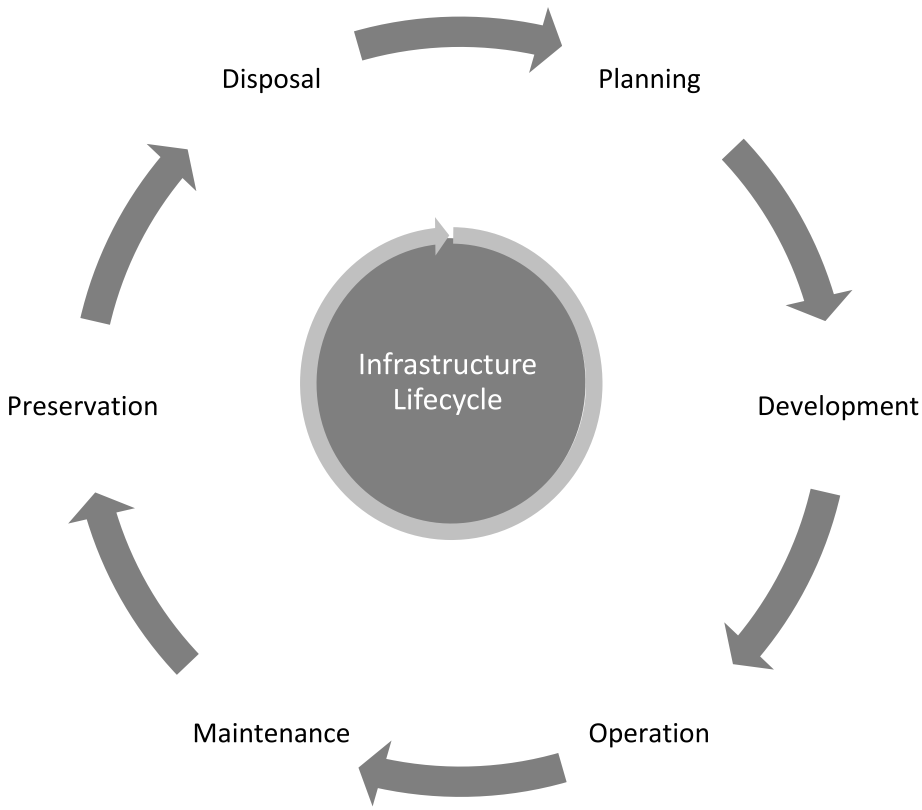

Figure 1: Infrastructure lifecycle (Giglio et al, 2018)

2.1.3 Aspects of infrastructure

Next to a subdivision in phases, infrastructural networks consist of many individual aspects. In public data and in research, it is often simplified to ‘roads’ and ‘waterways’. However, to construct, maintain and operate these, many underlying components or assets are needed. Think of bridges, locks, traffic lights, street lighting, culverts and fauna passages. In this thesis, the simplification in roads and waterways will be used because central databases only provide information at the aggregate level. Table 2 gives an indication of how many of such underlying constructions there are for only Province Overijssel. More than 40 moveable bridges are used for 154 kilometers of waterways and 9 locks are being used to enter these waterways. And to guide the traffic over the intersections in more than 800 kilometers of roads, 89 roundabouts and 50 traffic lights have been created. The number of other constructions is even larger, where constructions smaller than 250cm are not even counted. From this it can be learned that the underlying complexity is much larger than only roads and waterways.

Table 2: Infrastructural assets of Province Overijssel (Overijssel, 2018)

TYPE OF ASSETS PROVINCE OVERIJSSEL 2018	NUMBER/LENGTH
ROADS	818 km
CYCLE ROADS	518 km
ROUNDABOUTS	89
TRAFFIC LIGHTS	50
WATERWAYS	154 km
MOVEABLE BRIDGES	42
LOCKS	9
OTHER CIVIL CONSTRUCTIONS (VIADUCTS, CULVERTS (⌀ >2.5 METER) ETC)	294

2.1.4 Quality levels of infrastructure

At all these asset-types different quality levels can be reached. One might think of the difference in quality of roads in worldwide, as reported by the World Economic Forum, presented at the national level (Schwab, 2019). The parameter in their report for infrastructure quality is based on a survey, with the question "In your country, what is the quality (extensiveness and condition) of road infrastructure?" [1 = extremely poor—among the worst in the world; 7 = extremely good—among the best in the world]. In this research, the Netherlands score a 6.4/7, resulting in a 2nd place after Singapore who score a 6.5/7. To compare, the neighboring countries of the Netherlands, Germany and Belgium, score 5.3 and 4.4 respectively. (Schwab, 2019). Nevertheless, this parameter could be biased by perceptions and expectations. No validation of the survey to more scientific quality standards has been made. Furthermore, the World Economic Forum research is not distinguishable to subnational levels so cannot be of use for the Dutch context.

The societal and physical demands of infrastructure differ per place as well. For example, a pothole, which is an example of deteriorated road-quality, can be considered acceptable by a managing authority and the public in a local road with only a few daily users, whereas one in a major highway with thousands of daily users will be considered as a great danger and unacceptable. This implies that different quality standards can exist for a single managing authority. However, no global standards for infrastructure quality to which agencies could compare exist. At the national level in the Netherlands, the Centre for Rules and Investigation in Water- and Roadmanagement (CROW) publishes guidelines to distinguish quality levels of infrastructural maintenance. For example they provide the influential guideline 'Asphalt in Road- and Waterwayconstruction', 'Qualitycatalogue for Public Space' and 'Standard RAW Procurement' which describe the requirements for asphalt, a standard for measuring quality of public space and demands for procurement in infrastructure respectively. Although most infrastructural authorities use these standards, it is not published to what extent authorities meet the given standards.

2.1.5 Public and/or private

The research on the outsourcing of infrastructure management is based on practices in countries such as Italy and France where infrastructural networks are managed by private road-authorities. There has been a widespread tendency in western countries to outsource government functions (Alonso et al, 2017). Both movements are bringing management of infrastructure closer to regular, private economic activities. Recently, Gelderman et al (2019) performed a case study on the downsides of PBC, exploring the downsides of such a procurement approach. They found that PBC is usually only used for some aspects of investments and maintenance and not for all managerial phases. Therefore, studies on PBC are incomplete regarding the infrastructure lifecycle.

A development in managing infrastructure that tries to bring public and private strengths closer together can be found in research on Public-Private Partnerships (e.g. Engel et al., 2010). However, even with constructions that increase private activity and responsibility, ultimately users look to the governments as the principal responsible authority for infrastructure quality and safety (Engel et al., 2010). For governmental agencies it therefore is important to make sure that infrastructure is operated well in all phases, regardless the division between public and private activities in the infrastructure lifecycle.

2.1.6 Limitations to available research

Duivenvoorden et al (2021) made clear that there is a lack of interdisciplinary research. This single-discipline focus however is not the only difficulty, studies on the management of infrastructure are often also just focusing on just one asset type, such as highways (Rouse et al, 1997). Such type- and discipline focused research is too narrow for the greater infrastructural responsibility of most actors.

The reflection on available research for infrastructure management by Rouse et al (1997) shows how diverse the angles are. Because of this diversity, infrastructural agencies in different countries have developed in different directions. This makes it hard to compare countries and practices. However, the International Organization for Standardization (ISO) made an attempt to create a system of protocols that can be used at diverse infrastructure managing organizations. This resulted in ISO 55000 Asset Management system. Research by MuConsult (2015) shows that most Dutch provinces are implementing Asset Management.

2.2 ASSET MANAGEMENT

The ISO introduced the principles of Asset Management (AMS) in 2014 (ISO, 2014), after working on predecessors the years before. The system is described in three constituent documents which provide overview of the subjects, principles and terminology (ISO 55000), the requirements of an Asset Management system (ISO 55001) and an additional guidance for applying ISO 55001 (ISO 55002). The documents are balancing on the edge of being specific enough to be clear, but leaving room for different organizational circumstances.

2.2.1 Why standardization?

Standardization is believed to have a positive impact on performance of organizations. Chow-Chua et al (2003) designed a research model to investigate the perceived benefits of ISO 9000 certification on the performance of listed firms. Although related to a different set of standards, they conclude that indicators signal a positive relation between performance and ISO 9000 certification. This is in line with earlier research as conducted by Hendricks and Singhal (1997) on the positive relation between organizational performance and implementation of Total Quality Management systems (1997). Since other management systems have proven to have a positive result on the performance of organizations, such a relation will be assumed and investigated for AMS as well. To do so, first the principles of Asset Management will be explained.

2.2.2 Definition

An asset is defined as ‘something that has potential or actual value to an organization’. Value can be seen as tangible or intangible, financial or non-financial. Managing the assets is defined as ‘the set of coordinated activities that an organization uses to realize value from assets.’ When organizations want to follow the guidelines, they find 67 statements in the ISO 55001 which explain what an organization needs to define in order to fulfil the requirements (Hodkiewiez, 2015). The emerging management system is called an Asset Management System (AMS). When the requirements are fulfilled and the system is in function, an organization can apply for ISO certification.

2.2.3 Costs, Risks and Performance

The main aim of Asset Management is to balance between the demanded performance on the right balance of costs and risks (Too, 2012), as shown in Figure 2. Organizations can decide themselves what levels of risks they consider acceptable. They also can use their own performance criteria, as given by stakeholders, shareholders, boards or congresses. Maring and Blauw (2018) explain how Asset Management can be valuable to weigh different options, strategies and combinations of performances and risks given the challenges for managing infrastructure. Based on the available funding organizations can than reflect whether expected costs fit the performance and risk portfolio or that these need to be changed to a different level. This must be presented in a Strategic Asset Management Plan (ISO 55001, 2014).

2.2.4 Life cycle costs

Asset Management is not only focused on the short term but also on the longer term goals by demanding a plan that balances both time-periods (ISO 55001, 2014). In the sphere of public infrastructure managing agencies this means searching for a balance in which maintenance and replacing investments are in perfect balance. For example, resealing the top layer of a road costs only a fraction of entirely restructuring the same road. However, resealing cannot continue forever, so maintenance and replacement must be related. The high value of such a balance is stipulated in research, for example by Gibson and Rioja (2017) in a case study to the effects of maintenance and new investments in Mexico. They found that balancing these in a life-cycle analysis would lead to the highest societal impact.

2.2.5 Efficiency in Asset Management

The ISO norms have the aim of synchronizing management practices in order to increase efficient management. One of the principles in the standard is that an organization has to consider the effectiveness of its AMS. Effectiveness is defined as the degree to which planned activities are executed and planned objectives are reached (ISO 55000, 2014). This demand for an effectiveness check is not necessarily a check for efficiency. Only the fact whether the goal is reached matters for effectiveness. Efficiency, on the other hand, is about the way the goal is reached, about accomplishing the desired result with the least waste of time, efforts or resources.

Asset Management is introducing a way in which effectiveness can be reached without neglecting important aspects such as stakeholder management and compliancy. By doing so, organizations should become more effective. Increasing efficiency is not per se the aim of the ISO standard but for many organizations crucial to stay in business or to remain relevant.

Introducing and implementing ISO standards usually is a costly process but can increase efficiency (Chow-Chua et al, 2003). Therefore Hodkiewiez (2015) recommends both implementing such systems and measuring the impact of doing so. However, only few such studies are available (Hamdan et al, 2018, Duivenvoorden et al, 2021). In the practice of managing agencies, assessing efficiency of Asset Management proves to be a difficult task. Hamdan et al conclude that the research on this topic is still immature. Looking into the Dutch context, Schraven et al (2011) conclude that operationalization of objectives in Asset Management into performance measures is needed to account for efficiency and to prioritize interventions. This however has not yet been done as stated by Duivenvoorden et al (2021).

This lack of research on the most important standard in managing infrastructure leads to a great variety in the implementation due to limited knowledge on best practices. It creates a serious risk for organizations who are implementing a system which is not proven to be efficient. As Hodkiewiez (2015) warns, without such research, Asset Management is often implemented based on perceived benefits. Furthermore, it does not decrease the differences in reporting on resources. Therefore, only limited control on budgets can be exercised and no real comparison of practices is possible. This might lead to a loss of welfare and inefficient allocation of resources.

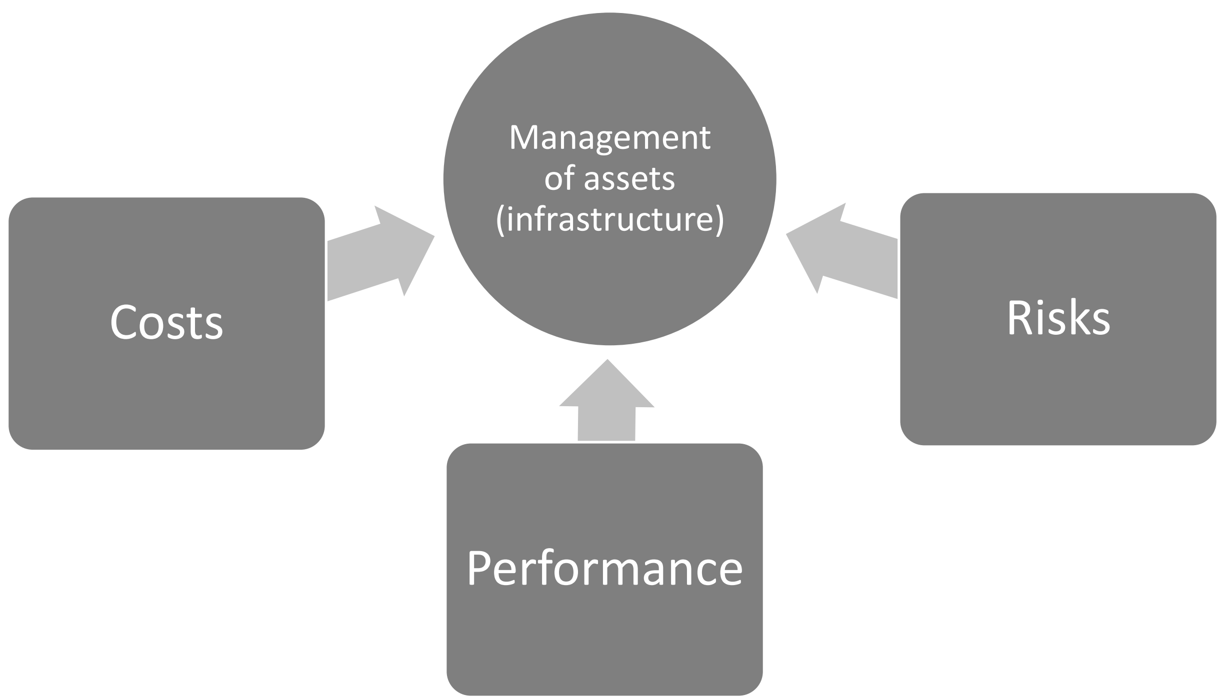

Figure 2: Asset Management explained

2.3 PUBLIC SECTOR MANAGEMENT

Financial management in the public sector is different from financial management in the private sector. Whereas the goal of most private organizations is to make profit, the goal of public organizations is to contribute to societal welfare. Both public and private organizations try to reach their goals by spending the minimum amount of money to achieve these goals. However whereas the supply side of finances in private sector is most often directly related to performance and sales, in the public sector financial supply is most often not so clearly related to outputs. Outputs are seldom clear, there is often a time lag between investments and outputs and for many activities no market transactions take place so no real measurement is possible (Somani, 2021). Budgets are provided by decisions in congresses where debates are dominated not by performance but rather by short term problems. In short, as Hood explains, public management is steered by input control, whereas private management is steered by output control (Hood, 1991). But research has shown that systems which measure public sector performance do have a positive impact on the output and performance of public sector actors (Spekle and Verbeeten, 2014).

2.3.1 New Public Management

An influential line of thinking on increasing output control of public management lies in the school of New Public Management (NPM) (Hood, 1991). This school claimed to offer an all-purpose key to better provision of public services. Hood explained what different aspects where used under the umbrella term of NPM, such as decentralization, privatization, outsourcing, greater competition, introducing private sector management practices and stress on greater discipline and parsimony in resource use. However, he concluded that real results of NPM's promises where not available, also because of different kinds of values playing a role in public management such as resilience of governance and fairness (Hood, 1991).
More recently, Pollitt and Dan (2011), Andrews and Van de Walle (2013) and Alonso et al (2015) also mention the scarceness of empirical assessments of NPM. Alonso et al (2015) argue that this is mainly due to the difficulty of quantifying the impact of measures. On two NPM-related aspects which were measurable, decentralization and outsourcing, they conclude that these had no significant impact on the size of public sector spending. Put otherwise, organizing differently did not lead to lower expenditure. They argue that this can be related to the fact that parts of management cycles (as shown for infrastructure in Figure 1) can be outsourced, but the government remains responsible for other parts. Outsourcing one phase increases pressure on other phases.

Andrews and Van de Walle (2013) researched the impact of NPM in a broad context. They agree with Alonso et al (2015) that the 'high tide of the NPM phenomenon has arguably passed' (Andrews and Van de Walle, 2013), but ask for attention on its continuing influence in governmental practices. More specific, they research how NPM practices are perceived by the public: what citizens' perceptions of efficiency, responsiveness, equity and effectiveness are with a sample of local governments in England. Especially performance measurement is found to have a significant positive effect on citizens perception of efficiency, responsiveness and effectiveness of government. Although citizens perceptions do not necessarily mean that government performance actually is more efficient or effective, citizens perceptions might be a crucial indicator for governments.

2.3.2 Public sector output measurement

Since public perception is influenced by performance management, it is recommendable for governmental agencies to undertake attempts to measure productivity and output. Somani (2021) provided an overview of possibilities to measure output of governments. These are:

1. *Cost-weighed output (based on Atkinson, 2006)*
   Identify activities and define unit costs for each, develop a output measure and calculate total input expenditure. Dividing the cost-weighted output by total input expenditure will provide a productivity metric. The metrics of multiple organizations will lead to an indicator of efficiency.
2. *Service delivery indicators*
   Instead of direct output indicators, proxies related to the output are used. However, many indicators depend on factors outside control of the agencies and make it difficult to distinguish between productivity gains and external sources.
3. *Budget execution rates*

This is a classical measurement of government productivity; when budgets are fully used output is assumed to be high. This however does neither explain quality nor efficiency of expenditure.

4. *Process-, project- and task completion rates*
   The completion of the number of processes, projects and tasks could tell something about output, when all organizations would have the same processes and tasks. For infrastructure this does not hold since agencies are organized in different ways and GAAP for agencies are too abstract to measure completely.
5. *Procurement outcomes*
   When all resources are outsourced, a comparison of procurement prices would lead to useable indicators. This however is not the case for infrastructure.
6. *Staff and user satisfaction*
   User satisfaction can be telling about output and quality (as stated above). The downsize of this measure is complexity and differences in expectations, so, an unconscious bias problem.
7. *Assessment by stakeholders*
   Stakeholders are asked how they perceive performance which can be used to compare performance. However this is not related to the output or inputs and has a bias problem.
8. *Independent observers and process productivity*
   By using standardized requests and comparing different organizations in e.g. speed or quality of responses, a comparison between agencies can be made. As long as requests can be standardized, this can be very insightful with specific data.
9. *Knowledge capacity of public officials.*
   Interviewing and assessing civil servants on knowledge or features of their jurisdiction can make comparison possible.

These nine methods all have different advantages and disadvantages. The main difference is that methods 1 to 3 provide insight at a macro level, related to a whole organization, sector or service, whereas methods 4 to 9 work at a micro level, related to individuals, tasks and processes. Another difference is that methods 1 to 5 focus on quantitative research, whereas 6 to 9 are qualitatively based. Another difference is in the type of data; where methods 1, 3 and 5 look to financial data, 2, 4 and 6-9 use other information sources. And at the qualitative side, methods 7 and 8 use outside-perspectives whereas 6 and 9 use inside-perspectives.

Somani (2021) concludes that pursuing a measurement based on cost-weighed outputs, when possible triangulated with other factors, gives the best impression of productivity. Dunleavy (2017) also concluded that a cost-weighted output method would be preferable to measure performance of a single governmental agency, which than can be compared to other agencies, where underperformers will become visible with a score below the average line. Dunleavy (2017) shows that there are limited large n-studies available in which such approaches have been used.

In the Netherlands such research has been performed, and even in the infrastructural sector, by Niaounakis and Van Heezik (2017). They did not include provinces because of the variety in the way provincial road-maintenance data has been captured. However it is possible to arrange the data for a single province in the way as done by the municipalities. This could lead to an impression of the performance of a province in its infrastructure management compared to at least the municipalities. In this thesis, the input and output of the province of Overijssel will be used as an example. The choice for this province lies in the fact that I have more insight in how this province is organized and what data should be in- and excluded. This will provide insight in the way the data of provinces could be presented to make larger comparisons possible.

2.4 ACCOUNTING PRINCIPLES IN PUBLIC SECTOR

In order to increase transparency and control on spending, organizations have to use generally accepted accounting principles (GAAP). This also holds for public, governmental organizations. For Dutch provinces, the ‘Law on Provinces’ provides in article 190 that a detailed decree should be published on the accounting principles (Staat der Nederlanden, 1992). This takes place in the ‘Budget and Accountability Decree for provinces and municipalities’ (BBV) (Staat der Nederlanden, 2019). The explaining document of this decree positions it as the Dutch public sector counterpart of GAAP.

GAAP and the BBV as its public sector counterpart should enable comparison between organizations. This is explicitly stipulated as a goal in the BBV as well. However, the research of Niaounakis and Van Heezik (2017) shows that the financial management amongst provinces vary too much to enable comparisons. This largely decreases the effectiveness of the BBV as GAAP. The lack of standardization of the strategic annexes for capital maintenance, which are demanded by the BBV, provides a problem because comparisons are hard to make. For these reasons, it would be beneficial to the management of provincial infrastructure if a single model was created in which financial accounting of infrastructure can be administered.

2.5 EMPIRICAL STUDIES ON INFRASTRUCTURE MANAGEMENT

Sections 3.2 and 3.3 discussed influential schools of thinking. Asset Management tries to increase effectiveness. New Public Management tries to make (public) management more accountable, in order to increase efficiency and strengthen the principal to control the agent. Nevertheless, the lack of rigorous and systematic analysis on both approaches is striking. Section 3.4 revealed how the BBV has a goal of increasing transparency. The BBV however failed to do so in the measurement of provincial management of infrastructure (Niaounakis and Van Heezik, 2017).

In order to be able to answer the main question on the efficiency of infrastructural management, it is valuable to know what other research has been published on the efficiency of infrastructure management. Therefore, a literature search has been performed, searching for literature covering ‘efficiency’, ‘infrastructure’ and/or ‘Asset Management’. Table 3 provides an overview of relevant literature. In this table, the type of research, the publications main concepts, conclusion and applicability to this thesis is summarized.

Most studies focus on single-cases. Three studies reflect on a larger number of actors; Rouse (1997), Kalb (2014) and Niaounakis and Van Heezik (2017). Rouse is focusing on the maintenance aspect, which is influenced by managerial decisions and differences in quality levels. The chosen method, DEA, is very interesting since it is a way to find the most efficient producer on a deeper level, as Dunleavy (2017) explains. Nevertheless, DEA cannot be used in this research for three reasons; the first that interesting parameters used, such as quality of pavements, are not available in the Netherlands. The second reason is that also for different parameters, e.g. the ones used by Niaounakis and van Heezik (2017), not all data on expenses and the allocation of spending for all provinces is available. Thirdly, and more fundamentally, more information about efficient methods in infrastructure management is needed in order to find the right frontier in a DEA analysis. Since no previous research on provincial infrastructure management exists, it is not yet possible to construct a good DEA analysis.
The conclusion of this case study for New Zealand is that stable and objective parameters should be developed to increase the strength of the research. Kalb (2014) is trying to discover factors in the way infrastructure is produced and finances that influence efficiency, but here holds the same, that such specified data such as loans and financial constructions is not available. And some of them are not applicable to the Dutch public sector context. Niaounakis and Van Heezik (2017) look to the whole infrastructural lifecycle, but state that more research to differences in local circumstances and organizational standards is needed. This is in line with remarks by Rouse (1997) and advise to triangulate with more performance indicators by Somani (2021).

Table 3: Overview of research to infrastructure management

Research	Type	Main concepts	Conclusion	Applicability
Sadek et al (2003)	Single case study, building a framework to assess which investment would be needed.	Integrated infrastructure management system, condition assessment, prediction, planning.	It is possible to create an integrated management system in which condition is linked to prediction and planning, however only for small urban areas since larger areas are too different to compare.	Since the US-case study is very different in tasks from NL-cases and the quality performance indicators are not available in the Netherlands, it cannot be used in this research. It could be integrated in an Asset Management system.
Li and Sinha (2004)	Single case study, building a framework how to deal with uncertainty in decision making processes in Asset Management.	Performance indicators, multicriteria decision making, highway management	Investment decisions, with risks, certainties and uncertainties can be enriched by making use of trade-off functions based on previous projects. This leads to better project selection	This research creates a model to select projects with the highest impacts, adapted to needs of the public. This however is not the aim of this thesis.
Petchrompo and Parlikad (2019)	Literature review on multi-asset systems (this is not an empirical study).	Asset Management, maintenance, portfolio optimization, multi-criteria decision analysis	Based on a literature review they provide a model to optimize maintenance strategies in multi-asset networks or fleets. In this model, dependencies in systems are connected.	The findings of this article help to optimize the management of a specific agency or asset type, however not to compare among agencies.
Rouse et al (1997)	Data Envelopment Analysis (DEA) using inputs, outputs, outcomes in New Zealand.	DEA, highway maintenance, performance measurement, environmental factors, Professional culture	Output parameters such as 'ride quality' and 'surface condition' are compared to inputs and outputs. This results in a systematic method. But, more consistent and objective methods are needed. Nevertheless, the model as created is promising to be used in different contexts.	The model seems promising to use for measuring performance of Asset Management. However, the outcomes are not yet available for different authorities in the Netherlands. Therefore only the input-output part aspects can be used.
Kalb (2014)	Data envelopment analysis to potential factors influencing efficiency of road management cost efficiency.	Road maintenance, cost-efficiency SFA, DEA	A DEA research enables a comparison between different approaches to infrastructure maintenance. It is found that Grants make investments less efficient, as well as a majority of leftist parliaments.	This research possible when all data is available. This is not yet the case in the Dutch context. Kalb uses parameters to account for the different situations of municipalities, fitting the German context, such as elevation.
Niaounakis and Van Heezik (2017)	Large-n study, empirical study to costs and efficiency of rad management. Regression on cost-output model.	Infrastructure management, cost model, efficiency	There is considerable variation in costs between different municipalities in similar circumstances. This can be related to the efficiency of management.	The context of this research is quite similar to the province of Overijssel. The parameters and data are all available; therefore, this research can be used as a base to build upon.

Deller and Halstead (1994)	Efficiency study of decentral road management with a cost-output model.	Rural road services, cost model, (in)efficiency	A cost-based model shows that managerial inefficiencies can lead to 40% higher costs than necessary, based upon a comparison in market prices. For example increasing scale could enhance efficiency.	Since market prices are assumed to be equal for Dutch agencies, managerial inefficiencies can be measured as well. Deller and Halstead use non-available parameters, so the model by Niaounakis and Van Heezik is more promising to apply in the Dutch provincial context.

2.6 BASIS FOR FURTHER RESEARCH IN THE DUTCH CONTEXT

The research by Niaounakis and Van Heezik (2017) measures and compares efficiency of infrastructure management in the Dutch context. Their research will provide a basis for this thesis. In this paragraph their approach will be explained.

2.6.1 Cost function

They start by using a basic cost function in which the financial resources (the input) are divided by the output. Which results in the following cost equation:

(1) cost function = costs / length of roads.

Based on equation 1, Niaounakis and van Heezik (2017) calculated the average costs for the infrastructural management by Dutch municipalities. All municipalities were included. They used data from the Dutch Central Bureau of Statistics (CBS). This resulted in a costs-curve for infrastructure management, presented below in Figure 3. On the horizontal axis the acreage and on the vertical axis the costs in euro's per kilometer of acreage are shown. The figure shows a short decrease in costs from the smallest acreage, a little over 50 kilometer with costs a little over €11,000.- to the lowest point with an acreage of 125 kilometer with average costs of around €10,500.-, larger acreages result in higher average costs.

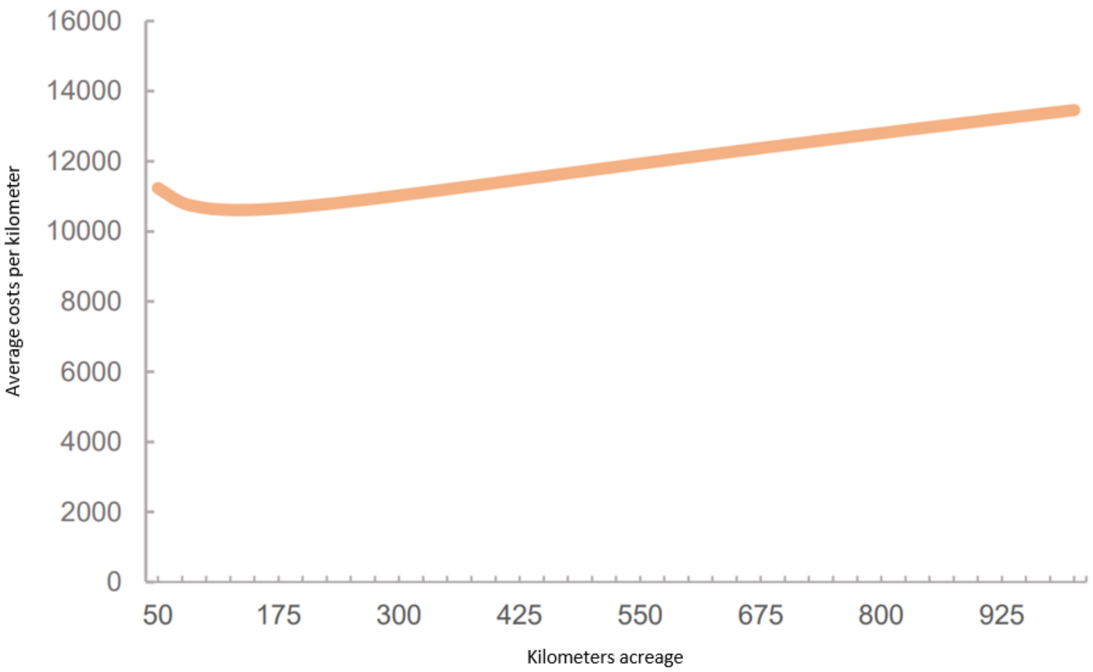

Figure 3: Average costs of infrastructure management per kilometer acreage (year: 2014) (horizontally kilometers acreage, vertically costs in €/km); Niaounakis and van Heezik, 2017)

2.6.2 Efficiency factor

The average costs as such do not say everything, since operational circumstances for different managing agents can vary a lot. Therefore an efficiency factor is calculated. The equation used to calculate this factor is the following:

(2) ln trimmed costs = $\alpha 0$ * (ln output + ½ (output*(ln interactions + ln density + ln intensity + ln surface))

In equation two, the efficiency is shown by $\alpha 0$ in which the output and different characteristics of the acreage of a managing agent is taken into account. The output, triangulated for some influencing factors, is divided by the costs (trimmed for inflation correction). This produces the efficiency factor $\alpha 0$.

By using equation two and, compared to equation one, more data from the Dutch Central Bureau of Statistics (CBS) Niaounakis and van Heezik (2017) were able to calculate the efficiency factors for Dutch municipalities. They found an efficiency factor for Dutch municipalities varying from 0.42 to 1 with an average of 0.78, as shown in Figure 4. An efficiency factor of 1 is considered the most efficient management, a factor close to 0 is considered less efficient; a higher factor indicates higher efficiency. There is no level set as sufficient or insufficient, but having a lower than average factor indicates poorer than average management. Based on Atkinson (2006), a higher factor is expected to be more efficient.

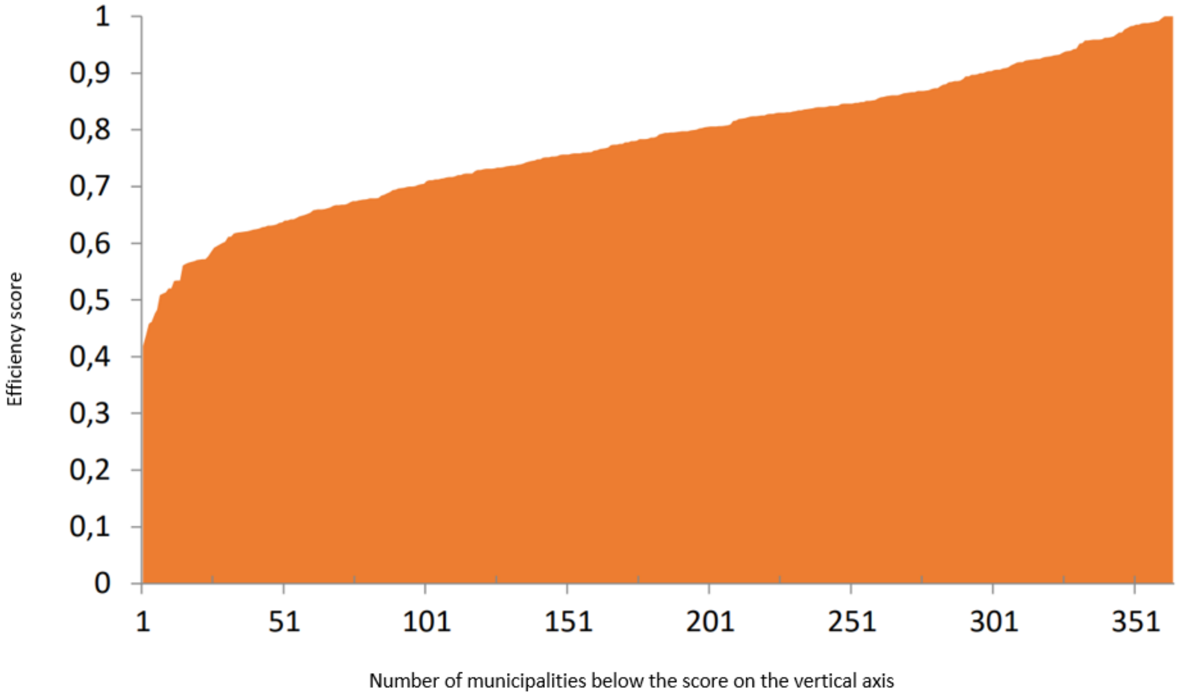

Figure 4: Efficiency factors infrastructure management (average 2008-2014) (Niaounakis and van Heezik, 2017)

3. METHOD

3.1 MEASUREMENT

Subquestion 1 – How can efficiency of infrastructural expenditure be defined and measured?
The first subquestion is about the way the efficiency of infrastructural expenditure can be defined and measured. Public agencies have quite different goals from private organizations and the question on efficiency is related to the aim of an organization. Financial profit is not the key goal of public agencies, and budgets are usually not steered towards gaining a profit but rather to spending resources. Therefore, a returning feature in the research on efficiency of public sector management is the focus on costs. Somani (2021) described such approaches as a cost-weighted output approach, largely based on Atkinson (2006). Dunleavy (2017) also uses cost-weighed approaches to compare measures of productivity at organizational level. Therefore, costs and outputs form the basis of attempts to measure efficiency. Given the differences in roles and circumstances of road authorities internationally, a national benchmark seems more relevant than an international benchmarks.

<u>First step: average costs</u>
Based on Somani (2021), core organizational activities need to be defined, the costs for these need to be found and the cost-weighed output should be divided by total input expenditure. In this, inflation costs should be taken into account.
The research by Niaounakis and Van Heezik (2017) uses a cost-model as shown in equation 3.

(3) Average costs = resources (input) / output

In equation 3, the needed resources for the production is divided by the output resulting in average costs. Average costs for different authorities then can be compared. Related to this research, the cost-function to be used is as given in equation 4.

(4) Average costs = total costs / length of roads.

The outcome of this model has been shown in Figure 3. Niaounakis and Van Heezik (2017) consider this the best way to compare managing agencies. In their research they use it to compare municipalities. They argue that this provides an insight in the efficiency of infrastructure management. They argue that a lower outcome of the cost function shows higher efficiency because the same output (a number of kilometers of road) is produced at different cost levels.

<u>Second step: efficiency model based on a cost-model with influencing factors</u>
The basic expression is further developed to a cost-function. To control for variety in circumstances, the output is related to several influencing factors, using a translog function.
Such a method is used by Niaounakis and Van Heezik (2017) for Dutch municipalities and by Kalb (2014) for the German context, with different influencing factors. In order to be able to compare the output for Overijssel with the outcome of municipalities in the Netherlands, the same influencing factors as used by Niaounakis and Van Heezik (2017) will be used.
In a translog function, many different parameters are included in a production function. Such functions run a risk of collinearity (Pavelescu, 2011). Collinearity means that parameters are closely related, which might influence the outcomes if they are too closely related. Since interactions, density and intensity are related to the amount of inhabitants and to the total surface of the province, Niaounakis and van Heezik decided to reduce this risk by taking the influencing factors for only half the weight into the equation. This reduces the amount to which they influence the outcome; if it would not be done, the same underlying parameter, which effects several influencing factors, would be taken into account more than others which would decrease the insight provided. In this research, this will be followed. For all data the natural logarithm is used. This factor makes a comparison with other actors possible. All variables will be explained in paragraph 3.2.
This led to equation 5:

(5) ln trimmed costs = $\alpha 0$ * (ln output + ½ (output*(ln interactions + ln density + ln intensity + ln surface))

In this equation, the trimmed costs are compared to the output in relation to the influencing factors times the production. This can be seen as the relative production. Since all these parameters van be found, as well as the trimmed costs, these can be related. This way, the efficiency factor $\alpha 0$ can be found by changing the equation:

(6) $\alpha 0$ = ln trimmed costs / (ln output + ½ (output*(ln interactions + ln density + ln intensity + ln surface))

Applying this method to the Overijssel context will lead to an answer to the first subquestion. It is expected to be possible to apply a measurement approach to the provincial context, but that data will be difficult to find. This factor can be calculated as an average but also for each specific year.

Subquestion 2 - How does the province Overijssel perform towards the benchmark as given by Niaounakis and Van Heezik?
The second question can be answered when the two steps for the first subquestion are answered. The method as explained above can be used to compare the infrastructure management of province Overijssel in relation to the performance for municipalities. This will lead to an answer to the second sub-question and partly to the research question.
Furthermore, both methods can be applied to find averages and to specify for years. Since the event of the introduction of Asset Management took place within the province of Overijssel recently, an analysis of the financial performance of the province in the period before and after this introduction can lead to at least a first impression of the potential financial effects of this introduction. Nevertheless, since quality-levels are a core element of Asset Management but since such data is not available, this thesis will only provide a basic insight and not a genuine analysis of the impact of the ISO methodology.

Subquestion 3 - How could provinces organize their (financial) reporting in order to enhance benchmarking?
For answering the last subquestion, the literature review and the lessons learned in answering the first two subquestions will be used. These will provide insights to how provinces could improve their (financial) reporting in order to enhance benchmarking. Recommendations to the BBV will be formulated in order to increase the ease of benchmarking.

3.2 VARIABLES

In this study, several variables are used in this study, which are also followed by Niaounakis and Van Heezik (2017). The variables, are short description, definition and the source to find it are given in table 4.

Table 4: description of variables and sources

Variable	Description	Definition	Datasource	Unit
Costs	The costs made to maintain a network of roads, waterways and supporting assets.	Costs of maintenance	Year reports	Euro's
Trimmed costs	In order to compare costs over several years, the costs have to be trimmed for inflation. The price index for infrastructural works will be used, not the general consumer price index, to trim the costs per year	Change in costs compared to base-year	CBS	Euro's
Outputs	Output of a managing authority, in length of roads and canals combined.	Length of roads plus length of canals	CBS	Kilometers
$\alpha 0$	Alpha0 is the factor that explains differences between organizations in relation to the given parameters. Thisway, it describes the efficiency of an agency	Efficiency factor	Calculated	Numeric value
Influencing factors				
Soil factor	Type of surface matters because different types of soil are more or less suited for constructions. Some soil types result in higher building costs. In this parameter, more difficult types of soil get a higher value.	Usability of surface for constructions	CBS	Numeric value
Interactions	Interactions between roads and canals (leads to higher costs because of needed bridges and locks)	Length of canals divided by land area	CBS	Numeric value
Building density	Building density (more buildings lead to more traffic)	Addresses per km2	CBS	Numeric value
Intensity	Intensity of roads (higher people density leads to more traffic and higher need for infrastructure)	Inhabitants divided by length of roads	CBS	Numeric value

3.3 DATA

The data used in this research are collected from public sources such as the Central Bureau of Statistics (CBS) and year reports of the Province of Overijssel. The Central Bureau for Statistics (CBS) was the first source for the data. Most of the parameters could be found there (see table 5). Nevertheless, not all data could be found there since the CBS only had financial data of the province Overijssel from 2017 onwards. Only the most recent years could be captured that way. The change in data with the CBS is a result from a change in data requirements by the BBV. The BBV is now requiring provinces to publish more specific per year and distinguish between costs made for roads and canals. No further specification to infrastructural phases, assets or quality level are available.

The remaining data therefore had to be found from other sources. The law of provinces states that the cabinet of the provincie ('Gedeputeerde Staten') has to provide financial statements yearly (Law of the Provinces, article 201[3]) and article 80 of the same law states that all information must be made public. Therefore, for all years needed in this research, financial

[3] Article 201 Law of the provinces - https://wetten.overheid.nl/BWBR0005645/2021-01-01#TiteldeelIV

statements are available. These have been found in the yearly reports as provided on the provincial website, www.overijssel.nl.

Although the BBV has changed and therefore more data has become available, it however is still not specified in type of costs as differentiated in the infrastructural life cycle as presented in Figure 1. Neither does it provide insight in quality of infrastructure, nor metrics of usage, accidents, or whatsoever. This makes it impossible to provide for more depth than only a analysis to inputs and general outputs. This fits the approach as presented in the measurement section.

The data used in this study is not confidential, since the province is a public body and all public information is accessible to the public via the Law on Public Transparency (in Dutch: Wet Openbaarheid Bestuur, hereafter WOB). Because of this, all aspects can be measured. Whether content validity is assured is not certain, since other factors might be relevant. But in relation to the research by Niaounakis and van Heezik (2017), content validity is certain since comparable data will be able found.

The data will be checked on validity in SPSS. The output for equation 3 will be calculated in Microsoft Excel. The output for equation 5 will be calculated in SPSS using the translog function.

4. RESULTS & DISCUSSION

4.1 DESCRIPTIVE STATISTICS

The main data for the province Overijssel is shown in table 5 below. The data for the analysis consist of 96 points, based on 8 parameters for 12 years. There are 180 underlying data points, used to calculate some of the influencing factors. All data is valid and there is no missing data.

Table 5: Data

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Costs (mln €)	23.284	19.069	28.498	24.167	24.500	34.522	27.679	32.362	33.153	27.317	24.937	27.304
Costs adjusted with price level (mln €)	23.284	18.941	29.115	25.936	27.117	38.853	31.069	35.359	35.629	30.867	28.718	32.096
Price level	1.00	0.99	1.02	1.07	1.11	1.13	1.12	1.09	1.07	1.13	1.15	1.18
Outputs	987.00	983.00	983.00	985.00	991.00	990.00	986.00	986.00	982.00	981.00	976.00	979.00
Surface (soil)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Interactions	0.0089	0.0090	0.0091	0.0095	0.0097	0.0098	0.0098	0.0102	0.0103	0.0104	0.0104	0.0104
Building density	1,220	1,236	1,244	1,248	1,247	1,245	1,245	1,307	1,316	1,323	1,330	1,342
Intensity of roads	1,305.70	1,322.31	1,335.04	1,340.86	1,342.56	1,336.86	1,340.41	1,347.16	1,348.29	1,359.00	1,364.67	1,377.39

Table 6: Descriptive statistics

Variable	Minimum	Maximum	Mean	Standard deviation	Median	N
Costs (mln €)	19.069	34.522	27.233	0.448	27.3105	12
Costs adjusted with price level	18.941	38.853	29.749	0.555	29.991	
Price level	0.99	1.18	1.088	0.053	1.11	
Outputs	976.00	991.00	984.08	4.337	984	
Surface	1	1	1	0	1	
Interactions	0.0089	0.0104	.00979	.00057	.00981	
Building density	1,220	1,342	1,275.25	44.048	1,247.50	
Intensity of roads	1,305.07	1,377.39	1,343.35	18.79	1,341.71	

Tables 5 and 6 above show the descriptive statistics for the data. The costs vary with 81% over the years, over € 15 mln between the minimum (€ 19.069 mln) and maximum (€ 34.522 mln). When adjusted for changes in the price levels the costs vary even more, with a lower minimum of almost € 19 mln, due to a short decrease in price levels and a maximum of almost € 39 mln; a difference of almost € 20 mln or percentage change of 105%. Other studies do not compare variation in costs over years.

The outputs are relatively stable, changing from 976 km to 991 km, an increase of 1,5%. The surface variable is entirely stable. Interactions are changing, with an increase of 16,9%. Looking to the nature of this number it is understandable with an increase in population. Building density therefore also increases, with 10%, as does intensity of roads, with 5,5%.

Because the two factors costs (adjusted) and outputs are most influential in the cost-weighed output method, these are shown in figure 5 and 6.

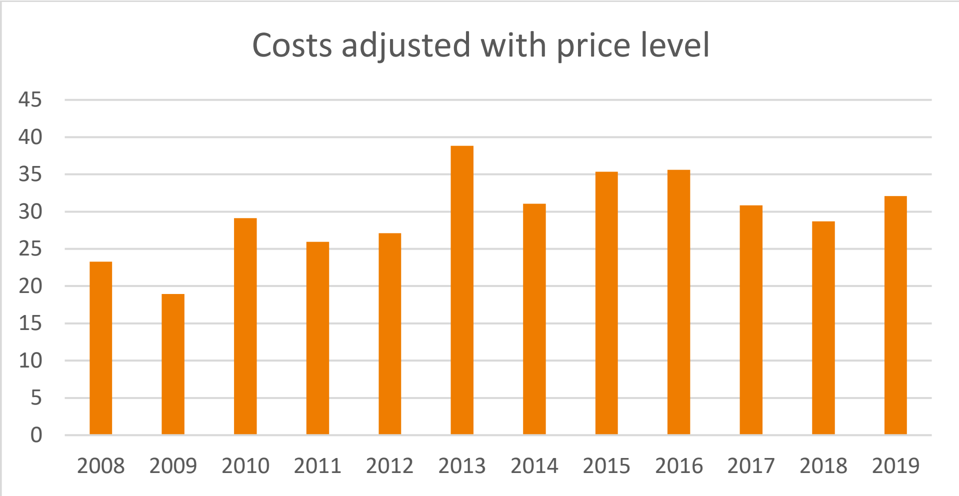

Figure 5 Costs adjusted with price level (in mln €)

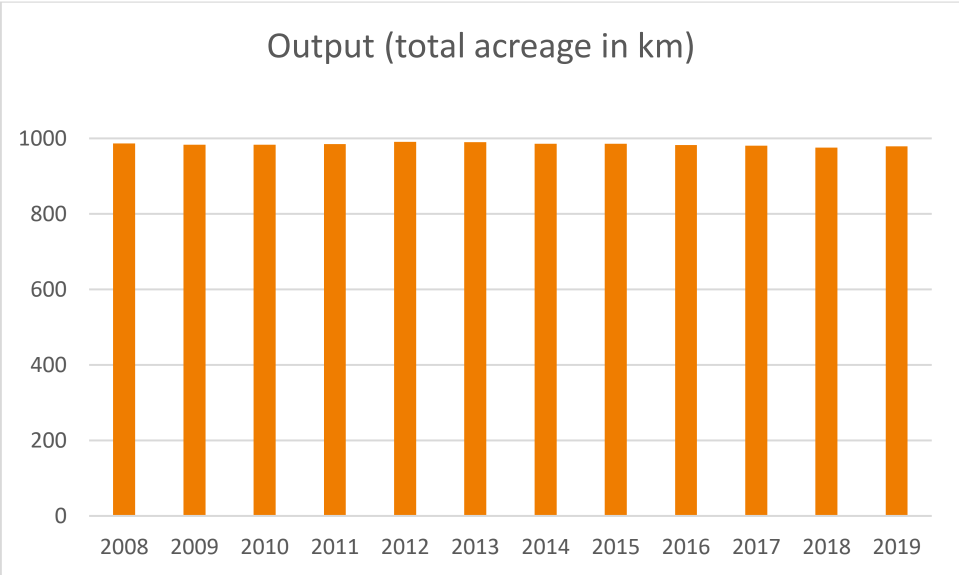

Figure 6 Output (total acreage in km)

4.2 ANALYSIS

First step - average costs per kilometer acreage

Based on this data, the costs per output per year can be calculated. This is calculated with the basic cost expression; average costs = resources (input) / output. Which in this case is calculated as: average costs = costs / length of roads + length of canals. In table 7 the outcome of this calculation is given per year for the absolute numbers (1) and corrected for inflation (2). Table 8 provides the averages over the periods of multiple years as relevant for the central questions in this thesis. In table 8 and thereafter also in table 9 and 10, a split is made between the data from 2008-2014 and 2008-2018, in order to be able to compare to the research by Niaounakis and van Heezik (2017) where only the years 2008-2014 were available.

Table 7: Costs per kilometer acreage

Averages per year		
Year	**Average cost (absolute per year) (1)**	**Average cost (trimmed for inflation per year) (2)**
2008	€ 23,590.68	€ 23,590.68
2009	€ 19,398.78	€ 19,268.39
2010	€ 28,990.84	€ 29,618.73
2011	€ 24,535.03	€ 26,330.72
2012	€ 24,722.50	€ 27,362.77
2013	€ 34,870.71	€ 39,245.82
2014	€ 28,072.01	€ 31,510.25
2015	€ 32,821.50	€ 35,860.98
2016	€ 33,760.69	€ 36,282.03
2017	€ 27,846.08	€ 31,464.61
2018	€ 25,550.20	€ 29,423.76
2019	€ 27,889.68	€ 32,784.44

Table 8: Average costs per kilometer acreage over longer periods

Average over longer periods		
Year	**Average cost (absolute per year) (1)**	**Average cost (trimmed for inflation per year) (2)**
'08-'14	€ 26,311.51	€ 28,132.48
'08-'19	€ 27,670.73	€ 30,228.60

Compared to the average costs for municipalities as shown in Figure 3 (based on Niaounakis and van Heezik, 2017), it is clear that the province has higher costs per kilometer than municipalities. Municipalities with a similar length of roads to manage have an average cost of around €13,000.- whereas Overijssel spends on average, corrected for inflation, €28,132.48, which is more than double the municipal costs. When looking to a longer period, adding the costs per year of the years thereafter, the average increases to €30,228.60 when corrected for inflation.

Intensity of Roads

However, when comparing the relative position of Overijssel in the intensity of the usage of its roads (as shown in table 6), Overijssel scores almost three times higher than the municipal category of 'Very High' as shown in table 9 (Niaounakis and Van Heezik, 2017). Higher intensity leads to faster deterioration and construction standards have to be higher in order to process the larger streams of traffic. Compared to municipalities, this factor does partly explain higher costs per kilometer.

Table 9: Intensity of Roads

Intensity of Roads 2008-2014	Categories
Low	82-132
Average	132-198
High	198-286
Very High	286-473
Overijssel	1377

Building density

Regarding the building density, table 10 shows different categories (Niaounakis and Van Heezik, 2017) and the average density for Overijssel. Overijssel has a score of 1,240.71 as shown in table 6. It fits in the average category for the Netherlands, but is on the low side of this category. This factor does not explain for higher cost.

Table 10: Building density

Building density 2008-2014	Categories
Very low	124-685
Low	685-1,202
Average	1,202-1,828
High	1,828-2,826
Very High	2,826-6,096
Overijssel	1,240.71

Soil quality

No explanation can be found in soil quality, which, as shown in table 6, has a stable value of 1. This is comparable to the very best soil categories in the Netherlands. Based on the soil category, costs would be expected to be lower for Overijssel.

Based on these values, it is not fully explainable why Overijssel has a much higher cost per kilometer acreage.

4.3 EFFICIENCY FACTOR

The step of showing the average costs per kilometer acreage is not all what is needed to make a real comparison. As shown with the comparisons on influencing factors in tables 9 and 10, more factors are at play. Therefore, as explained in chapter 3.1, the translog function with the influencing factors is used in order to find an efficiency factor. This efficiency factor is showing to what extent, related to the specific managing agencies' circumstances, the management is executed in an efficient way. The results of applying the cost function to the data of province Overijssel are given in table 11 below.

Table 11: Efficiency factor (alpha) in Overijssel (municipal data only on average for 2008-2013 available)

Year	α(Overijssel)	α(Municipalities)
Alpha 2008-2014	0.712	0.798
Alpha 2008-2019	0.703	n/a
Alpha 2018-2019	0.686	n/a

Table 11 shows that the efficiency factor for Overijssel over the period 2008-2014. It is lower than the average factor for the Dutch municipalities over the same period. Corrected for all available influencing factors, province Overijssel has a 0.087 lower factor than the municipal benchmark. There is no test on significance of this lower factor available.

Since more years than only 2008-2014 were available, the indicator for efficiency has also been calculated for the following years. When taking the next years into consideration, the efficiency factor of Overijssel is lowering. However, no comparison over those years is available with municipalities since no data is available over those years for municipalities.

As explained in the theoretical framework, the concept of Asset Management has been introduces in the field of managing infrastructural networks with high promises. For the years in which Asset Management was introduced at the province Overijssel, after 2018, the alpha is lower than the previous periods.

4.4 DISCUSSION

In this section, the results will be used to formulate answers to the subquestions.

4.4.1 Subquestion 1: Is it possible to perform a benchmark?

Regarding the first subquestion, it is found that the necessary data to perform a benchmark can be found. The provincial data for financial performance is available in publicly available sources. Since 2017 in an easier way than before because of changes in the reporting demand by the CBS, and earlier data can be found in financial statements and year reports of each province. The available data is complete and statistically acceptable.

Nevertheless, it can be discussed how useful the available data is. Only financial data is not telling the entire story. Niaounakis and van Heezik (2017) used some controlling figures. Other researchers use different parameters, often related to the quality of the delivered output. In the infrastructural sector it is common knowledge that important parameters about the average weight of traffic, incidents and the safety of roads or the quality levels provided result in large fluctuations in costs. For example, noise-cancelling pavements are much more expensive, but result in lower noise disturbance for citizens. Wider roads are safer in use, resulting in less traffic incidents, but more costly to develop. Roads with many heavy freight-trucks are deteriorating much faster, but that is not taken into account. It would be preferable to add such quality-related parameters, but since such data is not yet publicly available for the different provinces in the Netherlands, other parameters than the ones used by Niaounakis and van Heezik (2017) have not been included in this research. This will be developed under 4.5.3.

Another important aspect to mention is that the methods as found in the literature review all put the infrastructural lifecycle (as shown in Figure 1) into only two numbers; the actual acreage and the total amount of spending. The methods available therefore do not differentiate for the various phases in the infrastructural lifecycle. Otto and Ariaratnam refer to the importance of the whole infrastructure lifecycle (Otto and Ariaratnam, 1999). A more thorough method for analyzing, comparing and improving could be developed using different performance indicators related to the various phases in the infrastructural lifecycle.

Using these remarks in building a better model would result in more insightful and more realistic benchmarks.

4.4.2 Subquestion 2: How does Overijssel score on a benchmark?

With reference to the benchmark as given by Niaounakis and Van Heezik (2017) it appears that the provincial spending is less effective than at the municipal level. All municipalities in the Netherlands together have an average effectiveness factor of 0.798, whereas the province has a 0.712 factor (on a scale of 0 to 1). As explained in chapter 2.5, a higher factor indicates higher efficiency. Based on this parameter, the answer to the second subquestion is negative, although no significance test is available.

Nevertheless, it must be said that the provincial acreage is quite different from municipal acreages. The data shows that the intensity of usage is five times higher. Municipalities have many roads with a low intensity for example in a neighborhood, where only residents to the specific road are using that road. Provinces rather have roads with thousands of daily users of which more with heavy trucks than small local roads. That normally results in higher construction costs and faster degradation curves. This explains higher maintenance and replacement costs. Such differences however are not taken into account in the research by Niaounakis and Van Heezik (2017).

It therefore might be interesting to compare the provincial spending in Overijssel with other provinces to find how these relate to the benchmark for municipalities and towards each other. The data needed for such research are not easily available. For one province only it was quite hard to find that data. Next to that, there is the problem that year reports do not specify for various organizational choices. Looking into the grander question of the principal-agent theorem, this is a difficulty to create a set for measurement as advised by Otto and Ariaratnam (1999). Spekle and Verbeeten (2014) show that when performance in public sector is measured, usually increases in output performance become visible. It would be recommendable for managing authorities of infrastructural networks to measure performance in a uniform way in order to enable their principal, the chosen public representatives, to compare performance.

Based on the available data, the effects of introducing the appraised method of Asset Management can be measured. The efficiency factor has dropped from 0.712 over the period ’08-’13 to 0.686 over the period ’18-’19. This might be related to later returns and introduction cost. However, the year reports of the province do not provide information about the lowering efficiency factor. Since the data is only over the first two years of working with Asset Management, it is not a strong indicator. But since all data available could be accepted, it can be said that so far Asset Management has not delivered upon the promise of decreasing costs.

Based on this research it is not possible to make recommendations to the way Overijssel acts as a managing agent for its infrastructural network. A recommendation can be made in the way it reports to its principal, since no declarations are being made on the quality of the management as performed and few parameters on the quality of infrastructure are reported. Such reporting could increase performance (Spekle and Verbeeten, 2014) and would at least increase the ability of the principal to control the agent.

4.4.3 Subquestion 3: How can benchmarking be improved?

So far, this research has shown that it is possible to perform a benchmark and that good techniques are available from literature. Regarding the indicators available, questions can be raised. Firstly in the availability of information. Many parameters as used in international research, are not reported or published in the Dutch context. Secondly, even when parameters are found and used, such as in the research of Rouse et al (1997), the main advice is that better indicators should be developed in order to compare situations. There is a wide freedom in the meaning and measurement of indicators, such as quality indicators as used by Kalb (2014). But also the way infrastructure is managed varies a lot. Some agencies perform many of the tasks in the infrastructural life cycles within their own organization, others outsource tasks. Next to the way tasks are performed, quality demands vary a lot among countries and agencies. This results in difficulties of comparing the one to the other agency. This makes it difficult for the principal to control the agent effectively.

As Rouse et al (1997) conclude, more consistent and objective methods are needed for reliable measurement models. It therefore is useful to come with better indicators. Such indicators should provide more insight in the kinds of tasks performed.

The infrastructural lifecycle, as introduced in Figure 1, could be a useful method to split up costs to different activities. This would result in a better insight which phases of the lifecycle provide for which costs. Since investment costs are much higher in infrastructure than maintenance costs, a good system of amortization to spread costs over the years could be introduced to enable comparisons over years of the infrastructural lifecycle. This would also enable research to the balance between maintenance and replacement investments, as argued by Gibson and Rioja (2017).

Furthermore, more specification about what types of assets are being managed is useful. Moveable assets such as bridges are much more costly than non-moveable assts. Highways with more lanes are more expensive in total than highways with less lanes, but per kilometer they are cheaper. Therefore, the number of lanes, square meters of pavement, length and strength of bridges etcetera would be preferable to find in official reports and statistics as well. The quality of pavements is not publicly available and choices about noise-reduction are not provided. Although some information on traffic incidents can be found via media. These are until now not provided for by the agents themselves or via the CBS. More quality indicators, on the premise of equal measurement, would enable more in-depth research and more analysis.

The broad available literature on quality of infrastructural constructions is not yet used in relation to the principal-agent debate. There is a simple way in the Netherlands to create such a framework in which more data could be demanded from the managing agencies. If such indicators would be demanded by the BBV, all provinces would be obliged to provide this data to the public. This would ultimately increase the ease of all principals to control the agent.

5. CONCLUSION

With regard to the central question of this thesis it can be said that effectiveness of provinces can be measured in the way as Niaounakis and van Heezik have done at the municipal level. With regard to the principal-actor theorem as presented earlier, some leverage is given by the provisions of the law.

The province Overijssel seems on average to perform below the benchmark for municipalities, but its efficiency factor is closer to the municipal factor than one would expect based on the average costs. It might be that the large difference in intensity of usage of the provincial roads compared to municipal roads explains the difference between the efficiency factor and average costs. Expanding the research to more provinces could contribute to more insights.

However, this thesis also made clear that the way effectiveness is measured does not give all insights needed to see how performance is changing. Changes in spending levels differ a lot over the years and the GAAP do not specify enough requirements to test for the reasons of these differences.

In order to control for different factors and then perform a benchmark, the GAAP as given by the BBV must be changed into a more detailed and insightful level. Recently, the data provided by the provinces to the CBS is becoming slightly more insightful because of the subdivision between roads and waterways. However, there is a lot of room for improvement. It is possible that differences in acreage between provinces and municipalities can account for the different level of costs. Furthermore, the data from Overijssel shows large differences in expenditure over the years. It therefore is not simply possible to compare the one with the other year; investments and expenditure should be related tot the life cycle.

Next, as recommended with the method of Asset Management (ISO 55000), other factors can be uniformly organized and incorporated in the reporting as well. Examples are data about intensity of usage, quality, risks, congestion and also environmental factors such as emissions and noise that can be measured. An example for this can be found in the United States, where first attempts have been made to report in a similar way on infrastructural quality (Giglio et al, 2018). Therefore, it is possible to create such a reporting mechanism that provides real insights to the principal about the performance of the actor. Practitioners in the sector therefore are recommended to develop shared standards in accounting and ways of organizing their operations in the diverse phases of the infrastructural lifecycle. Specifying costs to different asset types such as roads, canals, bridges, etcetera, would be useful as well.

A major shortcoming of this thesis is directly related to this main recommendation. The lack of clarity on parameters related to the produces quality makes the conclusion that Overijssel management in Overijssel is relatively more expensive than the management by municipalities less strong, since major differences in quality might exist. Furthermore, the comparison to municipalities is flawed because of large differences in demand for the acreage such as the intensity in usage. Next to this, differences exist in how municipalities and provinces administrate their expenses. Because of my professional occupation at the province Overijssel I was able to deduct the right data from the provincial financial statements. However, this would not be possible for a layman. It would therefore be hard to increase the scope to other provinces. Next, since only one province is researched, it cannot be said how this authority is performing related to similar authorities. Therefore it cannot be considered a real benchmark. It is also a shortcoming that no differentiation in costs levels for diverse phases in the infrastructural life cycle are available. Specific circumstances such as faster deterioration of assets than expected, or managerial crises of different nature, might have caused changes in costs in specific years. This has not been researched. Future research to the different aspects and phases of infrastructure management and the way accounting is organized can be helpful for practitioners.

In relation to the method, it would be interesting for further research to look for parameters that would enable more statistical analysis. Based on the lack of availability that was not possible in this case. This decreases the certainty on robustness of the results.

6. APPENDICES

6.1 REFERENCES

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6.2 STATISTICS

Table 12 Descriptive Statistics

		Statistic	Std. Error
Costs	Mean	27232666,67	1292989,71
	Median	27310500,00	
	Variance	20061868787878,79	
	Std. Deviation	4479047,75	
	Skewness	,079	,637
	Kurtosis	-,274	1,232
Trimmmed costs	Mean	29748582,520	1602517,14
	Median	29990995,15	
	Variance	30816734251514,11	
	Std. Deviation	5551282,22	
	Skewness	-,291	,637
	Kurtosis	,072	1,232
Outputs (KM Roads)	Mean	984,08	1,25
	Variance	18,81	
	Std. Deviation	4,34	
	Skewness	-,164	,637
	Kurtosis	-,175	1,232
Surface	Mean	1,00	,000
	Median	1,00	
	Variance	,000	
	Std. Deviation	,000	
	Skewness	.	.
	Kurtosis	.	.
Interactions	Mean	,01	,00016
	Median	,01	
	Variance	,000	
	Std. Deviation	,0006	
	Skewness	-,459	,637
	Kurtosis	-1,22	1,23
Building density	Mean	1275,25	12,72
	Median	1247,50	
	Variance	1940,21	
	Std. Deviation	44,05	
	Skewness	,399	,637
	Kurtosis	-1,80	1,232
Intensity of roads	Mean	1343,350	5,42
	Median	1341,71	
	Variance	353,124	
	Std. Deviation	18,79	
	Skewness	-,172	,637
	Kurtosis	,797	1,232

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