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AGGLOMERATION AND THE PUBLIC SECTOR

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Contents

ABSTRACT

The public sector in the UK is large and diverse. It is, however, excluded from agglomeration benefit calculations in TAG, but can be included as a sensitivity test along with 'other missing' industries utilising the economy average rate.

How much the public sector will benefit from agglomeration is difficult to identify. Conceptually there is no reason to believe that the mechanisms of agglomeration economies, matching, sharing and learning, would not also hold for the public sector. It is however argued that a lack of competition may blunt or even block some of them, though these arguments are countered as different institutions (e.g. hospitals) may compete on quality. This is particularly the case in education and health where pupils and patients can choose where to get educated or treated. In support of these counter-arguments there is some, albeit limited, evidence of agglomeration impacts in education and health. These empirical studies cite as the sources of agglomeration, and in some places investigate, channels associated with all three categories of the micro-foundations (sharing, matching & learning). Analysis at an aggregate level of job switchers in the UK also identifies similar levels of flows of workers between different parts of the public sector and between the private and public sectors as within the private sector. The movement of workers is a key channel for learning.

A distinct feature of the empirical work on agglomeration in the public sector is the use of quality: reduced mortality, pupil attainment, etc. Improvements in productivity through increased agglomeration are therefore likely to manifest themselves as improvements in quality. These will unambiguously increase welfare, however, their linkage to changes in GDP are not clear.

Ultimately the evidence base on public sector agglomeration impacts is thin, but it does exist, and the conceptual arguments lead us to expect that. Further empirical work is therefore needed, particularly for the UK situation. As with other agglomeration empirical work this will not be an easy task, with data often being a limiting factor. The ONS public sector productivity data, which uses quality adjusted metrics, does at first sight seem ideal. However, it is too aggregate, in a spatial sense, to be useful in any future empirical work. A new dataset would need to be developed. This could potentially utilise the same data sources as the ONS's data.

1 INTRODUCTION

1.1 Background and objectives

In previous work for the Department, we reviewed TAG unit A2.4 (Department for Transport, 2020) and suggested that the current appraisal framework could be improved by including the public sector within the benefit calculations (Laird and Tveter, 2023). The relevant section of that report has been reproduced in Annex A. In that paper, we concluded:

> Our review of elasticities of the public sector is unfortunately only based on indirect evidence. Based on the limited available indirect evidence we find no evidence to support the assumption that the effect in the public sector is zero, as implicitly assumed in the DfT framework. The available evidence is too thin to make any assertion of a distinct agglomeration elasticity for the public sector. If anything, our review supports the hypothesis that the effect in the public sector is closer to the economy weighted average, than it is to zero.
>
> Laird and Tveter (2023 Chapter 3)

It was however felt by DfT that further work was needed to consider whether conceptually public sector agglomeration elasticities were justifiable, as the 2023 work did not go into significant depth on the concepts of why we might expect a positive public sector elasticity. Arguments that agglomeration may not apply to the public sector would include a lack of:

- profit maximising or cost minimising behaviour;
- equivalence of wages to the value of the marginal product;
- freedom in locational choice of production; and
- operation within a competitive market structure.

The purpose of this work is therefore to set out conceptually the ways in which the productivity of public sector institutions could be affected by transport improvements. Specifically the aims of the study are to understand:

- How the agglomeration mechanisms may differ between public sector industries, such as for example the education and healthcare sectors, and the civil service.
- Whether the same mechanisms (learning, matching and sharing) that are relevant to the private sector are also relevant to the public sector or if public sector productivity improvements may arise in a different way.
- What the relevant measures of output and productivity should be when measuring public sector agglomeration, given the long-recognised challenges in representing public sector output appropriately within GDP.

1.2 The public sector

The public sector in the UK comprises 5.9 million employees, with about 27 million in the private sector, giving a combined workforce of approximately 33 million. In terms of full-time equivalent (FTE) jobs there were 4.987 million FTEs in the public sector in September 2023 (see Table 1-1). The

majority (78%) of these are in three industries: the National Health Service (35%), education (23%) and public administration (20%). In this paper, whilst discussing the public sector in general, we focus on these three industries.

TABLE 1-1 PUBLIC SECTOR EMPLOYMENT BY INDUSTRY, FULL-TIME EQUIVALENT JOBS, (UK, THOUSANDS, SEASONALLY ADJUSTED, SEPTEMBER 2023)

	Public administration, defence, compulsory social security				Health and social work			
Construction	HM Forces	Police (including civilians)	Public administration	Education	National Health Service	Other health and social work	Other public sector	**Total public sector**
-	150 3%	270 5%	1,018 20%	1,129 23%	1,746 35%	163 3%	485 10%	**4,987** **100%**

Source: Office for National Statistics (Dec 2023), Quarterly Public Sector Employment Survey https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/publicsectorpersonnel/bulletins/publicsectoremployment/september2023

1.3 Sources of agglomeration economies.

Following Marshall (1890) the classic 'sources' of agglomeration economies are:

- Knowledge spillovers
- Labour market interactions/pooling
- Linkages between intermediate and final-goods suppliers

These Marshallian' sources' are however now regarded as aggregate effects or outcomes of agglomeration economies. As such they maybe confounded with other benefits of observed reduced transport and communication costs in agglomerations. The confounding occurs because in agglomerations individuals and firms receive direct benefits of better connectivity which can be internalised and spin off benefits. The latter spin off benefits are the external economies of scale. Thus, lower commuting costs in a large labour market are internal to the firm/individual, but better quality matches and the reduced risk of larger labour markets are sources of external benefit to the firm and individual. Similarly, reduced transport costs in buyer-supplier relationships are internal to the firms in the supply chain, but the improved variety of goods on offer in larger agglomerations is an external benefit.

It is these spin off benefits that are now considered to be the micro-foundations to agglomeration economies. The classic reference here is that by Duranton and Puga (2004) who set out ten sources of external economies of scale in cities, categorising them into three basic typologies of *sharing, matching and learning* (see Table 1-2).

Broadly speaking the sharing mechanisms concern the supply chain of firms and, based on evidence of clustering, are thought to act over reasonably long distances and particularly apply to manufacturing related firms which receive inputs from other firms (see e.g. Combes and Gobillon, 2015b, Rosenthal and Strange, 2020). The matching mechanisms are concerned with the interaction between workers and firms, and these are thought to apply at a city level. Finally, the learning mechanisms are concerned with how knowledge is created, held on to and spread. They are thought to require very close proximity. Based on the

observations that producer service type businesses tend to cluster in close proximity, are knowledge based and have the highest agglomeration elasticities (Melo et al., 2009, Graham et al., 2010) it is generally viewed that the learning sources give rise to the largest the largest agglomeration elasticities. This is also supported by econometric work by de la Roca and Puga (2017).

TABLE 1-2 MICRO-FOUNDATIONS TO AGGLOMERATION ECONOMIES

Sharing micro-foundation
Sharing indivisible goods and facilities. Indivisible goods and facilities are associated with large fixed costs and congestion. Market places, parks and transport services all constitute examples of indivisible goods. The sharing of these goods is one of the reasons cities exist. If the transport investment provides new or significantly enhanced transport capacity (e.g. a new train station or airport) this will immediately become available to the residents of that city. New transport infrastructure will also strengthen an agglomeration, giving more people access to existing shared facilities (e.g. market places). A third channel will also exist as the transport investment may lead to the creation of new shared facilities. Venables et al. (2014 Appendix 4.1) discuss this in the context of office or shopping development.
Sharing the gains from variety. Final producers become more productive when they have access to a wider variety of intermediate suppliers. Improved transport links by connecting cities together, or making the effective city larger, increase the number of intermediate firms available to final producers thereby increasing productivity of the final producers.
Sharing gains from individual specialisation. The underlying argument here is that the increased output within large agglomerations allows task or individual specialisation. Increased specialisation is more productive than each worker doing a bit of every task. Duranton and Puga also refer to this as 'learning by doing'.
Sharing risk. One of the benefits of labour market pooling is that firms, which face random increases or decreases in demand, are less constrained by the size of the labour market. For example, a firm that faces a positive shock, and wishes to take on more workers, will face paying a lower wage premium in a large labour market relative to a small labour market. In these circumstances the variance in the wage faced by the firm decreases the larger the labour market pool is.
Matching micro-foundation
Improving quality of matches. In the economy there is a heterogeneity of tasks and skills and small skill mis-matches will lower productivity. The same argument applies between suppliers and final good producers. An increase in the number of agents trying to match improves the quality of the match. Thereby increasing productivity. A transport improvement increases the number of agents within a certain travel time and therefore would be expected to improve the quality of the matches.
Improving the chances of matching. Here the argument is positioned that job search and recruiting is subject to frictions. In this situation a proportional increase in the number of job seekers and job vacancies results in a more than a proportional increase in the number of matches. The net result is that in larger cities we expect there to be less unused resources (e.g. lower unemployment levels) ceteris paribus.
Mitigating hold up problems through ease of matching. A potential problem to economic growth can occur if assets are specific but cannot be observed – for example a worker's skills. The firm cannot observe the worker's skills until they employ her. This can lead to a situation in which worker's do not invest in skills. In larger labour markets there is a larger market place for skills and this problem is mitigated. A similar argument can be extended to other assets.

Learning micro-foundation
Knowledge generation. A learning process is required to generate new knowledge. Arguably this learning process is higher in the larger diversified cities where there exist more opportunities to utilise different skills, techniques or production methods. Arguably a transport improvement that increases learning opportunities can intensify such learning processes.
Knowledge diffusion. Here the argument is that proximity to individuals with greater skills or knowledge facilitates the acquisition of skills and the exchange and diffusion of knowledge. That is after a transport improvement which increases the size of an agglomeration the rate at which knowledge is diffused will increase.
Knowledge accumulation. Larger cities are argued to be reservoirs of more knowledge. This stems from their ability to accumulate knowledge. In contrast to the previous two learning mechanisms, which relate to changes in rates of knowledge generation and diffusion, this reflects an absolute amount of knowledge. As a consequence, this is likely to be a medium to long term effect.

Source: Duranton and Puga (2004)

1.4 Study objectives and report structure

Following this introductory chapter, we discuss in Chapter 2 the evidence for the micro-foundations of agglomeration economies in the health, education and public administration. In Chapter 3, we consider possible empirical strategies for estimating agglomeration economies in the public sector, with our conclusions in Chapter 4.

2 SOURCES OF AGGLOMERATION IN THE PUBLIC SECTOR

2.1 The public sector versus the private sector

There are two main critiques that might suggest agglomeration economies either do not hold or are more muted in public sector industries compared to private sector industries: the lack of competition; and a non-market orientated business structure and culture. Competition is seen as a key driver to innovation, as with competition firms are forced to innovate or risk failure. Whilst knowledge creation (i.e. innovation) is enhanced in agglomerations, and arguably should apply to both private and public sectors, the motive for innovation by the firm comes from competition. Therefore the argument is that without competition in the public sector the benefits of agglomeration will not be realised. In terms of business structure public sector organisations may also not engage in profit maximising or cost minimising behaviour. This could affect the choice of suppliers thereby meaning that the public sector will not maximise its gain from variety in the supply chain. Alternatively, a vertically integrated public sector, e.g. the National Health Service (NHS), could actually limit the number of suppliers thus again reducing one of the sources of agglomeration that would usually be experienced in larger agglomerations. Having said that competition in agglomerations may act as an impediment to growth, as firms may not wish to innovate if their ideas will immediately 'leak' to others. Thus it becomes a largely empirical matter as to which effect of competition on innovation dominates, with the evidence on balance suggesting competition encourages growth (see e.g. Glaeser et al., 1992, Rosenthal and Strange, 2004 Section 2.6).

These critiques, however, arguably take a naïve view of the public sector and agglomeration. Firstly, there are multiple micro-foundations to agglomeration economies, and only some will depend on product market/inter-firm competition. We consider these other mechanisms below, particularly that of matching. Secondly, it will be context specific as to how muted the competition and industrial structure dependent agglomeration impacts will be. Does the National Health Service or the education industry act as a single entity, or is it actually de-centralised with individual 'units' acting in a quasi-independent manner? If the latter then conceptually we could imagine that individual 'units' (schools, hospitals, medical labs, etc.) may compete with each other, albeit not on price but on quality (see e.g. Gravelle et al. (2014) for a theoretical model as to the economic conditions that lead to quality competition between close rivals). A key driver to this competition is the manner that health and education services in Britain have been reformed such that funding for schools and hospitals follows pupils or patients respectively. This combined with patient and parent choice leads to health and education providers needing to be mindful of maintaining quality vis a vis rivals in order to maintain funding.[1] A further driver could be personal. The managers of the said units may wish to maintain and enhance employment prospects as well as deriving status from managing successful establishments. Conceptually therefore we may need to think of competition in the public sector playing out through quality rather than through price. Thus a 'business culture' to improve quality may exist in the public sector, and this would naturally take advantage of the benefits of being located in an agglomeration. If this is the case then we would expect quality outputs in public sector industries to systematically vary with agglomeration. In the subsequent sections, particularly on

[1] GP practices also receive part of their funding by meeting patient 'quality' targets, so whilst they do not compete they are incentivised to maximise quality in order to maximise incomes. The quality indicators include management of some of the most common chronic conditions, for example asthma and diabetes, management of major public health concerns, for example smoking and obesity and providing preventative services such as screening or blood pressure checks. See for example: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/general-practice-data-hub/quality-outcomes-framework-qof

health and education, we identify evidence that output quality of the public sector is enhanced in larger agglomerations.

These critiques also neglect the role of the worker. The matching micro-foundations are concerned with matches between firms and workers. Even should the public sector not be goal seeking in terms of either profits or quality, we would still expect workers to seek out the best match for themselves (i.e. matches will be of a higher quality in the public sector in larger agglomerations), we would also expect that workers (and public sector industries) will have a better probability of making a match in larger agglomerations than in smaller ones. The consequences of these behaviours would be seen in higher levels of specialisation by workers in larger agglomerations. The subsequent sections, again particularly on health and education, identify some evidence for this.

The competition critique is most associated with the learning micro-foundations. Firms innovate and acquire knowledge to avoid failure. Knowledge diffusion is a key part of this. Channels by which knowledge diffusion would occur are through mimicking behaviour between firms and movement of labour between firms. When firms are close together it is easier to mimic and for labour to switch firms. Ideas are therefore more quickly disseminated in larger agglomerations. Conceptually, if we think of public sector industries as comprising of quasi-independent organisations then we would also expect this diffusion channel to apply to the public sector, but for it to work well there is a for labour to not only move between different parts of the public sector (e.g. between hospitals or schools), but between the private and public sector.

By looking at job moves we can see whether the movement of workers between different parts of the public sector and between the public and private sector (and vice versa) are similar to that which happens within the private sector. The Office for National Statistics (ONS) (2019) find that between 2000 and 2018 on average approximately 9% of workers move jobs every year, with a low just after the 2008 recession, and the highest proportions in 2017 and 2018. They find little difference between the public and private sector, though there is slightly more job mobility in the private sector. Of the people who worked in the public sector between 2017 and 2018, 91.6% stayed in the same job as the previous year, while 88.5% of the people who worked in the private sector stayed in the same job as the previous year. Implying that 8.4% of the public sector workforce in 2018 had moved jobs over the previous year, with a slightly higher percentage in the private sector. Additionally, there is also movement between the public and private sector. 24.6% of job movers with a public sector job (after switching) came from the private sector, and a comparable number of workers moved from the public sector to the private sector. [2] We can therefore see that job movement within the public sector is comparable to that within the private sector,and that the movement of workers between the private and public sector is similar to their relative proportions in the labour force. Combined this would imply that one of the mechanisms for the diffusion of knowledge, the transfer of staff between organisations, would not be expected to be muted in the public sector.

Finally, it is worth considering the sharing mechanisms. One of the critiques regarding the public sector not benefitting from agglomeration economies focuses on an inability to share supply chains and benefit from gains in variety. For some aspects of the public sector this is a valid critique, for example NHS medical laboratories that support NHS hospital and GP diagnostic work may suffer from this. For other public sector industries the supply chain may draw heavily on the private sector.

[2] This equates to approximately 0.5% of the entire UK workforce switching between the public sector and private sector in 2018. That is approximately 5% of all job moves in a year are between the private and public sectors. 78.5% of workers worked in the private sector and 21.5%

School facilities for example maybe serviced under facility management contracts with private sector contractors, rather than by local authorities per se, and educational materials will likely be supplied by the private sector. Furthermore, the other sharing mechanisms in Table 1-2 are likely to apply to the public sector. For example we would expect the public sector to benefit from the sharing of fixed infrastructure such as transport links, high speed internet connectivity, water and other utilities, shared between the different public sector industries but also shared with the private sector. Other fixed assets that can be shared, such as conference centres, will also be shared between public sector industries and with the private sector.

Conceptually therefore we can see that there are good grounds to expect public sector performance to vary systematically with the size of the agglomeration, in much the same way that the private sector does. The next sections present evidence on the existence of the micro-foundations to agglomeration in the health, education and public administration industries in support of these conceptual arguments. Prior to that three remarks are worth elaborating before proceeding.

The first is that public sector industries might not be free to choose locations and therefore may not be able to take full advantage of the benefits of agglomerations. Clustering of public sector industries may not therefore show evidence of the potential relevance of agglomeration economies to them. From the perspective of transport appraisal this is likely to not be of great significance. This is because from an appraisal perspective we are interested in the incremental change to productivity from strengthening Access To Economic Mass (ATEM) via improved transport connectivity. Sub-optimal locations of public sector' production units' is less relevant in this context. In fact if public sector organisations are located sub-optimally a transport project may improve the connectivity of the said public sector organisations allowing them to better benefit from agglomeration economies. The key issue from an appraisal perspective is that the ATEM function needs to be sensitive to changes in transport costs, as the TAG ATEM function is.

The second is that whilst the public sector may experience the same or similar agglomeration mechanisms to the private sector, different dampening effects due to competition and industrial structure may result in the elasticities having a different size. Additionally as the activities the public sector engages in are more labour intensive on average than the private sector, it means that agglomeration impacts have to act primarily through the labour market channel, rather than by increasing capital productivity. This too would lead to differences between public sector and private sector agglomeration elasticities. Of course we see this variation between private industries too.

The second remark is that, if public sector productivity improvements manifest themselves as a unit cost reduction (e.g. for delivering the same quantity of output for less inputs), or as a quality improvements (e.g. improvements in quality adjusted life years (QALYs) or faster response times by police or fire fighters) then it may be difficult to capture all these benefits through a GDP measure. One would expect the productivity improvements that lead to cost reductions to be captured in GDP, but adjustments in quality are difficult to capture. Ideally, GDP measures should capture changes in quality of a priced good through some sort of price deflator. A £1,000 computer bought today has a different quality to a £1,000 computer bought ten years ago, and the deflators used should take this into account. This is notoriously difficult to estimate however (see for example Ahmad et al. (2017)). On top of this some of the changes quality outcomes associated with the public sector may not appear in GDP accounts. These could include such impacts on mortality, as per the Value of Statistical Life in transport appraisal, better grades for disadvantaged school pupils, faster response times by the fire service, waste collection and the reduced presence of refuse on the streets, etc. In these situations the public sector productivity improvement is welfare enhancing but this welfare

improvement is not fully captured in changes in GDP[3]., and may in particular circumstances not lead to any change in GDP. For example we could reduce mortality in hospitals through further agglomeration but the number of health workers and the other healthcare cost inputs remain unchanged. Thus unlike the private sector where we could interpret the change in agglomeration as both a welfare and GDP impact, a change in the productivity of the public sector should likely only be interpreted as a change in welfare. If we take it that the welfare for the public sector exceeds its GDP, then a lower bound on this change in welfare could be obtained by applying the productivity elasticity to the GDP/worker in the public sector industries.

2.2 Health

Conceptually we would expect that that agglomeration economies would be relevant in a knowledge intensive sector and in particular sectors where specialised intermediate inputs are required. The healthcare sector is one such industry. The empirical evidence supports this hypothesis (Bates and Santerre, 2005, Cohen and Paul, 2008, Baicker and Chandra, 2010, Gravelle et al., 2014, Li, 2014, Friedson and Li, 2015). This empirical evidence is reviewed in our earlier work for DfT, which is reproduced in Annex A. There is also evidence of the clustering of healthcare services within a city, which can be taken as indirect evidence of agglomeration forces. For example, Matti and Ruseski (2021) find that all healthcare service categories exhibit some form of clustering. This is clustering to each other, that is localisation, rather than to economic mass in general (urbanisation). Relative to the consumer services industry, which is itself subject to agglomeration economies, they find 13 health care subindustries are more clustered, 10 are similarly clustered, and 6 others more dispersed. In general, they find that the more specialist the subindustry is the more likely it is to cluster. For example cosmetic dentists are more tightly clustered than consumer services, whilst general dentistry is not. They also find that certain sectors within the healthcare sector will co-locate and others do not. Specialists co-locate with hospitals, whilst family and dentistry practices locate away from hospitals.

Regarding the actual mechanisms that give rise to agglomeration economies in the health sector, Bates and Santerre (2005) attribute agglomeration economies to localisation arising from "efficiency of labour market pooling, incentives to innovate, and from shared input suppliers and knowledge as more hospitals cluster in an area". They do not look for evidence of the mechanisms at play *per se*, but they cite Escarce (1996) and Phelps (1992) as evidence of the importance of close proximity for the diffusion of medical advances and medical techniques. Cohen and Paul (2008) also find evidence of agglomeration economies impacting on hospital services, which they attribute to knowledge spillovers and labour market pooling in the hospital sector, though they do not specifically test for these mechanisms. They make this attribution because their measure of agglomeration uses total labour force in the hospital sector.

Looking at the sharing mechanism specifically, Li (2013) finds evidence that suggests that agglomeration economies exist in the hospital service industry and are generated in part through the sharing of intermediate inputs. She examines the outsourcing behaviour of hospitals to clinical laboratories, blood bank and CAT scan services, and finds it is most intensive in denser locations. She

[3] There could however be indirect links to GDP from quality improvements. An improvement in QALYs may lead to less 'sick' days in workplaces, reduced mortality would lead to more production and consumption, improved fire service response times may lead to reduced re-building costs and reduced mortality, higher educational outcomes for primary school pupils would over time be expected to lead to higher worker productivity and wages (in the long term), etc.

interprets this as evidence of greater use of intermediaries in denser locations, occurring as a result of hospitals in denser locations taking advantage of agglomeration economies. Friedson and Li (2015) specifically focus on the sharing mechanism that may underpin agglomeration economies in the hospital sector. They find evidence that agglomeration of the hospital service industry attracts specialized medical labs, which in turn helps to reduce the cost of producing laboratory tests. Both of these papers use a localisation agglomeration measure (i.e. one that relates to employment within an industry), not an urbanisation measure (i.e. one that relates to total employment across industries).

Turning to evidence on learning mechanisms. Baicker and Chandra (2010) find that hospital quality is related to the quality of neighbouring hospitals, and this arises as they learn from their neighbours. They examined the diffusion of use of high- value, low- cost health care interventions and high- cost, low- value health care interventions between hospitals. They attribute the diffusion of quality between hospitals to learning, as they focused on the diffusion of interventions. Gravelle et al. (2014) also find that the quality of hospitals is dependent on proximity to other hospitals. In their case they attribute it to a model of hospital competition, where hospitals respond to rivals' quality. They find that of sixteen quality indicators seven are positively associated with proximity to other hospitals.[4] None are negatively associated with proximity. For those where a positive relationship is found they find that an increase in rivals' quality by 10% increases a hospital's quality by 1.7%–2.9%. They also hypothesise that competition is important driver as some of the quality indicators that hospitals respond to are related to patient perceptions and not clinical quality outcomes (e.g. cleanliness and patient's involvement). Of course competition is itself important for the diffusion of knowledge. It is the competitive process that motivates firms to innovate, copy and learn. This is also evident in the healthcare sector, as Bokhari (2009) identifies competition as a motivator to the adoption of cardiac catheterisation laboratories in the US. Both Baicker and Chandra (2010) and Gravelle et al. (2014) are using localisation measures of agglomeration.

Matching mechanisms imply that higher productivity matches occur in larger agglomerations. The healthcare evidence suggests that the quality of the match is important to health care outcomes, certainly in the context of cardiovascular and heart disease (Huesch, 2011, Clark and Huckman, 2012, Lee et al., 2015). Another way to look at match quality is to look at specialization. In this vein, Baumgardner (1988) shows that physicians perform a narrower range of activities in large markets. We would therefore expect that some of the agglomeration economies the healthcare sector experiences derives from matching mechanisms.

The strength of agglomeration benefits will of course be dependent, at least to some extent on market structure. The majority of the evidence available on agglomeration impacts in the healthcare sector is related to the US where the private sector plays a large role. In contrast, the UK with its nationalised health service, has quite a different healthcare structure. The question then arises as to how much freedom individual hospitals, medical laboratories, GP practices, etc. in the UK have. Do they operate as a single vertically and horizontally integrated health sector with a 'single mind'; or as a pseudo private sector operation with each individual unit behaving independently; or somewhere in-between? Ideally, we need UK specific evidence, of which there is a dearth. Of the studies identified only Gravelle et al. (2014) relates to the UK. However, that study is very relevant to this question, as they not only identify a theoretical model of competition, which relates to a public sector national health service, but also find evidence of improvements in quality resulting from increased proximity. A transport project that therefore increases the ability of healthcare

[4] The seven measures are: overall mortality, stroke mortality, knee replacement re-admission, stroke re-admission, clean hospital room/ward, patient involved in decisions and trust in doctors.

professionals to interact and share knowledge, that deepens the labour market in what is sector with many specialities, and provides better integration with the medical equipment and diagnostics supply chain could quite reasonably be expected to improve healthcare quality outcomes in the UK via increasing the effective level of agglomeration (i.e. ATEM).

2.3 Education

The education sector, as a teaching service provider, is one that is geared around learning. It clearly requires access to a knowledgeable and skilled workforce and would also be expected to benefit from sharing of fixed infrastructure such as transport links and high speed internet connectivity. It differs from the health sector in that it likely has a smaller supply chain – there is no equivalent to the medical laboratories in education – and it may benefit less from sharing gains in variety than the health sector does. Conceptually we may therefore expect that learning mechanisms, matching mechanisms and some of the sharing mechanisms may improve productivity of the education sector in agglomerations. As with health we may expect that some of these productivity improvements will manifest themselves as unit cost reductions, but others will appear as quality improvements (e.g. improved pupil performance).

Looking at sharing mechanisms initially. Chakraborty et al. (2000) find evidence of cost reduction in education services with increasing number of pupils at a school level (an internal economy of scale) and at a district level. They interpret the latter as a consequence of schools sharing regional facilities. These could potentially be physical facilities such as swimming pools, or services such as some administrative functions. Odell (2017) finds that attainment by disadvantaged pupils in geographically isolated schools is poorer than in urban settings. This is a localisation effect as he uses proximity to other schools as his 'isolation' measure. He attributes this to several factors including poorer physical infrastructure for transportation and internet connectivity. Such infrastructure would be shared with industries as well as with households.

Odell (2017) also attributes labour market size as a factor that leads to differences in performance between rural and urban schools. There is an evidence base he cites that highlights difficulties recruiting teachers in rural settings, particularly highly qualified teachers. Béteille and Loeb (2012) give an extensive review of the literature on teacher quality and teacher labour markets. There is an extensive literature on how teachers sort into schools based on wage related factors, and non-wage factors. Some of the non-wage factors naturally align to better teaching performance, such as avoiding teaching subjects they do not know, or being split between two subjects. Thus in larger labour markets one might expect teachers to be able to self-select into schools which better suit them. Additionally teachers account for the quality of work colleagues in their selection. This of course is related to peer to peer learning, with the movement of teachers between schools impacting on the spread of new ideas and methods between schools. It is these non-wage differences between schools that also become very important in teacher selectivity when there is little difference in wages between schools (as there is in the British schooling system). There is also a growing body of evidence to suggest that effective teachers, effective in the sense of giving more added value to pupils attainment, are just as likely to stay in an urban school as they are to leave. Overall, this evidence base leads Gibbons and Silva (2008) to consider that city schools are in a favourable position to exploit urban labour markets to hire and retain high-quality teachers and hypothesise that pupil outcomes will be higher in denser locations ceteris paribus. Using a localisation agglomeration (number of schools within 2km), they find that there are small but significant benefits from education in schools in more densely urbanised settings. They attribute it to greater school choice and competition between closely co-located educational providers.

Parental choice between schools combined with the manner that in Britain funding follows pupils leads firstly to competition between schools, but secondly allows pupils to select schools which best suit them in terms of preferences and capabilities. Both of these might be expected to lead to circumstances where higher levels of school choice, as in larger urban areas, would lead to better pupil attainment. Again there is a substantial empirical literature testing this assumption, however, it yields mixed findings. Taking a systematic review and also employing meta-analysis techniques Jabbar et al. (2022) look at this evidence base and find small positive effects of competition on student achievement. They also found evidence that the type of school-choice policy and student demographics moderated the effects of competition on student achievement. It is the confounding of higher school choice in urban areas combined with poorer student demographics in said areas that can lead to the wrong association being drawn between school choice and educational attainment.

A final channel by which increased agglomeration impacts on pupil performance is that the returns to education are higher in more dense settings, which incentivises pupils to obtain higher qualifications. On one hand the costs of accessing education, particularly higher education are lower in urban settings due to lower transport costs and this affects participation rates in tertiary education. Whilst on the other hand the benefits are larger. This is because agglomerations benefit the more highly educated than the less educated, thus the expected wage differential between a low skilled, medium skilled and high skilled worker is higher in larger agglomerations than in smaller ones. At the margin this affects pupil choice when considering whether to proceed to the next level in education and also potentially the number of exams to take. van Maarseveen (2021) finds evidence for this channel in the Netherlands. He finds that children growing up in urban regions consistently attain higher levels of human capital compared with children in rural regions, after controlling for individual and family characteristics. He finds an elasticity of university attendance with respect to population density of 0.07. This implies that the probability of a child growing up in the centre of Amsterdam attending university would be 3 percentage points higher than if they grew up in a place at the 25th percentile of the density distribution. van Maarseveen uses an urbanisation measure of density.

2.4 Public administration

The public administration part of the public sector is very broad.[5] The civil service comprises some 489,000 full-time equivalent workers[6] (so just under 50% of the total public administration which has just over 1 million workers in it – see Table 1-1) . Local Government and some public sector corporations comprise the rest. However, not all employees of local government fall under the category of public administration as some are categorised as 'other public sector'. The functions it fulfils are therefore quite wide ranging.

We have not identified any studies that have looked at the productivity benefits of the civil service from agglomeration. We can however extend some conceptual arguments that might support that they exist. Looking for example at the Department for Transport which has 15,000 full-time equivalent employees we can see that the Driver and Vehicle Licensing Agency comprises some 5,400 of them. It is responsible for creating and maintaining vehicle records and issuing vehicle registration certificates, collecting vehicle excise duty, providing refunds, and recording keeper, accident, scrapped and theft details. Effectively it is like a public sector version of a private sector administrative call centre. We would expect it to benefit from agglomeration economies in much the same way as would a private sector service orientated business. Specifically we would envisage it benefiting from matching mechanisms, sharing a large labour pool. We could also imagine learning mechanisms would also be relevant with staff moving from private sector consumer servicing call centre type businesses diffusing new knowledge and practices. Similar arguments can be extended to other parts of the Department for Transport which wholly owns agencies like National Highways, HS2, East West Rail. Such agencies would have close links to similar construction and asset management private sector companies, drawing from the same skilled labour pool and diffusing knowledge between themselves, as staff meet at conferences and switch between employers. Even the economists within the Department for Transport benefit could be thought of as benefitting from agglomeration with knowledge spillovers between them and the private sector, as well as between

[5] The ONS (2005) public sector methodology states:

Public administration: "A breakdown of Public administration, defence and compulsory social security (Standard Industrial Classification Division 75) has been provided for the police, HM Forces and public administration. The public administration series spreads across the activities of central government, local government and public corporations. It covers activities like central and local government administration, social security administration, justice and judicial activities, fire services, foreign affairs, supporting services for the government like archives maintenance."

Other public sector: "Other public sector potentially covers all divisions of SIC 2003 not mentioned above. It is roughly half local government and half public sector bodies. The local government element covers a wide range of activities including leisure centres, catering, industrial cleaning, accountancy, call centres, and architecture and engineering. Examples of public sector bodies would be organisations like Royal Mail, British Nuclear Fuels, transport bodies, housing associations, tourist bodies, etc."

Source:
https://www.ons.gov.uk/file?uri=/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/labourmarketarticlesandreports/psemethodologtcm77214979.pdf

[6] Source: Office for National Statistics (Dec 2023), Quarterly Public Sector Employment Survey
https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/publicsectorpersonnel/bulletins/publicsectoremployment/september2023

economists in different branches of government. Co-locating with the other government agencies would also facilitate easier co-ordination of policies and help address problems that require a multi-agency approach.[7] We can also imagine that the Department for Transport benefits from sharing facilities with other government departments and the private sector These could include conference centres, training facilities and services, and administrative support services. Similar arguments can be extended to other civil service departments.

Turning to local government there is a body of research that identifies that unit costs of local government administration is a function of density. This stems back many decades with an early literature review being published in 1974 (Real Estate Research Corporation, 1974), and has even been embodied into some national transport appraisal guidance (e.g. Australian Transport Assessment and Planning Guidelines[8]). This relationship with density is seen to stem from two sources and can be illustrated with an with an example:

> Consider, for instance, two municipalities with the same characteristics (in terms of both size and population), but different densities. In the less dense of the two, there will be a need for more garbage trucks or, alternatively, the trucks available will have to cover longer routes in order to provide the same quality of refuse collection to all its residents. Refuse collection costs, as well as road cleaning or police protection costs, vary directly with distance. Therefore, the provision of such services is more expensive in less dense municipalities. Spatially expansive development patterns also lead to greater costs because of the larger investments required in extending basic infrastructure (roadways, sewerage, electricity) over greater distances to reach relatively fewer numbers of residents.
>
> Hortas-Rico and Solé-Ollé (2010)

The first of these, how costs vary with distances, is a simple cost difference. The second, the extension of basic infrastructure, is a source of agglomeration externality. Basic infrastructure is shared, and the benefits of sharing are greater in denser locations. In the main the literature on costs of sprawl (or lack of density), focuses on aggregate cost reductions without distinguishing between the sources (e.g. Ladd (1994), Carruthers and Ulfarsson (2003), Hortas-Rico and Solé-Ollé (2010)). However, Prieto et al. (2015) focus specifically on infrastructure provision. They find evidence of economies to density in the provision of the three sets of infrastructure they examine: water supply; sewerage and cleansing of residual waters; and paving and lighting. In addition to this sharing source we would also extend the conceptual arguments utilised in discussion of the civil service to local government. Local government officials co-located in proximity for example to the civil service (e.g. as in London, Edinburgh and Cardiff) would be expected to benefit from sharing of facilities (e.g. conference facilities), and would also be expected to benefit from knowledge spillover benefits that 'more remote' local authorities would not.

The evidence supporting the presence of agglomeration impacts in public administration is much thinner than that supporting impacts in health and education. We attribute two primary reasons to

[7] Whether different branches of government are seen as external to each other is akin to whether different units within the health and education services are seen as external to each other.

[8] See the difference between existing and greenfield infrastructure costs in Chapter 7 Public Infrastructure Costs in ATAP unit *O8 Land-Use Benefits of Transport Initiatives.*
https://www.atap.gov.au/sites/default/files/documents/atap-o8-land-use-benefits.pdf

this. The first is that the public administration sector is very broad and therefore more difficult to study. It has to be segmented into the different sectors (as per the studies identified above). Secondly, the policy interest in this area has been driven by the costs of sprawl and the regulation of land use on urban fringes. It has been less about the efficiency of government administration. Studies therefore where they have been undertaken have been less interested in the individual mechanisms and more interested in the overall cost reductions associated with density. Nonetheless there are good conceptual arguments that support the manner that public administrative activities would benefit from agglomeration, and where a study has examined a particular source it has found evidence supporting the hypothesis.

3 ESTIMATING PUBLIC SECTOR AGGLOMERATION ECONOMIES AND EMPIRICAL STRATEGIES

The review of the evidence in the previous section discussed the existence of public sector agglomeration benefits from a theoretical point of view, and looked for supporting evidence of these agglomeration mechanisms existing in particular public sector industries. This section focuses further on the empirical evidence by discussing: the quality of the available evidence, and the most promising empirical strategies to uncover a robust evidence base for the benefits of agglomeration in the public sector.

3.1 Best practice in estimating agglomeration economies in the public sector

We need some criterions when reviewing the identified papers that examine the agglomeration benefits in the public sector. These criteria are needed because there are many empirical challenges to overcome to estimate agglomeration economies. These are discussed at a general level within agglomeration economies in Combes and Gobillon (2015a) and in the context of agglomeration benefits of transport improvement in Graham and Gibbons (2019).

Based on our reading of the literature, three requirements need to be satisfied to establish an empirical connection between agglomeration and productivity:

1. Whether a measurement of the level of productivity exists
2. Whether a measurement of the level of agglomeration exists
3. Whether a credible method to estimate the elasticity is available

The first requirement is related to productivity. In the private sector, productivity is usually measured at the firm level or by looking at workers' wages. In the public sector, this is more challenging. Next, an indicator of agglomeration at a suitable spatial level is needed. The last requirement is that a credible estimation method exists that can produce a robust estimate of the agglomeration elasticity. For this to be possible, the first two conditions need to be satisfied, but there is also a need for some credible (exogenous) variation of the agglomeration measure to uncover the effect. In addition, there is a need for data (variable) to address confounding factors that will lead to omitted variable bias.

It is beyond the scope of this report to assess every aspect of the available evidence. However, we executed a performance-based evaluation of the evidence to assess whether previous analysis provides robust evidence for use in future studies that estimate agglomeration economies in the public sector.

Inspired by the discussion in Combes and Gobillon (2015a), Graham and Gibbons (2019) and Overman (2014) we select three criteria for our assessment:

1. Aggregation level
2. Adequate controls
3. Exogenous variation of agglomeration

Aggregation level means that the study observes the unit at the relevant production level. The levels could be schools, hospitals, police stations or similar, as a minimum. It is even better if the study includes data at an even finer level, such as students or patients. Adequate controls mean that the

study can address the most important confounding factors. The last criterion is variation in the level of agglomeration. This entails the dataset including some variation in the level of agglomeration that can be used as a credible source of estimation.

As seen from Table 3-1, only three of the 21 studies use an empirical approach that can be recommended for future studies. The promising studies are from the areas of education and health. It is also important to note that output variable, to which the productivity relates, is often a quality variable, such as pupil attainment or reduced mortality. This type of productivity analysis therefore differs markedly from that used to analyse the private sector where financial information would be used.

Note that this assessment is subjective to some degree, but the view is based on what is typically regarded as state-of-the-art practice within the field of regional and urban economics at present, not when the study was undertaken. We would expect in the main that most would meet the standards of the time, as they are published in peer reviewed journals. Empirical practice has, however, changed substantially in the last decade. This aligns with the increased availability of detailed data and new sophisticated estimation techniques. As an example as to how practice has changed, for example, the study used to parameterize the agglomeration elasticities in the current DfT guidelines from Graham et al. (2010) would not be regarded as robust evidence using these criteria. This is mainly because there is no change in the transport infrastructure in the data used.

3.2 Review of the data from ONS that includes the productivity of the public sector

As mentioned in the above section, an estimate of the effects of agglomeration requires available productivity data in the public sector. Recently productivity in the public sector has started to be measured and published by the ONS. This is a potential data source that is readily available to be used to estimate public sector agglomeration benefits in different areas. We have therefore gone through the documentation provided in ONS (2022) to offer an opinion as to whether this can be used unadjusted or would require some additional analysis to be utilized in an estimation.

In the ONS data, productivity is measured as how many units of output (Q) are produced by one unit of input (I). Including a subscript t to denote time productivity (P) can be presented as

$$P_t = O_t / I_t$$

Whether the productivity data can be used to examine the agglomeration economies in the public sector depends on the methods used to calculate the input and output observations and whether these are available at a suitable spatial level. According to ONS, collecting data for the services produced in many areas is challenging. In the private sector, the produced units are usually countable products; in the most straightforward cases, the goods could be measured in tons. Obviously, such counting is more difficult when measuring a governmental service such as defence or police protection.

TABLE 3-1 EMPIRICAL EVIDENCE OF AGGLOMERATION ECONOMIES IN THE PUBLIC SECTOR

Study	Sector	Outcome	Independent variable	Unit	Estimation	Aggregation level	Adequate controls	Exogenous change
Chakraborty et al. (2000)	Education	Cost	Students in district	Expenditure per student in school districts	Panel data estimation	School districts (40 obs. over three years)	No (individual characteristics cannot be addressed)	None
Kirjavainen and Loikkanen (1998)		Quality	Categorical (urban, rural, dens)	Performance indicator of Finnish senior secondary schools	2nd stage DEA regression	291 schools	Yes, but only in the 2nd stage regression	None
Gibbons and Silva (2008)			Urban density	Pupil test score in UK	Panel fixed effects regression	1,202,970 pupils aged 11 to 16 in non-selective Secondary Schools	Yes	E.g. number of schools within 2 km
van Maarseveen (2021)		Human capital	Urbanization at age 11 years	Children	Panel data fixed effects estimation	631.731 children	Yes	Yes
Holmgren and Weinholt (2016)	Fire and rescue services	Cost	Population	Expenditure per firefighter in Swedish municipalities	Stochastic Frontier Analysis (SFA)	205 municipalities from 2009 to 2012	Yes, but only in the 2nd stage regression	None, only cross-sectional comparison
Duncombe and Yinger (1993)		Cost and Quality	Labour share	Translog production function of US fire departments	2 Stage Least Squares Estimation	NA	NA	NA
Friedson and Li (2015)	Health	Cost	Population density	Price of intermediate medical services in US hospitals	2SLS with panel data	6334 laboratory tests at three-digit zip codes	Yes	Yes – changes in lab employment
Bates and Santerre (2005)		Quality	Hospitals per capita	Inpatient days per bed in US metropolitan area	Cross-sectional regression on differenced data	Metropolitan area	Yes	No
Cohen and Paul (2008)			Proximity to other hospitals	Inpatients and outpatients US hospitals	Flexible cost function	Hospitals between 1997 and 2002	Yes	No
Gravelle et al. (2014)		Quality	Other hospitals within 30 min	English hospitals 2009-2010	Cross-sectional spatial regression	99 hospitals	Yes	No
Baicker and Chandra (2010)		Quality and spending	In one of the 100 largest cities	US hospital regions	Cross-sectional regression	262 hospital referral regions (HRR)	Yes	No

Study	Sector	Outcome	Independent variable	Unit	Estimation	Aggregation level	Adequate controls	Exogenous change
Byrnes and Dollery (2002)	Local public services	Cost	NA	NA	Literature review	NA	NA	NA
Carruthers and Ulfarsson (2003)			Population density	Expenditures per capita in US metropolitan areas	Panel fixed effects regression	283 counties in the years 1982, 1987 and 1992	Yes	No
Bönisch et al. (2011)			Population density	Expenditure of German municipalities	2nd stage DEA regression	203 German municipalities	Yes, but only in the 2nd stage regression	No
Büttner et al. (2004)			Population density	Expenditures per capita in German states	Cross-sectional regression	13 German states with different categories (year 1997)	No	No
Hortas-Rico and Solé-Ollé (2010)			Urbanized land per capita	Expenditures per capita in Spanish municipalities	Cross-sectional regression (piece-wise linear function)	2500 Spanish municipalities in 2003	Yes	No
Soukopová et al. (2014)			Population size	Expenditure per capita in Czech Rep. municipalities	Cross-sectional regression	205 municipalities between 2008 and 2012	No controls	No
Ladd (1994)			Change in population	Change in expenditure per capita in large US counties	Cross-sectional regression	248 US counties	Yes	No
Matějová et al. (2017)			Population size	Expenditure per capita in Czech municipalities	Cross-sectional regression	672 municipalities	Partly	No
Prieto et al. (2015)			Population size and number of dwellings	Expenditures per capita in Spain municipalities of basic infrastructure	Translog production function equation and SURE estimation	Spanish municipalities (between 1793 and 1139)	No	No
Hauner (2008)		Quality	Population density	Three measures of public sector performance in Russian regions	Cross-sectional regression (univariate regression on four different sectors)	89 Russian regions	Yes	No

Notes: NA – required information not found from the paper. DEA – Data Envelopment analysis, SFA – Stochastic Frontier Analysis.

Although challenging, some governmental services are countable to some degree in volume terms; for example, they represent the number of students at school each year to some degree, the output in that sector. It is possible to create a productivity level using information about the total costs in this sector. Since many different services are produced in each area, they have different services must be combined via some weighting strategy. The most common weight is a cost-weighted activity index. This is an example of a direct technique used to measure productivity.

If possible these measurements should be adjusted to reflect quality. The quality adjustment is supposed to provide a more accurate link between output the desired outcome. One example of a quality adjustment is the use of test scores in schools to adjust the quality of the outcome in the education sector.

In the cases where it is too difficult to calculate the units of outputs (O) it is assumed that input equals out when constructing the numbers. Regarding the above equation, productivity is always identical to unity in these areas, and the data cannot be used for any productivity analysis.

The level of aggregation is another crucial element in using these data to examine how agglomeration affects productivity. The essential requirement here, as stated above, is that the measurement of productivity must be available at a spatial scale such that there could be a meaningful change in agglomeration over time or space to be used to estimate the relationship of interest.

Looking at Table 3-2 we can see that healthcare, education, social care, social security administration, public order, and safety all involve some degree of volume measurement. Police, defence, and other public services are all mainly "collective" services and are more difficult to measure directly. For these areas, "output-equals-input" conventions apply, where output volume is assumed to equal the inputs used to create them. Hence, productivity is not measured. Around 41 per cent of the output is measured using "output-equals-inputs" conventions, as it includes the public administration 'industry' discussed in Chapter 2. Hence, productivity could only be observed from the remaining 61 per cent of the sector.

TABLE 3-2 ONS PUBLIC SERVICE PRODUCTIVITY ESTIMATES – MEASUREMENT, QUALITY ADJUSTMENT AND AGGREGATION LEVEL

Areas	Main measurement technique	Quality adjustment	Aggregation level
Healthcare	Direct	Yes	UK (country)
Education	Direct	Yes	UK (country)
Adult social care	Direct	Yes	UK (country)
Children's social care	Direct	Yes	UK (country)
Social security administration	Direct	No	UK (country)
Public order and safety	Direct	Yes	UK (country)
Police	Output-equals-inputs	No	UK (country)
Defence	Output-equals-inputs	No	UK (country)
Other government services*	Output-equals-inputs	No	UK (country)

*Includes general government services, economic affairs, environmental protection, housing, recreation, and other public order and safety.

Where data are available and relevant, output measures are quality-adjusted. Quality adjustments are currently applied to five service areas: healthcare, education, children's social care, adult social care, and public order and safety. An example of such adjustment is to include test scores in schools to adjust the quality of the outcome in the education sector. An example from public order and safety is to include physical and emotional well-being within prisons for staff and inmates; the escape rate; or the activities the inmates can partake in (ONS, 2019).

Inputs comprise volume estimates of labour, goods and services (intermediate inputs), and capital assets used in delivering public services. These series are aggregated together to estimate the volume of inputs used to provide each of the public services identified in the total public service productivity articles. For most service areas, inputs are indirectly measured using current expenditure adjusted by a suitable deflator. In some areas, inputs are measured directly, such as the number of full-time equivalent staff.

3.3 Summary

Our review of the evidence shows that a few studies within the areas of health and education provide robust evidence of agglomeration economies in the public sector. These offer an approach that could be used in future studies. A key aspect in these analyses is the use of quality measures as output variables.

In part the ONS public sector productivity data provide quality adjusted outputs. However, in their current form they do not provide data that can be used to estimate the agglomeration benefits of the public sector. The measurement of productivity varies between public sector industry. In healthcare, education, social care, social security administration and public order and safety the data is collected in a way such that the data can be used to interpret productivity changes. In other areas the measurement of productivity is difficult and "output-equals-inputs" convention is applied. Hence, constant productivity is assumed when constructing the data, and the data can never say anything about productivity. Quality adjustment is used for some of the areas, which in theory, should make the data more useful as a measure of productivity. Critically though none of the data are however published at a level that allows for a investigation of agglomeration economies. Given this, the only statistical analysis possible is to examine changes in productivity over time using national data for example with some national measure of agglomeration as the independent variable. We do not believe such an analysis will give robust estimates of the relationship between public sector productivity and agglomeration. To move forward there would be a need to either disaggregate the ONS data spatially, to the unit of production ideally, or alternatively use the same or similar data sources to collate spatially disaggregate data. Whilst not useable in its current form, what the ONS data does demonstrate is that it is possible to generate some output estimates that can be used to estimate agglomeration impacts on the public sector.

4 CONCLUSIONS

The public sector in the UK comprises 5.9 million employees with 78% of them in three industries: the National Health Service (35%), education (23%) and public administration (20%).

Empirically it is challenging to identify agglomeration effects in the public sector. Conceptually however we expect them to occur, although some channels may be muted by a lack of a competitive market structure. These would include the main sharing and matching mechanisms. A lack of competition may be expected to mute some of the learning mechanisms. However, against this we see evidence that supports at least one channel of learning, that of knowledge diffusion through movement of workers between organisations, remaining open. This is because at an aggregate level there is similar levels of movement of workers to/from the public sector and within it as there is within and to/from the rest of the economy.

Whilst it is true that the public sector does not compete in terms of price, reforms within the health and education sector have encouraged competition in quality. There is also empirical evidence that health and education outcomes are of higher quality in denser areas. These sectors comprise the majority of the public sector. We consider that there are conceptual arguments that the public administration would also be subject to agglomeration economies. There is also evidence that the cost of public administration increases with sprawl (i.e. decreases with density) – implying some economy to density. However, the empirical evidence in this aspect of the literature does not disentangle the pure cost reductions of density (e.g. reduced travel times) and the external benefits of density.

As we set out in our 2023 report, there is a dearth of evidence on the size of the agglomeration elasticity in the public sector. Indirect evidence on it, alongside the conceptual arguments and empirical support for mechanisms underpinning agglomeration in the public sector outlined here, suggest that an elasticity close to the economy wide average can be justified. There is however a need for additional analysis utilizing state of the art approaches within the UK context to quantify how agglomeration impacts vary between different parts of the public sector and between the private and public sector. Undoubtedly there will be variations, with some parts benefitting significantly from agglomeration economies and others to a lesser degree – just as there is in the private sector.

Some of the empirical work in this field utilises quality related outputs, and the ongoing work by the ONS on public sector productivity utilises quality adjusted GDP outputs to measure changes in public sector of productivity. The incorporation of quality is likely to be the best way forward to empirically measure the impact of agglomeration on the public sector. It differs markedly from the approach that would be used to measure productivity changes in the private sector. The ONS data on public sector productivity, however, is not sufficiently spatially disaggregate to be able to utilise in a study. Any study into a public sector agglomeration elasticity would need to either disaggregate the ONS data or collate the underlying quality data that the ONS uses to a more spatially disaggregate level – ideally to the unit of production.

An agglomeration elasticity based on quality measures would be interpreted as one in which quality (i.e. welfare) increases by a certain percentage as result of a corresponding change in access to economic mass. This is not necessarily the same as a change in GDP. In fact, one could contrive a situation in which welfare improves as a result of an increase in public sector productivity, but GDP remains unchanged. For example we could reduce mortality in hospitals through further agglomeration but the number of operations, treatments, health workers and the other cost inputs remain unchanged. Thus unlike the private sector where we could interpret the change in

agglomeration as both a welfare and GDP impact, a change in the productivity of the public sector should likely only be interpreted as a change in welfare.

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ANNEX – EVIDENCE ON A PUBLIC SECTOR ELASTICITY (LAIRD AND TVETER, 2023 CHAPTER 4)

A.1 Agglomeration economies in the public sector

Productivity benefits in the public sector are not included in the current TAG guidelines. The main reason for this is that the set of parameters is taken from the study of Graham et al. (2010), which are based on firm data and therefore exclude the public sector. However, the micro-mechanisms usually used as the explanation of agglomeration economies of transport improvements are conceptually just as valid for the public sector. The problem is that public sector production usually is not market based, i.e., has no observable prices, making the standard approach of examining agglomeration benefits unapplicable.

Our examination of the agglomeration economies of the public sector is informed by indirect evidence only. One reason for the lack of direct evidence is that wages to a lesser degree reflect the marginal labour productivity. The reason could be political interfering, a missing market for the output, or both. Another reason is that different productivity indicators at the firm level to a lesser degree reflect productivity differences. The standard approach in the literature of estimating the relationship between productivity and concepts of agglomeration, such as ATEM, is therefore to a lesser degree applicable. Still, we believe that the literature that examines how the cost of providing public services at the local level, and a closer look at a selection of estimated agglomeration elasticities will provide a second-best approach to understand how agglomeration affects the public sector.

In this chapter, we examine the literature that sheds some light on possible agglomeration benefits in the public sector. First, we review the empirical literature that examines agglomeration economies in the public sector. Second, we take a fresh look at recent estimates of agglomeration economies that include or exclude the public sector , and try to back out the likely size of the public sector agglomeration elasticity.

A.2 Empirical evidence of agglomeration economies in the public sector

Table 0-1 displays an overview of the papers we have found when searching the literature. We have only included papers that, in our opinion, say something about scale or agglomeration economies in the public sector. The table distinguishes between outcome (cost or quality), sector (fire and rescue, education, hospitals, or total local services), independent variable (mainly size or density), estimation technique, and finding.

A conceptual challenge when interpreting these findings is whether the possible benefits of agglomeration result in cost savings or better services (quality). Both possibilities are possible. One may examine this issue by examining the properties of the production function in the public sector. Another possibility is to look at the managerial incentives in public sector when there is a productivity uplift together with price elasticity of the public good. If the result mainly gives a cost reduction of public services the effects is in principle monetized, while if the benefits are harvested as better quality they are close to the amenities benefits of agglomeration discussed in Glaeser et al. (2001) and discussed earlier in Section 2.8. However, in both cases the benefits are additional to the standard user benefits.

TABLE 0-1 EMPIRICAL EVIDENCE OF AGGLOMERATION ECONOMIES IN THE PUBLIC SECTOR

Study	Sector	Outcome	Independent variable	Unit	Estimation	Agglomeration economies?
Chakraborty et al. (2000)	Education	Cost	Students in district	Expenditure per student in school districts	Panel data	Yes
Kirjavainen and Loikkanen (1998)		Quality	Categorical (urban, rural, dens)	Performance indicator of Finnish senior secondary schools	2nd stage DEA regression	None
Gibbons and Silva (2008)			Urban density	Pupil test score in UK	Panel fixed effects regression	Yes
Holmgren and Weinholt (2016)	Fire and rescue services	Cost	Population	Expenditure per firefighter in Swedish municipalities	SFA (descriptive)	Yes
Duncombe and Yinger (1993)		Cost and Quality	Labour share	Translog production function of US fire departments	2SLS	IRC to quality/ CRS to population
Friedson and Li (2015)	Hospitals	Cost	Population density	Price of intermediate medical services in US hospitals	2SLS with panel data	Yes
Bates and Santerre (2005)		Quality	Hospitals per capita	Inpatient days per bed in US metropolitan area	Cross-sectional regression on differenced data	Yes
Cohen and Paul (2008)			Proximity to other hospitals	Inpatients and outpatients US hospitals	Flexible cost function	Yes
Byrnes and Dollery (2002)	Local public services	Cost	NA	NA	Literature review	Mixed evidence
Carruthers and Ulfarsson (2003)			Population density	Expenditures per capita in US metropolitan areas	Cross-sectional regression	Yes (most services)
Bönisch et al. (2011)			Population density	Expenditure of German municipalities	2nd stage DEA regression	Yes
Büttner et al. (2004)			Population density	Expenditures per capita in German states	Cross-sectional regression	No
Hortas-Rico and Solé-Ollé (2010)			Urbanized land per capita	Expenditures per capita in Spanish municipalities	Cross-sectional regression	Yes (most services)
Soukopová et al. (2014)			Population size	Expenditure per capita in Czech Rep. municipalities	Cross-sectional regression	No (only education)
Ladd (1994)			Change in population	Change in expenditure per capita in large US counties	Cross-sectional regression	Yes
Matějová et al. (2017)			Population size	Expenditure per capita in Czech municipalities	Cross-sectional regression	Mixed
Prieto et al. (2015)			Population size and number of dwellings	Expenditures per capita in Spain municipalities of basic infrastructure*	Translog production function equation and SURE estimation	Yes
Hauner (2008)		Quality	Population density	Three measures of public sector performance in Russian regions	2nd stage Cross-sectional regression	Only for health services

DEA – Data Envelopment analysis, SFA – Stochastic Frontier Analysis

* Water supply, sewerage and cleansing of residual waters, and paving and lighting.

The table includes 18 different studies. 12 consider cost output, 5 quality, and 1 both. Regarding sectors, 10 studies consider all or several local public services, three focus on education, three on hospitals, and two on fire and rescue services. Most studies use rather aggregated data at the municipality level or similar. However, a few studies use more detailed data, such as hospitals, schools, fire departments, or pupils. 9 of the studies use accessibility type measures in their estimation strategy, which in our opinion best captures the concept of agglomeration. We also regard the estimation strategies using panel data estimation, two stage least square (2SLS), or both as preferable. Below we review these studies grouped by sector.

Education

Three studies consider agglomeration economies in the education sector (Kirjavainen and Loikkanen, 1998, Gibbons and Silva, 2008, Chakraborty et al., 2000). Kirjavainen and Loikkanen (1998) examines efficiency of Finnish senior secondary schools using date envelopment analysis (DEA). The study reports a positive association between productivity and school size, although the association is rather weak. However, no statistical effects are found between urban, density, or rural areas. This implies no evidence of agglomeration economies. Chakraborty et al. (2000) investigates scale economies of public education using panel data from Utah school districts and a cost function. This study reports scale economies from district size using fixed effects panel data estimation. Gibbons and Silva (2008) explore the association between urban density and pupil attainment using pupils in England. They find small, but significant benefits from education in schools in densely urbanised settings. We put most weight on the two latter studies because they apply both the preferable indicator of agglomeration economies and a good estimation strategy (panel data estimation is regarded as better than cross-sectional analysis). Although there is only one example of each, this shows evidence of agglomeration economies in the education sector both for costs and quality.

Fire and rescue services

Two studies examine the efficiency of fire and rescue services (FRS) in relation to agglomeration. In an early contribution, Duncombe and Yinger (1993) uses a translog production function to estimate productivity in fire protection. The study reports constant returns to population size. In the second study, Holmgren and Weinholt (2016) study the efficiency of the Swedish fire protection service using DEA. They report that the cost of spending of FRS is clearly lower in a large sized municipality. But at the same time, they show that the largest cities have more workers in FRS and a shorter response time. Although the evidence is mixed and thin, there is some support of scale economies from city size in fire protection and rescue services.

Hospitals

Three studies examine agglomeration economies of hospitals. Bates and Santerre (2005) examine agglomeration economies in the hospital service industry by examining how inpatient days per bed at the US metropolitan level is affected by hospital clustering. They find that inpatient days per bed are lower when the hospital density increases. Interpreting inpatient days per bed as a quality indicator, this result implies that hospital clustering results in a better health service. The authors hypothesise that the mechanism from hospital clustering to better health services runs through a

faster spread of knowledge in denser areas.[9] They also discuss a possible utilization of the sharing mechanisms through capacity utilization. Cohen and Paul (2008) uses more detailed data with hospital-level data and a cost function. Agglomeration is included as the proximity to other hospitals. This study also reports agglomeration economies, which is explained by benefits from knowledge sharing through proximity to other hospitals. Friedson and Li (2015) examine the extent agglomeration in the hospital industry enhances productivity. They focus on a particular mechanism by looking at how concentrated hospital services increase the specialization of intermediate medical labs. They find that this specialization reduces the price of these services. They interpret this effects as benefits working through competition and specialization.

Local public services in general

The largest group of evidence are the studies that examine several or all local services together using aggregated data at the level of municipality, metropolitan area, state, or region. All studies except one consider monetized effects. This strand of the literature is older and was initiated in the late 1950s. The typical approach is to consider per-capita expenditure of different services as the dependent variable. The early literature (from the 1950s until 2001) is reviewed in Byrnes and Dollery (2002) and they find mixed results of scale economies. This result holds both when examining the total cost of providing public sector services and when looking at different types of services, such as water, public libraries, public transportation, and education. Below, we review the more recent literature. We start with the studies using accessibility measures to identify the effect, and next the studies that consider indicators of city size.

The studies that consider density measures report mixed evidences. Carruthers and Ulfarsson (2003) examines how the expenditures per capita in 283 US metropolitan counties vary with density considering 12 different measures of public expenditure. They find that the per capita cost of services declines with density. Bönisch et al. (2011) examine efficiency in German municipalities using DEA. They also run a second stage regression after their efficiency analysis and include population density as an explanatory factor. This factor is estimated to slightly improve efficiency, which implies agglomeration economies. These findings are, however, inconsistent with the results of an earlier analysis of German municipalities (Büttner et al., 2004) which finds no effect on the cost of public goods from differences in population density, when estimating a range of different sectors separately. This study finds, however, the there is a cost-disadvantage for the smallest states.

The five studies that use population size also report mixed evidence. Hortas-Rico and Solé-Ollé (2010) examine the relationship between urban sprawl and the costs of providing local public services. They use data of 2,500 Spanish municipalities and estimate a cross-sectional analysis. They find that low-density areas have a higher provision cost in most spending categories. The exception is housing , basic infrastructure, and transport. Prieto et al. (2015) investigates economies of scale in association to population and housing in urban areas of providing the basic infrastructure water, sewage, cleansing of water, paving and lightning. The find scale economies in the cost of providing basic infrastructure, which is reinforced when the density increases. Ladd (1994) examines how population growth is associated with per capita spending in large US counties. In a cross-sectional regression analysis, higher density is associated with reduced per capita spending, but only in sparsely populated counties. Soukopová et al. (2014) examine returns to scale in the Czech Republic,

[9] The authors control for a range of factors in the analysis. The controls consist of population size, staff per bed, salary, physicians per bed, nurses per bed, health insurance, trainees per bed, per capita income, and average hospital size.

considering the provision of the services: sports and leisure activities; culture, church, and media; environmental protection, housing, municipal services and development; and education. They use a log-linear regression model and trend comparison for 205 municipalities. The study finds little evidence of increasing return to scale in the production of local services. Similar results are found in Matějová et al. (2017). They also find scale economies in collecting local fees, pre-school, and elementary education, but not for local administration using a cross-sectional regression analysis. Also, this study argues that there are inefficiencies for the smallest municipalities.

Only Hauner (2008) examines overall productivity effect of the public sector productivity using quality outcomes. This study considers how public sector performance in Russia varies with population density. Two of the quality indicators are based on indicators such as infant mortality, education, and poverty, while the last is based on efficiency performance from an DEA analysis. The findings suggest that higher population density improves public sector performance in health, but no robust effects are identified on education, social protection, and social sectors.

Summary

Although the evidence is mixed and our review gives no complete picture, some implications can be drawn. First, there seems to be a varying degree of scale economies when providing municipal services. The reason for this could be that only some types of public sector services have scale economies (education, fire and rescue services and hospitals), while other do not. Another reason could be that scale economies are only relevant up a point, that is it is only small municipalities that benefit of becoming larger. Given this interpretation one should not assume that there is a general return to scale in all forms of public sector production. Such an effect appears to be sector specific, but also quite relevant in remote areas with a small population size.

A.3 Private and public sector agglomeration elasticities

Another approach to explore the public sector agglomeration elasticity is to review the literature and try to extract some indirect evidence from it. We follow this approach by focusing on studies that have used state-of-the-art methods in recent years, and where public sector activities are in their sample. Based on this strategy we identified six studies (see Table 0-2). Carlsen et al. (2016) estimates the city wage premium using a panel of Norwegian workers. The primary focus in this paper is to examine how the return to education affects the urban wage premium. In their instrumental variable (IV) estimation they find an initial impact on wages between 0.03 and 0.04 in the short run, and a medium premium between 0.04 to 0.05. This study excludes the public sector sectoral workers arguing that "wages are determined by national regulation, public sector workers" (p. 41). The study could, however, serve as a control study for the other studies that includes workers in the public sector.

The D'Costa and Overman (2014) uses a similar strategy as Carlsen et al. (2016). Including workers from all sectors, they report an effect of city size of 0.023 and cannot find any difference between the initial and medium run effect. This study includes workers in the public sector. When they restrict their sample to only private sector workers the elasticity falls slightly to 0.021. Regarding differences between private and public sector workers this difference is consistent with a *higher* elasticity for public sector workers than the workers in the private sector. The difference is however too small to conclude that there is any significant difference. It does, however, at least indicate that the benefits of agglomeration are not any lower in the public sector than the private sector. It is however possible to argue that wages are set in the private sector and that the local level of wages in the public sector is set in a second stage of the wage bargaining process.

TABLE 0-2 INDIRECT EVIDENCE OF PUBLIC SECTOR ELASTICITY

	Outcome	Model	Accessibility indicator	Including public sector	Country	Elasticity (subsample)
Börjesson et al. (2019)	Wages	Panel data estimation	ATEM with exponential decay	Yes	Sweden	0.028 (movers)
Carlsen et al. (2016)	Wages	Panel data estimation	City size	No	Norway	0.03–0.04 (movers)
D'Costa and Overman (2014)	Wages	Panel data estimation	City size	Yes	UK	0.023 (full sample) 0.021 (only private)
Knudsen et al. (2022)	Wages	Panel data estimation	ATEM with exponential decay	No	Denmark	0.027 (movers)
Roca and Puga (2017)	Wages	Instrumental variable panel data estimation	City size	No	Spain	0.020 (short-term) 0.053 (medium term)
Maré and Graham (2013)	Gross output	Panel data and a translog production function	ATEM with power decay	Yes (but how?)	New Zealand	0.049 (full sample) 0.051 (education and health & community services)*

*Weighted average of elasticities in the sectors education; and health and community services.

Both Knudsen et al. (2022) and Börjesson et al. (2019) estimate the effect on wages using ATEM functions with exponential decay using data at the individual level. The first study uses data from Denmark, and the latter from Sweden. Although the Swedish study includes all workers in their sample and the Danish study excludes public sector workers (and agricultural workers) their estimated elasticity is rather similar at between 0.026 and 0.028.

Roca and Puga (2017) consider the wage premium in Spain and attempt to identify a dynamic impact on the wage premium. They find a short run effect of wages pf 2 pct. and a medium run effect of 5 pct. This study excludes the workers in the public sector using the same arguments as Knudsen et al. (2022) and Carlsen et al. (2016) that these wages are not market based. But the size of the estimates are comparable to D'Costa and Overman (2014) that includes the public sector.

Our final paper Maré and Graham (2013), examines sector heterogeneity using firm data from New Zealand and a standard ATEM formulation of accessibility. We do not understand how they manage to include public sector firms, but from their estimation results we observe that the estimated agglomeration elasticity for sectors that produce similar services to in the public sector (education and health and community services) have elasticities close to the economy weighted average. Hence, also in this study the results indicates that the observable benefit of agglomeration is similar in the public sector and other part of the economy.

Our review of elasticities of the public sector is unfortunately only based on indirect evidence. Based on the limited available indirect evidence we find no evidence to support the assumption that the effect in the public sector is zero, as implicitly assumed in the DfT framework. The available evidence is too thin to make any assertion of a distinct agglomeration elasticity for the public sector. If anything, our review supports the hypothesis that the effect in the public sector is closer to the economy weighted average, than it is to zero. The inclusion of a public sector elasticity in the

productivity agglomeration calculations has an implication for the treatment of some amenity benefits, and there will be a need to avoid potential double counting.