Economies of scale: a multi-level perspective
Applications in Dutch local public services

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ECONOMIES OF SCALE:
a multi-level perspective

Applications in Dutch local public services

Thomas Niaounakis

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Applications in Dutch local public services

Dissertation

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by

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Thomas Niaounakis, February 2021

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Introduction

1

1.1. SCALE: A COMPLEX CONCEPT

Over the past decades, many countries have witnessed merger waves across the entire breadth of the public sector, driven by a quest for efficiency (Blank, 2015). The key underlying assumption is that in the delivery of public services, there are economies of scale – the idea that the average cost of public services decreases as the size of public organizations increases.

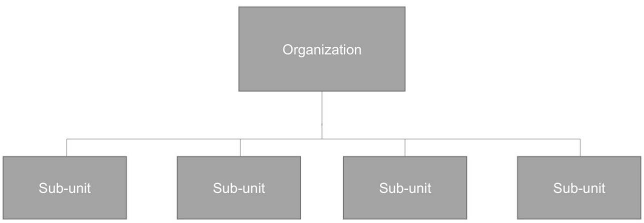
The analysis of economies of scale in public service delivery and the related quest for the optimal size of public organizations has attracted considerable attention from researchers for decades. Economies of scale are typically investigated by comparing the (average) cost of homogeneous organizations – such as hospitals, local governments and schools – to measures of size, in which the administrative, overall organization is the unit under investigation. Nonetheless, despite its size, the literature on economies of scale in public service delivery has been characterized as inconclusive and inconsistent in many areas. As a result, it has proven difficult for researchers to provide policymakers and public managers with consistent recommendations regarding the optimal scale of public organizations and, more generally, the extent to which public services can expect to benefit from economies of scale.

Indeed, the analysis of economies of scale is not without its challenges. This dissertation focuses on one specific methodological issue: it departs from the observation that a troublesome factor in the analysis of economies of scale is the conceptual complexity of 'scale'. In essence, complexity in this context means that there is more to the scale of public service delivery than simply the administrative size of the organizations that deliver those services. Large hospitals, for example, may be organized internally in such a way that they can provide small-scale care. To this end, this dissertation calls for and develops econometric frameworks for analysing economies of scale which incorporate measures of scale beyond sheer organizational size, resonating more fully with the many relevant levels of scale that may exist in practice. The resulting approach taken throughout this dissertation is referred to as a multi-level perspective towards scale.

1.1.1. EXAMPLES OF SCALE AS A MULTI-LEVEL CONCEPT

It is useful to illustrate some common examples where scale can be characterized as a multi-level concept. First, organizations are typically organized into several hierarchical levels or sub-units, such as plants, locations or teams. Figure 1.1 presents a simplified schematic diagram of an organization and its sub-units.

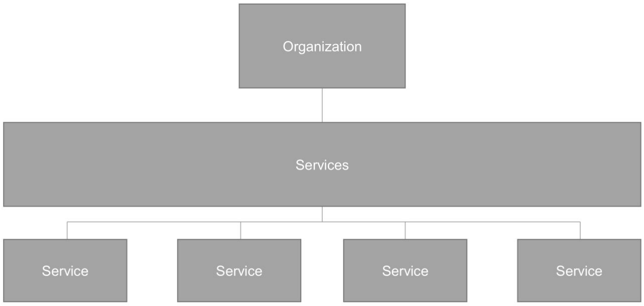
Figure 1.1: Schematic example of a multi-level organization



Large-scale public organizations may be organized into a few larger units or many smaller units. Economies of scale may then arise at different hierarchical levels within organizations through various mechanisms. The most convincing analysis of economies of scale incorporates all relevant size measures of an organization and its sub-units. The distinction between organizational and sub-unit size is particularly relevant when the size of an organization provides little indication of the size of its sub-units. For example, large hospitals may be organized into either many smaller locations which provide small-care scale or a few large locations.

Second, many public organizations deliver multiple, heterogeneous services or outputs. It may well be that the delivery of one service is subject to greater economies of scale than others. Figure 1.2 presents a schematic example of a multi-service organization. For example, it has been argued that, due to the associated fixed cost, capital-intensive services are subject to more scale economies than labour-intensive services which require intensive contact with the client. Among other things, this service heterogeneity has implications for the economic effects of organizational consolidation. In theory, consolidating organizations may achieve economies of scale in one service and diseconomies of scale in others.

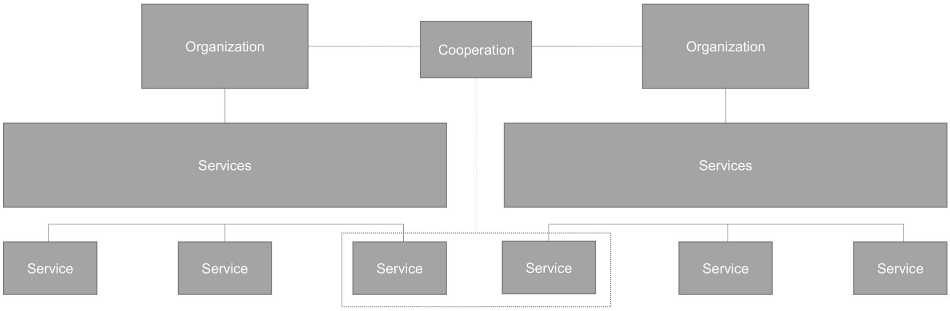
Figure 1.2: Schematic example of a multi-service organization



Third, public organizations may engage in outsourcing or co-operation to import economies of scale. In such cases, the size of the co-operative agreement (or private firm) may determine the effective scale of production of public service delivery. Co-operating and outsourcing may be regarded as less drastic measures of scaling compared to consolidation, and they allow organizations to seek economies of scale where they exist. As an example, Figure 1.3 provides a schematic diagram of multi-service organizations that seek economies of scale through co-operation in a specific service. Here, the size of the co-operative agreement also becomes a relevant measure of size.

The remainder of this chapter is organized as follows: Section 1.2 briefly elaborates on the concept of economies of scale; Section 1.3 then narrows the scope of this dissertation and formulates the research questions; and finally, Section 1.4 concludes with an overview of the dissertation structure.

Figure 1.3: Schematic example of multi-service organizations engaged in co-operation

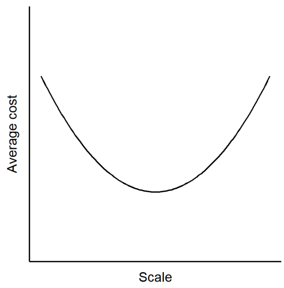


1.2. ECONOMIES OF SCALE

Economies of scale are a well-documented concept rooted in traditional production economics. Economies of scale exist when the average cost of producing a good or service reduces as output increases. Economies of scale may exist due to, for example, the indivisibility of capital, fixed costs, increased utilization rates of fixed assets or labour specialization (Blom-Hansen et al., 2016; Boyne, 1995; Hirsch, 1959). As output size grows, increased firm hierarchy and complexity may exert upward pressure on average cost as concerns over bureaucratic congestion surface (Schumacher, 1973; Williamson, 1967).

When negative effects start offsetting positive returns to scale, diseconomies of scale persist. It is commonly assumed that average cost is U-shaped, which indicates that from an average cost perspective, an optimal scale of production exists (Stigler, 1958), as illustrated in Figure 1.4.

Figure 1.4: U-shaped average cost curve



The tipping point, shape and slope of the (average) cost function varies across services, products and organizations, and it ultimately depends on the underlying technology. For example, a common assumption is that capital-intensive services are more likely to benefit from scaling than labour-intensive services. The formulation and estimation of cost functions is at the heart of the analysis of economies of scale. Organizations may seek to move closer to the optimal size of production by altering their scale. To achieve this, they have four instruments at their disposal:

1. **Consolidation** First, there is the 'big stick' approach of consolidation through an amalgamation or a merger, in which two or more previously independent organizations consolidate into one larger unit.

2. **Joint production** Second, public organizations may seek scale through joint service delivery, for example via co-operative agreements. In theory, co-operation allows public organizations to achieve economies of scale where they exist, such as in capital-intensive or highly standardized (back-office) services.

3. **Outsourcing** Third, organizations may seek economies of scale via the (joint) outsourcing of activities to large-scale private sector organizations or other public organizations, where the latter may also be regarded as a form of co-operation.

4. **Organic growth** Fourth, the scale of public organizations may change due to organic growth, for example via demographic changes or one organization growing at the expense of another.

1.3. DISSERTATION SCOPE AND RESEARCH QUESTIONS

The central research question this dissertation seeks to explore is as follows:

What is the cost-optimal scale of public service delivery from a multi-level perspective?

At its core, the answer to this question is hidden in the relationship between scale and cost at the various relevant levels of scale. If, at any given scale level, average cost is U-shaped (as depicted in Figure 1.4), then the optimal size here corresponds with the lowest average cost.

Regarding scope, this dissertation focuses on economies of scale in Dutch local public services, where municipalities are the primary delivering units. Between 1950 and 2020, the number of municipalities decreased from 1,015 to 355. While the population grew from 10 million to 17 million, average municipality size increased from 10,000 to roughly 50,000. Encouraged by the recent large-scale decentralization of tasks in 2015 from the national government to municipalities that are supra-municipal in nature, municipalities are now increasingly also seeking scale through co-operative agreements. There is, however, little evidence to substantiate the presumed efficiency gains of colossal local government structures. The ongoing trend of scaling underlines the policy relevance of understanding how cost and scale are empirically related and what this means for optimal scale policy.

A key motive for analysing local public services, in addition to the long and ongoing trend of scaling, stems from the observation that the literature on economies of scale in (local) public service delivery has been characterized as inconclusive and that the multi-level factor may be a core issue here (Blom-Hansen et al., 2016). Additionally, economies of scale in Dutch local government are relatively understudied compared to those in other countries.

Local governments provide a large number of heterogeneous services, and it has often been suggested that some are more subject to economies of scale than others. In turn, service heterogeneity implies that local governments may simultaneously face economies of scale in one service and diseconomies of scale in another. To shed more light on this multi-level relationship between local government size and cost, this dissertation takes a step back and analyses specific local government services, namely, road maintenance, tax collection and public health services. The first sub-question is as follows:

1. To what extent are different local government services subject to economies of scale?

By addressing this question, the optimal scale of local governments is investigated at the level of specific services.

Furthermore, this dissertation seeks to apply the multi-level framework in the context of the two main mechanisms through which local governments have sought to achieve economies of scale over the past decades: amalgamation and co-operation. From a policy perspective, the goal here is to shed more light on whether and when the two mechanisms can be effective in achieving economies of scale.

In the case of amalgamation, two or more municipalities consolidate into a single larger unit. Amalgamation may be considered as the most drastic measure to achieve economies of scale, as it scales all local government services indiscriminately, irrespective of which services are subject to economies of scale. The net scale effect of amalgamation on cost then depends both on the size of the consolidating units and the cost structure of each service. The second sub-question is as follows:

2. What is the relationship between economies of scale, amalgamation and cost in local government?

To address this question, an econometric framework is developed that can be used to assess and predict the effects of amalgamation on cost, in which the effect is allowed to vary across services, as well as the size of consolidating municipalities.

In contrast to amalgamation, inter-municipal co-operation allows local governments to seek economies of scale where they exist. Co-operative agreements typically focus on specific services, and many Dutch municipalities are now involved in up to tens of different co-operative agreements. Therefore, an interesting question is whether inter-municipal co-operation is an effective instrument for achieving economies of scale:

3. What is the relationship between economies of scale, co-operation and cost in local government?

Here, the multi-level framework is used to explicitly analyse how the relationship between co-operation and cost is driven by scale, and whether co-operation can be effective in achieving economies of scale. The multi-level aspect here is the distinction between municipality and co-operation size.

Finally, another interesting example of the multi-level scale issue is found in the delivery of local education services. The multi-level aspect here stems from the distinction between schools and school boards. Primary school boards (equivalent to school districts in the US) sometimes govern up to tens of small schools, and both school and board size may affect average pupil cost. At the board level, economies of scale may arise from spreading fixed IT or overhead costs over a larger number of pupils or schools. At the school level, economies of scale may exist due to optimization of school buildings' utilization rates or the specialization of teachers and school managers, for example. School board size and school size are only slightly correlated, which implies that large boards in terms of enrolment numbers may govern either a few large schools or a larger number of smaller schools. This observation highlights that both measures of board and school size must be accounted for when analysing economies of scale in education. The fourth and fifth research questions hence ask the following:

4. To what extent are primary schools subject to economies of scale?
5. To what extent are primary school boards subject to economies of scale?

1.3.1. Literature review

This sub-section briefly summarizes the key findings from the literature on economies of scale in local public services, limited to local government services and local education.

Local government

The quest for the optimal scale of local government jurisdiction has attracted considerable attention from international researchers across various disciplines, and the policy background of the long and ongoing trend of local government amalgamation and decentralization in the Netherlands has been documented extensively (Allers, 2013; Boogers et al., 2010; Portengen, 2018). Essentially, the choice between small and big is debated based on trade-off arguments that favour accessible, approachable local governments and involved citizens on the one hand, and big, cost-efficient governments on the other. Internationally, economies of scale (i.e. cost arguments) seem to have been the dominant argument in favour of increasing local government size (Blom-Hansen et al., 2016; Fox & Gurley, 2006).

A vast amount of literature has empirically analysed economies of scale in local government. These studies essentially revolve around regressing measures of cost on measures of (output) size to fit cost functions. Applications began to emerge over 60 years ago (Hirsch, 1959). Furthermore, a distinction can be made between studies that focus on the overall local government level and those that focus on the analysis of specific services (De Borger & Kerstens, 1996), such as waste collection, road maintenance and administration. In analyses at the local government level, by far the most common measure of output size is population count, despite being considered a poor measure of local government output (Turley et al., 2018). Service-specific studies have seen far more detailed and accurate output measures used than population count, such as kilograms of waste collected, the length of the road network maintained and the number of taxes invoiced. Moreover, economies of scale are often reported as a by-product of more general analyses of local government efficiency (see Narbón-Perpiñá and De Witte (2018) and Narbón-Perpiñá and De Witte (2018) for extensive, recent overviews of literature on local government efficiency), which use so-called frontier techniques such as stochastic frontier analysis (SFA) and data envelopment analysis (DEA) to estimate cost functions. In terms of economies of scale and efficiency, Dutch local governments are relatively understudied, although some studies have recently emerged (Bikker & van der Linde, 2016;

Blank, 2018). In the past decade, a series of local government efficiency research reports was commissioned, which forms the basis for this dissertation (Niaounakis & van Heezik, 2017; Niaounakis & van Hulst, 2017).

To date, several articles have examined (parts of) the empirical literature on economies of scale in the provision of local government services (Bish, 2001; Blom-Hansen et al., 2016; Byrnes & Dollery, 2002; Holzer et al., 2009; Reingewertz, 2012; Turley et al., 2018). Despite its size, the literature is described as inconclusive and, in some cases, contradictory (Byrnes & Dollery, 2002; Holzer et al., 2009; Reingewertz, 2012). In their review of the existing evidence, Blom-Hansen et al. (2016) note that the '*the empirical literature on the effects of municipal mergers has failed to identify systematic patterns that hold across time and space*'. Based on an extensive international comparison of empirical studies, Holzer et al. (2009) conclude that municipalities with populations of less than 25,000 may still increase efficiency, although this depends on the context and is mostly restricted to specialized, capital-intensive services. In municipalities with more than 250,000 inhabitants, more consistent evidence suggests that diseconomies of scale persist (Holzer et al., 2009). Local governments provide a heterogeneous set of services, and some services are more subject to economies of scale than others. In particular, economies of scale are more likely to occur in capital-intensive services due to the associated fixed cost (Andrews, 2013; Bel, 2013; Bel & Mur, 2009; Blom-Hansen et al., 2016; Dollery & Fleming, 2006; Foged, 2016; Hirsch, 1959; Holzer et al., 2009; Turley et al., 2018) and in highly specialized, seldomly used services where there is room for labour specialization (Blom-Hansen et al., 2016; Holzer et al., 2009). Surprisingly, the mechanisms underlying potential diseconomies of scale in local government services have been discussed to a lesser extent. As previously mentioned, diseconomies of scale are typically discussed in relation to bureaucracy concerns (Drew et al., 2016; Ferguson & Saving, 1969; Williamson, 1967). Diseconomies of scale due to bureaucratic congestion occur when the required input for co-ordination increases disproportionally as output volumes increase. While high-complexity services may arguably be subject to more pronounced diseconomies of scale, little literature exists on the moderating factors driving bureaucratic congestion in local government and thus why some may be more subject to bureaucratic congestion than others. In summary, the three most frequently suggested key mechanisms underlying economies of scale are 1) fixed cost, 2) specialization and 3) bureaucratic congestion.

A more recent strand of literature exploits within-municipal variation resulting from amalgamation reforms implemented in several countries, including the Netherlands, Denmark and Israel. These studies enable a more causal identification of the relationship between scale and cost, since they observe actual changes that occur after amalgamation, as opposed to the cross-sectional and correlation analysis of economies of scale prevalent in the literature discussed previously. The picture emerging from these studies is that amalgamation has not led to a systematic decrease in spending in the Netherlands (Allers & Geertsema, 2016) and Denmark (Blom-Hansen et al., 2016), although evidence of positive merger effects was found in Israel (Reingewertz, 2012). Regarding Denmark, Blom-Hansen et al. (2016) have demonstrated that cost savings in some services (roads, administration) are offset by cost increases in other areas (labour market services, culture), although most services remain unaffected. In this dissertation, the scale effect of amalgamation on cost will be allowed to vary across both services and the size of consolidating municipalities within each service.

Inter-municipal co-operation is a relatively recent phenomenon through which local governments in Western countries seek economies of scale. In the last few years, literature has emerged that analyses whether cost can be reduced through co-operation. In addition, in a recent review of the evidence, Bel and Warner (2015) point out that some results indicate that co-operation may reduce cost, but that the results are contradictory. Recent analyses in the Netherlands, including one chapter of this dissertation, also suggest that inter-municipal co-operation has been effective in decreasing costs in tax collection but not in other, financially more significant and labour-intensive services (Allers & de Greef, 2018; Niaounakis & Blank, 2017). Interestingly, while most studies have suggested that the relationship between cost and co-operation is driven by scale, few have allowed the effect of co-operation to vary with the scale of the co-operation. In this dissertation, the relationship between scale, co-operation and cost is explicitly analysed.

LOCAL EDUCATION

Considerable literature can be found on education costs that addresses economies of scale, and here, too, several review articles have emerged (Andrews et al., 2002; Blank & Valdmanis, 2019; Colegrave & Giles, 2008; Schiltz & De Witte, 2017; Stiefel et al., 2009). In a review of the evidence on U.S. school districts, which are comparable to Dutch school boards (i.e., the governing layer), Andrews et al. (2002) found that sizeable cost savings may exist as district size increases to around 2,000–4,000 pupils, with the optimal size estimated at roughly 6,000. Schiltz and De Witte (2017) gauged district-level cost functions for Flemish schools, and they estimate an optimal size of around 6,500 pupils. Regarding school size, Colegrave and Giles (2008) reviewed the evidence on cost function estimates of U.S. (high) schools and performed a meta-regression analysis on the reported optimal school sizes, finding an optimal school size of 1,543 pupils. Most of the underlying studies have found a decreasing or flat relationship between size and average cost up to 1,000 pupils (Stiefel et al., 2009). Blank et al. (2007) analysed economies of scale among Dutch schools and reported an optimal school size of 550 pupils.

Lewis and Chakraborty (1996) jointly analysed the relationship between school size, school district size and average cost by estimating district cost functions and controlling for average school size. Here, the results indicate that when controlling for average school size, district size becomes insignificant for average cost. Furthermore, Duncombe et al. (1995) estimated U.S. school district cost functions and also included a measure of (median) school size as a control variable, but they found sizeable cost savings for districts up to 500 pupils. Urlings and Blank (2012) estimated Dutch (high) school board cost functions and included measures of average school and school building size as determinants of efficiency. The results here suggest an optimal board size of 6,500 pupils and indicate that while school size does not significantly affect average cost, there are economies of scale at the school building level – a level which precedes the level of schools. Moreover, Wales (1973) estimated an aggregated cost function incorporating both measures of school and district size in British Columbia. The results here indicate that district size does not significantly affect cost, while the optimal school size is estimated at approximately 520 pupils.

Summarizing the evidence, the smallest schools and school districts (<500 pupils) are most likely to face economies of scale. As for enrolment above 500 pupils, the evidence as to whether economies of scale persist is more inconsistent. Reported optimal district (or board) sizes fluctuate between 2,000 and 6,500 pupils, while optimal school sizes fluctuate between 500 and 1,500. Based on the few studies that include measures of both school and school board (or district) size, there is evidence that economies of scale mainly arise from the size of the school, and that the size of the district is less important.

Interestingly, most applications estimate either district (or board) cost functions or school cost functions, although some district cost functions have included measures of, for example, average school size as control variables (Duncombe et al., 1995; Lewis & Chakraborty, 1996; Urlings & Blank, 2012). In this dissertation, an aggregated model is developed and estimated that allows for a simultaneous analysis of economies of scale at both the school board and school level that does not require individual school cost data (Blank & Niaounakis, 2019). The observation that both levels may each affect the (average) cost of education on their own has been noted, but follow-up has remained scarce. Schiltz and De Witte (2017) state that *'only a limited number of studies in this literature have simultaneously included measures of school and district size to disentangle both effects'*. As noted by Stiefel et al. (2009), the unit of analysis is typically determined by data availability constraints rather than theoretical considerations: '*although the school is the appropriate unit of analysis for investigating school costs, district-level data are often used, largely because school-level data are unavailable*'. These arguments resemble the distinction between the previously discussed firm- and plant-level in the context of local government services (Blom-Hansen et al., 2016).

1.4. DISSERTATION STRUCTURE

This dissertation is structured as follows. Chapters 2 to 4 contain analyses of economies of scale in local government service delivery and in relation to amalgamation and inter-municipal co-operation. Chapter 5 analyses economies of scale in the delivery of local education services by primary schools and school boards. Finally, Chapter 6 summarizes and discusses the main results of the four individual studies with reference to the research questions. Table 1.1 provides a summary of the dissertation per chapter, including the services analysed and the research questions addressed.

Chapter 2 investigates economies of scale in the provision of tax collection services among municipalities. In particular, it analyses the relationship between inter-municipal co-operation and economies of scale. Tax collection was one of the first services where inter-municipal co-operation gained traction in the Netherlands. It is a relatively capital-intensive and highly standardized service, where co-operating municipalities assumed that economies of scale exist.

Chapter 3 explores economies of scale in the provision of three heterogeneous services: road maintenance, school accommodation and public health. The focus is on evaluating how amalgamation has affected the scale efficiency of consolidating municipalities since 2005 across each of the three services considered.

Chapter 4 provides a more in-depth analysis of the cost efficiency and cost structure (including economies of scale) in road maintenance. This study specifically addresses the service analysed, since road maintenance is one of the core responsibilities of local

Table 1.1: Dissertation outline per chapter

Chapter	Outline	RQ
2	An analysis of economies of scale in local government in relation to inter-municipal co-operation. *Service analysed: tax collection.*	1,3
3	An analysis of economies of scale in local government in relation to amalgamation. *Services analysed: 1) road maintenance, 2) school accommodation, 3) public health*	1,2
4	An extended analysis of the cost structure and cost efficiency of road maintenance in local government *Service analysed: road maintenance*	1
5	A simultaneous analysis of economies of scale in primary education in both schools and school boards	4,5
6	Summary of main results and policy recommendations	

and regional governments in many countries, yet is relatively understudied (both in the Netherlands and internationally), thus warranting a more in-depth approach.

Chapter 5 presents an analysis of economies of scale among primary school boards and schools.

Finally, Chapter 6 summarizes and discusses the main results of this dissertation and concludes with policy implications and recommendations for future research.

Bibliography

Allers, M. (2013). Decentralisatie en gemeentelijke opschaling. *Liberaal reveil*, *2*.

Allers, M., & de Greef, J. (2018). Intermunicipal cooperation, public spending and service levels. *Local Government Studies*, *44*(1), 127–150. https://doi.org/10.1080/03003930.2017.1380630

Allers, M., & Geertsema, J. (2016). The effects of local government amalgamation on public spending, taxation and service levels: evidence from 15 years of municipal consolidation. *Journal of Regional Science*, *56*(4), 659–682. https://doi.org/10.1111/jors.12268

Andrews, M., Duncombe, W., & Yinger, J. (2002). Revisiting economies of size in American education: are we any closer to a consensus? *Economics of Education Review*, *21*(3), 245–262. https://doi.org/10.1016/S0272-7757(01)00006-1

Andrews, R. (2013). Local government size and efficiency in labor-intensive public services: evidence from local educational authorities in England. In S. Lago-Peñas & J. Martinez-Vazquez (Eds.), *The challenge of local government size. theoretical perspectives, international experience and policy reform* (pp. 171–188). Edward Elgar Publishing.

Bel, G. (2013). Local Government Size and Efficiency in Capital-Intensive Services: What Evidence is there of Economies of Scale, Density and Scope? In S. Lago-Peñas & J. Martinez-Vazquez (Eds.), *The challenge of local government size. theoretical perspectives, international experience and policy reform* (pp. 148–170). Edward Elgar Publishing.

Bel, G., & Mur, M. (2009). Intermunicipal cooperation, privatization and waste management costs: Evidence from rural municipalities. *Waste Management*, *29*(10), 2772–2778. https://doi.org/10.1016/j.wasman.2009.06.002

Bel, G., & Warner, M. (2015). Inter-municipal cooperation and costs: expectations and evidence. *Public Administration*, *93*(1), 52–67. https://doi.org/10.1111/padm.12104

Bikker, J., & van der Linde, D. (2016). Scale economies in local public administration. *Local Government Studies*, *42*(3), 441–463. https://doi.org/10.1080/03003930.2016.1146139

Bish, R. (2001). *Local Government Amalgamations. Discredited Nineteenth-Century Ideals Alive in the Twenty-First.* C.D. Howe Institute.

Blank, J. L. T. (2018). Measuring the performance of local administrative public services. *BRQ Business Research Quarterly*, *21*(4), 251–261. https://doi.org/10.1016/j.brq.2018.09.001

Blank, J. L. T., & Valdmanis, V. G. (2019). *Principles of productivity measurement; an elementary introduction to quantative research on the productivity, efficiency, effectiveness and quality of the public sector.* Institute for Public Sector Efficiency Studies.

1

Blank, J. (2015). *Illusies over fusies. Een kritische beschouwing over de schaalvergroting in de Nederlandse publieke sector*. Den Haag, Centrum voor Arbeidsverhoudingen Overheidspersoneel.

Blank, J., Koot, P., & van Hulst, B. (2007). *Basisonderwijs en bureaucratie. Een empirisch onderzoek naar de allocatie van middelen in basisscholen*. Rotterdam, Ecorys.

Blank, J., & Niaounakis, T. (2019). Managing Size of Public Schools and School Boards: A Multi-Level Cost Approach Applied to Dutch Primary Education. *Sustainability*, *11*(23), 6662. https://doi.org/10.3390/su11236662

Blom-Hansen, J., Houlberg, K., Serritzlew, S., & Treisman, D. (2016). Jurisdiction Size and Local Government Policy Expenditure: Assessing the Effect of Municipal Amalgamation. *American Political Science Review*, *110*(4), 812–831. https://doi.org/10.1017/S0003055416000320

Boogers, M., Denters, B., & Reussing, R. (2010). Bestuur in beweging: veranderingen in het lokale politiek-bestuurlijke landschap. *Bestuurswetenschappen*, *3*, 6–28.

Boyne, G. (1995). Population Size and Economies of Scale in Local Government. *Policy & Politics*, *23*(3), 213–222. https://doi.org/10.1332/030557395782453446

Byrnes, J., & Dollery, B. (2002). Do Economies of Scale Exist in Australian Local Government? A Review of the Research Evidence. *Urban Policy and Research*, *20*(4), 391–414. https://doi.org/10.1080/0811114022000032618

Colegrave, A., & Giles, M. (2008). School cost functions: A meta-regression analysis. *Economics of Education Review*, *27*(6), 688–696. https://doi.org/10.1016/j.econedurev.2007.05.006

De Borger, B., & Kerstens, K. (1996). Cost efficiency of Belgian local governments: A comparative analysis of FDH, DEA, and econometric approaches. *Regional Science and Urban Economics*, *26*(2), 145–170. https://doi.org/10.1016/0166-0462(95)02127-2

Dollery, B., & Fleming, E. (2006). A Conceptual Note on Scale Economies, Size Economies and Scope Economies in Australian Local Government. *Urban Policy and Research*, *24*(2), 271–282. https://doi.org/10.1080/08111140600704111

Drew, J., Kortt, M., & Dollery, B. (2016). Did the Big Stick Work? An Empirical Assessment of Scale Economies and the Queensland Forced Amalgamation Program. *Local Government Studies*, *42*(1), 1–14. https://doi.org/10.1080/03003930.2013.874341

Duncombe, W., Miner, J., & Ruggiero, J. (1995). Potential cost savings from school district consolidation: A case study of New York. *Economics of Education Review*, *14*(3), 265–284. https://doi.org/10.1016/0272-7757(94)00011-T

Ferguson, C., & Saving, T. (1969). Long-Run Scale Adjustments of a Perfectly Competitive Firm and Industry. *American Economic Review*, *59*(5), 774–783.

Foged, S. (2016). The Relationship Between Population Size and Contracting Out Public Services: Evidence from a Quasi-experiment in Danish Municipalities. *Urban Affairs Review*, *52*(3), 348–390. https://doi.org/10.1177/1078087415591288

Fox, W. F., & Gurley, T. (2006). *Will consolidation improve sub-national governments?* (World Bank Policy Research Working Paper No. 3913). World Bank. Washington, DC.

Hirsch, W. (1959). Expenditure implications of metropolitan growth and consolidation. *The Review of Economics and Statistics*, *41*(3), 232–241.

Holzer, M., Fry, J., Charbonneau, E., Van Ryzin, G., Wang, T., & Burnash, E. (2009). *Literature Review and Analysis Related to Optimal Municipal Size and Efficiency*. Rutgers University.

Lewis, W., & Chakraborty, K. (1996). Scale economies in public education. *Journal of Regional Analysis and Policy*, *26*(1), 23–35.

Narbón-Perpiñá, I., & De Witte, K. (2018). Local governments' efficiency: a systematic literature review-part II. *International Transactions in Operational Research*, *25*(4), 1107–1136. https://doi.org/10.1111/itor.12389

Narbón-Perpiñá, I., & De Witte, K. (2018). Local governments' efficiency: a systematic literature review—part I. *International Transactions in Operational Research*, *25*(2), 431–468. https://doi.org/10.1111/itor.12364

Niaounakis, T., & Blank, J. (2017). Inter-municipal cooperation, economies of scale and cost efficiency: an application of stochastic frontier analysis to Dutch municipal tax departments. *Local Government Studies*, *43*(4), 533–554. https://doi.org/10.1080/03003930.2017.1322958

Niaounakis, T., & van Heezik, A. (2017). *Wegen gewogen. Een empirisch onderzoek naar de kosten en doelmatigheid van het decentrale wegbeheer tussen 2008 en 2014*. Institute for Public Sector Efficiency Studies.

Niaounakis, T., & van Hulst, B. (2017). *Doelmatig huisvesten. Een empirisch onderzoek naar de relatie tussen krimp, schaal, rolverdelingen en de doelmatigheid van onderwijshuisvesting in het basisonderwijs*. Institute for Public Sector Efficiency Studies.

Portengen, R. (2018). *Beleidsdynamiek en schaalpolitiek. Opkomst van de menselijke maat in schaalbeleid?* (Doctoral dissertation). Erasmus University Rotterdam.

Reingewertz, Y. (2012). Do municipal amalgamations work? Evidence from municipalities in Israel. *Journal of Urban Economics*, *72*(2-3), 240–251. https://doi.org/10.1016/j.jue.2012.06.001

Schiltz, F., & De Witte, K. (2017). Estimating scale economies and the optimal size of school districts: A flexible form approach. *British Educational Research Journal*, *43*(6), 1048–1067. https://doi.org/10.1002/berj.3312

Schumacher, E. (1973). *Small is beautiful: A study of economics as if people mattered*. Blond & Briggs.

Stiefel, L., Schwartz, A. E., Iatarola, P., & Chellman, C. (2009). Mission matters: The cost of small high schools revisited. *Economics of Education Review*, *28*(5), 585–599. https://doi.org/10.1016/j.econedurev.2009.01.005

Stigler, G. (1958). The economies of scale. *The Journal of Law & Economics*, *1*, 54–71.

Turley, G., Mcdonagh, J., McNena, S., & Grzedzinski, A. (2018). Optimum Territorial Reforms in Local Government: An Empirical Analysis of Scale Economies in Ireland. *The Economic and Social Review*, *49*(4), 463–488.

Urlings, T., & Blank, J. (2012). *Benchmark bedrijfsvoering voortgezet onderwijs*. Institute for Public Sector Efficiency Studies.

Wales, T. J. (1973). The Effect of School and District Size on Education Costs in British Columbia. *International Economic Review*, *14*(3), 710–720.

1

Williamson, O. (1967). Hierarchical Control and Optimum Firm Size. *Journal of Political Economy*, *75*(2), 123–138.

2

ECONOMIES OF SCALE AND INTER-MUNICIPAL CO-OPERATION

Inter-municipal co-operation is becoming increasingly popular in European countries. Saving costs is one of the main motives driving this trend. This chapter analyses the relationship between inter-municipal co-operation and cost efficiency among Dutch municipal tax departments between 2005 and 2012. Motivated by the notion that cost savings are ascribed to scale economies, the relationship between co-operation and cost is modelled explicitly through scale. The size of the co-operation is incorporated as a determinant of cost efficiency, and the results indicate that inter-municipal co-operation can contribute to a reduction in costs and that the relationship can be explained by scale. Municipalities or inter-municipal co-operation schemes with around 10,000 inhabitants are estimated to be up to 30% inefficient. The benefits of scaling are largely exhausted at around 60,000 inhabitants. Other than through scale, co-operating municipalities are not estimated to operate significantly more or less efficiently.

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2.1. INTRODUCTION

Municipalities aim to provide local public services in a cost-efficient manner. It is widely recognized that many local government services are subject to returns to scale (Lago-Peñas & Martinez-Vazquez, 2013). For example, the average cost of small municipalities may be higher due to the indivisibility of fixed capital assets. From a certain size onwards, the level of managerial oversight required may increase exponentially, giving rise to diseconomies of scale (Drew et al., 2016) and a U-shaped average cost function.

A traditional approach to effectuate economies of scale is through the consolidation or amalgamation of municipalities (Bel & Warner, 2015). However, local government amalgamation has several drawbacks. First, the current scientific consensus is that municipal consolidation has often not led to the anticipated decrease in costs in, for example, Australia (Dollery & Johnson, 2005; Drew et al., 2016) and Denmark (Blom-Hansen et al., 2016). A similar empirical view is emerging in the Netherlands (Allers & Geertsema, 2016). Second, since municipal services and tasks are rather heterogeneous, it is questionable whether the scaling of one municipal service is also beneficial for another municipal service. Scale effects may vary significantly between municipal services such as waste collection, civil affairs and tax collection. There may be no such thing as 'one size fits all'. The heterogeneity of municipal services also highlights the methodological difficulty of measuring municipality output. Output is frequently calculated by some measure of population, which may be a rather poor proxy for overall output (Boyne, 1996).

Inter-municipal co-operation is an alternative and relatively understudied reform (Bel & Warner, 2015) through which municipalities can exploit economies of scale, and its popularity is on the rise in the Netherlands, among other countries. Inter-municipal co-operation allows for the scaling of municipal services or back offices, benefiting from potential economies of scale and maintaining jurisdictional autonomy.

Based on these experiences, one might wonder whether inter-municipal co-operation schemes are successful in exploiting economies of scale. Emerging literature on the matter indicates that co-operation can be effective in decreasing cost, but some of the results are contradictory (for an extensive and recent overview, see Bel and Warner (2015)). As inter-municipal co-operation is often based on specific services or back offices, it is appropriate to analyse these separately. A number of authors have used this research strategy in the past, with most of the available studies concerning waste collection (Bel et al., 2014; Bel & Costas, 2006; Bel & Mur, 2009; Dijkgraaf & Gradus, 2013; Sørensen, 2007; Zafra-Goméz et al., 2013).

This chapter analyses the relationship between inter-municipal co-operation and cost efficiency among Dutch municipal tax departments. While tax collection is a small municipal task in terms of the cost involved, it is one of the first areas where inter-municipal co-operation gained traction in the Netherlands, thus providing an ideal case for analysis. The aim of this chapter is to determine whether inter-municipal co-operation has contributed to reducing cost here and how the relationship depends on scale. Motivated by the notion that the cost effects of inter-municipal co-operation are generally ascribed to economies of scale, the relationship between co-operation and cost is modelled through continuous variables reflecting the scale of production. In contrast, the more common approach in literature is for the institutional form in which the activities are organized, such as co-operation, to be included in the model through dummy variables, for example. The latter approach boils down to the implicit assumption that co-operation influences cost by a constant percentage or amount independent of co-operation size.

The basic model used is a stochastic cost frontier in which tax collection costs are related to output volumes and determinants of cost efficiency. The latter includes variables reflecting the scale of production and the characteristics of co-operation. The model is applied to an extensive panel data set covering 2005–2012, comprising data on the administrative costs of taxing and levying, and detailed data on production. Municipal taxation in the Netherlands is a popular subject for inter-municipal co-operation. The number of municipalities levying taxes through a form of inter-municipal co-operation increased from 25 out of a total of 467 municipalities in 2005 to 124 out of 415 in 2012. In the context of the Netherlands, this renders them an interesting case for analysis.

Chapter 2 is organized as follows. Section 2.2 discusses the relevant literature. Then, Section 2.3 outlines the methodology, and Section 2.4 includes a description of the data. Section 2.5 presents the results, and finally, Section 2.6 contains the discussion and concluding remarks.

2.2. LITERATURE

This section draws on literature regarding the organization of local governments. In particular, it draws on the emerging literature that specifically addresses the relationship between inter-municipal co-operation and cost. Furthermore, it builds upon a more general and well-developed strand of literature on the measurement of scale economies in local governments.

Regarding the latter, the literature acknowledges that many local governments are subject to returns to scale (Lago-Peñas & Martinez-Vazquez, 2013), and many studies empirically address the relationship between scale and (average) cost. A common assumption is that the average cost curve is U-shaped (Drew et al., 2016). Increasing output is expected to reduce the burden of fixed costs, but at some point, the increase in bureaucracy, for example, may start to take over. These are just two of many possible mechanisms at play. In general, labour-intensive services are relatively less likely to benefit from scaling up compared to capital-intensive services with high associated fixed costs and back office functions (Andrews & Boyne, 2011; Drew et al., 2016). This particularly holds for labour-intensive services that are difficult to standardize or which require intensive contact with the clients.

Byrnes and Dollery (2002) provide an extensive discussion on many empirical studies concerning local governments in the UK and USA. As they note, most studies use population as a measure of scale, which may be a poor proxy for overall municipal output. In other words, a higher per capita cost does not necessarily indicate diseconomies of scale if actual output is also higher. More reliable output measures, such as the number of kilograms of waste collected and the number of taxes invoiced, have thus generally been used in analyses at the service level. Remarkably, many papers only allow for a linear relationship between average cost and scale (i.e. they assume that average cost monotonically increases or decreases with output). In other words, a potential U-shaped relationship between average cost and scale is excluded a-priori. As such, more flexible specifications must be used, so that the presence of the U shape can be tested empirically.

Compared to the privatization of municipal services, empirical evidence on the relationship between inter-municipal co-operation and cost is still rather scarce (Bel & Warner, 2015; Holzer & Fry, 2011). In the past decade, several parametric empirical studies have emerged, most of them focusing on waste collection (Bel et al., 2014; Bel & Costas, 2006; Bel & Mur, 2009; Dijkgraaf & Gradus, 2013; Dijkgraaf & Gradus, 2014; Pérez-López et al., 2015; Pérez-López et al., 2016; Sørensen, 2007; Zafra-Goméz et al., 2013). An exception is the analysis of water, electricity and gas service delivery by Garrone et al. (2013). Furthermore, Bel and Warner (2015) provide an up-to-date and extensive discussion of the potential theoretical effects of inter-municipal co-operation on cost, and they discuss the emerging evidence on the matter.

This chapter directly links inter-municipal co-operation to scale. Many papers have suggested that inter-municipal co-operation may be an effective reform for exploiting economies of scale (Bish & Ostrom, 1973; Parks & Oakerson, 1993; Plata-Díaz et al., 2014). Indeed, scale economies appear to be the 'most important efficiency motivation for inter-municipal co-operation' (Bel & Warner, 2015). Other recent papers confirm that, from an economic perspective, economies of scale are the most important driver of inter-municipal co-operation (Plata-Díaz et al., 2014; Warner, 2006; Warner & Hefetz, 2003; Zullo, 2009). Moreover, inter-municipal co-operation may give rise to transaction and co-ordination costs (see, for example, Brown and Potoski (2003) and Feiock (2007)). The degree to which each effect applies likely depends on the type of service, the scale of production and the institutional design of the co-operative governance arrangement (Bel & Warner, 2015).

With regard to methodology, it is insightful to discuss some of these papers in more detail. In the context of Dutch municipalities, Dijkgraaf and Gradus (2013) studied the effects of inter-municipal co-operation in Dutch waste collection on the total associated cost of municipalities. They found that co-operation leads to cost reduction, although the result is statistically insignificant. They performed their analysis at the municipality level, and the effect of inter-municipal co-operation was modelled by including a dummy variable. In earlier work on the topic, Bel and Costas (2006) followed a comparable identification strategy. In their study on waste collection costs in Spanish municipalities, they found that inter-municipal co-operation is negatively related to costs. Bel and Mur (2009) also used dummy variables to identify the effect of co-operation (among other factors) on cost, but estimated the model for different subsamples by size, and they found that small Spanish municipalities decreased waste collection costs through inter-municipal co-operation. Moreover, they noted that in the regular cost function, 'no evidence of scale economies is found because small municipalities have likely exploited them by means of inter-municipal co-operation'. As such, it may be useful to measure the scale of co-operation and include it in the empirical framework to test the assumption on economies of scale statistically.

An exception is the analysis by Garrone et al. (2013) on the impact of inter-municipal joint ventures and other multi-government utilities on the efficiency of Italian municipal utilities. Interestingly, they found that scale benefits are outweighed by co-ordination costs. The authors used multi-utility firms as the unit observation instead of municipalities; therefore, they also measured the actual scale of production. While their application area differs significantly from this study (water, electricity, gas and waste versus tax collection), their analysis emphasizes that co-ordination costs may be a significant downside of co-operation.

Finally, Pérez-López et al. (2016) recently estimated the relationship between efficiency and inter-municipal co-operation using a meta-frontier approach. Hence, they estimated whether, for example, inter-municipal co-operation or privatization is better for a certain group of municipalities. They found that co-operation is generally the most suitable option, but for municipalities with over 20,000 inhabitants, contracting out leads to higher levels of efficiency.

2.3. EMPIRICAL STRATEGY

This section explains the empirical strategy using a stochastic cost frontier approach for Dutch municipalities between 2005 and 2012. The frontier identifies efficient municipalities that minimize cost given their output level and the environmental factors faced. The representation of the stochastic cost frontier is given by

$$c = g(y, w, q, \beta) + v + u(z, \delta), u(z, \delta) \geq 0. \tag{2.1}$$

In (1), c is the log municipality cost of municipality tax departments; y is a vector of log outputs; w is a vector of log input prices; q is a vector of log environmental variables; v is an independent, identically distributed random error term; and u specifies cost (in)efficiency as a function of covariates z and parameters δ. The variables included in the model are discussed in Chapter 4. Furthermore, $g(\cdot)$ is some parametric function parameterized by β. By choosing a flexible mathematical specification, a cost frontier approach allows for multiple outputs and can account for multiple environmental characteristics. Here, a specification based on a translog function – a more general function than the Cobb-Douglas specification – is used (Berndt & Christensen, 1973).

The unit of analysis is a municipality tax department. That is, the variable c and the variables in $g(\cdot)$ correspond to the observed cost and output of an individual municipality tax department, respectively. The relationship between inter-municipal co-operation, scale and cost is modelled as follows. The actual scale at which a municipality produces is incorporated as a z variable as a determinant of efficiency. For co-operating municipalities, this variable equals the size of the co-operative agreement. For non-co-operating municipalities, the variable is equal to the individual municipality size. The size variable equals the number of properties, as will be discussed in the Data section. Furthermore, to allow for a U-shaped relationship between scale and efficiency, z also includes a squared scale variable. Hence, output influences cost through both $g(\cdot)$ and $u(z, \delta)$. The approach is completed by imposing constant returns to scale in the cost function $g(\cdot)$). Constant returns to scale imply that a 1 per cent increase in the output of municipalities increases cost through $g(\cdot)$ by 1 per cent. Scale effects are then isolated in the efficiency term, both for individual municipalities and those active within a co-operation. By also including a dummy variable for co-operating municipalities, the set-up further allows us to analyse whether municipalities within inter-municipal co-operation schemes are more or less efficient than individually operating municipalities, under a comparable scale of production.

An additional advantage of this approach is that analysis at the level of the decision-making unit (DMU), the municipality, is preserved. An alternative method that incorporates the scale of actual production is to analyse at the level of co-operation by aggregating municipality data. However, a disadvantage of this approach is that it sacrifices relevant information and requires the aggregation or averaging of included variables. Furthermore, one may also want to analyse how the effects on efficiency within inter-municipal co-operation are dispersed among the various participants or incorporate individual municipality efficiency determinants unrelated to co-operation.

Note that $u(z,\delta)$ is not yet specified. The pioneering SFA models (Aigner et al., 1977; Meeusen & Van den Broeck, 1977) assumed that u was an independently distributed random variable. Early attempts to model u conditional on potential determinants z involved so-called two-step approaches in which estimates of u were only regressed on z in a second stage. It is now widely recognized that this leads to invalid inference (Wang & Schmidt, 2002).

The alternative proposed here is to estimate (1) in a single-step procedure that is based on the so-called scaling property (Alvarez et al., 2006; Simar et al., 1994; Wang & Schmidt, 2002). It is said that the model satisfies the scaling property if $u(z,\delta)$ can be written as

$$u(z,\delta) = h(z,\delta) \cdot u^*,$$

where $h(z,\delta) \geq 0$, and $u^* \geq 0$ is a random variable whose distribution does not depend on z. The scaling property implies that the shape of the distribution of u does not depend on z, but that the scale of the distribution of u is determined by the scaling function $h(z,\delta)$. One convenient advantage of the scaling property is that to estimate the model, no distributional assumptions on the basic variable u^* are required – a common criticism of SFA models. It holds that

$$E(c|y,w,q,z) = g(y,w,q,\beta) + h(z,\delta)\mu^*, \tag{2.2}$$

where $\mu^* = E(\mu^*)$. The parameters β,δ and μ^* can then be estimated using non-linear least squares (NLLS). Taking expectations of u gives

$$E(u) = h(z,\delta) \cdot E(\mu^*),$$

so that replacing δ and μ^* by their estimates $\hat{\delta}$ and $\hat{\mu^*}$ gives the expected value of u.

An appealing candidate for the scaling function is the exponential function $h(z,\delta) = \exp z'\delta$. This function always generates positive values (as it should). Here, the scaling function is defined as the sum of two exponential functions – one that incorporates the variables relating to scale and one that relates to the co-ordination costs arising from co-operation:

$$h(z,\delta) = \left(\exp(z_1'\delta_1) + \exp(z_2'\delta_2)\right)\mu^*. \tag{2.3}$$

In other words, it is assumed that the relationship between co-ordination and efficiency is independent of the scale of production. Co-ordination costs potentially increase in the number of co-operating municipalities, but for reasons of parsimony, this relation is not tested here.

Finally, the following equation is estimated:

$$c = a + \sum_k b_k y_k + \frac{1}{2}\sum_k \sum_{k'} b_{kk'} y_k y'_k + \sum_m g_m q_m$$
$$+ \left(\exp(d_1 z_1 + d_2 z_2) + \exp(d_3 z_3 + d_4 z_4 + d_5 z_5)\right)\mu^* + \varepsilon. \quad (2.4)$$

Then, the parameters under estimation are a, b, g, d and μ. Four outputs (y), five environmental variables (g) and five efficiency determinants will be included (z). The choice of variables is elaborated upon below.

2.4. DATA

The main data used in this study were sourced from Statistics Netherlands, the national statistical agency in the Netherlands. Furthermore, information on municipal tax rates was provided by the Centre for Research on Local Government Economics (COELO), while information on the composition of inter-municipal co-operation arrangements was obtained from the Association of Dutch Municipalities (VNG) and the Council of Real Estate Assessment, as well as by accessing legal co-operation agreements or telephone enquiries

The data cover the period 2005–2012. Dutch municipalities typically set up a designated department to perform tax-associated tasks; it operates fairly independently of other municipality departments and services. Due to municipal consolidations, the number of municipalities in the Netherlands decreased from 467 in 2005 to 415 in 2012. In total, 3,116 observations are included in the analysis. Municipalities with negative reported costs or high (>x%) intertemporal variation were systematically dropped from the analysis. This resulted in the omission of approximately 250 observations. Table 2.1 contains a statistical description of the data ultimately included in the model for 2012. On average, municipality tax costs were just under €1 million, but a large variation was observed between municipalities. The variables included are discussed in more detail below.

2.4.1. TAX DEPARTMENTS AND CO-OPERATION SCHEMES

Dutch municipal tax departments carry out two primary tasks. First, municipalities levy and collect several taxes and fees. In terms of revenues, the main taxes are a real estate or property tax (43% of municipal tax revenues) and waste collection and sewerage fees (41%). The remaining 16% is related to tourist taxes, dog taxes and other smaller taxes. Second, Dutch municipalities are obliged to perform an annual revaluation of all real estate properties. This revaluation is generally based on property characteristics, the market prices of recently listed properties in the vicinity and other potentially relevant demographic information. Municipalities inform property owners of the valuation assessment, and the property value is then used as a basis for taxation. Note that the difference between taxes and fees is irrelevant for the purpose of this study.

2

Table 2.1: Summary statistics of key variables, 2012 (N = 373)

	Mean	Std. dev.	Minimum	Maximum
Nominal cost (€ mln.)	0.96	3.07	0.04	49.28
Output variables				
Housing properties (1,000)	17.63	30.86	0.45	390.45
Non-housing properties (1,000)	3.10	4.03	0.19	459.66
Taxed tourist nights (1,000)	249.69	629.07	1.10	8,778.89
Imposed dog taxes (1,000)	2.32	2.98	0.19	29.18
Environmental variables				
Average property value (€1,000)	251.08	63.88	133.00	630.00
Property tax rate (%)	2.62	0.63	1.06	4.98
Single person households (%)	0.30	0.06	0.19	0.60
Net property tax returns	0.94	0.03	0.78	1.10
Welfare recipients	918.00	3,262.00	10.00	40,870.00
Efficiency determinants				
Actual scale of production (1,000)	45.83	66.51	1.08	450.31
Cooperation with water authority	0.1			
First year in cooperation	0.07			

The number of municipalities that levy taxes through a form of inter-municipal co-operation increased from 25 out of 467 municipalities in 2005 to 124 out of 415 in 2012, while the number of inter-municipal co-operation arrangements increased from 3 in 2005 to 29 in 2012. Between 2005 and 2012, the percentage of total cost incurred by co-operation arrangements increased from 1% to 35%. Furthermore, inter-municipal co-operation arrangements differ in size. While the smallest consists of only two municipalities, the largest is composed of more than 20 municipalities. Figure 2.1 presents a geographic overview of the co-operative arrangements in 2012.

Figure 2.1: Overview of co-operative agreements, 2012

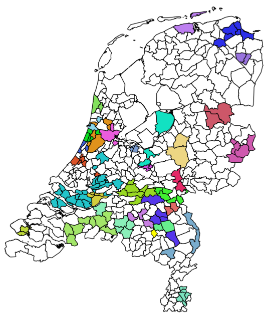
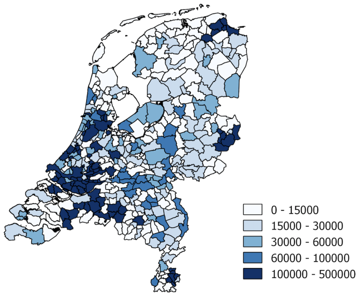


Figure 2.2 presents the actual scale of production per levying unit (co-operation or

municipality) in 2012 as measured by the number of properties.

Figure 2.2: Actual scale of production per levying unit (single municipality or co-operative agreement) as measured by the number of properties, 2012



2.4.2. COST AND INPUT PRICE VARIABLES

The dependent variable in the cost function analysis is the (log) cost level of municipality tax departments. Between 2005 and 2012, total nominal costs increased from roughly €360 million to €380 million. Costs are composed of mainly labour, IT and office supply costs, but no data on this breakdown is available. While municipal tax departments are a popular subject for inter-municipal co-operation, their relevance in terms of cost is limited (less than 1% of the total municipality cost).

In terms of input prices, only the consumer price index is included. Dutch municipalities face largely equal input prices (Bikker & van der Linde, 2016), as wages are set in collective agreements, and the purchase of other inputs, such as office supplies, is done on national markets. The cost of capital (e.g. housing) may vary; however, this are not relevant here, as municipalities report housing costs separately. In the analysis, costs are effectively deflated using the consumer price index, which is invariant between municipalities.

2.4.3. OUTPUT MEASURES

The majority of local government studies measure output by population count. While a large strand of literature carefully studies the methodological sensitivity in measuring scale economies (for a recent analysis, see Bikker and van der Linde (2016)), finding consistent, better aggregate output measures of local government production has proven to be difficult (Andrews & Boyne, 2009). Studies of specific municipality services or back offices have typically used more accurate measures of output. For example, analyses of waste collection services have utilized output measures such as the quantity of waste collected (Bel & Costas, 2006; Zafra-Goméz et al., 2013) in addition to or instead of population measures.

For municipal tax departments, no comparable literature is available from which to draw output measures. Recall that Dutch tax departments carry out two primary tasks: the imposition and collection of several taxes and fees, and the (re)valuation of all real estate property. Finally, four output variables are included: (1) the number of housing properties, (2) the number of non-housing properties, (3) the number of taxed tourist nights and (4) the number of imposed dog taxes. The motivation for these measures is discussed below. The output of the taxation task is ideally defined as the number of imposed and processed tax assessments, by type. However, no data are available that directly measure this. In terms of revenue, the most important are the real estate tax (43%) and waste collection and sewerage fees (41%). Although revenues are known, they offer no suitable output measures, as tariffs vary among municipalities. Higher tariffs lead to higher revenues but not to increased administrative effort. Moreover, the number of real estate properties is known at the municipality level, which is an accurate proxy for the number of levied real estate taxes. The number of real estate properties is also used to proxy the number of levied waste collection fees. Although these are usually levied at household level, they correlate strongly with properties. The next two important taxes are the tourist tax and dog tax (together 3% of revenues). These may be a source of heterogeneity, since not all municipalities levy tourist taxes and/or tourist fees, and tourism varies significantly between municipalities. Tourism is an often overlooked but important source of municipal heterogeneity. (Bel and Costas (2006) discuss this in the context of waste collection). Dutch municipalities typically levy tourist taxes per tourist night. The tourist tax revenue is used as a proxy for the number of levied tourist taxes, and the revenues are divided by the prevailing tax rate. This measure is equal to the number of taxed tourist nights. Following the same line of reasoning, dog tax revenues are divided by the dog tax rate to proxy the number of levied dog taxes. The second primary task of tax departments is the valuation of all real estate properties. This output can also be measured by the number of properties. On average, fewer resources are required to valuate more common properties, such as apartments, than more heterogeneous properties, such as schools and hospitals. One distinction in the data is between housing and non-housing properties – both are included separately in the model. Finally, the first two output measures (housing and non-housing properties) then measure both the output of the valuation process and part of the taxation process (real estate tax).

2.4.4. VARIABLES IN THE EFFICIENCY COMPONENT

The cost efficiency component includes five variables that all relate to scale and co-operation characteristics. The first two – and most important – variables relate to scale: (i) the scale of services measured by the total number of properties and (ii) the square of (i) to allow for an (inversely) U-shaped effect – that is, to allow for a shift from increasing to decreasing economies of scale at some point (and to allow for the existence of a tipping scale or optimum scale). These scale variables express the actual level of production. Thus, for municipalities in an inter-municipal co-operation, (i) is equal to the sum of total co-operation output, while for single municipalities, it equals the individual output of the municipality. The production (y) variables, on the other hand, always relate to the individual municipality output. The third, fourth and fifth managerial variables are dummy variables that indicate (iii) whether a municipality participates in the co-operation (co-ordination costs), (iv) whether a water authority is included in the co-operation (vertical integration eliminates the need for double administrative systems) and (v) whether it is a municipality's first year in a co-operation (transition or start-up costs). Finally, recall that $h(z,\delta) = \left(\exp(z_1'\delta_1) + \exp(z_2'\delta_2)\right)\mu^*$. The scale variables (i) and

(ii) make up z_1, while (iii), (iv) and (iv) are included in z_2.

2.4.5. ENVIRONMENTAL VARIABLES

Exogenous variables may influence the cost level through the production environment. The efforts to levy taxes may depend on the municipality's socio-economic, demographic or fiscal characteristics. Variables included are (i) the average value of properties, (ii) the municipal property tax rate (in %), (iii) the number of welfare benefit recipients, (iv) the ratio of single households to the total number of households and (v) the net property tax returns (i.e. the percentage of imposed property taxes that are successfully collected). As literature on the economies of municipality tax collection agencies is rather scarce, not all variables are justified by literature; rather, they have arisen from interviews held with civil servants employed by municipality tax departments. Expensive properties are on average less homogeneous and thus require more effort to valuate. To control for this, the average value of properties is included as an additional measure. (Bikker and van der Linde (2016) also include this to account for municipality heterogeneity).

As discussed in Section 2, the waste collection fee is typically collected per household. Although strongly correlated with the number of properties, this may lead to a bias in municipalities with a relatively high number of single-person households. The relative number of single-person households to total households in the municipality is therefore included.

Furthermore, inhabitants of a municipality may fail to pay some or all of the imposed taxes. This requires municipalities to exert more effort to collect those taxes, for example by engaging bailiffs. The degree to which a municipality succeeds in collecting the total property income (tax rate multiplied by total property value) can be interpreted as a measure of quality of the levying process. To control for this, the net property tax return (in %) – that is, the percentage of the total imposed property tax collected – is included. This percentage may also vary due to environmental variables, such as income level and other factors, for which a correction is made by a separate, single OLS regression.

The number of welfare recipients is also included in the model, as low-income households are more likely to apply for a tax exemption. In addition, municipalities are more likely to have to send repeated requests for payments or fines, and this is expected to drive up average costs.

A final, potentially significant cost driver is the number of submitted appeals. Inhabitants may lodge an appeal if they disagree with the valuation report or the tax assessment, for example, and the handling of such an appeal is rather expensive. The returns of a successful appeal are higher if the property tax rate is higher. This justifies the inclusion of the average property tax rate.

2.4.6. TECHNOLOGICAL AND INSTITUTIONAL CHANGES

IT innovations play an important role in administrative processes for taxation, as valuations are increasingly carried out using automated software. Therefore, an annual trend parameter is included in the specification. The estimated parameter of the annual trend (2005–2012) reflects the average annual percentage change in cost due to these technological changes.

2.5. RESULTS

2.5.1. GENERAL

The main results are presented in Table 2.2.

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Table 2.2: Cost function estimation results (Equation 2.4)

		Estimate	Standard error
Housing properties	b_1	0.736***	0.062
Non-housing properties	b_2	0.203***	0.058
Taxed tourist nights	b_3	0.029*	0.017
Dog taxes	b_4	0.032	0.029
Housing properties^2	b_{11}	0.136	0.126
Housing properties × non-housing properties	b_{12}	-0.128	0.131
Housing properties × taxed tourist nights	b_{13}	-0.014	0.024
Housing properties × dog taxes	b_{14}	0.007	0.036
Non-housing properties^2	b_{22}	0.171	0.142
Non-housing properties × taxed tourist nights	b_{23}	0.000	0.025
Non-Housing properties × dog taxes	b_{24}	-0.043	0.036
Taxed tourist nights^2	b_{33}	0.009	0.007
Taxed tourist nights × dog taxes	b_{34}	0.006	0.007
Imposed dog taxes^2	b_{44}	0.030	0.026
Autonomous cost growth	g_0	-0.031***	0.004
Average property value	g_1	0.390***	0.079
Property tax rate (in %)	g_2	0.105**	0.042
Single households (in %)	g_3	0.113	0.107
Net property tax returns	g_4	0.703**	0.331
Welfare recipients	g_5	0.095***	0.029
Mean inefficiency	u^*	1.016***	0.227
Scale of production	d_1	-9.757***	2.467
Scale of production^2	d_2	0.985***	0.249
Cooperation (dummy)	d_3	-0.052	0.057
Cooperation incl. water authority (dummy)	d_4	-0.197*	0.116
First year of cooperation (dummy)	d_5	0.239***	0.077

* p<0.1, ** p<0.05, *** p<0.01

The results are obtained by estimation of Equation 2.4 regressing the log cost of municipalities on output, environmental characteristics and inefficiency determinants using (non-linear) least squares. Due to the logarithmic specification used and the inclusion of second-order terms, most parameters have no clear, direct interpretation. However, the first-order output parameters (b_1, b_2, b_3, b_4) have plausible (positive) signs. The third parameter is estimated significantly only at a 10 per cent significance level, and the fourth output parameter (dog taxes) is not estimated significantly. Note that most cross terms are estimated insignificantly. A simpler Cobb-Douglas formulation with no cross terms is, however, rejected by an LR test. Recall that constant returns to scale have been imposed: the first-order and second-order parameters sum to one and zero, respectively. Scale economies are tested through the efficiency parameters d_1 and d_2, which are discussed later.

One way to assess the plausibility of the estimates is by inspection of marginal costs. The marginal costs for a cost-efficient municipality facing average environmental factors equal €40, €63, €0.11 and €13 for a housing property, non-housing property, tourist night and dog tax, respectively, which seem plausible.

2.5.2. SCALE, EFFICIENCY AND CO-OPERATION

Next, consider the parameter estimates of the efficiency component u: $d_1 - d_5$. A negative (positive) sign here implies a positive (negative) relationship with efficiency, as u is a measure of cost inefficiency.

Recall that co-operation enters the model in two ways. The first is through scale – the actual scale of production and its square are included as determinants of inefficiency $(d1, d_2)$ to allow for a U-shaped relationship between scale and inefficiency. Second, a dummy variable is included to test whether co-operative agreements are significantly more or less efficient other than through scale.

Regarding scale, evidence of economies of scale exists, as d_1 and d_2 are estimated significantly. Furthermore, the parameters indicate a U-shaped relationship between inefficiency and scale. The optimum scale is estimated at 226,961 real estate properties. This roughly corresponds to 450,000 inhabitants, as there are two inhabitants per property on average. Below (above) this point, production is characterized by (dis)economies of scale. In the Dutch context, the optimum size is large, with only a handful of municipalities exceeding the optimum size.

The most important point to take from the estimated relationship between scale and cost inefficiency is that scale effects are particularly pronounced for municipalities or co-operation agreements with fewer than roughly 30,000 properties. After this point, additional cost savings are limited. Figure 2.3 charts the estimated relationship between expected efficiency and scale for fewer than 50,000 properties. Hence, despite the estimated large optimum size, economies of scale are defined mainly for smaller municipalities.

Figure 2.3: Estimated relationship between cost efficiency and scale (number of properties)

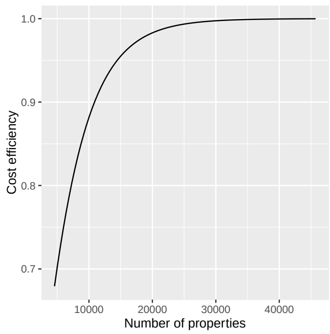

Table 2.3 presents simulations of the estimated (scale) effect of co-operation on cost for municipalities of varying sizes. The simulations confirm that the cost-saving effects are more pronounced (in %) for smaller municipalities. Two municipalities, each currently sized at 5,000 properties, are estimated to save up to 20% by co-operating together. Two larger municipalities, sized at 10,000 properties each, can expect to save 10% through co-operation. For average to larger municipalities, scale effects have been exhausted.

Table 2.3: Predicted scale effect of co-operation

Scale ex-ante	Proportion	Scale ex-post	Predicted cost effect
		10,000	20.4%
5,000	5%	20,000	28.9%
		50,000	29.8%
		20,000	10.3%
10,000	25%	50,000	11.8%
		100,000	11.8%
		50,000	0.6%
25,000	60%	75,000	0.7%
		100,000	0.7%

Now consider the estimated co-operation dummy variable (d_3). Remarkably, other than through scale, cost efficiency is not significantly associated with co-operation. Hence, there is no evidence of significant co-ordination costs. The point estimate is even slightly negative (co-operation is associated with higher efficiency).

Finally, municipalities that collaborate with a water authority are estimated to be more efficient (d_4). Co-operation between municipalities and water authorities implies the discontinuation of some of the activities that were previously duplicated, such as administering duplicate address databases. Finally, municipalities are estimated to be significantly (d_5) less cost efficient in the first year of co-operation, suggesting that some start-up costs are involved.

Finally, autonomous productivity growth is deduced from the change in costs over time, corrected for changes in production and all other control variables (g_0). On average, costs decreased by 3.1 per cent a year. A plausible mechanism here is that automatization and standardization software became more advanced and cheaper.

2.6. DISCUSSION AND CONCLUSION

This chapter analysed the relationship between inter-municipal co-operation, scale and cost efficiency in Dutch municipal tax departments. In the Netherlands, tax collection is a popular subject for inter-municipal co-operation. The results indicate that this type of co-operation is related to lower cost and that the relationship can be explained by scale. Economies of scale are particularly pronounced at small levels of production. A scale of 5,000 properties (roughly 10,000 inhabitants) is associated with a 30 per cent cost inefficiency. Moreover, the benefits diminish with scale and are largely exhausted at 30,000 properties (roughly 60,000 inhabitants).

Remarkably, no significant association between inter-municipal co-operation and cost efficiency was found other than through scale (e.g. through co-ordination and transaction costs), except for a temporary downward shock of efficiency in the first year in which a municipality is active in a co-operation. Although non-significant, co-operating municipalities are, surprisingly, associated with a slightly higher cost efficiency. One contributing factor here may be that co-operation schemes are not as susceptible to political inference from a single municipality. In addition, tax collection is a relatively low-complexity and standardized task, which may limit the amount of co-ordination required.

Municipalities do seem to incur extra costs initially for setting up or joining a co-operation. Work processes between different municipalities need to be integrated, and personnel need to be relocated. Additionally, municipalities that co-operate with water authorities are more efficient. This is expected, since this co-operation eliminates the need to maintain fairly similar administrative systems (duplication of tasks).

Inter-municipal co-operation is becoming an increasingly common phenomenon in European countries, and its popularity in the Netherlands is on the rise as well. In many western European countries, co-operation is motivated by cost savings. Co-operative agreements often focus on a specific municipal service, task or output, such as waste collection, road maintenance or social services. In the Netherlands, municipalities can be active in tens of different co-operative agreements. From a scale perspective, inter-municipal co-operation then offers tailored scaling of services that may benefit from it. Furthermore, existing literature on inter-municipal co-operation confirms that co-operation may contribute to reducing cost, and the effects are generally ascribed to scale economies. So far, most empirical studies on EU inter-municipal co-operation and cost concern waste collection.

A practical implication of the results is that by scaling production, co-operation can be effective in decreasing cost, especially for smaller municipalities. It should be stressed, however, that the results are not easily generalizable to other municipality services, as both scale and co-ordination effects likely vary. Further research on the relationship between inter-municipal co-operation, scale and cost efficiency in other services may help shed light on the factors which determine the feasibility of inter-municipal co-operation to reduce cost. More generally, analysis of specific services may also be useful to decompose overall municipality scale effects. Examples of potential determinants that drive scale and co-ordination effects include the size of fixed cost, labour intensity, task complexity and the level of standardization in the delivery of the service between municipalities (see also Bel and Warner (2015)). In the case of Dutch tax departments, task complexity is low, and there is a high degree of standardization driven by legal requirements. Therefore, co-ordination requirements are likely to be limited, and scale effects due to the spreading of fixed asset costs are plausible.

Finally, it should be noted that inter-municipal co-operation has also been subject to criticism: co-operation comes at the expense of democratic legitimacy, and municipalities that are active in dozens of co-operation schemes become less transparent. They may also incur increased overall administrative burdens, for example in terms of overall municipality management. Such effects remain unclear when focusing on a single municipal service, as the costs of other services and general municipal management are not included. Moreover, even today, little is known about the relationship between inter-municipal co-operation and the quality of service delivery. Future research on the relationship between flexible structures of inter-municipal co-operation, efficiency and the quality of service delivery is thus desirable to uncover these relationships in more detail.

APPENDIX

Table 2.4: Description of included variables in Chapter 2

Variable	Description	Source
Tax collection cost	Total cost	Statistics Netherlands
Housing properties	Number of housing properties	Statistics Netherlands
Non-housing properties	Number of non-housing properties	Statistics Netherlands
Taxed tourist nights	Number of taxed tourist nights levied, proxied by total tourist tax income divided by tourist tariff	Statistics Netherlands (tax income) and COELO (tariff)
Dog taxes	Number of dog taxes levied, proxied by tax income divided by tariff	Statistics Netherlands (tax income) and COELO (tariff)
Average property value	Average property value	Statistics Netherlands
Property tax rate	Average housing property tax rate	COELO
Single households	Proportion of single households	Statistics Netherlands
Net property tax returns	Percentage of imposed property taxes that are successfully collected	IPSE Studies
Welfare recipients	Number of welfare recipients	Statistics Netherlands
Cooperation dummy	Dummy variable indicating cooperation	IPSE Studies
Cooperation including water authority	Dummy variable indication cooperation with water authority	IPSE Studies
First year of cooperation	Dummy indicating first year of cooperation	IPSE Studies

Bibliography

Aigner, D., Lovell, C., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37. https://doi.org/10.1016/0304-4076(77)90052-5

Allers, M., & Geertsema, J. (2016). The effects of local government amalgamation on public spending, taxation and service levels: evidence from 15 years of municipal consolidation. *Journal of Regional Science*, *56*(4), 659–682. https://doi.org/10.1111/jors.12268

Alvarez, A., Amsler, C., Orea, L., & Schmidt, P. (2006). Interpreting and Testing the Scaling Property in Models where Inefficiency Depends on Firm Characteristics. *Journal of Productivity Analysis*, *25*(3), 201–212. https://doi.org/10.1007/s11123-006-7639-3

Andrews, R., & Boyne, G. (2011). Corporate capacity and public service delivery. *Public Administration*, *89*(3), 894–908. https://doi.org/10.1111/j.1467-9299.2010.01891.x

Andrews, R., & Boyne, G. A. (2009). Size, Structure and Administrative Overheads: An Empirical Analysis of English Local Authorities. *Urban Studies*, *46*(4), 739–759. https://doi.org/10.1177/0042098009102127

Bel, G., Fageda, X., & Mur, M. (2014). Does cooperation reduce service delivery costs? Evidence from residential solid waste services. *Journal of Public Administration Research and Theory*, *24*(1), 85–107. https://doi.org/10.1093/jopart/mus059

Bel, G., & Costas, A. (2006). Do Public Sector Reforms Get Rusty? Local Privatization in Spain. *The Journal of Policy Reform*, *9*(1), 1–24. https://doi.org/10.1080/13841280500513084

Bel, G., & Mur, M. (2009). Intermunicipal cooperation, privatization and waste management costs: Evidence from rural municipalities. *Waste Management*, *29*(10), 2772–2778. https://doi.org/10.1016/j.wasman.2009.06.002

Bel, G., & Warner, M. (2015). Inter-municipal cooperation and costs: expectations and evidence. *Public Administration*, *93*(1), 52–67. https://doi.org/10.1111/padm.12104

Berndt, E., & Christensen, L. (1973). The translog function and the substitution of equipment, structures, and labor in U.S. manufacturing 1929-68. *Journal of Econometrics*, *1*(1), 81–113. https://doi.org/10.1016/0304-4076(73)90007-9

Bikker, J., & van der Linde, D. (2016). Scale economies in local public administration. *Local Government Studies*, *42*(3), 441–463. https://doi.org/10.1080/03003930.2016.1146139

Bish, R., & Ostrom, V. (1973). *Understanding Urban Government*. American Enterprise Institute for Public Policy Research.

Blom-Hansen, J., Houlberg, K., Serritzlew, S., & Treisman, D. (2016). Jurisdiction Size and Local Government Policy Expenditure: Assessing the Effect of Municipal Amal-

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gamation. *American Political Science Review*, *110*(4), 812–831. https://doi.org/10.1017/S0003055416000320

Boyne, G. (1996). Competition and Local Government: A Public Choice Perspective. *Urban Studies*, *33*(4-5), 703–721. https://doi.org/10.1080/00420989650011799

Brown, T., & Potoski, M. (2003). Transaction Costs and Institutional Explanations for Government Service Production Decisions. *Journal of Public Administration Research and Theory*, *13*(4), 441–468. https://doi.org/10.1093/jpart/mug030

Byrnes, J., & Dollery, B. (2002). Do Economies of Scale Exist in Australian Local Government? A Review of the Research Evidence. *Urban Policy and Research*, *20*(4), 391–414. https://doi.org/10.1080/0811114022000032618

Dijkgraaf, E., & Gradus, R. H. J. M. (2013). Cost advantage cooperations larger than private waste collectors. *Applied Economics Letters*, *20*(7), 702–705. https://doi.org/10.1080/13504851.2012.732682

Dijkgraaf, E., & Gradus, R. (2014). Waste Management in the Netherlands. In T. Kinnaman & K. Takeuchi (Eds.), *Handbook on waste management* (pp. 287–315). Edward Elgar Publishing.

Dollery, B., & Johnson, A. (2005). Enhancing Efficiency in Australian Local Government: An Evaluation of Alternative Models of Municipal Governance. *Urban Policy and Research*, *23*(1), 73–85. https://doi.org/10.1080/0811114042000335278

Drew, J., Kortt, M., & Dollery, B. (2016). Did the Big Stick Work? An Empirical Assessment of Scale Economies and the Queensland Forced Amalgamation Program. *Local Government Studies*, *42*(1), 1–14. https://doi.org/10.1080/03003930.2013.874341

Feiock, R. (2007). Rational Choice and Regional Governance. *Journal of Urban Affairs*, *29*(1), 47–63. https://doi.org/10.1111/j.1467-9906.2007.00322.x

Garrone, P., Grilli, L., & Rousseau, X. (2013). Management Discretion and Political Interference in Municipal Enterprises. Evidence from Italian Utilities. *Local Government Studies*, *39*(4), 514–540. https://doi.org/10.1080/03003930.2012.726198

Holzer, M., & Fry, J. C. (2011). *Shared services and municipal consolidation: A critical analysis*. Public Technology Institute.

Lago-Peñas, S., & Martinez-Vazquez, J. (Eds.). (2013). *The Challenge of Local Government Size: theoretical perspectives, international experience and policy reform*. Edward Elgar Publishing.

Meeusen, W., & Van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, *18*(2), 435–444.

Niaounakis, T., & Blank, J. (2017). Inter-municipal cooperation, economies of scale and cost efficiency: an application of stochastic frontier analysis to Dutch municipal tax departments. *Local Government Studies*, *43*(4), 533–554. https://doi.org/10.1080/03003930.2017.1322958

Parks, R., & Oakerson, R. (1993). Comparative Metropolitan Organization: Service Production and Governance Structures in St. Louis (MO) and Allegheny County (PA). *Publius*, *23*(1), 19. https://doi.org/10.2307/3330797

Pérez-López, G., Prior, D., & Zafra-Gómez, J. (2015). Rethinking New Public Management Delivery Forms and Efficiency: Long-Term Effects in Spanish Local Government. *Journal of Public Administration Research and Theory*, *25*(4), 1157–1183. https://doi.org/10.1093/jopart/muu088

Pérez-López, G., Prior, D., Zafra-Gómez, J., & Plata-Díaz, A. (2016). Cost efficiency in municipal solid waste service delivery. Alternative management forms in relation to local population size. *European Journal of Operational Research*, *255*(2), 583–592. https://doi.org/10.1016/j.ejor.2016.05.034

Plata-Díaz, A. M., Zafra-Gómez, J., Pérez-López, G., & López-Hernández, A. (2014). Alternative management structures for municipal waste collection services: The influence of economic and political factors. *Waste Management*, *34*(11), 1967–1976. https://doi.org/10.1016/j.wasman.2014.07.003

Simar, L., Lovell, C., & Vanden Eeckaut, P. (1994). *Stochastic frontiers incorporating exogenous influences on efficiency*.

Sørensen, R. J. (2007). Does dispersed public ownership impair efficiency? The case of refuse collection in Norway. *Public Administration*, *85*(4), 1045–1058. https://doi.org/10.1111/j.1467-9299.2007.00681.x

Wang, H., & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis*, *18*(2), 129–144. https://doi.org/10.1023/A:1016565719882

Warner, M. (2006). Market-based Governance and the Challenge for Rural Governments: US Trends. *Social Policy and Administration*, *40*(6), 612–631. https://doi.org/10.1111/j.1467-9515.2006.00523.x

Warner, M., & Hefetz, A. (2003). Rural—Urban Differences in Privatization: Limits to the Competitive State. *Environment and Planning C: Government and Policy*, *21*(5), 703–718. https://doi.org/10.1068/c008r

Zafra-Goméz, J., Prior, D., Plata Díaz, A., & López-Hernández, A. (2013). Reducing costs in times of crisis: delivery forms in small and medium sized local governments' waste management. *Public Administration*, *91*(1), 51–68. https://doi.org/10.1111/j.1467-9299.2011.02012.x

Zullo, R. (2009). Does Fiscal Stress Induce Privatization? Correlates of Private and Intermunicipal Contracting, 1992-2002. *Governance*, *22*(3), 459–481. https://doi.org/10.1111/j.1468-0491.2009.01447.x

3

ECONOMIES OF SCALE AND LOCAL GOVERNMENT AMALGAMATION

This study analyses the relationship between economies of scale, amalgamation and cost in Dutch local government across three heterogeneous services (road maintenance, school accommodation and public health). Two effect channels of amalgamation on cost are considered: a scale and a cost-efficiency effect, with the latter being a residual effect of the changes in cost not explained by scale. Cost functions are estimated using stochastic frontier methods to derive the service-specific relationship between scale and cost and to obtain individual estimates of cost efficiency. The cost function estimates suggest that the scale effect of amalgamation is heterogeneous across services and depends on the size of the units under consolidation. Averaged over a group of 40 amalgamations that took place between 2005 and 2016, the increase in scale is associated with a deterioration in productivity. However, amalgamation is associated with a positive change in cost efficiency. Together, the offsetting results are in line with an emerging literature that has failed to find systematic effects of amalgamation on cost. In the long term, the estimated cost functions suggest that amalgamation for the purpose of decreasing cost is, at best, a viable strategy only for the smallest of Dutch municipalities.

3

3.1. Introduction

The Netherlands is witnessing a long and ongoing trend of local government amalgamation in a quest for economies of scale. Between 1950 and 2020, the number of municipalities decreased from 1,015 to 355, while the average population increased from roughly 10,000 to 50,000. Remarkably, emerging literature that exploits the variation induced by amalgamation finds no systematic effects of amalgamation on cost in the Netherlands (Allers & Geertsema, 2016) and other countries that have implemented amalgamation reforms, such as Denmark (Blom-Hansen et al., 2016).

There is extensive related and long-standing literature on economies of scale in local government service delivery. Although specific methods and scopes vary, the bulk of these studies revolve around regressing measures of cost on measures of (output) size to fit cost functions. To date, several articles have examined (parts of) the empirical literature on economies of scale in the provision of local government services (Bish, 2001; Blom-Hansen et al., 2016; Byrnes & Dollery, 2002; Holzer et al., 2009; Reingewertz, 2012; Turley et al., 2018). Despite its size, the literature has been described as inconclusive and, in some cases, contradictory. In this regard, Blom-Hansen et al. (2016) note that '*the empirical literature on the effects of municipal mergers has failed to identify systematic patterns that hold across time and space*'. Moreover, Holzer et al. (2009) conclude that municipalities with populations under 25,000 may still increase efficiency, although this is dependent on the context and is mostly restricted to specialized, capital-intensive services. For municipalities with more than 250,000 inhabitants, there is more consistent evidence to suggest that diseconomies of scale resulting from bureaucratic congestion persist. Local governments provide a heterogeneous set of services, and economies of scale are known to vary accordingly (Holzer et al., 2009; Turley et al., 2018). Service heterogeneity implies that there are potentially offsetting effects of amalgamation on cost across services, thus emphasizing the relevance of service heterogeneity with regard to economies of scale (Blom-Hansen et al., 2016).

Motivated by the complex relation between local government scale and cost, the study in this chapter investigates the relationship between economies of scale, amalgamation and cost in three heterogeneous services: road maintenance, school accommodation and public health services. Two potential effect channels of amalgamation on cost are considered: a *scale effect* and a *cost-efficiency effect*.

The scale effect of amalgamation is allowed to vary across both services and the size of units under consolidation with respect to those services. For example, an amalgamation of two smaller municipalities may lead to a more productive scale in one service but a deterioration of productivity in another. The scale of municipalities may also vary across services. For example, rural, large surface municipalities may be small in terms of the population that is provided with health services, but large in terms of the road network maintained. These aspects motivate an assessment of the effects of amalgamation on a per-service, per-case basis.

The cost-efficiency effect is defined as a residual container for all changes in cost not explained by the scale effect. For instance, amalgamation may give rise to transition costs or lead to the elimination of inefficiencies, for example by adapting best practices among consolidating units. In the short term, changes in cost efficiency post-amalgamation may also reflect the inaptitude of local governments to reap scale economies or, conversely, the build-up time of bureaucratic congestion associated with diseconomies of scale. More generally, the cost-efficiency effect is characterized more as a short-term effect, whereas the scale effect reflects long-term changes in productivity.

To analyse the relations under interest, this chapter is outlined as follows. First, service-specific cost functions are estimated using stochastic frontier methods to derive the long-term relationship between scale and cost and to obtain individual estimates of cost efficiency, using data on Dutch municipalities between 2005 and 2016. The estimated cost functions are then used to compare the predicted efficient cost levels of the post-amalgamation unit to the sum of the smaller pre-amalgamation units for a group of 40 amalgamations that took place between 2005 and 2016. The average difference between the pre- and post-amalgamation (efficient) cost level is then presented as an estimate of the service-specific scale effect.

Second, cost efficiency is regressed on amalgamation dummies among the same group of observations, resulting in an estimate of the cost-efficiency effect.

As mentioned above, the study in this chapter relates to the literature on amalgamation and economies of scale in local government. It is most closely related to the work of Allers and Geertsema (2016), which analysed the effects of municipal amalgamation in the Netherlands on local government spending and found no significant effect on aggregate spending, also after controlling for average jurisdiction size. The main difference is that the present study explicitly allows for more heterogeneous scale effects of amalgamation across services and the precise size of units under consolidation. In addition, the overall effect of amalgamation is decomposed into a scale and cost-efficiency effect. In that sense, this study is an attempt to further unravel the complex relation between local government amalgamation, scale and cost. The proposed framework can be used to predict and test the effect of amalgamation on cost on a per-service, per-case basis.

The remainder of this chapter is organized as follows: Section 3.2 outlines the methodology, while Section 3.3 elaborates on the services analysed and the data used; Section 3.4 then presents the results, and Section 3.5 contains the concluding remarks.

3.2. METHODOLOGY

To analyse the long-term relationship between scale and cost, cost functions were estimated using stochastic frontier methods. The cost frontier function identifies the minimum cost of service delivery for any given combination of outputs produced and environmental (control) variables faced. The estimation of a cost function requires a functional specification. Here, translog cost functions (Berndt & Christensen, 1973) were used, which are popular in the analysis of economies of scale due to their flexibility. Translog functions are quadratic in logs, which allows the average cost curve to take on a variety of shapes, from a clearly U-shaped to a more L-shaped characterization. In other words, translog functions impose relatively few curvature restrictions compared to, for example, linear, quadratic or log-linear cost functions. More specifically, the equation under estimation for each service is given by

$$c = \alpha + \sum_k \beta_k y_k + \frac{1}{2}\sum_k \sum_{k'} \beta_{kk'} y_k y'_k + \sum_m \gamma_m z_m + \frac{1}{2}\sum_m \sum_{m'} \gamma_{mm'} z_m z_{m'} + \tag{3.1}$$
$$\frac{1}{2}\sum_k \sum_m \mu_m y_k z_m + \sum_k \eta_k y_k t + \lambda_t + v + u.$$

Here, c denotes the (log) deflated reported service cost, y_k denotes the kth (log) service, z denotes the mth (log) environmental factor faced, and t denotes time in years since 2005. The parameters under estimation are β, γ, μ, η and λ. The latter denote yearly time dummies that capture autonomous productivity shifts in the frontier. Furthermore, η_t captures output-biased technological change and allows the relationship between scale and cost to change over time. For notational brevity, municipal and time subscripts i and t are subdued.

In the stochastic frontier framework, differences between observed and minimum costs may arise due to random shocks, denoted by v, or due to inefficiency, denoted by $u, u \geq 0$. As both v and u are not directly observable, identifying assumptions are required to disentangle efficiency from random shocks (e.g. measurement errors, local weather conditions). Here, the assumption is that $v \sim N(0, \sigma_V)$ and $u \sim N^+(0, \sigma_U)$, following Aigner et al. (1977). Then, σ_v and σ_u are additional parameters under estimation.

3.2.1. SCALE EFFECT

Economies of scale are defined by the curvature of the estimated cost frontier with respect to output. Under (dis)economies of scale, expanding output decreases (increases) average cost. The cost elasticity of output is equal to $\sum_k \frac{\partial c}{\partial y_k}$. By definition, it then holds that (dis)economies of scale exist for $\sum_k \frac{\partial c}{\partial y_k} < 1 (\sum_k \frac{\partial c}{\partial y_k} > 1)$.

The *scale effect* of amalgamation is measured by evaluating the following expression:

$$\theta_A = \frac{\exp\left[\hat{c}\left(\mathbf{y}_A, \mathbf{z}_A\right)\right]}{\sum_{a, a \in A} \exp\left[\hat{c}\left(\mathbf{y}_a, \mathbf{z}_a\right)\right]}. \tag{3.2}$$

Here, A denotes the nth amalgamation, $A = 1, \ldots 40$. The numerator equals the predicted efficient cost of the post-amalgamation unit, while the denominator reflects the efficient cost level of the sum of pre-amalgamation units that will later form the larger, post-amalgamation unit. Then, θ_A equals the ratio of the efficient cost level post-amalgamation over the efficient cost-level pre-amalgamation. It then holds that amalgamation is associated with a more (less) productive scale for $\theta_A < 1$ $(\theta > 1)$. Again, Equation 3.2 is evaluated separately for each of the three services. Note that θ may also reflect changes in cost resulting from changes in the environmental variables z post-amalgamation.

3.2.2. COST-EFFICIENCY EFFECT

Following the estimation of Equation 3.1, service-specific municipality cost efficiencies are obtained using the JLMS estimator (Jondrow et al., 1982), denoted by eff, $eff \in [0, 1]$. For example, $eff = 0.8$ indicates that cost can be decreased by 20%, keeping constant current service levels. To analyse the *cost efficiency* effect, the following expression is estimated for each service:

$$eff_{i,t} = \alpha_i + \sigma_i t + \omega I_{t \geq t_{i_A}}. \tag{3.3}$$

Here, α_i are fixed municipality effects, $\sigma_i t$ are municipal-specific time trends, and $I_{t \geq t_{i_A}}$ is a dummy equalling one following the year of amalgamation. The estimation of Equation 3.3 is restricted to the group of 40 amalgamations (cf Allers and Geertsema (2016)). Then, ω identifies the average *cost-efficiency effect* of amalgamation among this group.

Additionally, the following expression is estimated:

$$eff_{i,t} = \alpha_i + \sigma_i t + \omega_1 I_{t \geq t_{t_i}} + \omega_2 I_{t \geq t_{i_A}(t - t_{i_A})}, \tag{3.4}$$

Here, cost efficiency is allowed to change over time as well. For example, transition costs may be incurred especially in the first years after amalgamation.

3.3. DATA AND SERVICE CHARACTERISTICS

Table 3.4 (Appendix) provides summary statistics for the included cost, output and environmental variables for each service: road maintenance (R), school accommodation (E) and public health services (H). Data are included for 2005–2016 and for all Dutch municipalities. In 2016, average costs equalled €8.8 million (R), €2.2 million (E) and €2.2 million (H). Considerable variation exists between municipalities, primarily due to size. For example, the length of the road network maintained varies between 30 km and 1,931 km, and population varies between 919 and 833,624. Cost differences are also partly due to the different environmental conditions faced by municipalities.

Note that these variables reflect actual cost as opposed to spending levels and thus include depreciation cost. This distinction is relevant, as road maintenance and school accommodation in particular are capital-intensive services. School buildings, for example, typically have a 40-year depreciation period, and actual spending levels will reflect more erratic patterns over time. For capital-intensive services in particular, it is more challenging to adjust costs than expenses in the short term. This may also indicate that (dis)economies of scale resulting from amalgamation take time to build up.

The three services were selected on the basis of size, heterogeneity and policy autonomy. Road maintenance, school accommodation and public health vary in several relevant aspects, including labour and capital intensity. For example, road maintenance has been demonstrated to be subject to considerable economies of scale in England (Wheat, 2017) and was one of the services for which cost was affected positively following amalgamation in Denmark (Blom-Hansen et al., 2016). In contrast, public health services are more labour intensive and, as such, may be subject to fewer economies of scale. Similar to road maintenance, school accommodation is rather capital intensive. Furthermore, each of the included services is characterized by a large degree of policy autonomy: the national government imposes relatively few legal requirements on how the service should be organized or how much money should be spent. This implies that cost and efficiency differences are more likely to arise than in services for which there are strict frameworks regarding spending and for which cost levels closely follow the budget allocation rules used to fund them. The three services are discussed in more detail in the next sub-sections.

3.3.1. ROAD MAINTENANCE

Road maintenance is a core activity of Dutch municipalities, and it is characterized by a large degree of policy and financial autonomy. The main measure of output – and therefore scale – used is the total length of roads maintained by municipalities. Comparable measures have been used before in the analysis of road maintenance efficiency by U.S. townships (Deller et al., 1988), local authorities in England (Wheat, 2017), German counties (Kalb, 2014) and, more recently, Eastern German counties in particular (Fritzsche, 2019).

Several environmental measures are included. As road length is determined to a large extent by geographic size and the degree of urbanization, road use may vary significantly between geographically small but densely populated municipalities and larger, rural but less populated municipalities. Although no direct traffic volume indicator is available, road length divided by the number of inhabitants is included as a proxy for the intensity of road use per kilometre of road. Traffic or road intensity measures have been included in several other applications (Deller et al., 1988; Kalb, 2014; O'Donnell et al., 2017; Wheat, 2017). Additionally, the degree of urbanization is included as an environmental variable, since road maintenance may be more complex and costlier in urban areas. As a proxy for the number of bridges under maintenance, a measure of relative bank length (bank length / land surface) is included. Finally, the fourth environmental variable included is soil quality. Municipalities in the central-western region of the Netherlands face worse (softer) soil conditions, and this factor is known to have a negative impact on road maintenance costs.

3.3.2. SCHOOL ACCOMMODATION

Dutch municipalities are obliged to provide school accommodation to primary and secondary schools. The obligations are limited to the construction and outdoor maintenance of school buildings; indoor maintenance and running costs are paid for by school boards. Notably, the division of roles between local government and school boards was explicitly motivated by scale, since local governments were found to be more financially resilient and efficient than smaller school boards in the management and construction of school buildings. Output here is measured by enrolment. Two output indicators are included: the number of pupils attending regular education schools and the number of pupils at special education schools. The latter have smaller classes and thus higher per-unit costs. Control variables included here are the degree of urbanization and the soil factor, the latter leading to potentially higher construction costs.

3.3.3. PUBLIC HEALTH

Municipal public health services carry out a wide range of public health-related activities, such as organizing programmes to promote health, discourage the consumption of alcohol and combat obesity. Public health services are tailored to local communities and are often targeted at communities where the perceived health risks are higher (e.g. age, socio-economic background). Output here is measured by population count, and environmental control variables correspond to the demographic heterogeneity of the population.

3.4. RESULTS

Table 3.1 presents the estimation results obtained from estimating the cost functions (Equations 3.1) using maximum likelihood (ML). Due to the inclusion of second-order terms, most parameters offer no clear intuitive interpretation. For notational brevity, the estimated parameters of the environmental control variables (see Table 3.4 for the definitions of the included variables) are therefore omitted here but are available in the appendix (Tables 3.5, 3.6 and 3.7). The first-order output parameters (β_k) have plausible, positive signs. More restrictive specifications excluding second-order terms (Cobb-Douglas) were rejected. The theoretical requirements of monotonicity in outputs (positive marginal costs) are fulfilled for all observations. Furthermore, no significant yearly output-biased technical change was estimated in any of the services (η_k). In other words, there is no evidence for a significant yearly change in the relationship between scale and cost.

3

Table 3.1: Service-specific cost function estimation results (Equation 3.1)

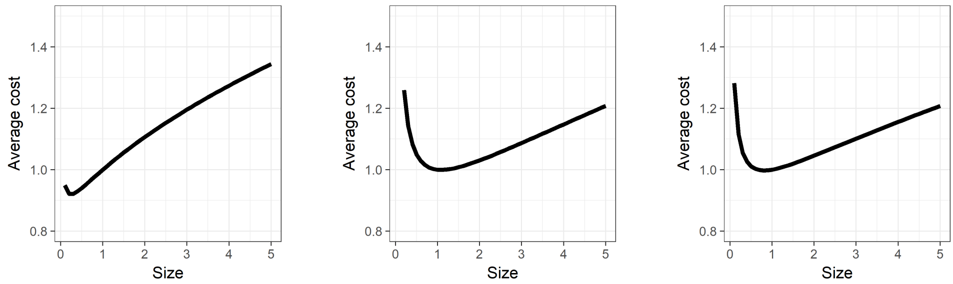
Parameter	**R**	**E**	**H**
β_1	1.137***	1.023***	1.032***
	(0.015)	(0.025)	(0.015)
β_2		0.019	
		(0.013)	
β_{11}	0.082***	0.212***	0.115***
	(0.018)	(0.030)	(0.019)
β_{12}		-0.030***	
		(0.007)	
β_{22}		0.011**	
		(0.005)	
η_1	-0.002	-0.005	-0.001
	(0.002)	(0.003)	(0.002)
η_2		0.000	
		(0.001)	
σ_u	0.222***	0.162***	0.123***
	(0.024)	(0.023)	(0.010)
σ_v	0.269***	0.379***	0.190***
	(0.030)	(0.016)	(0.007)
Controls included	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
N	5,013	4,929	4,889

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

3.4.1. AMALGAMATION AND ECONOMIES OF SCALE

The estimated cost functions can be used to derive the relationship between scale and cost for each service. This relationship can be illustrated by evaluating (standardized) average cost functions, which are plotted in Figure 3.1 for 2016. Each panel illustrates how average cost develops as output size increases for an otherwise average municipality in terms of the environmental variables faced. For example, a size of 1 in the left panel (road maintenance) corresponds with a mean length of road network of roughly 292 km. The average cost of road maintenance is estimated to be 20% higher for municipalities that maintain three times the average length of the road.

Figure 3.1: Standardized average service cost functions with respect to size, 2016. A size of 1 corresponds with the average output size with respect to this service.



(a) Road maintenance (b) School accommodation (c) Public health

While each of the cost curves is estimated to take on a U shape, the precise shape, slope and tipping point vary. The strongest diseconomies of scale are estimated in road maintenance, where the optimal size of production is estimated well below the mean municipality size (optimal: 70 km, mean: 292 km). The strongest economies of scale are estimated in school accommodation (optimal size: 4,100 pupils, mean size: 3,800 pupils), and the shape of the average cost function in public health resembles school accommodation, but the optimal size is estimated to be smaller (optimal: 31,500 population, mean size: 39,000 population).

An interesting question concerns the factors that moderate economies of scale. A common assumption is that due to the associated fixed costs, capital-intensive services are more subject to economies of scale than labour-intensive services. As enrolment increases, the fixed cost of a school building can be spread over more units, and the occupancy rate between school buildings can be optimized. From a certain size onwards, having more pupils will potentially lead to increased managerial complexity or bureaucratic congestion, giving rise to diseconomies of scale. For example, when enrolment increases, municipalities must negotiate with an increasing number of schools and school boards. In this respect, the results regarding road maintenance, which is a rather capital-intensive service, are surprising. The complexity of the road network potentially increases exponentially with the size of the road network. In any case, the results here indicate that Dutch local government road maintenance is characterized by substantial diseconomies of scale.

Table 3.2: Proportion of municipalities operating under significant (dis)economies of scale in 2005 and 2016, per service

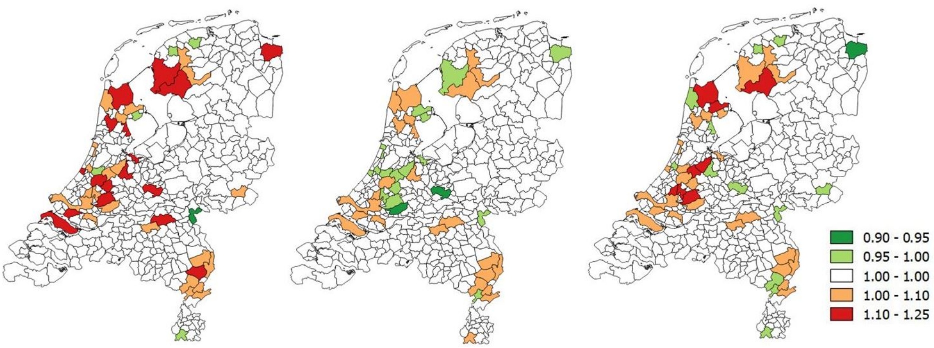
	R		E		H	
	2005	2016	2005	2016	2005	2016
Economies of scale	3%	2%	14%	37%	38%	34%
Constant returns to scale	32%	24%	42%	47%	30%	34%
Diseconomies of scale	65%	75%	44%	16%	33%	32%

Table 3.2 presents the number of municipalities operating under significant economies or diseconomies of scale in 2005 and 2016. For road maintenance, roughly three out of four municipalities were operating under significant diseconomies of scale. For these municipalities, increasing output is associated with an increase in average cost. Regarding school accommodation and public health, roughly one out of three municipalities was operating under economies of scale in 2016. Over time, the proportion of municipalities operating under significant (dis)economies of scale may change as a result of 1) output-biased technical change and 2) changes in output size, for example, as a result of amalgamation.

Recall from Table 3.1 that yearly output-biased change was estimated insignificantly. However, the aggregated effect over a longer period of time (11 years) is significant, which becomes clear especially from school accommodation. Here, the number of municipalities operating under significant diseconomies of scale decreased from 44% in 2005 to 16% in 2016. In other words, the optimal scale of school accommodation grew between 2005 and 2016.

Figure 3.2 presents the estimated, service-specific *scale effect* for each of the considered amalgamations obtained from evaluating Equation 3.2.

Figure 3.2: Scale effect of amalgamation on cost in road maintenance (left), school accommodation (centre) and public health (right) obtained from evaluating Equation 3.2



Red areas correspond with municipalities in which the increase in scale following amalgamation is associated with a deterioration (increase) in cost. A value of 1.05, for example, indicates that amalgamation is estimated to have led to a 5% increase in cost due to scale. Averaged over the 40 amalgamations under consideration, the scale effect of cost is estimated at +7.6%, +0.0% and +4.2% for road maintenance, school accommodation and public health, respectively. As Figure 3.2 illustrates, the scale effect of amalgamation on cost varies across both services and size.

3.4.2. AMALGAMATION AND COST EFFICIENCY

3

In addition to the scale effect of amalgamation, a cost efficiency is considered. Table 3.3 presents the results obtained from estimating Equations 3.3 and 3.4 using OLS.[1]. Cost efficiency is regressed on fixed effects, individual time trends, and an amalgamation dummy, including (Equation 3.3) and excluding (Equation 3.4) the number of years since amalgamation.

Table 3.3: Estimation results of regressing cost efficiency on amalgamation characteristics (Equation 3.3 and Equation 3.4)

Variable	**R**	**E**	**H**	**R**	**E**	**H**
Amalgamation dummy	0.056***	0.017	0.025***	0.056***	0.015	0.026***
	(0.019)	(0.016)	(0.007)	(0.018)	(0.016)	(0.007)
Years since amalgamation				0.001	0.008	-0.004
				(0.010)	(0.009)	(0.003)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual time trends	Yes	Yes	Yes	Yes	Yes	Yes
N	458	450	450	458	450	450
Within-R^2	0.187	0.307	0.207	0.187	0.317	0.210

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The results in the left panel indicate that cost efficiency is significantly and positively affected by amalgamation in road maintenance and public health, by 5.6% and 2.5%, respectively. In school accommodation, the estimated effect is also positive (1.7%), but insignificant. The second specification indicates that the cost-efficiency effect does not increase or decrease significantly from year to year. However, over a period of 11 years, the effect becomes significant in school accommodation and public health. Regarding the former, cost efficiency is estimated to increase further, while in public health, cost efficiency is estimated to first increase (positive dummy effect) but then decrease again over time (negative trend effect).

Together, there appear to be offsetting effects between scale and cost efficiency across services, both in terms of sign and size. The change in scale among the considered amalgamations led to lower productivity most strongly in the case of road maintenance, while cost efficiency increased most strongly here. The contrasting effects potentially reflect

[1]The dependent variable (eff) is only defined between 0 and 1, which implies that a censored estimation procedure, such as tobit regression, is more suitable than OLS. However, tobit regression for fixed models is known to rely on very strong theoretical assumptions. Additional tobit regressions were ran including fixed effects which did not result in noteworthy different outcomes, and the OLS results are presented in Table 3.3

the time it takes for (dis)economies of scale to build up. There is some evidence for this mechanism in the case of public health services, where the estimated cost efficiency trend is negative, but not in road maintenance and school accommodation, where the trend points to a further increase in cost efficiency post-amalgamation. These trend estimates are, however, quite uncertain. On average, the change in cost following amalgamation is only observed for four or five years. To perform a more thorough analysis of the long-term cost-efficiency effect, the costs of (ideally a larger group of) amalgamated municipalities should be monitored over a longer period of time.

3.5. CONCLUSION

The study in this chapter analysed the relationship between local government amalgamation, economies of scale and cost in three heterogeneous services provided by Dutch municipalities: road maintenance, school accommodation and public health. Two potential effect channels of amalgamation on cost were explored: 1) a scale effect and 2) a cost-efficiency effect, with the latter being a residual effect of the changes in cost not explained by the change in scale.

The results confirm that, in line with a large body of literature, local government services are subject to economies of scale but that heterogeneity exists across services. The heterogeneous relationship between local government scale and cost implies that the theoretical effect of amalgamation on cost varies across both services and the size of the units under consolidation.

U-shaped cost functions were estimated for all three services. The weakest economies of scale were estimated in road maintenance, followed by public health and then school accommodation. On average, amalgamation of Dutch local governments between 2005 and 2016 led to a less productive scale in road maintenance and public health. In school accommodation, the average scale effect on cost was null. The estimated cost functions indicate that in the long term, amalgamation as a strategy for achieving economies of scale is fruitful only for the smallest municipalities, although this also depends on the cost structure of the local government services not yet analysed and any other efficiency effects of amalgamation.

In that regard, the offsetting results with respect to cost efficiency channel suggest positive, offsetting efficiency effects of amalgamation on cost. Amalgamation potentially allows municipalities to eliminate inefficiencies by adopting best practices. Another potential explanation for this finding is that it reflects the time taken for the bureaucratic congestion associated with the estimated diseconomies of scale to build up, especially given the capital intensity of the analysed services.

In any case, the results are in line with emerging literature that has failed to find systematic effects of local government amalgamation on cost, including in the Netherlands (Allers & Geertsema, 2016). While the present study paints a more detailed picture of the theoretical scale effects of amalgamation on cost on a per-service and per-case basis, the offsetting efficiency effects highlight a certain rigidness of cost in amalgamating municipalities.

The estimated cost functions thus did not predict the actual changes in cost following amalgamation. The usability of such cost functions to predict the long-term effects of amalgamation on cost then depend crucially on whether the cost-efficiency effect of amalgamation wears out over a longer period of time.

Appendix

Table 3.4: Summary statistics of key variables (2016)

	Measurement	Service	Mean	Std. dev.	Minimum	Maximum
Nominal cost						
Road maintenance	€1,000	R	8,782.12	24,069.77	24.00	352,740.00
School accommodation	€1,000	E	2,224.90	5,304.48	55.00	64,727.00
Public health	€1,000	H	2,168.27	9,335.70	4.00	165,153.00
Output variables						
Road length	Kilometer	R	323.13	241.55	30.00	1,931.00
RE pupils	Count	E	3,659.74	5,508.25	58.00	62,468.00
SE pupils	Count	E	259.74	525.87	1.00	5,161.00
Population	Count	H	43.536,21	67,609.56	919.00	833,624.00
Environmental variables						
Address density	Addresses per sq. km.	R,E	1,080.91	753.65	129.00	6,011.00
Soil factor	Weighted index	R,E	1.09	0.14	1.00	1.85
Rel. bank length	Bank length (km) / land surface (km^2)	R	0.37	0.36	0.01	3.25
Traffic intensity	Population / road length (km)	R	133.13	78.96	26.41	484.10
Population <20y	Population proportion	H	0.23	0.02	0.16	0.38
Population >65y	Population proportion	H	0.20	0.03	0.09	0.31
Minorities	Population proportion	H	0.04	0.04	0.00	0.03
Low income households	Population proportion	H	0.12	0.03	0.07	0.21

Table 3.5: Translog cost function estimation results: road maintenance (Equation 3.1)

		Estimate	Standard error
Road length	β_1	1.137***	0.015
Road length x road length	β_{11}	0.082***	0.018
Urbanization	γ_1	0.196***	0.027
Soil quality	γ_2	0.120	0.076
Relative bank length	γ_3	0.113***	0.013
Traffic density	γ_4	0.756***	0.033
Urbanization x urbanization	γ_{11}	0.224***	0.082
Urbanization x soil quality	γ_{12}	0.388**	0.176
Urbanization x rel. bank length	γ_{13}	0.056**	0.028
Urbanization x traffic density	γ_{14}	-0.066	0.100
Soil quality x soil quality	γ_{22}	2.676***	0.729
Soil quality x rel. bank length	γ_{23}	-0.070	0.119
Soil quality x traffic density	γ_{24}	-0.740***	0.256
rel. bank length x rel. bank length	γ_{33}	0.088***	0.016
rel. bank length x traffic density	γ_{34}	-0.120***	0.037
Traffic density x traffic density	γ_{44}	0.322**	0.138
Road length x urbanization	μ_{11}	0.031	0.031
Road length x soil quality	μ_{12}	-0.269***	0.087
Road length x rel. bank length	μ_{13}	0.022	0.014
Road length x traffic density	μ_{14}	0.027	0.039
Time x road length	η_1	-0.002	0.002
Wadden Islands		0.431***	0.044
Constant		-0.554***	0.029
	σ_u	0.222***	0.024
	σ_v	0.270***	0.030
Observations	5,013		

Standard errors are clustered at the municipality level.

All variables are in log (except for proportions) and divided by their sample means.

Year dummies included (not shown here).

* p<0.1, ** p<0.01, *** p<0.01

Table 3.6: Translog cost function estimation results: school accommodation (Equation 3.1)

		Estimate	Standard error
RE pupils	β_1	1.023***	0.025
SE pupils	β_2	0.019	0.013
RE pupils x RE pupils	β_{11}	0.212***	0.030
RE pupils x SE pupils	β_{12}	-0.030***	0.007
SE pupils x SE pupils	β_{22}	0.011**	0.005
Address density	γ_1	0.071***	0.018
Soil quality	γ_2	-0.111	0.112
Address density x address density	γ_{11}	0.274***	0.045
Address density x soil quality	γ_{12}	-0.100	0.118
Soil quality x soil quality	γ_{22}	-2.873***	0.656
RE pupils x address density	μ_{11}	-0.080***	0.030
RE pupils x soil quality	μ_{12}	0.164	0.110
SE pupils x address density	μ_{21}	-0.001	0.006
SE pupils x soil quality	μ_{22}	-0.083***	0.030
Time x regular pupils	η_1	-0.005	0.003
Time x SE pupils	η_2	0.000	0.001
Constant		-0.441***	0.033
	σ_u	0.162***	0.023
	σ_v	0.379***	0.016
Observations	4,929		

Standard errors are clustered at the municipality level.
All variables are in log (except for proportions) and divided by their sample means.
Year dummies included (not shown here).
* p<0.1, ** p<0.01, *** p<0.01

Table 3.7: Translog cost function estimation results: public health (Equation 3.1)

		Estimate	Standard error
Population	β_1	1.032***	0.015
Population x population	β_{11}	0.115***	0.019
Population <20y (%)	γ_1	-0.115	0.097
Population >65y (%)	γ_2	-0.228***	0.045
Minorities (%)	γ_3	-0.010	0.007
Low income households (%)	γ_4	0.074**	0.036
Pop. <20y x pop. <20y	γ_{11}	4.030***	1.500
Pop. <20y x pop. >65y	γ_{12}	1.516**	0.640
Pop. <20y x minorities	γ_{13}	0.295***	0.098
Pop. <20y x low inc. hh.	γ_{14}	0.443	0.467
Pop. <65y x pop. >65y	γ_{22}	0.562*	0.341
Pop. <65y x minorities	γ_{23}	0.103**	0.045
Pop. <65y x low inc. hh.	γ_{24}	0.087	0.200
Minorities x minorities	γ_{33}	0.016*	0.008
Minorities x low inc. hh.	γ_{34}	0.169***	0.030
Low inc. hh. x low inc. hh.	γ_{44}	0.224**	0.100
Population x pop. <20y	μ_{11}	-0.785***	0.125
Population x pop. >65y	μ_{12}	-0.265***	0.056
Population x minorities	μ_{13}	-0.020*	0.011
Population x low inc. hh.	μ_{14}	-0.159***	0.043
Time x regular pupils	η_1	-0.001	0.002
Constant		-0.673***	0.012
	σ_u	0.123***	0.010
	σ_v	0.190***	0.007
Observations	4,889		

Standard errors are clustered at the municipality level.
All variables are in log (except for proportions) and divided by their sample means.
Year dummies included (not shown here).
* p<0.1, ** p<0.01, *** p<0.01

Bibliography

Aigner, D., Lovell, C., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37. https://doi.org/10.1016/0304-4076(77)90052-5

Allers, M., & Geertsema, J. (2016). The effects of local government amalgamation on public spending, taxation and service levels: evidence from 15 years of municipal consolidation. *Journal of Regional Science*, *56*(4), 659–682. https://doi.org/10.1111/jors.12268

Berndt, E., & Christensen, L. (1973). The translog function and the substitution of equipment, structures, and labor in U.S. manufacturing 1929-68. *Journal of Econometrics*, *1*(1), 81–113. https://doi.org/10.1016/0304-4076(73)90007-9

Bish, R. (2001). *Local Government Amalgamations. Discredited Nineteenth-Century Ideals Alive in the Twenty-First.* C.D. Howe Institute.

Blom-Hansen, J., Houlberg, K., Serritzlew, S., & Treisman, D. (2016). Jurisdiction Size and Local Government Policy Expenditure: Assessing the Effect of Municipal Amalgamation. *American Political Science Review*, *110*(4), 812–831. https://doi.org/10.1017/S0003055416000320

Byrnes, J., & Dollery, B. (2002). Do Economies of Scale Exist in Australian Local Government? A Review of the Research Evidence. *Urban Policy and Research*, *20*(4), 391–414. https://doi.org/10.1080/0811114022000032618

Deller, S., Chicoine, D., & Walzer, N. (1988). Economies of Size and Scope in Rural Low-Volume Roads. *The Review of Economics and Statistics*, *70*(3), 459. https://doi.org/10.2307/1926784

Fritzsche, C. (2019). Analyzing the Efficiency of County Road Production – Evidence from Eastern German Counties. *German Economic Review*, *20*(4), 415–435. https://doi.org/10.1111/geer.12170

Holzer, M., Fry, J., Charbonneau, E., Van Ryzin, G., Wang, T., & Burnash, E. (2009). *Literature Review and Analysis Related to Optimal Municipal Size and Efficiency*. Rutgers University.

Jondrow, J., Knox Lovell, C., Materov, I., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, *19*(2-3), 233–238. https://doi.org/10.1016/0304-4076(82)90004-5

Kalb, A. (2014). What Determines Local Governments' Cost-efficiency? The Case of Road Maintenance. *Regional Studies*, *48*(9), 1483–1498. https://doi.org/10.1080/00343404.2012.731044

O'Donnell, C. J., Fallah-Fini, S., & Triantis, K. (2017). Measuring and analysing productivity change in a metafrontier framework. *Journal of Productivity Analysis*, *47*(2), 117–128. https://doi.org/10.1007/s11123-017-0494-6

Reingewertz, Y. (2012). Do municipal amalgamations work? Evidence from municipalities in Israel. *Journal of Urban Economics*, *72*(2-3), 240–251. https://doi.org/10.1016/j.jue.2012.06.001

Turley, G., Mcdonagh, J., McNena, S., & Grzedzinski, A. (2018). Optimum Territorial Reforms in Local Government: An Empirical Analysis of Scale Economies in Ireland. *The Economic and Social Review*, *49*(4), 463–488.

Wheat, P. (2017). Scale, quality and efficiency in road maintenance: Evidence for English local authorities. *Transport Policy*, *59*, 46–53. https://doi.org/10.1016/j.tranpol.2017.06.002

3

4

AN EXTENDED ANALYSIS OF ROAD MAINTENANCE

The study in this chapter outlines an extended[1] analysis of the cost determinants and cost efficiency of road maintenance in Dutch municipalities, including economies of scale. A cost function is estimated for 2005–2016 using stochastic frontier methods. The results indicate that environmental factors (soil type, waterway length, urbanization, traffic intensity) are important determinants of road maintenance costs. After controlling for environmental factors, there is substantial variation in cost efficiency between municipalities. Average cost efficiency is estimated at 80%. The results warrant the performance of more in-depth analyses of road maintenance costs, both to substantiate the findings and to identify efficiency determinants and best practices. More detailed performance benchmarking for road maintenance is recommended as a promising tool to initiate and subsequently encourage learning processes among local governments.

[1] This study is an extended analysis of the road maintenance analysis also contained in Chapter 3. It presents the same cost function regressions using the same data. This chapter focuses particularly on the environmental factors that affect cost, and it goes into more detail on the dispersion of cost efficiency and economies of scale among municipalities, whereas the previous chapter focused on the theoretical and empirical effects of local government amalgamation. Both chapters are intended to be submitted as separate papers.

4

4.1. Introduction

Municipalities in the Netherlands maintain an intricate network of local roads spanning just over 125,000 km, or 91 per cent of total road length in the Netherlands. In 2016, total municipality expenditure amounted to €3.4 billion, an amount which, given the start of overdue maintenance work (as a result of the global financial crisis; see e.g. Groot et al. (2016)), is expected to increase in the coming years.

This study outlines an analysis of the cost structure and cost efficiency of road maintenance in Dutch municipalities. The analysis is motivated by four considerations. First, 'roads are among the most important public assets in many countries' (Burningham & Stankevich, 2005), and road maintenance is a core activity of Dutch local government. Despite the (financial) significance of road provision, empirical studies on the cost structure and cost efficiency by local and regional authorities are still scarce, although the number of applications has increased over the past years (Fritzsche, 2019; Kalb, 2014; Wheat, 2017).

Second, in many existing efficiency analyses of road maintenance costs, less attention has been paid to environmental factors, which can in fact significantly influence the cost of road maintenance. Examples of relevant factors include geological and climate conditions (Ozbek et al., 2010; Rouse & Putterill, 2000). For a meaningful benchmark, it is important to disentangle true efficiency differences from heterogeneity outside municipalities' sphere of influence.

A third motivation relates specifically to the concept of economies of scale. Dutch local governments are witnessing a long and ongoing trend of consolidation, driven by a quest for economies of scale (the idea that public service delivery size and efficiency go hand in hand). However, municipal consolidation has not led to the expected decrease in cost in the Netherlands (Allers & Geertsema, 2016). Analysing economies of scale in local government service delivery has also proven to be difficult. This complexity is partly due to the heterogeneity of the many services local governments provide. For example, it has been suggested that capital-intensive services are subject to more economies of scale than labour-intensive services. Given the capital intensity of road maintenance, considerable economies of scale may exist here. The relationship between scale and cost in road maintenance is relevant for both amalgamation and co-operation.

Fourth, road maintenance is an attractive candidate for benchmarking among local governments, as it is characterized by a large degree of policy autonomy. Compared to other municipal services, for example the issuing of official documents, few restrictions are imposed on local governments regarding the way in which they organize and spend money on road maintenance, other than the obligation to work in accordance with legal safety regulations. This policy autonomy may fuel considerable heterogeneity in the organization of road maintenance across municipalities, which may also result in efficiency variation. Benchmarking can be used to identify best and worst practices and to initiate learning processes between local governments. To this end, this study develops a prototype of a fair benchmarking framework that disentangles efficiency from heterogeneity in the operating environment of municipalities.

The study in this chapter proceeds as follows. A cost model is estimated using stochastic frontier methods, using data on municipality road maintenance cost, road length and various environmental factors over the period 2005–2016. The estimated frontier identifies the minimum cost of road maintenance given some level of output and environmental factors faced by municipalities. Results regarding the cost structure (environmental factors, economies of scale) and cost efficiency are then discussed.

The remainder of this chapter is organized as follows. Section 4.2 discusses the relevant literature, and Section 4.3 briefly describes the institutional context of local government road maintenance in the Netherlands. Thereafter, Section 4.4 outlines the methodology, while Section 4.5 discusses the data, and Section 4.6 presents the estimation results. Section 4.7 finally presents the discussion and concluding remarks.

4.2. LITERATURE

The study in this chapter addresses the well-developed strand of literature on the measurement and analysis of local government efficiency. Within this literature, a distinction can be made between studies that focus on overall local government efficiency and those that analyse efficiency regarding the provision of specific services, such as waste collection or road maintenance. This study belongs to the latter. Regarding the former, Narbón-Perpiñá and De Witte (2018) and Narbón-Perpiñá and De Witte (2018) provide an up-to-date overview of the literature on (overall) local government efficiency. Many such studies have included some indicator of road length or area to proxy the provision of maintenance services.

While specific empirical analyses of road maintenance are relatively scarce, several studies have been conducted (Deller et al., 1988; Deller & Halstead, 1994; Deller & Nelson, 1991; Fritzsche, 2019; Kalb, 2014; Link, 2014; Lopez et al., 2009; Rouse et al., 1997; Wheat, 2017). These studies typically analyse the cost efficiency of road maintenance using parametric (stochastic frontier methods) or non-parametric methods (such as DEA). While the application areas are rather different from this study in terms of the country and government layer under analysis, they provide some guidance regarding the choice of variables included. Common output indicators are road length or road surface area by road type, sometimes complemented by a measurement of traffic or road use. Regarding quality, Kalb (2014) has included the number of accidents due to poor road conditions as an indicator. Moreover, Fritzsche (2019) has used a direct measurement of road condition, and Wheat (2017) has included a public satisfaction index.

The importance of environmental factors for the cost of road maintenance has been stressed by Rouse and Putterill (2000), who have identified three categories of environmental factors: policy, market and physical environment. Cost drivers in the policy environment relate to strategic decisions with regard to organizational structure and executional processes. In this study, such factors are regarded as determinants of efficiency rather than (uncontrollable) environmental variables. The market environment relates to, for example, competitiveness in the market for road services and the price premium demanded by contractors. In particular, Rouse and Putterill (2000) has emphasized the great significance of physical environmental factors. These factors relate to the road and its adjacent environment, including the geological conditions and vegetation, the availability of materials for road construction, traffic intensity, climatic conditions (intensity of rainfall, snow, ice and flooding) and road geometry. Physical environmental factors are an important variable omitted from road management performance research (Rouse & Putterill, 2000). Since then, the number of applications including physical factors has increased (Ozbek, 2007; Ozbek et al., 2010; Rouse & Chiu, 2009; Rouse & Putterill, 2007) but remains scarce. For example, three more recent applications (Fritzsche, 2019; Kalb, 2014; Wheat, 2017) do not include physical environmental factors, although Kalb (2014) includes socio-economic variables such as the unemployment rate and other demographic factors as controls.

Beyond the focus of this research, few studies have explored the determinants of road maintenance (in)efficiency, although there are some exceptions. Blom-Hansen (2003) analysed the relation between cost and private sector involvement and found that private companies are more efficient in Denmark. The authors argue that this may be due to a difference in ownership or a difference in competitive pressure. Kalb (2014) explored how local government funding schemes affect efficiency. The results here indicate that efficiency is negatively related to the amount of intergovernmental grants awarded, suggesting that local taxes are spent more efficiently. The lack of research on the determinants of efficiency suggests that this would be a promising avenue for future research in particular. In other local government services, efficiency has been linked to delivery modalities, such as contracting out (Dijkgraaf & Gradus, 2003), privatization (Bel et al., 2010; Bel & Warner, 2008) and inter-municipal co-operation (Allers & de Greef, 2018; Bel & Warner, 2015; Niaounakis & Blank, 2017).

4.3. Institutional context

As mentioned before, road maintenance is a core task of Dutch municipalities and is characterized by a large degree of policy and financial autonomy. To comply with national and European laws regarding road conditions, municipal administrations draft a general road maintenance policy, broadly outlining the policy goals of its road maintenance strategies. Administrations then translate the general road maintenance policies into practical road maintenance plans, describing the actual activities to be carried out, as well as the quality and budgets of road maintenance (Niaounakis & van Heezik, 2017). Dutch municipalities are primarily funded by a lump sum grant provided by the national government, which also forms the main basis for road maintenance budgets.

Municipalities may deliver road maintenance through various delivery modes. In a survey of Dutch municipalities, Gradus et al. (2019) distinguished four delivery modes: in-house, inter-municipal co-operation, municipality-owned firm, and private corporation. Delivery modes vary both across municipalities and over time. Between 2010 and 2018, the popularity of in-house production decreased, while inter-municipal co-operation and the use of municipality-owned and private firms increased (Gradus et al., 2019; Schoute et al., 2020). Delivery modes may be key drivers of efficiency, and outsourcing has been associated with lower costs in Danish road maintenance (Blom-Hansen, 2003). Interestingly, municipalities vary in how they choose to outsource road maintenance. For example, in contracting out road maintenance to private corporations, there is substantial heterogeneity with respect to tender designation (Niaounakis & van Heezik, 2017). One such aspect includes the tender size of road maintenance projects, with some municipalities outsourcing few, larger tenders, whilst other tend to outsource a larger number of smaller tenders. Tender designation may be a significant driver of efficiency differences between municipalities that outsource, as has been shown to be the case in, for example, waste management (Felso et al., 2012).

4.4. METHODOLOGY

In this study, the cost structure and cost efficiency of Dutch municipal road maintenance were analysed by applying stochastic frontier methods to a cost model. The cost model was specified as a frontier that identifies the minimum cost for a municipality given output levels and the physical and environmental factors faced. The use of a cost model assumes that municipalities aim to minimize cost as opposed to output or quality maximization. Dutch municipalities are largely financed through an intergovernmental grant from the national government and are free to allocate funds across services or to save budget surpluses, which arguably suggests that cost minimization can reasonably be assumed. The basic model can be represented as

$$c = g(\mathbf{y}, \mathbf{z}, T) + v + u, \tag{4.1}$$

where c denotes the observed (log) maintenance cost in real terms, and $g(\mathbf{y}, \mathbf{z}, T)$ is a parametric specification of a cost frontier, which identifies minimum cost given a vector of (log) outputs $\mathbf{y}$, (log) environmental factors $\mathbf{z}$ and time T. The unit of analysis is the road maintenance department of individual municipalities. For notational ease, municipal and time subscripts i and t are subdued in Equation 4.1 and in the following equations.

In the stochastic frontier framework, differences between observed and minimum costs may arise due to random shocks, denoted by v, or due to inefficiency, denoted by $u, u \geq 0$. As both v and u are not directly observable, identifying assumptions are required to disentangle efficiency from random shocks (e.g. measurement errors, local weather conditions). The pioneering SFA models (Aigner et al., 1977; Meeusen & Van den Broeck, 1977) assumed that v follows a normal distribution and that u follows a half-normal respectively exponential distribution. Following the former, it is assumed here that $v \sim N(0, \sigma_V)$ and $u \sim N^+(0, \sigma_U)$. Furthermore, the estimation of Equation 4.1 requires a functional specification of $g(\mathbf{y}, \mathbf{z}, \mathbf{t})$. Here, a translog specification is applied. Translog functions are a second-order approximation of a general function and are popular in efficiency research due to their flexibility. Translog functions impose less a-priori restrictions on the shape of the cost function compared to simpler specifications such as quadratic or linear cost functions. Finally, the following function is estimated:

$$\begin{aligned} c = &\alpha + \beta_1 y + \frac{1}{2}\beta_{11} y^2 + \sum_m \gamma_m z_m + \frac{1}{2}\sum_m \sum_{m'} \gamma_{mm'} z_m z_{m'} + \\ &\frac{1}{2}\sum_m \mu_m y z_m + \eta_1 y t + \lambda_t + v + u. \end{aligned} \tag{4.2}$$

Here, lowercase letters (c, y, z) denote the natural logarithm of variables; T reflects time in years since 2005; and $\alpha, \beta, \gamma, \mu, \eta$ and λ are the parameters under estimation. Note that only one output indicator is included (y, road length). Section 4.4 elaborates on the choice of variables included for analysis. The λ_t parameters denote yearly time dummies that capture autonomous productivity shifts of the frontier. Due to innovations, for example, the minimum attainable cost of road maintenance may decrease over time. Furthermore, output-biased change is allowed for, captured by the parameter η_1. This term captures potential changes in the shape of the frontier over time.

To illustrate the relationship between physical factors and road maintenance costs, the following expression is evaluated:

$$\theta = \hat{c}(Y,\mathbf{z}) - \hat{c}(Y,\bar{\mathbf{Z}}). \tag{4.3}$$

For each municipality, θ reflects the predicted efficient cost level compared to if it were facing average environmental factors (i.e. facing $\bar{\mathbf{Z}}$ instead of $\mathbf{Z}$). For example, a value of $\theta = 0.1$ implies that costs are estimated to be 10 per cent higher.

Another relationship of interest concerns economies of scale. Economies of scale are defined by the curvature of the estimated cost frontier with respect to output. Under (dis)economies of scale, expanding output decreases (increases) average cost. The cost elasticity of output is equal to

$$EOS = \frac{\partial \log C}{\partial \log Y} = \frac{\partial c}{\partial y}. \tag{4.4}$$

By definition, it then holds that (dis)economies of scale exist for $EOS < 1 (EOS > 1)$.

4.5. Data

Data used in this study were mainly sourced from Statistics Netherlands, the national statistical agency in the Netherlands. The data cover the period between 2005 and 2016. Table 4.1 presents the summary statistics, and the appendix contains a description of the included variables (Table 4.5).

Table 4.1: Summary statistics of key variables included for analysis

		Mean	Std. dev.	Minimum	Maximum
Nominal cost (€1,000)	C	8160.18	23800.73	24.00	480700.00
Road length (km)	Y	291.54	229.97	16.00	1937.00
Urbanization	Z_1	977.79	719.94	111.00	6094.00
Soil quality	Z_2	1.09	0.15	1.00	1.86
Relative bank length	Z_3	0.37	0.37	0.01	3.25
Traffic density	Z_4	132.61	77.20	25.99	484.10
Observations		5,110			

The measure of cost included reflects the reported cost of the construction and maintenance of the road network and associated facilities, including streets, squares, bridges, level crossings, public lighting and quality assessments of the road network. Reported cost figures vary considerably, ranging from €24,000 to €480 million.

The sole output measure used is the total length of the road network under maintenance, which varies between 16 km and 1,937 km (in the smallest and largest municipalities respectively). Comparable measures were utilized in the analysis of road maintenance efficiency by U.S. townships (Deller et al., 1988), local authorities in England (Wheat, 2017), German counties (Kalb, 2014) and Eastern German counties (Fritzsche, 2019). These studies typically employed multiple measures of road length or area, differentiated by road type. Unfortunately, our data do not allow for such a distinction.

Several environmental factors were included in the study. First, as a measure of road complexity, we included the degree of urbanization, as measured by address density. Second, we included a measure of soil quality, which varies considerably within the Netherlands. Soft soil (e.g. peat and clay) is known to complicate infrastructure construction and increase maintenance costs (Davitt et al., 2000; Erwich & Vliegen, 2001; Hassan et al., 2013; Henkens, 2013). According to estimates, infrastructure maintenance costs for municipalities with soft soil conditions are up to 40% higher(Lambert et al., 2015). This is also recognized by the national government, which uses soil quality as a funding parameter for determining municipality budgets. Third, we included a measure of relative bank length (i.e. the length of waterways, such as canals). Bank length is correlated with the number of bridges and tunnels, for which there may be increased maintenance costs. The relative bank length is computed as the nominal bank length divided by municipality land surface area. Fourth, a measure of traffic intensity was included, measured by capita per kilometre of road. Traffic or road intensity measures have also been included in several other applications (Deller et al., 1988; Kalb, 2014; O'Donnell et al., 2017; Wheat, 2017).

Due to the unavailability of data, no quality indicators were included. The omission of quality indicators may lead to an underestimation of the efficiency of municipalities that carry out high-quality road maintenance. As discussed previously, other studies of road maintenance have used more explicit quality indicators, such as road condition assessments (Fritzsche, 2019), physical road conditions (Wheat, 2017), the number of defects Rouse et al. (1997), the number of accidents due to poor road conditions (Kalb, 2014) and public satisfaction surveys (Wheat, 2017).

Furthermore, nominal costs are deflated by an input price index constructed by Statistics Netherlands specifically for groundwork and road projects. This price index is the same for all municipalities and varies only over time. Dutch municipalities face largely homogeneous input markets, since wages are set in collective agreements, and input goods are purchased on national markets (Bikker & van der Linde, 2016).

Finally, a dummy variable was included for five island municipalities, namely, the Wadden Islands.

4.6. RESULTS

Table 4.2 presents the results obtained from estimating Equation 4.2 using ML. The estimated parameters have no direct interpretation due to the non-linearity imposed by the cross terms. A simpler Cobb-Douglas specification – omitting the cross terms – was rejected. Furthermore, the estimated function increases in output for all observations, indicating that the theoretical requirement of monotonicity is fulfilled. The estimated cost model can be used to derive a variety of relationships regarding the cost structure and cost efficiency of road maintenance.

4.6.1. ENVIRONMENTAL FACTORS

Four environmental factors (z_1, z_2, z_3, z_4) were included: urbanization, soil quality, bank length and traffic intensity. Figures 4.1 and 4.2 illustrate the results obtained from evaluating Equation 4.3, reflecting the procentual difference in cost compared to when facing

Table 4.2: Translog cost function estimates (Equation 4.2)

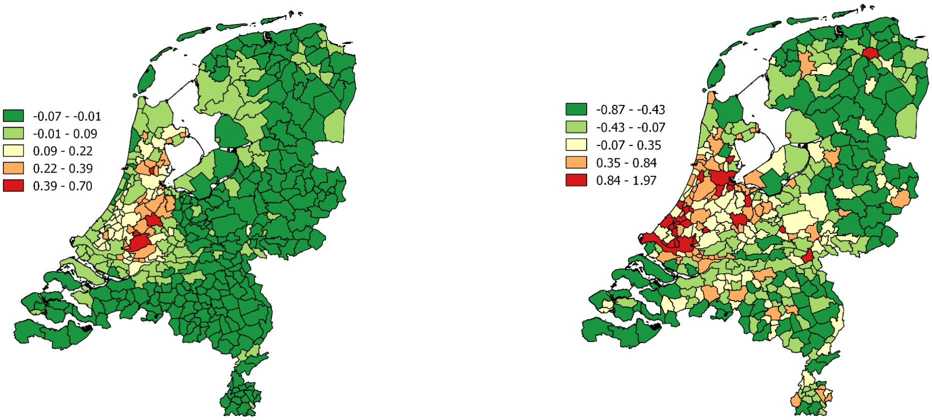
		Estimate	Standard error
Road length	β_1	1.137***	0.015
Road length x road length	β_{11}	0.082***	0.018
Urbanization	γ_1	0.196***	0.027
Soil quality	γ_2	0.120	0.076
Relative bank length	γ_3	0.113***	0.013
Traffic density	γ_4	0.756***	0.033
Urbanization x urbanization	γ_{11}	0.224***	0.082
Urbanization x soil quality	γ_{12}	0.388**	0.176
Urbanization x rel. bank length	γ_{13}	0.056**	0.028
Urbanization x traffic density	γ_{14}	-0.066	0.100
Soil quality x soil quality	γ_{22}	2.676***	0.729
Soil quality x rel. bank length	γ_{23}	-0.070	0.119
Soil quality x traffic density	γ_{24}	-0.740***	0.256
rel. bank length x rel. bank length	γ_{33}	0.088***	0.016
rel. bank length x traffic density	γ_{34}	-0.120***	0.037
Traffic density x traffic density	γ_{44}	0.322**	0.138
Road length x urbanization	μ_{11}	0.031	0.031
Road length x soil quality	μ_{12}	-0.269***	0.087
Road length x rel. bank length	μ_{13}	0.022	0.014
Road length x traffic density	μ_{14}	0.027	0.039
Time x road length	η_1	-0.002	0.002
Wadden Islands		0.431***	0.044
Constant		-0.554***	0.029
	σ_u	0.222***	0.024
	σ_v	0.270***	0.030
Observations	5,013		

Standard errors are clustered at the municipality level.
All variables are in log (except for proportions) and divided by their sample means.
Year dummies included (not shown here).
* p<0.1, ** p<0.01, *** p<0.01

average environmental conditions.

The four variables were grouped into sets of two. Figure 4.1a reflects the procentual difference in cost for each municipality compared to if it faced an average soil quality and bank length. Figure 4.1b reflects the procentual difference in cost for the other two variables (urbanization and traffic intensity). In that sense, Figure 4.1a illustrates the higher cost (per kilometre of road maintenance) associated with physical environmental factors, particularly soft soil. The presence of soft soil is concentrated in the central-western region of the Netherlands, corresponding with the areas that are darkest red. The other two variables, namely, urbanization and traffic intensity, are also strongly significantly correlated with a higher road maintenance cost, as shown in Figure 4.1b. Urban, densely populated municipalities have high values of both measures.

Figure 4.1: Estimated deviation in municipal road maintenance cost due to physical factors, relative to average conditions (Equation 4.3)



(a) Estimated deviation in cost per municipality due to the deviation in soil quality (Z_2) and relative bank length (Z_3) from the sample means ($\bar{Z}_2$ and $\bar{Z}_3$), x 100%

(b) Estimated deviation in cost per municipality due to the deviation in urbanization (z_1) and traffic density (z_4) from the sample mean ($\bar{z}_1$ and $\bar{z}_4$), x 100%

4.6.2. ECONOMIES OF SCALE

Economies of scale are defined by the curvature of the estimated cost function with respect to output. Figure 4.2 plots the cost elasticities of the municipalities against size (2016). The optimal size with respect to average cost is estimated at roughly 70 km, a size already surpassed by most municipalities.

Table 4.3 presents the results obtained when testing the hypothesis of constant returns of scale for municipalities in 2005 and 2016. These numbers indicate that 65% (2005) and 75% (2016) of municipalities are estimated to operate under significant diseconomies of scale. The increase from 65% to 75% between 2005 and 2016 is primarily the result of various amalgamations, as the number of municipalities decreased from 467 to 390. There is no evidence of a significant output-biased technological change, as reflected by the cross term between time and road length.

Figure 4.2: Cost elasticity of scale with respect to road length, 2016 (Equation 4.4)

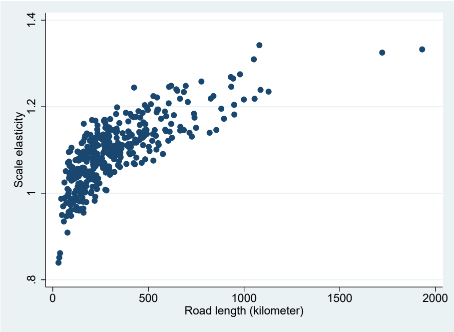


Table 4.3: Number of municipalities operating under significant (dis)economies of scale in 2005 and 2016

	2005	2016
Economies of scale	3% (12)	2% (6)
Constant returns to scale	32% (150)	24% (92)
Diseconomies of scale	65% (350)	75% (292)
	100% (467)	100% (390)

Finally, as depicted in Figure 4.2, cost elasticities may vary for municipalities of equal size. Specifically, municipalities facing soft soil conditions were found to operate under stronger economies of scale, as is reflected by the cross term between road length and soil quality. In other words, the upward effect of soft soil on cost decreases with size, which may imply that some lessons have been learned when it comes to dealing with this adverse circumstance. The other three variables (urbanization, bank length and traffic density) individually do not significantly affect economies of scale.

4.6.3. COST EFFICIENCY

Efficiency predictions were obtained using the JLMS estimator (Jondrow et al., 1982). Cost efficiency is expressed between 0% and 100%, and a cost efficiency equal to 80% indicates that, if output levels remain the same, road maintenance costs can be reduced by 20%. Table 4.4 contains the distribution of the predicted efficiency scores in 2016. In that year, average efficiency was estimated at 80%. Roughly one third of the municipalities scored below 80%, while the top 10 per cent had a lower bound of roughly 90%. More generally, the variation in efficiency scores illustrates that large differences in cost remain, even after controlling for road length and various environmental factors.

A significant result here concerns the ratio between σ_u and σ_v, an indication of the 'signal-to-noise' ratio. This ratio is estimated to be rather small (0.27), which implies that considerable uncertainty exists regarding the efficiency estimates.

Table 4.4: Distribution of predicted efficiency scores (2016)

Percentile	Efficiency score
10%	0.689
20%	0.770
30%	0.796
40%	0.815
50%	0.835
60%	0.853
70%	0.865
80%	0.881
90%	0.897

4.7. Discussion and conclusion

This chapter analysed the cost structure (including economies of scale) and cost efficiency of road maintenance in Dutch local government using stochastic frontier methods. Regarding the cost structure, the results indicate that environmental factors such as soil quality and traffic intensity have a significant impact on maintenance costs. These results emphasize the importance of controlling for environmental factors in the analysis of road maintenance efficiency and in the fair benchmarking of local governments. Failing to do so risks ascribing uncontrollable heterogeneity to (in)efficiency, and, in turn, identifying best practices on invalid grounds.

With regard to economies of scale, 75% of municipalities in 2016 were estimated to operate under significant diseconomies of scale. This may appear to be a counter-intuitive result given that road maintenance is a rather capital-intensive service, and, in contrast, strong economies of scale were recently estimated for English local authorities (4,000–8,000 km) (Wheat, 2017). However, similarities between the application areas are limited. Dutch municipal road networks are much more finely meshed, whereas English local authority roads are more regional in nature. It is possible that the complexity and required managerial oversight of the road network increases exponentially with size. Another potential underlying mechanism for finding no economies of scale is that small municipalities may have achieved economies of scale through contracting out road maintenance to larger market organizations.

Finally, after controlling for environmental factors and road length, average cost efficiency was estimated at 80% in 2016, and roughly one third of municipalities are estimated to operate with a cost efficiency below 80%. At first sight, this suggests that there is still considerable room for improvement in many municipalities. However, the efficiency results are subject to much restraint, particularly regarding the reliability of the reported cost figures and the coarse output measurement used.

The results therefore warrant further data collection and analysis to improve the efficiency estimates obtained and, finally, to extend analysis towards the determinants underlying (in)efficiency. Data collection should be targeted specifically towards 1) improving the consistency of cost administration, 2) extending the level of detail regarding output measurement (e.g. road types, traffic indicators), 3) collecting quality indicators and

4) gathering information on potential determinants of efficiency. Regarding the latter, a particularly fruitful avenue for future research is the relation between road maintenance efficiency and its various delivery modes, such as outsourcing, in-house production and inter-municipal co-operation (Blom-Hansen, 2003; Gradus et al., 2019; Schoute et al., 2020).

When those conditions are met, the stochastic frontier approach applied in this study may offer an attractive benchmarking framework for a fair comparison between local governments. Given that road maintenance is among the core responsibilities of local governments in many countries, initiating learning processes through benchmarking is specifically encouraged.

Appendix

Table 4.5: Description of included variables in Chapter 4

Variable	Description	Source
Road maintenance cost	Nominal cost	Statistics Netherlands
Road length	Total road length maintained by municipalities (km)	Statistics Netherlands
Address density	Average number of addresses (per km^2)	Statistics Netherlands
Soil factor	The weighted average share of inland water and various soil types under land. A higher soil factor implies worse conditions.	Statistics Netherlands
Relative bank length	Total bank length divided by total land surface area	Statistics Netherlands
Traffic intensity	Number of inhabitants divided by road length (proxy variable)	

Bibliography

Aigner, D., Lovell, C., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37. https://doi.org/10.1016/0304-4076(77)90052-5

Allers, M., & de Greef, J. (2018). Intermunicipal cooperation, public spending and service levels. *Local Government Studies*, *44*(1), 127–150. https://doi.org/10.1080/03003930.2017.1380630

Allers, M., & Geertsema, J. (2016). The effects of local government amalgamation on public spending, taxation and service levels: evidence from 15 years of municipal consolidation. *Journal of Regional Science*, *56*(4), 659–682. https://doi.org/10.1111/jors.12268

Bel, G., Fageda, X., & Warner, M. (2010). Is private production of public services cheaper than public production? A meta-regression analysis of solid waste and water services. *Journal of Policy Analysis and Management*, *29*(3), 553–577. https://doi.org/10.1002/pam.20509

Bel, G., & Warner, M. (2015). Inter-municipal cooperation and costs: expectations and evidence. *Public Administration*, *93*(1), 52–67. https://doi.org/10.1111/padm.12104

Bel, G., & Warner, M. (2008). Challenging Issues in Local Privatization. *Environment and Planning C: Government and Policy*, *26*(1), 104–109. https://doi.org/10.1068/c2601ed

Bikker, J., & van der Linde, D. (2016). Scale economies in local public administration. *Local Government Studies*, *42*(3), 441–463. https://doi.org/10.1080/03003930.2016.1146139

Blom-Hansen, J. (2003). Is Private Delivery of Public Services Really Cheaper? Evidence from Public Road Maintenance in Denmark. *Public Choice*, *115*, 419–438. https://doi.org/10.1023/A:1024274527502

Burningham, S., & Stankevich, N. (2005). *Why road maintenance is important and how to get it done* (Transport Notes Series TRN 4). World Bank. http://hdl.handle.net/10986/11779

Davitt, S., Lynch, J., Mullaney, D., & Wall, W. (2000). *Guidelines on Rehabilitation of Roads over Peat*. Department of the Environment and Local Government.

Deller, S., Chicoine, D., & Walzer, N. (1988). Economies of Size and Scope in Rural Low-Volume Roads. *The Review of Economics and Statistics*, *70*(3), 459. https://doi.org/10.2307/1926784

Deller, S., & Halstead, J. (1994). Efficiency in the Production of Rural Road Services: The Case of New England Towns. *Land Economics*, *70*(2), 247–259. https://doi.org/10.2307/3146326

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Deller, S., & Nelson, C. (1991). Measuring the Economic Efficiency of Producing Rural Road Services. *American Journal of Agricultural Economics*, *73*(1), 194–201. https://doi.org/10.2307/1242895

Dijkgraaf, E., & Gradus, R. H. J. M. (2003). Cost Savings of Contracting Out Refuse Collection. *Empirica*, *30*(2), 149–161. https://doi.org/10.1023/A:1024175730230

Erwich, B., & Vliegen, M. (2001). *Klei en veen*. Statistics Netherlands.

Felso, F., Wilschut, J., de Groot, H., & Niaounakis, T. (2012). *Contractvoorwaarden en de kostendoelmatigheid van gemeentelijk afvalbeheer*. Institute for Public Sector Efficiency Studies.

Fritzsche, C. (2019). Analyzing the Efficiency of County Road Production – Evidence from Eastern German Counties. *German Economic Review*, *20*(4), 415–435. https://doi.org/10.1111/geer.12170

Gradus, R., Schoute, M., & Budding, T. (2019). Shifting modes of service delivery in Dutch local government. *Journal of Economic Policy Reform*, 1–14. https://doi.org/10.1080/17487870.2019.1630123

Groot, P., Saitua, R., & Visser, N. (2016). *Investeren in de infrastructuur. Trends en beleidsuitdagingen*. Economisch Instituut voor de Bouw.

Hassan, Z., Daud, M., Yahya, M., & Shaharuddin, M. (2013). Effect of granular material on the rate of consolidation of peat soil. *Electronic Journal of Geotechnical Engineering*, *18*, 6113–6123.

Henkens, D. (2013). *Towards a sustainable peat meadow. Cost-benefit scenarios of soil subsidence in the jurisdiction of water board de Stichtse Rijnlanden* (Master's thesis). Utrecht University. Utrecht.

Jondrow, J., Knox Lovell, C., Materov, I., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, *19*(2-3), 233–238. https://doi.org/10.1016/0304-4076(82)90004-5

Kalb, A. (2014). What Determines Local Governments' Cost-efficiency? The Case of Road Maintenance. *Regional Studies*, *48*(9), 1483–1498. https://doi.org/10.1080/00343404.2012.731044

Lambert, J. W. M., van Meerten, J. J., Woning, M. P., Eijbersen, M. J., & Huber, M. (2015). Tools to support maintenance strategies under soft soil conditions. *Proceedings of the International Association of Hydrological Sciences*, *372*, 529–531. https://doi.org/10.5194/piahs-372-529-2015

Link, H. (2014). A cost function approach for measuring the marginal cost of road maintenance. *Journal of Transport Economics and Policy*, *48*(1), 15–33.

Lopez, M., Dollery, B., & Byrnes, J. (2009). An empirical evaluation of the relative efficiency of roads to recovery expenditure in New South Wales local government, 2005/06. *Australasian Journal of Regional Studies*, *15*(3), 311–328.

Meeusen, W., & Van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, *18*(2), 435–444.

Narbón-Perpiñá, I., & De Witte, K. (2018). Local governments' efficiency: a systematic literature review-part II. *International Transactions in Operational Research*, *25*(4), 1107–1136. https://doi.org/10.1111/itor.12389

Narbón-Perpiñá, I., & De Witte, K. (2018). Local governments' efficiency: a systematic literature review—part I. *International Transactions in Operational Research*, *25*(2), 431–468. https://doi.org/10.1111/itor.12364

Niaounakis, T., & Blank, J. (2017). Inter-municipal cooperation, economies of scale and cost efficiency: an application of stochastic frontier analysis to Dutch municipal tax departments. *Local Government Studies*, *43*(4), 533–554. https://doi.org/10.1080/03003930.2017.1322958

Niaounakis, T., & van Heezik, A. (2017). *Wegen gewogen. Een empirisch onderzoek naar de kosten en doelmatigheid van het decentrale wegbeheer tussen 2008 en 2014*. Institute for Public Sector Efficiency Studies.

O'Donnell, C. J., Fallah-Fini, S., & Triantis, K. (2017). Measuring and analysing productivity change in a metafrontier framework. *Journal of Productivity Analysis*, *47*(2), 117–128. https://doi.org/10.1007/s11123-017-0494-6

Ozbek, M. E. (2007). *Development of a Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies Using Data Envelopement Analysis* (Doctoral dissertation). Virginia Polytechnic Institute and State University.

Ozbek, M., de la Garza, J., & Triantis, K. (2010). Data and Modeling Issues Faced during the Efficiency Measurement of Road Maintenance Using Data Envelopment Analysis. *Journal of Infrastructure Systems*, *16*(1), 21–30. https://doi.org/10.1061/(ASCE)1076-0342(2010)16:1(21)

Rouse, P., & Chiu, T. (2009). Towards optimal life cycle management in a road maintenance setting using DEA. *European Journal of Operational Research*, *196*(2), 672–681. https://doi.org/10.1016/j.ejor.2008.02.041

Rouse, P., & Putterill, M. (2000). Incorporating environmental factors into a highway maintenance cost model. *Management Accounting Research*, *11*(3), 363–384. https://doi.org/10.1006/mare.2000.0133

Rouse, P., & Putterill, M. (2007). Highway Performance. In D. A. Hensher & K. J. Button (Eds.), *Handbook of transport modelling* (pp. 743–759). Emeral Group Publishing Limited. https://doi.org/10.1108/9780857245670-039

Rouse, P., Putterill, M., & Ryan, D. (1997). Towards a General Managerial Framework for Performance Measurement: A Comprehensive Highway Maintenance Application. *Journal of Productivity Analysis*, *8*(2), 127–149. https://doi.org/10.1023/A:1007743606303

Schoute, M., Gradus, R., & Budding, T. (2020). Drivers of service delivery modes in Dutch local government: an analysis over time and across domains. *International Review of Administrative Sciences*, 1–15. https://doi.org/10.1177/0020852320968906

Wheat, P. (2017). Scale, quality and efficiency in road maintenance: Evidence for English local authorities. *Transport Policy*, *59*, 46–53. https://doi.org/10.1016/j.tranpol.2017.06.002

5

ECONOMIES OF SCALE IN EDUCATION

In many countries, the provision of primary education is among the core responsibilities of local governments. A key question local governments face concerns the optimal configuration of school boards and the optimal size of schools. This chapter analyses the relationship between cost and scale in school boards and in schools. The influence of both the governing layer (board) and the operational layer (school) on average cost are jointly modelled and simultaneously analysed. In contrast to existing studies, board cost is modelled as an aggregation of individual school cost functions so that individual school cost data are not required to estimate the model. The results indicate that small schools (<60 pupils) are operating under sizable economies of scale. The optimum school size is estimated at roughly 450 pupils, but average cost remains roughly constant with regard to size. In contrast to school size, school board size matters less for cost. Saving cost thus should not be considered a valid argument for the consolidation of school boards.

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5.1. INTRODUCTION

In many countries, providing (primary) education is a core task of local and/or state governments. To maintain sustainable levels of government expenditure and improve the quality of education, governments are constantly seeking ways to deliver more value for money, especially when facing increasing enrolment. One of the main channels through which policymakers in the US and the Netherlands, among others, have sought to increase the efficiency of educational spending is through the consolidation of schools and/or school districts (Andrews et al., 2002; Blank, 2015). A key driver behind consolidation is the notion of economies of scale – that is, the idea that larger units have lower average (per-pupil) costs.

There is a large strand of literature on economies of scale in educational institutions, and several review articles have emerged over the past decades (Andrews et al., 2002; Colegrave & Giles, 2008). Although models, data and techniques vary, the majority of these studies have focused on estimating the relationship between (average) cost and enrolment (Bowles & Bosworth, 2002; Butler & Monk, 1985; Chakraborty et al., 2000; Duncombe et al., 1995). In general, while results differ across countries and methodologies, the smallest of schools and school districts have generally been found to operate under economies of scale (Andrews et al., 2002; Colegrave & Giles, 2008; Schiltz & De Witte, 2017; Stiefel et al., 2009), although the tipping point (optimal size) varies.

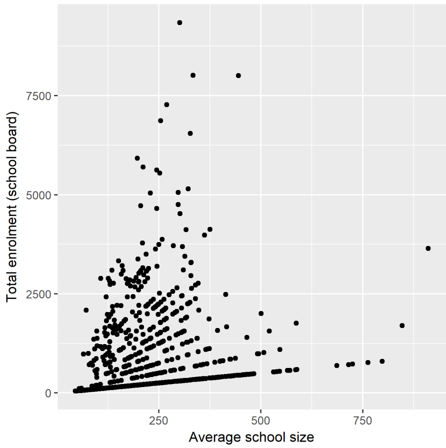
One issue with regard to economies of scale that has received less attention from empirical researchers is the distinction between the governing layer of school districts (US) or boards (Netherlands) and the operational layer (schools). In the Netherlands, one board may govern up to thousands of pupils and tens of schools, while other boards govern only one school and 200 pupils. Similarly, some boards govern a few large schools, and others govern a larger number of smaller schools. The study in this chapter departs from the observation that both layers matter for average (i.e. per-pupil) cost. From a policy perspective, this recognition has implications for policymakers and educational managers in terms of the size and number of school boards and schools. For example, given some level of enrolment, school boards (or districts) face the challenge of determining the optimal number of schools. The size and number of school boards or districts is, in turn, a design choice influenced by national or local government. In other words, given the cost structure of schools and school boards, the following questions must be answered: what is the optimal size of boards and schools in terms of enrolment and the number of schools governed by boards, and what does this mean for choices regarding the consolidation or closure (when faced with declining enrolment) of school (boards)?

Regarding the mechanisms that drive economies of scale at each level, school districts may, for example, benefit from scaling by requiring less overhead per governed school or pupil. At the school level, the potential effects of scale on cost include occupancy rates of school buildings, the spreading of fixed costs over a larger number of pupils and the specialization of teaching and managerial staff. Although the bundling of activities (joint purchases, integrated IT systems and manpower sharing) may be beneficial for all schools, cost savings may be voided by increased managerial complexity, extra managerial layers and complex bureaucratic procedures, among other things. If studies of economies of scale focus on only one layer, bias may occur, for instance, because large school boards concentrated in densely populated areas may also govern large schools.

Possible observed (dis)economies of scale at the board layer may then be a result of the (dis)economies of scale of the associated schools instead of the board. To avoid any of these biases, the interdependency between the two layers should be integrated into the empirical model.

To understand why the distinction is particularly relevant in Dutch primary education, consider Figure 5.1. Each dot represents a single school board. The vertical axis corresponds to the enrolment at each board, and the horizontal axis corresponds to the average school size of the schools governed by a board. Both size indicators are only weakly correlated; that is, there are both small boards (in terms of enrolment) governing relatively large schools and large boards governing many relatively small schools.

Figure 5.1: Relationship between average school size (enrolment) and school board size (enrolment)



Despite the lack of empirical analyses, multiple studies have recognized the importance of both layers. For example, Bickel and Howley (2000) performed a multi-level analysis to explore the relationship between district and school scale and performance. In a more recent study, Schiltz and De Witte (2017) estimated district-level cost functions for Flemish schools and also noted the potential joint influence of scale effects at both the district and the school level. The analysis by Duncombe et al. (1995) is also related. They modelled U.S. school district costs and included the median governed school size as an exploratory variable, shedding some light on the importance of school size and dynamics between the different levels of scale. The analysis conducted in the present study most closely resembles Wales (1973), who followed an aggregation approach. In most previous studies, however, the unit of analysis was usually either the school district (or board) or school, depending on the availability of data: *'although the school is the appropriate unit of analysis for investigating school costs, district-level data are often used, largely because school-level data are unavailable'* (Stiefel et al., 2009). More generally, the observation that the administrative scale of public organizations may not correspond with the scale at which they produce or deliver services has been recognized in other domains as well. For example, Blom-Hansen et al. (2016) have distinguished between the administrative size of municipalities and the plant level of production, where economies of scale actually arise.

The study in this chapter develops and estimates a model that allows for the simultaneous analysis of economies of scale at both the governing (districts or boards) and operational (school) levels. This is done by modelling school board cost as an aggregation of school cost functions, so that individual school cost data are not required for estimation of the model.

Methodologically, solving this issue poses quite the challenge, since it is an aggregation problem. If the structure of a micro unit (e.g. a school) is known, then the question arises as to whether we are able to derive the structure of an aggregated unit. From the seminal work of van Daal and Merkies (1984), we know that 'aggregation is nearly always impossible' and that the aggregated function can only be derived under specific conditions. In this study, we do not claim to solve this issue, but we can work around the impossibility by aggregating individual cost functions through computational means. The model does not require individual school cost data. Therefore, the research question is whether an empirical model can be designed that takes into account production technology and economic behaviour at both the school and school district level, and whether these can be estimated, even without school-level financial data.

The remainder of this chapter is outlined as follows. Section 5.2 first outlines the methodology, and Section 5.3 then discusses the data used for estimating the model. Section 5.4 follows with the results of the estimation, and Section 5.5 provides some concluding remarks and suggestions for further research.

5.2. METHODOLOGY

5.2.1. MODEL DESIGN

To establish an empirical relationship between (minimum) cost and production (scale), applying a so-called cost function is common. Cost functions are a mathematical representation of this relationship, which may also include resource prices and a number of control variables. Cost functions can be used to derive all kinds of economic relationships, including economies of scale. For an introduction to the use of cost functions, see, for example, Fried et al. (2008). Formally, a cost function can be written as follows:

$$C = c(y, w) = \min_x \{w \times x | (y, x) \in T(x, y)\} \tag{5.1}$$

where C denotes (minimum) costs, y is a vector of produced services, w is a vector of resource prices, x is a vector of resources, and $T(x, y)$ is a set of feasible combinations of services produced and resources used.

The parameters of cost functions are estimated on the basis of data on individual firms or other economic entities that can be indicated as DMUs. Other economic entities might include lower-level functional entities (departments) or higher-level entities (regions, boards, districts, etc.). The choice of DMU is a matter of perspective, depending on the policy or managerial issue being addressed. In general, a series of layers can be identified – each with its own specific responsibilities and discretionary powers. In this case, a distinction is made between schools and boards, which corresponds to the distinction between the (primary) teaching process and the (secondary) general management process. The former is directly concerned with course content, teaching time and timetables, whereas the latter deals with administrative and financial tasks, employment contracts and building investment and maintenance. These two different processes cannot be seen in isolation from each other, but may strongly interact.

Estimating cost functions that consider complex, multi-level organizational structures is still a relatively unexplored area. As discussed in the introduction, there are conceptual similarities in many sectors, and several authors have dealt with analysing different scale levels (e.g. in health and local government). For this application, data on production (enrolment, test scores, etc.) and on the environment of individual schools are available, but costs and other input data are not. Thus, in developing a suitable cost model, we must not only account for the complex organizational structure, but also deal with a number of unobserved variables, in particular individual school cost. The solution to this problem, putting it simply, is to sum up all the underlying cost functions of the associated schools to an aggregate cost function at the board level and to estimate the parameters of the aggregated model. We will formally derive the relationship between schools and school boards. Suppose that the minimum cost of an individual school s connected to school board b can be displayed as follows:

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$$C_{bs}^{min} = c\left(Y_{bs}, W_{bs}, Z_{bs}\right), \tag{5.2}$$

where C_{bs}^{min} reflects the minimum costs of school s governed by school board b, Y_{bs} is a vector of services produced by school s governed by school board b (e.g. enrolment), W_{bs} denotes a vector of resource prices of school s governed by school board b (e.g. wages, material price index), and Z_{bs} is a vector of environmental factors of school s governed by school board b (e.g. socio-economic variables).

This also includes costs for student administration, the ICT department, accounting, human resources and management. In case these (secondary) costs are carried by a separate body (the board), it is assumed that they can be allocated to the associated schools. This can be regarded as a school outsourcing these managerial and auxiliary activities to a third party (the board). Secondary costs are assumed to be directly related to service delivery and the size and quality of the board providing these services. In fact, the latter refers to the efficiency component of the school. Therefore, we may add to the minimum cost an efficiency term that is strongly correlated with a number of attributes of the board, such as the number of associated schools or the total services provided by the associated schools:

$$ineff_{bs} = \exp\left[g(z_b)\right], \tag{5.3}$$

where $Ineff_{bs}$ is the inefficiency of school s governed by school board b, and Z_b are attributes of board b.

The inefficiency term is a factor that inflates the minimum costs by a certain factor greater than one. This implies that the function $g(\cdot)$ must be defined such that it always produces outcomes greater than, or equal to, zero. Actual costs of school s governed by school board b then equal

$$C_{bs} = c(Y_{bs}, W_{bs}, Z_{bs}) \times \exp\left[g(Z_b)\right]. \tag{5.4}$$

5

The total cost of board b then equals the summation of all governed schools:

$$C_b = \sum_s c(Y_{bs}, W_{bs}, Z_{bs}) \times \exp\left[g(Z_b)\right]. \tag{5.5}$$

Taking the natural logarithm then yields the following:

$$\ln C_b = \ln\left[\sum_s c(Y_{bs}, W_{bs}, Z_{bs})\right] + \left[g(Z_b)\right]. \tag{5.6}$$

The common procedure is that the (minimum) cost function $c(Y_{bs}, W_{bs}, Z_{bs})$ is reflected by a mathematical equation (the functional specification), whose parameters can be estimated by an econometric method (e.g. NLLS). From the estimated parameters, an estimate of scale effects can be derived.

The above equation now only includes observable variables. The left-hand side includes the total cost for all member schools, including the costs for management of the school board. The problem is now reduced to a statistical problem because on the right-hand side, we find – if many schools are associated with a school board – a large number of terms. There are two solutions. The first solution is to specify a simple representation of the cost function, so that different terms can be analytically aggregated. There remains a simple regression equation consisting of terms such as the total number of pupils belonging to a school board. The second solution is based on the ability to solve the problem entirely numerically. The search for economies of scale requires a flexible functional form that allows scale elasticities to vary with size. The suggested simple solution does not meet this requirement and is therefore disregarded. We hence focus entirely on the numerical solution.

As the parameters of $c(Y_{bs}, W_{bs}, Z_{bs})$ and $g(Z_b)$ are empirically established, elasticities with respect to services produced by the school and with respect to the boards' attributes can be calculated.

5.2.2. FUNCTIONAL SPECIFICATION

For an empirical application of the economic model, we use the well-known translog cost function (Berndt & Christensen, 1973). The model includes first-order, second-order and cross terms between outputs and year dummies representing technical change. Due to the lack of accurate price indices for different resources, we ignore the possibility of price substitution. We divide actual cost by a general consumer price index to control for nominal developments. The translog cost function looks as follows:

$$\begin{aligned} &c(Y_{bs}, w_{bs}, Z_{bs}, T) = \\ &\exp\left[\alpha + \sum_m b_m \ln(y_m) + \frac{1}{2}\sum_m\sum_{m'} \beta_{mm'} \ln(y_m)\ln(y'_m) + \sum_p d_p \ln(z_p) + \sum_p\sum_{p'} \ln(z_{p'})\right] + \\ &\sum_t h_t(yr = t). \end{aligned} \tag{5.7}$$

Here, a, b and h_t are the parameters under estimation. The model that will be estimated is obtained after substitution of Equation 5.7 into Equation 5.6.

5.3. DATA

Data were sourced from the Education Executive Agency (DUO) of the Dutch Ministry of Education, Culture and Science. The agency publishes available data sets, including the annual financial statements of boards and enrolment at schools. Recall that the key issue in this study is that enrolment and other pupil-related indicators are registered at the level of individual schools, while financial statements are observed at the board level.

The data set was constructed as follows. Each observation corresponds to a single school board and contains data on total school board cost and enrolment at each of the individual schools it governs. Three output (enrolment) variables were included, reflecting the socio-economic background of pupils (SES-1, SES-2, SES-3) – Dutch schools are eligible for extra funding for pupils from socio-economically disadvantaged backgrounds.

Data were included for 2011–2015. Note that as the yearly (within) variation of school boards in terms of enrolment or cost is limited in most cases, little additional information is gained from analysing multiple years. In 2015, there were 971 school boards governing schools providing elementary education. The final sample included for analysis contained 723 (roughly three quarters) of these boards. In total, these boards govern 2,601 different schools, or 4.60 on average. Omissions are due to the fact that some boards in primary education may also govern one or more special-needs schools, and some boards even govern one or more vocational education schools. Their inclusion requires an extension of the cost function by additional output (enrolment) variables to account for the different pupils. While this offers the possibility to study economies of scope and a larger sample, the advantage of analysing a homogeneous group of boards outweighs the computational difficulties posed by including several poorly comparable school boards. In roughly 30 per cent of the schools, test scores were not available. For a board that governs schools both with test scores and without known test scores, the missing school scores are set equal to the average test scores of the other schools governed by the boards. Otherwise, the observations are omitted.

In addition to the cost and enrolment variables discussed, a number of additional indicators were included: the average test score at each school and the number of schools governed by each board. Table 5.1 provides a set of summary statistics on the included variables, and the appendix includes a description of the included variables (Table 5.4).

5.4. RESULTS

The main estimation results are presented in Table 5.2. The results were obtained by estimating Equation 5.6, after substituting Equation 5.7, using NLLS.

The first-order parameters have plausible positive signs and are estimated significantly at the 1% level [1]. The requirements concerning monotonicity with respect to out-

[1] Standard errors have not been clustered and are therefore underestimated. Due to the special aggregation structure and the high non-linearity of the model, precisely calculating the corrected standard errors is cumbersome. Therefore, we applied a raw correction measure based on the intra-correlation of the residuals only. The formula for this raw correction factor is as follows:

$$\tau = \sqrt{1 + \rho_u(\bar{N} - 1)}, \tag{5.8}$$

where τ is the correction factor, ρ_u is the intra-correlation of the residuals, and $\bar{N}$ is the average number of

Table 5.1: Summary statistics of key variables included for analysis

	Mean	Std. dev.	Minimum	Maximum
Board level (N=723)				
Nominal cost (€)	5.20	6.46	0.37	52.41
Enrolment (total)	983.15	1,214.64	45.00	9,340.00
Enrolment (SES-1)	903.00	1,199.274	44.00	8,347.00
Enrolment (SES-2)	46.10	63.14	0.00	447.00
Enrolment (SES-3)	34.05	4.60	0.00	31.00
Number of schools	4.60	5.53	1.00	31.00
School level (N=2,601)				
Enrolment (total)	213.30	128.25	12.00	1,283.00
Enrolment (SES-1)	196.00	123.14	12.00	1,246.00
Enrolment (SES-2)	10.11	12.30	0.00	174.00
Enrolment (SES-3)	7.19	16.72	0.00	205.00
Average test score	535.26	3.92	514.70	546.20

Table 5.2: Translog cost function estimation results (Equation 5.7)

	Parameter	Estimate	Standard error
Constant	a	-0.984***	(0.006)
Enrolment (SES-1)	b_1	0.634***	(0.006)
Enrolment (SES-2)	b_2	0.058***	(0.003)
Enrolment (SES-3)	b_3	0.128***	(0.002)
SES-1 x SES-1	b_{11}	0.215**	(0.010)
SES-1 x SES-2	b_{12}	-0.008***	(0.002)
SES-1 x SES-3	b_{13}	-0.038***	(0.002)
SES-2 x SES-2	b_{22}	0.023***	(0.001)
SES-2 x SES-3	b_{23}	0.003***	(0.001)
SES-3 x SES-3	b_{33}	0.045***	(0.001)
Number of schools	d_1	-0.017***	(0.006)
Num. schools x num. schools	d_{11}	0.016***	(0.005)
Avg. test score	d_2	0.100**	(0.026)
Avg. test score x avg. test score	d_{22}	1.742	(0.190)
Year = 2011	h_1	-0.019***	(0.006)
Year = 2012	h_2	-0.035***	(0.006)
Year = 2013	h_3	-0.025***	(0.006)
Year = 2014	h_4	0.006***	(0.006)

* p<0.1, ** p<0.05, *** p<0.01

replications in the panel. Even after inflating the standard errors by the correction factor (not reported here), most parameters are still significant. The exceptions are the parameters corresponding to the number of associated schools and the average test score. After inflation, parameters b_{12} and b_{23} are only significant at puts are met (positive parameters).

As an indicator of the plausibility of the estimates, Table 5.3 presents estimates of the marginal cost of the different enrolment categories. The marginal costs have been evaluated for a fictional school, which is assigned 220 pupils (corresponding to an average school) with an average output composition (SES-1: 200, SES-2: 12 and SES-3: 8) and an average test score, and which is associated with a board that governs three schools. Hence, the marginal cost of a pupil with SES-1 is approximately €4,300, while it is roughly €7,800 for an SES-2 pupil and about €20,000 for an SES-3 pupil. These numbers are plausible, although the latter may be regarded as somewhat high.

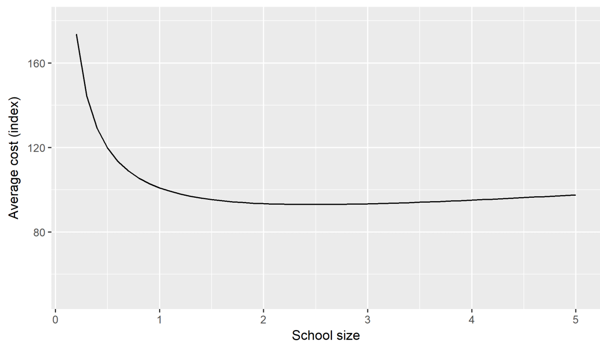
Table 5.3: Marginal costs of enrolment per SES category at an average school, 2011

Output category	Marginal cost
SES-1	€4,253
SES-2	€7,830
SES-3	€20,411

Furthermore, the year dummies' estimates (significantly negative) indicate that in 2011, 2012 and 2013, the conditional mean of costs was lower than in 2015, implying a substantial negative productivity change.

We now turn to the key results regarding economies of scale. Figure 5.2 presents the estimated average cost curve at the school level. Figure 5.2 is again based on the average composition of a school with respect to output (90% SES-1, 6% SES-2 and 4% SES-3). The size of the average school is set to 1. Furthermore, the average costs are presented in an index where the average cost of a school with an average size is set equal to 100.

Figure 5.2: Average school cost with respect to standardized school size. A size of 1 corresponds to the average school size

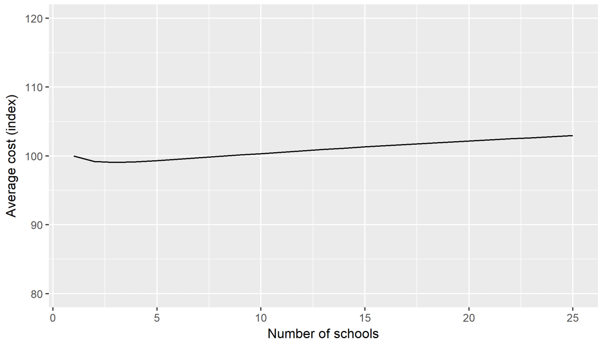


the 10% level. The parameters of the number of associated schools and the square of associated schools are no longer significant at the 5% level after correction (the square term is still at the 10% level). Therefore, the hypothesis that no relationship exists between the number of associated schools cannot be rejected. Furthermore, the parameter estimate of the average test score and the square average test score are significant at the 5% level, even after the correction, implying that the hypothesis that no relationship exists between cost and average test score must be rejected.

Figure 5.2 suggests that the average cost for small schools – for example, a school with a size less than one quarter of the average school size – is 60% higher than for the average school. The estimated average cost curve indicates substantial economies of scale for small schools. Average cost increases for schools larger than twice the average school size, implying that diseconomies of scale prevail, though the rise in average cost is modest. From the estimated parameters in Table 5.2, we can easily derive that, for a substantial number of (small) schools, scaling up is beneficial from a cost perspective.

Figure 5.3 represents the average cost with respect to the number of associated schools in a school board. The reference category here is a school with an average number of pupils and with an average composition with respect to the SES categories. The average cost is presented as an index and set to 100 in case the number of associated schools equals one.

Figure 5.3: Average school board cost with respect to the number of schools governed



From Figure 5.3, we conclude that expanding a one-school school board by adding two extra schools leads to a decline in average cost of about 2%. However, as the number of associated schools increases beyond that, average cost also increases. The average cost of a board with 25 or more associated schools is 5% higher than a board with three associated schools. Note that these outcomes are controlled for the size of the associated schools and purely reflect the effect of the number of associated schools. Although these may be regarded as interesting outcomes, they must be put in perspective. From the parameters presented in Table 5.2, we can calculate the efficiency component due to the number of associated schools (and its statistical properties, such as standard errors and t-values). Applying this to all observations reveals that the efficiency of only 10% of the observations significantly differs (at the 5% level) from the most efficient configuration (three schools in a board). In other words, the effect of board size is practically negligible. The resulting policy implication is that there is hardly any empirical evidence to suggest that the size of the board substantially affects average costs.

5.5. CONCLUSIONS

In many countries, local governments are confronted with the challenge of determining the optimal configuration of school boards and schools. From a cost perspective, the answer to this challenge depends on whether, and to what extent, economies of scale exist at both levels. Driven by data availability constraints, existing studies have focused mainly on the existence of economies of scale at either the school or school board level.

In the study in this chapter, we proposed a model that allows for the simultaneous analysis of economies of scale at both levels without requiring individual school cost data. School board cost was modelled as an aggregate of individual school cost functions. In this way, the relation between total board cost and the size of the individual schools governed was explicitly established.

The model was applied to a panel data set of primary schools in the Netherlands over the period 2011–2015. The results indicate that there are significant economies of scale for schools with fewer than 60 pupils in particular. Optimal school size was estimated at 440 pupils, from which average cost again increased modestly.

After controlling for school size, school board size (as measured by the number of schools governed) was estimated to be less influential. The optimal size here was estimated at three schools, but overall, the average cost curve with respect to size was estimated flatly.

The results suggest that in studies which find increasing economies of scale for small districts, the increase may in fact be driven by the (small) schools that these districts govern. In light of this possibility, it would be useful to carry out a comparative analysis for the US, where district studies are common.

In the past, it was common practice for one board to manage all public primary schools (the municipality itself). Due to a change in legislation, a municipality was then allowed to initiate different school boards within their jurisdiction. However, many municipalities still operate from the original, centralized perspective. There may be arguments in favour of either multiple, smaller school boards or rather, one or few larger boards. The results in this study, however, highlight that economies of scale themselves form no argument in favour of either. In other words, the results indicate that saving cost is no substantial argument for consolidating school boards. Theoretically, the optimal number of schools per school board is three, but cost differences between large and small school boards are of limited size.

In contrast, school size is a far more important factor with respect to per-pupil cost. Small schools are currently already eligible for additional funding in the Netherlands. In that sense, the results replicate the funding of primary schools and are not surprising. An important question not addressed so far then concerns the economic behaviour of school boards. Under the assumption that school boards exhibit cost-minimizing behaviour, the results in this chapter confirm that small schools indeed operate under diseconomies of scale because otherwise, school boards would save the excess funding, and small schools would not be estimated to operate under diseconomies of scale. If school boards in fact exhibit a behaviour of spending all funding, any cost function would simply replicate budget allocation rules, and the estimated cost diseconomies of scale may in fact be a disguised form of cost inefficiencies. However, one would then expect that such schools achieve higher quality (e.g. in terms of test scores, for which this study controlled), which was not found to be the case.

In summary, the study in this chapter confirms that small schools operate under diseconomies of scale. Therefore, while maintaining the smallest schools may be desirable for other reasons, for example in assuring the liveability of small villages with otherwise no school, respecting these values comes at an economic cost.

APPENDIX

Table 5.4: Description of included variables in Chapter 5

Variable	Description	Source
School board cost	Total cost	Dienst Uitvoering Onderwijs (DUO)
Enrolment (SES-1)	Pupils enrolled (at the school level) belonging to category one out of three. Pupils belonging to category two or three are characterized as coming have a worse socio-economic background. The categories are related to the educational attainment level of pupils' parents.	Dienst Uitvoering Onderwijs (DUO)
Enrolment (SES-2)	Enrolled pupils belonging to category two out of three.	Dienst Uitvoering Onderwijs (DUO)
Enrolment (SES-3)	Enrolled pupils belonging to category three out of three.	Dienst Uitvoering Onderwijs (DUO)
Number of schools	Total number of schools governed by school boards	Dienst Uitvoering Onderwijs (DUO)
Test score	Average test score at the school level (CITO-test)	Dienst Uitvoering Onderwijs (DUO)

Bibliography

Andrews, M., Duncombe, W., & Yinger, J. (2002). Revisiting economies of size in American education: are we any closer to a consensus? *Economics of Education Review*, *21*(3), 245–262. https://doi.org/10.1016/S0272-7757(01)00006-1

Berndt, E., & Christensen, L. (1973). The translog function and the substitution of equipment, structures, and labor in U.S. manufacturing 1929-68. *Journal of Econometrics*, *1*(1), 81–113. https://doi.org/10.1016/0304-4076(73)90007-9

Bickel, R., & Howley, C. (2000). The influence of scale on school performance: A multilevel extension of the Matthew principle. *Education Policy Analysis Archives*, *8*(22), 1–32.

Blank, J. (2015). *Illusies over fusies. Een kritische beschouwing over de schaalvergroting in de Nederlandse publieke sector*. Den Haag, Centrum voor Arbeidsverhoudingen Overheidspersoneel.

Blank, J., & Niaounakis, T. (2019). Managing Size of Public Schools and School Boards: A Multi-Level Cost Approach Applied to Dutch Primary Education. *Sustainability*, *11*(23), 6662. https://doi.org/10.3390/su11236662

Blom-Hansen, J., Houlberg, K., Serritzlew, S., & Treisman, D. (2016). Jurisdiction Size and Local Government Policy Expenditure: Assessing the Effect of Municipal Amalgamation. *American Political Science Review*, *110*(4), 812–831. https://doi.org/10.1017/S0003055416000320

Bowles, T., & Bosworth, R. (2002). Scale Economies in Public Education: Evidence from School Level Data. *Journal of Education Finance*, *28*(2), 285–299. https://www.jstor.org/stable/40704168?seq=1

Butler, R., & Monk, D. (1985). The Cost of Public Schooling in New York State: The Role of Scale and Efficiency in 1978-79. *The Journal of Human Resources*, *20*(3), 361. https://doi.org/10.2307/145887

Chakraborty, K., Biswas, B., & Lewis, W. (2000). Economies of scale in public education: an econometric analysis. *Contemporary Economic Policy*, *18*(2), 238–247. https://doi.org/10.1111/j.1465-7287.2000.tb00021.x

Colegrave, A., & Giles, M. (2008). School cost functions: A meta-regression analysis. *Economics of Education Review*, *27*(6), 688–696. https://doi.org/10.1016/j.econedurev.2007.05.006

Duncombe, W., Miner, J., & Ruggiero, J. (1995). Potential cost savings from school district consolidation: A case study of New York. *Economics of Education Review*, *14*(3), 265–284. https://doi.org/10.1016/0272-7757(94)00011-T

Fried, H. O., Lovell, C. A. K., & Schmidt, S. S. (2008). *The measurement of productive efficiency and productivity growth*. Oxford University Press.

Schiltz, F., & De Witte, K. (2017). Estimating scale economies and the optimal size of school districts: A flexible form approach. *British Educational Research Journal*, *43*(6), 1048–1067. https://doi.org/10.1002/berj.3312

Stiefel, L., Schwartz, A. E., Iatarola, P., & Chellman, C. (2009). Mission matters: The cost of small high schools revisited. *Economics of Education Review*, *28*(5), 585–599. https://doi.org/10.1016/j.econedurev.2009.01.005

van Daal, J., & Merkies, A. H. Q. M. (1984). *Aggregation in Economic Research*. Springer Netherlands. https://doi.org/10.1007/978-94-009-6334-4

Wales, T. J. (1973). The Effect of School and District Size on Education Costs in British Columbia. *International Economic Review*, *14*(3), 710–720.

6

CONCLUSIONS

6.1. INTRODUCTION

This dissertation concerned the analysis of economies of scale, recognizing that scale is often a complex, multi-level concept, with no single measure doing justice to the many relevant levels of scale that exist beyond organizational size alone. The scope and application area of this dissertation was contained to local public service delivery, where municipalities are among the core delivering units. Here, the assumption of economies of scale has driven a long and ongoing trend of consolidation. This concluding chapter summarizes and discusses the main findings of the various chapters, reflects on the limitations and finally concludes with policy implications and suggestions for future research.

This dissertation sought to explore the following central research question:

What is the cost-optimal scale of public service delivery from a multi-level perspective?

This dissertation was motivated by the observation that while the literature on economies of scale in public service delivery is vast, the evidence has been described as inconclusive in many regards. As a result, researchers have had difficulty in providing policymakers and public managers with recommendations regarding the efficient size of public service delivery rooted in consistent empirical evidence.

This dissertation departed from the view that the conceptual complexity regarding 'scale' is a troublesome factor in the analysis of economies of scale. Economies of scale are typically analysed by comparing the (average) cost of homogeneous organizations to measures of size, in which the administrative, overall organization is the unit of analysis. In contrast, this dissertation embraced the fact that economies of scale may emerge at different levels within organizations (e.g. teams, plants or sub-units) or even outside the administrative boundaries of individual organizations (e.g. via co-operation or outsourcing). To this end, the introduction section called for a multi-level perspective on scale that resonates with the many relevant levels of scale that exist beyond organizational size alone.

The remainder of this concluding chapter is structured as follows. Section 6.2 briefly summarizes the main empirical conclusions along the lines of the research questions. Section 6.3 then discusses the implications of the empirical conclusions and, in doing so, discusses the main research questions, while Section 6.4 reflects on the limitations of this dissertation. Finally, Section 6.5 concludes by discussing policy implications and identifying several potential, fruitful avenues for future research.

6.2. SUMMARY OF EMPIRICAL CONCLUSIONS

Chapter 1 outlined the following research questions:

1. To what extent are different local government services subject to economies of scale? (*Analysed in Chapters 2–4*)

2. What is the relationship between economies of scale, amalgamation and cost in local government? (*Analysed in Chapter 3*)

3. What is the relationship between economies of scale, co-operation and cost in local government? *(Analysed in Chapter 2)*

4. To what extent are primary schools subject to economies of scale? (*Analysed in Chapter 5*)

5. To what extent are primary school boards subject to economies of scale? (*Analysed in Chapter 5*)

In the next sub-section, the main empirical conclusions are discussed along the lines of these research questions, followed by a discussion in Section 6.3.

To what extent are different local government services subject to economies of scale?

Economies of scale were analysed in four local government services (Chapters 2–4): 1) tax collection, 2) road maintenance, 3) school accommodation and 4) public health. The results indicate that these services are subject to (dis)economies of scale but that there is heterogeneity across services. For each service, the relationship between scale and cost was estimated to take on a U shape. This indicates that as output volumes grow, average cost first decreases, but then rises again after a certain tipping point. The strongest economies of scale (EOSs) were estimated in tax collection. Here, most municipalities are still estimated to operate under increasing economies of scale. In school accommodation and public health, 16% and 32% of municipalities, respectively, were estimated to operate under significant economies of scale, while 37% and 34% already operated under diseconomies of scale. The optimal scale in school accommodation corresponds roughly with an average-sized municipality. Furthermore, the strongest diseconomies of scale were estimated in road maintenance, with 75% of municipalities estimated to operate under significant increased cost due to scale. Here, increasing size is associated with a significant decrease in cost for only 2% of municipalities.

What is the relationship between economies of scale, amalgamation and cost in local government?

To achieve economies of scale, the most straightforward strategy is through amalgamation. The relationship between economies of scale, cost and local government amalgamation was analysed in Chapter 3. For a group of 40 amalgamations that took place between 2005 and 2016, the study analysed whether amalgamation led to a more favourable scale across three services: road maintenance, school accommodation and public health. The results here indicate that the scale effect of amalgamation on cost varies across services and size. Averaged over all amalgamations, consolidation led to a worsened scale in road maintenance and public health. In school accommodation, the average scale effect was estimated at virtually null. The results demonstrate that local government amalgamation can lead to offsetting scale effects across different services, as municipalities operating under economies of scale in one service may be operating under diseconomies of scale in another.

Additionally, amalgamation may affect cost through other mechanisms. For example, amalgamation may give rise to transition or merger costs. On a positive note, amalgamation may allow the amalgamated unit to adopt the management best practices of the consolidating municipalities. Therefore, in addition to a scale effect, a cost-efficiency effect of amalgamation was estimated as well. The results here indicate that, surprisingly, the negative scale effects were offset in large part by an upward cost-efficiency effect. In the long term, however, the cost-efficiency effect is more uncertain.

What is the relationship between economies of scale, co-operation and cost in local government

Inter-municipal co-operation is increasingly popular in European countries and may be considered a targeted, less drastic measure of scaling than amalgamation. As such, inter-municipal co-operation may allow municipalities to seek economies of scale where they are most pronounced. The relationship between inter-municipal co-operation, economies of scale and cost was analysed in Chapter 2 in the context of local government tax collection, and the results suggest that tax collection is subject to considerable economies of scale and that scale economies can effectively be achieved through inter-municipal co-operation. Other than through scale, municipalities that co-operate were not estimated to operate more or less cost-efficiently. In other words, no significant monitoring or transaction costs of co-operation were estimated here.

To what extent are primary schools and school boards subject to economies of scale?

Chapter 5 analysed economies of scale in primary education simultaneously for school boards and schools. School boards govern up to tens of individual schools, and in terms of enrolment, board and school size are only weakly correlated. The results here indicate that small schools are operating under significant economies of scale and that the optimal school size corresponds with an enrolment of roughly 450 pupils. It is estimated that the optimal school board size, as measured by the number of governed schools, is three. However, school board size affects the cost of education to a far lesser extent than school size. In particular, schools with fewer than 60 pupils are associated with a significant increased average cost.

6.3. Discussion of empirical conclusions

With regard to economies of scale, the results demonstrate that local government services are subject to economies of scale, the extent of which varies across the different services they provide. These findings are in line with extensive literature on economies of scale in local government which recognizes that scale affects cost (Lago-Peñas & Martinez-Vazquez, 2013). Table 6.1 presents an overview of the estimated optimal scales in terms of output (second column) and the corresponding population count (third column).

In 2016, the average municipality population was roughly 44,000. The fourth column contains a qualitative characterization of the degree to which each service is subject to economies of scale. An interesting question then concerns the factors that shape the relationship between scale and cost and that moderate the differences found between services. An understanding of these factors is relevant for, amongst other things, assessing the generalizability of the results to the many other local government services not yet analysed. If patterns exist that consistently hold among the four analysed services, then these patterns are likely to hold for other services as well. In turn, this affects whether

Table 6.1: Optimal scale associated with the different services analysed

	Optimal scale	Corresp. population	Characterization
Tax collection	230,000 properties	460,000	Very strong EOS
School accommodation	4,100 pupils	41,700	Moderate EOS
Public health	31,500 population	31,500	Moderately weak EOS
Road maintenance	70-km road length	9,400	Very weak EOS

conclusions can be drawn that are expected to hold in the broader context of local government.

Chapter 1 identified three key mechanisms underlying (dis)economies of scale that are suggested most frequently in the literature: 1) *fixed cost*, 2) *labour specialization* and 3) *bureaucratic congestion*. The strongest economies of scale are expected in capital-intensive services with high associated fixed costs, with a low risk of bureaucratic congestion and/or in which there is room for labour specialization. Here, bureaucratic congestion refers to the relative increase in the required overhead, co-ordination and communication as output volumes grow, and it is generally regarded as the primary and sole source of diseconomies of scale. Between capital intensity and specialization, the former has by far been the most often suggested mechanism driving economies of scale in local government, for example in the provision of roads, sewerage and waste collection. Surprisingly, however, these mechanisms by no means paint the whole picture, as highlighted by the inconsistent evidence in this regard (Holzer et al., 2009).

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An interesting question therefore concerns the relationship between the economies of scale and characteristics of the services analysed throughout this dissertation. Table 6.2 summarizes these relationships. To this end, each service characteristic was assessed on a three-point scale (-/-+/+), and very strong economies of scale were found in tax collection. With regard to the two most important mechanisms, namely, fixed cost and bureaucratic congestion, the results seem to resonate here. Tax collection can be characterized as a fairly capital-intensive service with a sizeable associated fixed cost (e.g. software). Since tax collection is a relatively low-complexity, homogeneous task, it seems unlikely to be prone to bureaucratic congestion as output volumes increase.

Table 6.2: Economies of scale and characteristics per service

Service	EOS	Fixed cost	Specialization	Bureaucratic congestion
Tax collection	Very strong	+	-	-
School accommodation	Moderate	+	-	-+
Public health	Moderately weak	-+	-+	-+
Road maintenance	Very weak	+	-	-+

Moderate economies of scale were found in school accommodation, where the optimal scale corresponds with an average-sized municipality. School accommodation is eminently a capital-intensive service, and economies of scale may arise through fixed costs associated with school buildings in particular. However, as enrolment exceeds a certain size, the required number of school buildings increases accordingly. This suggests that economies of scale through fixed costs are strongest for the smallest municipalities with one or few school buildings. Furthermore, school accommodation can be characterized as a low-specialization service, which suggests that few economies of scale are achievable through labour specialization. While school accommodation in itself is a straightforward, low-complexity task, some bureaucratic congestion may occur as enrolment increases, since the number of schools and school boards also increases accordingly. As municipalities must co-ordinate and negotiate housing between an increasing number of actors, a relatively strong increase in transaction costs may occur.

Moderately weak economies of scale were estimated for public health services. While public health can be characterized as labour intensive, there may be some fixed costs. In contrast to regular healthcare services, local government public health is geared towards groups and does not target individuals specifically. This may fuel some economies of scale, as the initial fixed cost of setting up health programmes and so forth can be spread over an increasing population. Furthermore, public health services comprise both highly specialized activities and low-complexity, homogeneous routine tasks. With regard to the specialized activities, some economies of scale may arise through labour specialization opportunities.

Most surprisingly, very weak economies of scale were estimated in road maintenance, where the optimal scale has already been surpassed by most municipalities, and only 2% of the smallest municipalities are estimated to operate under significant economies of scale. This result is surprising, especially since road maintenance can be characterized as capital intensive, and studies conducted in different countries have indeed estimated stronger economies of scale (e.g. Wheat (2017)). Road maintenance is a core task of local governments with seemingly little room for labour specialization, so, in that regard, few economies of scale are expected. It is possible that the relative complexity of and the required managerial oversight involved in road maintenance increase strongly with the size of the road network. Dutch municipality road networks are, in comparison with many other countries, finely meshed. This may indicate, for example, that as the size of the road network grows, maintenance plans also become more complex, resulting in diseconomies of scale.

In summary, the variation in the estimated scale economies is explained only in part by the presumed key mechanisms. In particular, there is some inconsistent evidence with regard to the expectation that economies of scale are stronger in capital-intensive services with high fixed costs. In this sense, the findings are in line with the literature that the evidence regarding underlying mechanisms is inconsistent (Holzer et al., 2009). This implies that the results obtained for the four analysed services cannot easily be generalized to other local government services.

Finally, the following question must be addressed: what do the results imply for the desirability and effectiveness of amalgamation and co-operation for achieving economies of scale? Regarding amalgamation, based on the services analysed, amalgamation is, at best, expected to lead to a more productive scale only among the smallest of municipalities. In most cases, economies of scale were estimated only for the smallest municipalities, with tax collection being the exception (but of limited financial significance). Thus, while we should be careful when generalizing the findings to other local government services, the results are in line with emerging literature which has found no positive effects of amalgamation on cost (Allers & Geertsema, 2016; Blom-Hansen et al., 2016). Regarding co-operation, the results offer a rosier perspective. In services where there are strong scale economies, co-operation can be an effective strategy for achieving economies of scale and decreasing cost. However, again, caution should be exercised when generalizing these results to other local government services. For example, co-operation in services which are more complex than tax collection may require a larger degree of co-ordination or monitoring.

Regarding the delivery of local (primary) education services, the results indicate that substantial economies of scale exist, especially at the school level. In particular, schools with fewer than 60 pupils are associated with considerably higher (average) costs, and the average cost again increases from 450 pupils upwards. Plausible mechanisms here are fixed cost and labour specialization. For example, in small schools, no distinction is made between management and teaching staff. Average class size is also smaller in small schools, as different age groups require different teachers. At the board level, economies of scale were expected, mainly due to a relative reduction in required overhead, which is also more or less a fixed cost mechanism. However, the results indicate that school board size, as measured by the number of schools governed, has much less influence on cost. Nonetheless, boards comprising fewer or more than three schools are estimated to have slightly higher costs. When taken together, the results highlight that, from a cost perspective, the optimal size of schools is 450 pupils and that the optimal number of schools per school board is three.

6.4. LIMITATIONS

Before concluding with the policy implications of this dissertation, this section discusses its main limitations. First, this dissertation focused on one outcome related to scale: cost. However, scale may affect many other public outcomes, such as citizen satisfaction or, more generally, the social discontent that is associated with large-scale public organizations. Even in terms of cost, the scale of an individual organization may affect more than the cost of its own service delivery alone. For example, it has been suggested that the national government prefers to deal with a group of large municipalities rather than a larger group of small municipalities due to the transaction costs involved on both sides (Blank, 2015). Such factors were outside the scope of this dissertation. Another example of externalities not addressed are users' transportation costs, such as when pupils need to travel further to get to school after consolidation. Scale may also correspond to economic outcomes other than cost. For example, urban areas are known to pose agglomeration effects, which may offset diseconomies of scale in the cost of local government service delivery.

A second limitation stems from data limitations. In particular, the omission of variables that correlate with both cost and output (i.e. scale) may lead to biased inference on economies of scale. For example, properly controlling for the quality of output often appeared to be infeasible. When quality correlates with size, this may become a source of bias. In turn, biased cost function estimates may lead to invalid predictions of the effect of changing scale on cost.

6.5. POLICY IMPLICATIONS AND FUTURE RESEARCH

Policymakers and managers of public organizations may seek to increase productivity and decrease cost through size, and they have often done so over the past decades. The viability of this strategy crucially hinges on the extent to which public service delivery is subject to economies of scale. To contribute to our understanding of these matters, this dissertation analysed economies of scale in local public service delivery, explicitly recognizing that scale is a complex concept.

Regarding local government, the first policy implication is that policymakers and municipal managers should not seek an optimal organization or jurisdiction size, but rather should strive for a bandwidth in which both strong economies and diseconomies of scale are unlikely. This recommendation is based on the finding that there is considerable service heterogeneity in terms of the relationship between scale and cost and, additionally, on the observation that scale may affect many outcomes other than cost. An optimal size of production in terms of cost may be suboptimal for other outcomes, and optimal sizes may also be subject to changes over time. In light of these considerations, the quest for an optimal scale seems ambitious.

Second, large cost savings as a result of scaling should generally not be expected. Regarding the analysed services, the results indicate that most municipalities are operating under constant or even decreasing returns to scale. In other words, for these municipalities, consolidation is not expected to lead to a significant decrease in cost. For tax collection, and to a lesser extent school accommodation, there are still significant economies of scale among smaller municipalities. Depending on the cost structure of services not yet analysed, amalgamation may still be associated with a decrease in cost in the smallest municipalities (e.g. <5,000 inhabitants). However, more research is required to substantiate such claims and to determine the bounds of a bandwidth of municipal size where large-scale suboptimalities can be excluded.

A third implication stems from the empirical analysis of inter-municipal co-operation. In view of the fact that significant (i.e. non-minor) economies of scale in local government are rare but may exist in some specific cases, the policy recommendation here is that they can be achieved through measures such as co-operation or outsourcing. This seems most likely for standardized services such as IT, tax collection and other administrative services.

Regarding education, the recommendation is that policymakers should not expect large cost savings from large school boards and that small schools (<60 pupils) should be avoided. However, small schools may serve other public values, for example in small villages where there would otherwise be no school. Policymakers and politicians seem to be aware of this trade-off between economic and other public values, as small schools receive extra funding.

Finally, this dissertation concludes by identifying several fruitful avenues for future research. The first interesting approach would be to include values other than cost in the assessment of scale. For example, the scaling of public organizations in the Netherlands has come under scrutiny because it is associated with a loss of the human dimension of public service provision (Blank et al., 2016). In this respect, measures of citizen satisfaction and other public value outcomes could be included in a more comprehensive assessment of scale. Note that the multi-level aspect is relevant here as well. For example, large healthcare institutions which are organized into small-scale teams and organizations may uphold the human dimension in service delivery to the same extent as smaller institutions.

Second, the uncertainty that still surrounds the moderating factors which shape the relationship between public service delivery and cost justifies a more structural analysis of these determinants, for example by directly modelling the relationship between average cost and potential determinants, such as fixed cost or measures of bureaucratic congestion. A more thorough understanding of these factors is crucial for gaining insights into why observed empirical patterns emerge. In turn, this can contribute to a more general understanding of when and how economies of scale in public service delivery are or are not to be expected.

Lastly, a fruitful avenue for future research stems from the multi-level framework itself. While an attempt was made to do justice to the various relevant levels of scale in the applications throughout this dissertation, there is ample scope to increase the level of detail further still. For example, in the analysis of school accommodation provided by local governments, the size of schools and school buildings was not taken into account. In the case of road maintenance, which is often outsourced, the decision to outsource and the size of the corresponding firm were not taken into account either. These considerations highlight the difficulty of fully incorporating all size measures, both from methodological (modelling) and data perspectives.

Bibliography

Allers, M., & Geertsema, J. (2016). The effects of local government amalgamation on public spending, taxation and service levels: evidence from 15 years of municipal consolidation. *Journal of Regional Science*, *56*(4), 659–682. https://doi.org/10.1111/jors.12268

Blank, J. (2015). *Illusies over fusies. Een kritische beschouwing over de schaalvergroting in de Nederlandse publieke sector*. Den Haag, Centrum voor Arbeidsverhoudingen Overheidspersoneel.

Blank, J., van Hulst, B., & Valdmanis, V. (2016). Concentrating Emergency Rooms: Penny-Wise and Pound-Foolish? An Empirical Research on Scale Economies and Chain Economies in Emergency Rooms in Dutch Hospitals. *Health Economics*. http://doi.wiley.com/10.1002/hec.3409

Blom-Hansen, J., Houlberg, K., Serritzlew, S., & Treisman, D. (2016). Jurisdiction Size and Local Government Policy Expenditure: Assessing the Effect of Municipal Amalgamation. *American Political Science Review*, *110*(4), 812–831. https://doi.org/10.1017/S0003055416000320

Holzer, M., Fry, J., Charbonneau, E., Van Ryzin, G., Wang, T., & Burnash, E. (2009). *Literature Review and Analysis Related to Optimal Municipal Size and Efficiency*. Rutgers University.

Lago-Peñas, S., & Martinez-Vazquez, J. (Eds.). (2013). *The Challenge of Local Government Size: theoretical perspectives, international experience and policy reform*. Edward Elgar Publishing.

Wheat, P. (2017). Scale, quality and efficiency in road maintenance: Evidence for English local authorities. *Transport Policy*, *59*, 46–53. https://doi.org/10.1016/j.tranpol.2017.06.002

Summary

Driven by a quest for efficiency, many Western countries have witnessed merger waves across the entire breadth of their public sectors. The underlying assumption is that economies of scale exist in public service delivery; the idea that the average cost of public services decreases as the size of public organizations increases.

The analysis of economies of scale in public service delivery and the related quest for the optimal size of public organizations has attracted a great deal of attention from researchers across disciplines. Nonetheless, despite its size, the literature on economies of scale in public service delivery has been characterized as inconclusive and inconsistent in many areas. As a result, it has proven difficult for researchers to provide policy makers and public managers with consistent recommendations regarding the optimal scale of public organizations and, more generally, the extent to which public services can expect to benefit from economies of scale.

The analysis of economies of scale is subject to several methodological challenges. This dissertation focuses on one specific methodological concern: it departs from the observation that a troublesome factor in the analysis of economies of scale is the conceptual complexity of 'scale'. In essence, complexity here refers to the notion that there is more to the scale of public service delivery than simply the administrative size of the organizations that deliver those services. Typically, economies of scale are investigated by comparing the (average) cost of homogeneous organizations - such as hospitals, local governments or schools - to measures of size, in which the administrative, overall organization is the unit under investigation. However, large organizations may be organised into many smaller units and vice versa, or some services such as ICT may be subject to more economies of scale than others.

Research objective

To this end, this dissertation calls for and develops econometric frameworks for analysing economies of scale which incorporate measures of scale beyond sheer organizational size. This approach is referred to as a multi-level perspective on scale. The frameworks developed and applied enable an enriched analysis of economies of scale and constitute this dissertation's main contribution to the literature on economies of scale. From a policy perspective, this dissertation aims to contribute to our understanding of how scale shapes public service delivery cost and its implications for the optimal scale of public service delivery. The central research question this dissertation addresses is:

What is the cost optimal scale of public service delivery from a multi-level perspective?

Scope

The frameworks developed are applied within the context of Dutch local public services, where municipalities are the primary delivering units. Between 1950 and 2020, the number of municipalities decreased from 1,015 to 355 while population grew from 10 to 17

million. As a result, average municipality size increased from 10,000 to roughly 50,000. Encouraged by the recent large-scale decentralization of regional tasks in 2015 from the national government to municipalities, municipalities are now increasingly also seeking scale through cooperative agreements.

Municipalities provide a large number of heterogeneous services, and it has often been suggested that some are more subject to economies of scale than others. For example, capital-intensive services such as tax collection are likely to benefit more from increasing scale than labour-intensive, specialized services such as health services. To shed more light on this multi-level relationship between local government cost and scale, the first sub-question addressed is:

1. To what extent are different local government services subject to economies of scale?

Throughout this dissertation, four local government services are analysed: tax collection, road maintenance, school accommodation and public health services.

In theory, the effect of local government amalgamation on cost varies among services and depends on the size of the consolidating municipalities as well. To this end, a framework is developed in which both service heterogeneity and the characteristics (size) of amalgamating municipalities is incorporated. The framework can be used to assess or predict the overall or service-specific effects of any given amalgamation. The framework is applied to a data set covering 40 amalgamations and three heterogeneous services (road maintenance, public health, school accommodation). The research question formulated here is:

2. What is the relationship between economies of scale, amalgamation and cost in local government?

In theory, cooperation allows local governments to seek economies of scale where they are most likely to exist, such as in capital-intensive or highly standardized services. Here, the question is whether inter-municipal cooperation can be effective instrument for achieving economies of scale. The multi-level aspect here refers to the distinction between the size of individual municipalities and the size of the cooperative agreements in which they participate. A framework is developed that explicitly relates the scale of cooperative agreements to individual municipal cost, which is applied in the context of local government tax collection. To this end, the following sub-question is addressed:

3. What is the relationship between economies of scale, cooperation and cost in local government?

Finally, another interesting example where the multi-level scale issue can be observed is in the delivery of local education services. In the Netherlands, primary education is provided by school boards, and each school board governs between one and tens of individual schools. At the board level, economies of scale may arise from spreading fixed IT or overhead costs over a larger number of pupils. At the school level, economies of scale may arise due to teacher specialization or optimized utilization rates of school buildings. To investigate these relationships, a framework is developed which allows for the simultaneous analysis of economies of scale at both the board and school level. The final sub-questions formulated are:

4. To what extent are primary schools subject to economies of scale?

5. To what extent are primary school boards subject to economies of scale?

METHODS

The various relationships of interest are investigated using micro-econometric regression techniques. In essence, the relationships between scale and cost are analysed by regressing measures of cost on measures of scale. To this end, cost and output data for all local governments and primary schools and school boards were collected, as well as data on local government amalgamations and cooperative agreements.

RESULTS

1. To what extent are different local government services subject to economies of scale?

The results indicate that local government services are subject to (dis)economies of scale but that there is substantial heterogeneity across services. For each service analysed, the relationship between scale and cost was estimated to take on a U-shape. This indicates that as output volumes grow, average cost first decreases, but then rises again after a certain tipping point. The optimal scale and curvature of the cost function, however, depends on the service considered. For example, tax collection is subject to stronger economies of scale than road maintenance, where most municipalities already operate under diseconomies of scale.

2. What is the relationship between economies of scale, amalgamation and cost in local government?

The results here indicate that the effects of amalgamation on cost indeed depend both on the service considered as well as on the size of the consolidating units providing that service. Regarding three services (school accommodation, road maintenance, public health) and 40 amalgamations that took place between 2005 and 2016, it is estimated that, on average, amalgamation led to a less productive scale (and thus higher cost).

3. What is the relationship between economies of scale, cooperation and cost in local government?

Here, the results indicate that inter-municipal cooperation can be effective for achieving economies of scale in services that are subject to economies of scale. The results suggest that tax collection among municipalities is subject to sizeable economies of scale and that municipalities can effectively exploit economies of scale and lower cost through cooperation.

4. To what extent are primary schools subject to economies of scale?

5. To what extent are primary school boards subject to economies of scale?

Regarding the delivery of local (primary) education services, the results indicate that there are substantial economies of scale especially at the school level. In particular, schools with fewer than 60 pupils are associated with considerably higher (average) costs. The optimal school size is estimated at roughly 450 pupils. Furthermore, the results indicate that school board size, as measured by the number of schools governed, has much less influence on cost. Nonetheless, boards comprising fewer or more than three schools are estimated to have slightly higher costs. When taken together, the results indicate that, from a cost perspective, the optimal size of schools is 450 pupils and that the optimal number of schools per school board is three.

IMPLICATIONS

Regarding local government, the first policy implication is that policy makers and municipal managers should not seek an optimal organization or jurisdiction size, but rather should strive for a bandwidth in which both strong economies and diseconomies of scale are unlikely to persist. This recommendation is based on the finding that there is considerable service heterogeneity in the relationship between scale and cost and, additionally, on the observation that scale may affect many (non-financial) outcomes other than cost. The optimal size from a cost perspective differs between services and may also change when considering other public values. In light of these considerations, the quest for one optimal scale seems an ambitious one.

Secondly, large cost savings as a result of scaling should generally not be expected for local governments. Regarding the analysed services, the results indicate that most municipalities are operating under constant or even decreasing returns to scale. In other words, for these municipalities, consolidation is not expected to lead to a significant decrease in cost. Depending on the cost structure of services not yet analysed, amalgamation may still be associated with a decrease in cost in the smallest municipalities (e.g. <5,000 inhabitants). However, more research is required to substantiate such claims and to determine the bounds of a bandwidth of municipal size where large scale suboptimalities can be excluded.

A third implication stems from the empirical analysis of inter-municipal cooperation. In view of the fact that significant (i.e. non-minor) economies of scale in local government are rare but may exist in some specific cases, the policy recommendation here is that they can be achieved through measures such as cooperation or outsourcing. This seems most likely for standardized services such as IT, tax collection and other administrative services.

Regarding local education services, the implications are that policy makers should not expect large cost savings from large school boards and that very small schools (<60 pupils) have higher costs. For school boards, cost reduction thus offers no valid argument for further consolidation. Regarding very small schools, these may contribute to other (non-financial) public values, for example in ensuring that schools remain to exist in small villages. Such values come at a financial cost, for which small schools are already eligible for additional funding.

Samenvatting

In vrijwel alle Nederlandse publieke sectoren heeft de afgelopen decennia schaalvergroting plaatsgehad. De gedachte die hieraan ten grondslag ligt is dat er schaalvoordelen (*economies of scale*) gelden in de publieke dienstverlening, oftewel de gedachte dat publieke diensten goedkoper worden naarmate de schaal waarop ze geleverd worden groeit.

Het onderzoek naar schaaleffecten in de publieke sector heeft dan ook op brede wetenschappelijke belangstelling mogen rekenen. Veel onderzoek richt zich daarbij op de optimale schaalgrootte van publieke instellingen, zoals rechtbanken, scholen, of gemeenten. Ondanks de beschikbaarheid van een groot aantal empirische studies is er nog de nodige onzekerheid over of en in welke mate *economies of scale* in de publieke sector opgaan. Dat maakt het lastig om beleidsmakers en bestuurders praktische aanbevelingen te geven over schaalgrootte.

Onderzoek naar schaaleffecten kent een aantal methodologische uitdagingen. In dit proefschrift staat één specifiek probleem centraal. Het vertrekpunt van dit proefschrift is de opvatting dat onderzoek naar schaaleffecten bemoeilijkt wordt door de conceptuele complexiteit van het begrip 'schaal'. Complexiteit verwijst hier naar de gelaagdheid van schaal. Zo richt onderzoek naar schaaleffecten zich vaak op het vergelijken van de kosten van grote en kleine, maar verder vergelijkbare organisaties, zoals scholen, ziekenhuizen en gemeenten. Eenheid van analyse bij dit soort analyses is doorgaans de administratieve organisatie, het niveau waarop de jaarverslaglegging wordt afgelegd: hét ziekenhuis, hét schoolbestuur of dé gemeente. Grote organisaties kunnen intern echter heel klein georganiseerd zijn en vice versa. Ook kunnen sommige bedrijfsonderdelen mogelijk veel meer profiteren van schaalvergroting, zoals ICT. Een eendimensionale benadering van schaal doet dan geen recht aan de daadwerkelijke schaal waarop instellingen hun dienstverlening organiseren.

Onderzoeksdoel

Dit proefschrift heeft tot doel de ontwikkeling van empirische methoden om schaaleffecten te analyseren waarin meer rekenschap gegeven wordt van de complexiteit van het begrip schaal. Deze aanpak wordt aangeduid als een multilevelbenadering. Deze benadering vormt in de basis de belangrijkste bijdrage van dit proefschrift aan de wetenschappelijke literatuur op het terrein van schaaleffecten. Beleidsmatig beoogt dit proefschrift bij te dragen aan kennis over de relatie tussen schaal en kosten in de publieke sector, specifiek bij gemeenten en in het primair onderwijs. De centrale onderzoeksvraag luidt:

Wat is de optimale schaalgrootte van de publieke dienstverlening vanuit een multilevelbenadering?

EMPIRISCH TOEPASSINGSGEBIED

Het toepassingsgebied van dit proefschrift is de Nederlandse lokale publieke dienstverlening. Gemeenten zijn in deze context veruit de belangrijkste dienstverleners. Het aantal gemeenten is tussen 1950 en 2020 afgenomen van 1015 tot 355, terwijl het aantal inwoners tegelijkertijd juist is toegenomen van 10 tot 17 miljoen. De gemiddelde gemeentegrootte is dus bijna vervijfvoudigd, van 10.000 tot ongeveer 50.000 inwoners. De trend van gemeentelijke schaalvergroting lijkt voorlopig nog wel door te zetten. Aangejaagd door de decentralisatie van omvangrijke taken in 2015 zoeken steeds meer gemeenten nu ook schaalgrootte via regionale samenwerkingsverbanden met andere gemeenten.

Gemeenten verzorgen een groot aantal uiteenlopende diensten, en sommige zijn mogelijk meer vatbaar voor schaalvoordelen dan andere. Zo ligt het voor de hand dat kapitaalintensieve diensten zoals de belastinginning of afvalinzameling meer baat hebben bij schaalvergroting dan arbeidsintensieve diensten zoals op terrein van de gezondheidszorg. Dit is dus een voorbeeld van een multilevelaspect: een grote gemeente kan bij de ene dienst goedkoper uit zijn, maar bij de andere dienst juist weer duurder. Om deze multilevelrelatie tussen gemeentegrootte en kosten te onderzoeken is de volgende deelonderzoeksvraag geformuleerd:

1. In welke mate zijn de verschillende gemeentelijke diensten onderhevig aan schaaleffecten?

In dit proefschrift worden vier heterogene gemeentelijke diensten geanalyseerd: belastinginning, wegbeheer, onderwijshuisvesting en de publieke gezondheidszorg.

Het antwoord op deze deelvraag heeft ook gevolgen voor de theoretische effectan van gemeentelijke herindeling. Theoretisch hangt het effect van gemeentelijke herindeling op de kosten af van zowel de dienst als de omvang van de fuserende gemeenten. Om dit te onderzoeken, wordt een kader ontwikkeld waarin zowel rekening wordt gehouden met de kenmerken van verschillende diensten als van de fuserende gemeenten. De aanpak maakt het mogelijk een gedetailleerder meting en prognose te maken van de effecten van gemeentelijke herindeling dan op basis van analyses op het niveau van gemeenten mogelijk is. Het model wordt geschat op een dataset met 40 herindelingen en met betrekking tot drie diensten (wegbeheer, onderwijshuisvesting, publieke gezondheidszorg). De deelonderzoeksvraag hier luidt:

2. Wat is de relatie tussen schaaleffecten, herindeling en de kosten van gemeenten?

De derde deelonderzoeksvraag heeft betrekking op gemeentelijke samenwerking. In theorie kunnen gemeenten via samenwerking gericht schaalvoordelen realiseren. Het multilevelaspect hier is het onderscheid tussen de omvang van individuele gemeenten enerzijds en de schaalgrootte van samenwerkingsverbanden anderzijds. Om de multilevelrelatie tussen schaal, kosten en samenwerking inzichtelijk te maken wordt een econometrisch kader ontwikkeld waarin de relatie tussen samenwerking, schaalgrootte en kosten nadrukkelijk aan de orde wordt gesteld en toegepast op de gemeentelijke belastinginning, een beleidsterrein waar veel gemeenten samenwerken. Het kader maakt het bijvoorbeeld mogelijk om de optimale schaal van een samenwerkingsverband te onderzoeken. De deelonderzoeksvraag hier luidt:

3. Wat is de relatie tussen schaaleffecten, intergemeentelijke samenwerking en de kosten van gemeenten?

Een ander interessant voorbeeld van een lokale dienst waar het multilevelprobleem zich voordoet is het basisonderwijs. Hier zijn schoolbesturen (financieel) eindverantwoordelijk, maar wordt het onderwijs feitelijk verzorgd door individuele scholen. Het aantal scholen per schoolbestuur varieert tussen de één en vele tientallen. Op het bestuursniveau kunnen schaaleffecten zich bijvoorbeeld voordoen door vaste ICT-kosten of overheadkosten over steeds meer leerlingen te spreiden. Op schoolniveau kunnen schaaleffecten bijvoorbeeld optreden door arbeidsspecialisatie of door het optimaliseren van de bezettingsgraad van schoolgebouwen. Om deze relaties te analyseren wordt in dit proefschrift een econometrisch kader ontwikkeld waarin schaaleffecten op bestuursniveau en schoolniveau tegelijkertijd onderzocht kunnen worden. De deelonderzoeksvragen hier luiden:

4. In welke mate doen zich schaaleffecten voor bij scholen binnen het basisonderwijs?

5. In welke mate doen zich schaaleffecten voor bij schoolbesturen binnen het basisonderwijs?

METHODEN

De verschillende onderzoeksvragen worden beantwoord met behulp van micro-econometrische technieken. De relatie tussen schaal en kosten wordt in essentie steeds onderzocht door de kosten van de publieke dienstverlening te regresseren op (onder meer) maatstaven van schaal. Hiertoe zijn gegevens verzameld over de kosten en productie van gemeenten, scholen en schoolbesturen, en zijn daarnaast ook gegevens verzameld over de samenstelling van gemeentelijke herindelingen en samenwerkingsverbanden.

RESULTATEN

1. In welke mate zijn de verschillende gemeentelijke diensten onderhevig aan schaaleffecten?

De resultaten laten zien dat gemeentelijke diensten onderhevig zijn aan schaaleffecten, maar dat de mate waarin inderdaad varieert tussen verschillende diensten. Voor elk van de vier onderzochte gemeentelijke diensten (belastinginning, wegbeheer, onderwijshuisvesting, publieke gezondheidszorg) is een U-vormige kostenfunctie vastgesteld. Dit impliceert dat de gemiddelde kosten van de gemeentelijke dienstverlening eerst afnemen naarmate de schaalgrootte toeneemt, maar vanaf een bepaald punt juist weer groeien. De optimale schaal en het verloop van de gemiddelde kosten verschilt echter tussen de verschillende beleidsterreinen.

2. Wat is de relatie tussen schaaleffecten, herindeling en de kosten binnen gemeenten?

Uit de resultaten blijkt dat de effecten van herindeling op kosten inderdaad afhangen van het beleidsterrein én de schaal van de fuserende gemeenten. Uit een analyse van 40 herindelingen die plaatsvonden tussen 2005 en 2016, en beperkt tot 3 gemeentelijke beleidsterreinen (onderwijshuisvesting, wegbeheer, publieke gezondheidszorg), blijkt dat herindelingen gemiddeld eerder tot hogere kosten hebben geleid dan tot lagere kosten.

3. Wat is de relatie tussen schaaleffecten, intergemeentelijke samenwerking en kosten binnen gemeenten?

De resultaten laten zien dat intergemeentelijke samenwerking een effectieve strategie kan zijn om schaalvoordelen te benutten. Een voorwaarde is dus wel dat er op het betreffende beleidsterrein ook daadwerkelijk schaalvoordelen bestaan. Zo blijkt uit de resultaten dat kleine gemeenten die zijn gaan samenwerken op het terrein van de belastinginning kostenbesparingen hebben gerealiseerd.

4. In welke mate doen zich schaaleffecten voor op het niveau van scholen in het basisonderwijs?

5. In welke mate doen zich schaaleffecten voor op het niveau van schoolbesturen in het basisonderwijs?

Met betrekking tot het basisonderwijs blijkt dat er voornamelijk schaalvoordelen bestaan voor scholen met minder dan 60 leerlingen. Voor deze scholen leidt schaalvergroting nog tot significant lagere gemiddelde kosten. De optimale schoolgrootte wordt geschat op 450 leerlingen. De resultaten laten verder zien dat de omvang van schoolbesturen er veel minder toe doet voor de gemiddelde kosten per leerling. Er zijn wel aanwijzingen dat schoolbesturen met meer of minder dan 3 scholen onder hun hoede nog iets hogere gemiddelde kosten hebben. De optimale schaal van een school wordt dus geschat op 450 leerlingen, die van een schoolbestuur op 3 scholen.

IMPLICATIES

Een eerste beleidsaanbeveling is dat het niet zinvol is om te streven naar een optimale schaalgrootte van gemeenten. Alleen vanuit kostenperspectief hangt het antwoord op deze vraag al af van naar welke dienst je kijkt. Bovendien kan schaal ook andere uitkomsten dan uitvoeringskosten beïnvloeden, zoals reistijden van burgers of democratische participatie. Dat maakt het vraagstuk nog veel ingewikkelder. Een meer praktische benadering is daarom om niet te streven naar een optimale schaalgrootte, maar een richtinggevende bandbreedte waarbinnen de grootste schaalnadelen uitgesloten worden.

Een tweede beleidsimplicatie, ook met betrekking tot gemeenten, is dat de mogelijkheden voor kostenreductie door schaalvergroting eerder uitzondering dan regel zijn. Bij de vier onderzochte diensten laten de resultaten zien dat veruit de meeste gemeenten al schaalnadelen ondervinden, oftewel al op een te grote schaal opereren. Met andere woorden: schaalvergroting of herindeling leidt voor deze gemeenten niet meer tot kostenverlaging. Mogelijk leidt schaalvergroting voor de allerkleinste gemeenten nog wel tot kostenverlaging (<5.000 inwoners), maar dit hangt ook af van de kostenstructuur van de niet in dit proefschrift onderzochte beleidsterreinen. Dit zou dus een mogelijke ondergrens van een normstellende bandbreedte kunnen zijn.

Een derde implicatie met betrekking tot gemeenten volgt uit de analyse van intergemeentelijke samenwerking. Hieruit blijkt namelijk dat gemeenten gericht schaalvoordelen kunnen realiseren door middel van samenwerking op beleidsterreinen waar schaalvoordelen gelden. In dit proefschrift is specifiek gekeken naar de belastinginning. Mogelijk zijn vergelijkbare effecten aanwezig in andere gestandaardiseerde of kapitaalintensieve diensten, zoals IT-processen. Samenwerking lijkt daarmee dus een beter instrument dan herindeling.

Met betrekking tot het basisonderwijs zijn de belangrijkste implicaties dat grote schoolbesturen niet goedkoper zijn, en dat de kleinste scholen (<60 leerlingen) nog wel beduidend hogere gemiddelde kosten hebben. Schaalvoordelen zijn dus geen steekhoudend argument voor schaalvergroting van schoolbesturen. De uitkomst dat kleine scholen duurder zijn is verder weinig verrassend, want zij ontvangen al extra financiering. Hier vindt dus een uitruil met andere publieke waarden plaats, zoals het behoud van onderwijsvoorzieningen in kleine dorpskernen.

Curriculum Vitæ

Thomas Kostas Niaounakis was born on 8 October 1989 in Voorburg, The Netherlands. He holds MSc degrees in Econometrics and Economics (*cum laude*) from the Erasmus University Rotterdam. He conducted his PhD research while working at the Institute for Public Sector Efficiency (IPSE) Studies. His resesarch experience includes work on local governments and more recently, quasi non-governmental organizations. He has worked with several public and governmental organizations, including the Ministry of the Interior and Kingdom Relations and the Ministry of Social Affairs and Employment. From October 1, 2020 he works at the Inspectorate of the Budget of the Ministry of Finance in the Netherlands.

List of Publications

Refereed journal articles

3. Blank, J. L. T., **Niaounakis, T. K.**, Valdmanis, V. G. (2020). Biased technical change in hospital care and the demand for physicians. Human Resources for Health, 18(1), 1–8.

2. Blank, J. L. T., & **Niaounakis, T. K.** (2019). Managing Size of Public Schools and School Boards: A Multi-Level Cost Approach Applied to Dutch Primary Education. Sustainability, 11(6662).

1. **Niaounakis, T. K.**, & Blank, J. L. T. (2017). Inter-municipal cooperation, economies of scale and cost efficiency: an application of stochastic frontier analysis to Dutch municipal tax departments. Local Government Studies, 43(4), 533–554.

Reports and other publications

22. **Niaounakis, T. K.** & van Heezik, A. A. S. (2021). Productiviteit Kadaster. Een analyse van de productiviteitsontwikkeling bij het Kadaster tussen 2015 en 2019. Delft: IPSE Studies.

21. **Niaounakis, T. K.**, van Heezik, A. A. S., & Blank, J. L. T. (2020). Productiviteit uitvoering sociale zekerheid. Een analyse van de productiviteitsontwikkeling bij UWV en SVB tussen 2002 en 2018. Delft: IPSE Studies.

20. **Niaounakis, T. K.**, & van Heezik, A. A. S. (2019). Opzet voor een handreiking voor de evaluatie van de doelmatigheid en doeltreffendheid van zbo's (in opdracht van de Werkgroep evaluatie zbo's). Delft: IPSE Studies.

19. Blank, J. L. T., van Heezik, A. A. S., & **Niaounakis, T. K.** (2020). Design doelmatige departementen. Een verkennend onderzoek naar de mogelijkheden voor productiviteitsmeting bij kerndepartementen. Delft: IPSE Studies.

18. **Niaounakis, T. K.**, & van Heezik, A. A. S. (2019). Op afstand de beste? Een analyse van de productiviteitsontwikkeling bij IND, CJIB, SVB, RDW en het Kadaster. Delft: IPSE Studies.

17. **Niaounakis, T. K.**, & Blank, J. (2019). Schaal en doelmatigheid van gemeenten. Delft: IPSE Studies.

16. **Niaounakis, T. K.**, Blank, J. L. T., & van Heezik, A. A. S. (2018). Kosten van de lokale publieke gezondheidszorg in verband. Delft: IPSE Studies.

15. **Niaounakis, T. K.**, & van Hulst, B. L. (2017). Doelmatig huisvesten. Een empirisch onderzoek naar de relatie tussen krimp, schaal, rolverdelingen en de doelmatigheid van onderwijshuisvesting in het basisonderwijs. Delft: IPSE Studies.

14. **Niaounakis, T. K.**, & van Heezik, A. A. S. (2017). Wegen gewogen. Een empirisch onderzoek naar de kosten en doelmatigheid van het decentrale wegbeheer tussen 2008 en 2014. Delft: IPSE Studies.

13. Blank, J. L. T., & **Niaounakis, T. K.** (2016). Is big wel echt zo beautiful? Illusies over fusies. Publiek Denken, (5), 38–41.

12. Blank, J. L. T., & **Niaounakis, T. K.** (2016). Nieuwe fusietoets scholen overbodig. Me Judice.

11. Blank, J. L. T., & **Niaounakis, T. K.** (2016). Naar een verantwoorde schaal en geografische spreiding in de rechtspraak. Een inventarisatie van de mogelijkheden voor het ontwikkelen van een onderzoeksprogramma. Delft: IPSE Studies.

10. Blank, J. L. T., van Heezik, A. A. S., & **Niaounakis, T. K.** (2016). Productiviteit van overheidsbeleid, deel II: de Nederlandse zorg, 1980-2013. Delft: IPSE Studies.

9. **Niaounakis, T. K.**, & Blank, J. L. T. (2015). Gerichte gemeentelijke samenwerking beter dan fuseren. TPC, 4, 4–8.

8. **Niaounakis, T. K.**, & Blank, J. L. T. (2015). Lasten van (samen) belasten. Een empirisch onderzoek naar de doelmatigheid van de gemeentelijke belastingheffing en de uitvoering van de Wet WOZ tussen 2005 en 2012. Delft: IPSE Studies.

7. Dumaij, A. C. M., Urlings, T., & **Niaounakis, T. K.** (2014). Productiviteitstrends bij de rechterlijke macht. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling van rechtspraak en Openbaar Ministerie tussen 1965 en 2011. Delft: IPSE Studies.

6. Urlings, T., Blank, J. L. T., & **Niaounakis, T. K.** (2014). Doelmatige dienders. Een vergelijking tussen regiokorpsen van de Nederlandse politie in de 21e eeuw. Delft: IPSE Studies.

5. **Niaounakis, T. K.**, Urlings, T., & van Heezik, A. A. S. (2014). Productiviteitstrends in het gevangeniswezen. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling tussen 1970 en 2012. Delft: IPSE Studies.

4. **Niaounakis, T. K.** (2013). Productiviteitstrends in de geestelijke gezondheidszorg. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling tussen 1982 en 2010. Delft: IPSE Studies.

3. Dumaij, A. C. M., & **Niaounakis, T. K.** (2013). Productiviteitstrends in de gehandicaptenzorg. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling tussen 1975 en 2010. Delft: IPSE Studies.

2. **Niaounakis, T. K.** (2012). Productiviteitstrends in het hoger beroepsonderwijs. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling tussen 1975 en 2010. Delft: IPSE Studies.

1. Blank, J. L. T., & **Niaounakis, T. K.** (2011). Productiviteitstrends in het wetenschappelijk onderwijs. Een empirisch onderzoek naar het effect van regulering op de productiviteitsontwikkeling tussen 1982 en 2009. Delft: IPSE Studies.