AGGLOMERATION – HOW LONG UNTIL WE SEE THE BENEFITS?

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Abstract:

A consensus exists that firms and workers are more productive in larger cities because of agglomeration benefits. It is then only a small conceptual step from this observation to the conclusion that improvements in transport networks will improve productivity. Across the world the productivity benefits are therefore being incorporated into national appraisal guidelines for transport investments. Enough evidence, now exists to begin to examine in more detail the veracity of this conceptual step. In this paper, we therefore study the speed at which such agglomeration benefits materialize. We examine the research that deals with impacts from transport improvements and assess how long it takes before there are impacts on short-term productivity, traffic and commuting. Based on an admittedly small evidence base, we suggest that productivity benefits take between 10 and 20 years to fully appear in the economy. In a cost-benefit analysis, the significance of the delayed impact also depends on the appraisal period and the discount rate, with largest effects for countries with short appraisal periods and high discount rates.

Keywords: Wider economic benefits; Agglomeration economies; Transport policy; Transport Appraisal

1 Introduction

During the last two decades, there has been an emerging consensus of economic gains from transport improvements that are additional to those reflected in the transport market. This is evident by the growing number of countries that includes such benefits in transport appraisal (Wangsness et al., 2016). The most significant of these benefits are productivity effects from a larger effective city size (agglomeration economies). Up until now most attention has been on estimating the relationship between transport accessibility and productivity. Little attention has been given to the speed at which these productivity impacts appear in the economy.

From a policy perspective the speed of adjustment is important. If the adjustment is slow, such effects are less important to the overall benefits of a transport investment, than if the impacts were instantaneous. Given that productivity gains through increased agglomeration rest on the need to create new relationships there is likely to be some frictions (search and transaction costs). The productivity gains are likely therefore not to appear instantaneously. It probably takes some time before the effective city size changes, and before this effect, in turn, improves productivity. This build up of agglomeration benefits is, however, neglected in all transport appraisal, and we examine under what circumstances this is acceptable.

In this paper, we start Section 2 by reviewing the economic theory relating transport with agglomeration economies. Through different mechanisms, agglomeration is expected to have impacts in both the short term and the long term. In a frictionless economy, the short-term effect—the static impact—comes primarily from improved matching and sharing. Whilst the longer-term impact—the dynamic impact—comes from learning effects. Frictions in the economy, associated with search and transaction costs, will slow down the speed of these productivity effects.

In Section 3 of the paper, we review the empirical evidence on the speed of the productivity impacts. We focus on studies that identify both the static and dynamic productivity impacts, and on ex-post work. We show that most estimates of the short-term productivity impacts fail to find significant effects. The evidence base is however limited, so we also examine studies of the impact on commuting behaviour and traffic. This is because we expect commuting behaviour to alter as part of some of the mechanisms that delivery productivity gains through increased agglomeration. For both commuting and traffic, we show that for several projects it takes several years before the total traffic impact is visible. In several cases, there is no immediate commuting effect.

Bringing this evidence together in Section 4, we consider that it is reasonable to think that agglomeration impacts will take between ten and twenty years to fully appear in the economy. We show for different appraisal regimes that this can lead to an error of between just under 10% to up to 50% in the agglomeration benefits in the cost benefit analysis. Scotland with a 60-year appraisal period, reasonably high long-run expect rate of growth, and low discount rate vis a vis other countries is at the lower end of this range. The focus in this paper is on the speed at which agglomeration productivity gains appear in the economy. But other wider economic benefits exists, such as effects from increased labor supply and several others (Laird and Venables, 2017). Although not directly reviewed in this paper, the same arguments apply for most of these effects. The reason for our focus on agglomeration economies is that they are usually shown to have the most significant additional benefits.

2 Transport, agglomeration and growth

2.1 Micro-mechanisms and short and long-term effects.

In the long run, with variable factors of production, agglomeration effects not only have an instantaneous impact on productivity (i.e. a short-term impact) but can also have a long-term impact by initiating land use change (dynamic clustering) and influencing the creation of human capital (see for example Lakshmanan, 2012). Following Marshall (1890) we think that agglomeration economies deliver these impacts on productivity via: labour market interactions; linkages between suppliers and producers; and knowledge spillovers. These are, however, aggregate effects and underlying them is a set of microeconomic mechanisms. Duranton and Puga (2004) classify these into three basic typologies of sharing, matching and learning. From our perspective, it is useful to review these mechanisms and assess how quickly a transport shock may trigger a change in behaviour that facilitates productivity impact through increased agglomeration.

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. In this instance we would expect agglomeration benefits that arise via this channel to appear in the short term with no changes in land uses (i.e. in the short run too). New transport infrastructure will also strengthen an agglomeration, giving more people access to existing shared facilities (e.g. market places). Subject to congestion at these facilities this will also be a benefit that would be expected to appear in the short term and short run too. 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. In this instance land uses would alter (i.e. it is a long run impact), and the agglomeration benefits would appear in the medium or long term.

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. Of course, final producers will need to adjust behaviour to the new opportunities, but we would expect this response to occur in the short term with no changes in land uses.

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’. Given that it is a learning task, then a certain amount of time will be needed for these tasks to be learned. Thus, it would be viewed as medium or long-term effect.

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. A transport improvement that immediately enlarges the labour market pool, would with a reasonably flexible labour market, be expected to have a reasonably quick impact on this labour market effect.

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. This is likely to occur in the short term, but new relationships have to be formed. Workers need to leave their jobs and find new and better jobs, and businesses need to find new suppliers. The impact will not therefore be instantaneous.

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. With a flexible labour market this would also be expected to be a relatively short-term response to transport improvement.

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. Once again as with the matching mechanisms this would be expected to occur in the short term, though the benefits may take a sometime to fed through into the economy as the benefits are only delivered once the asset (e.g. skills) have been acquired through investment.

Learning – 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 process. Similar to matching effects, learning effects will also occur in the short term.

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. This is likely to be a short-term response, subject to the time needed to form new interactions with different people.

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 rats 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.

The literature on agglomeration also distinguishes between static and dynamic agglomeration channels or mechanisms. These should not be confused with the transport economic terms of static and dynamic clustering, which relate to changes in land use – though of course there is an inter-relationship. Static agglomeration benefits relates to the productivity benefits that are fixed. For example, the inherent characteristics of a city make all workers in that city a bit more productive. If they leave that agglomeration then that productivity uplift is lost – as it is fixed to the agglomeration in which they had worked. These are typically associated with the matching and sharing channels discussed above.

Dynamic agglomeration benefits channels or mechanisms relate to the manner that agglomerations may change productivity over time. These are associated with rates of learning. Higher rates of learning, and human capital creation, diffusion and accumulation will be associated with the larger city. An important element of the dynamic mechanisms is that the productivity uplift gained is transferable from one place to another. Thus, a worker who learns in a larger city becomes more productive than a worker who learns in a smaller city, and if they move cities are able to transfer some of this additional learnt productivity with them.

We therefore categorise the mechanisms related to changing rates of learning as dynamic agglomeration mechanisms and those purely fixed to the place as static (see Table 1). A frictionless economy will deliver static agglomeration benefits immediately, but the dynamic agglomeration benefits would take longer to appear.

Table 1: Categorisation of agglomeration mechanisms

Static agglomeration mechanisms	**Dynamic agglomeration mechanisms**
Sharing indivisible goods and facilities	Sharing gains from individual specialisation
Sharing the gains from variety	Knowledge generation
Sharing risk	Knowledge diffusion
Improving quality of matches	Knowledge accumulation
Improving the chances of matching	
Mitigating hold up problems through ease of matching	

2.2 Economy frictions

This discussion has posited that the majority of the micro-economic mechanisms underpinning agglomeration economies would be expected to act in the short term. Of course, even with short term there may be a lag as relationships or contracts need to be terminated to form new and better ones. Search and transaction costs including those associated with information asymmetries will be associated with these.

In the real world, one in which these frictions exist, the static agglomeration mechanisms will not deliver an instantaneous uplift in productivity following a transport improvement. The speed of response will be dependent on the frictions. In our view only three of the ten behavioural mechanisms identified by Duranton and Puga will lead to a very quick adjustment in productivity following a transport shock in an economy with frictions. Between two and four of the mechanisms might not be expected to appear in the economy until the medium to long term.

Table 2: Stylised categorisation of the speed in which different agglomeration mechanisms will appear in the economy

Speed of response	Agglomeration mechanisms	Frictions
Short term - quick	Sharing indivisible goods and facilities – new transport facilities and uncongested existing facilities	There will be limited frictions in a flexible labour market.
	Improving the chances of matching	
	Sharing risk	
Short term - slower	Sharing the gains from variety	There is a need to form new relationships which build some frictions into the system
	Improving quality of matches	
	Knowledge generation	
	Knowledge diffusion	
Short to medium term	Sharing indivisible goods and facilities – new non-transport facilities	There is a need for the creation of new facilities (land use change)
	Mitigating hold up problems through ease of matching	There is a need for workers to invest in new skills and
Medium to long term	Sharing gains from individual specialisation	Lags behind the changes in the rates of growth in the learning mechanisms
	Knowledge accumulation	

3 Review of the empirical evidence

The implication that both static and dynamic micro-mechanisms exist, and that frictions may also slow down how quickly they appear in the economy mean that an empirical study examining differences between agglomerations would identify the combined impact of both the long run (variable factors of production) agglomeration effects, as well as the short run (fixed factors) effects. If the timeframe for the all the effects to fully appear is relatively short, say medium term at ten years, then the relevance for policy may be limited. However, if the opposite is the case then the timeframe over which they act becomes important from a policy perspective. It then becomes an empirical question as to how long that timeframe is. We consider four sets of studies. First are studies that separate the static and dynamic agglomeration impact on wages. These studies do not consider transport improvements directly. Still, they are relevant because these results show how fast productivity increases once new interactions between workers and businesses occur. The second set of studies are ex-post studies examining productivity impacts from transport improvements. We consider that these studies examine short-run productivity effects, as in the main they focus on data over a ten-year period.

As can be seen from Table 3 there are only a limited number of studies that give a direct insight into these productivity impacts. Our third and fourth set of studies therefore examine changes in travel behaviour as a proxy for agglomeration impacts taking place. The third set of studies we are interested in analysing deal with the dynamic effects on traffic—traffic lags. We are interested in this effect because it provides evidence of changes in interactions between people living—or working—in different places. The final set

of studies consider commuting effects over time (commuting lags), which are thought of as one of the main sources behind improved labour market matching.

Table 3 Evidence of staggered proximity benefits from transport improvements

Issue	Source	Key finding
Static and dynamic agglomeration effects	Henderson (1974)	Productivity effects from changes five years in the past.
	Glaeser and Mare (2001)	Long-time residents in big cities earn a premium over newly arrived workers.
	D'Costa and Overman (2014)	No evidence of an urban wage growth premium
	Carlsen et al. (2016)	Total agglomeration effect: 60% learning and 40% matching
	Korpi and Clark (2017)	Evidence of dynamic wage premium of all educational categories
	Roca and Puga (2017)	Evidence of urban wage growth premium
Ex post short-run productivity effects	Isacsson et al. (2015)	Insignificant short-run effect.
	Gibbons et al. (2012)	Insignificant short-run effect.
	Sanchis-Guarner (2014)	Insignificant short-run effect.
	Cambridge Systematics (2008)	Significant productivity effects after 5–8 years.
Ex post traffic lags	Bain and Polakovic (2005)	No demand ramp-up.
	George et al. (2003)	Significant demand ramp-up
	Odeck (2013)	Demand ramp-up of 1% each year
	Welde et al. (2017)	Demand ramp-up of more than 1% each year
Ex post commuting lags	Rotger and Nielsen (2015)	No initial effect and growing effects after 3–5 years
	Tveter (2018)	Small initial effect and increasing effects after seven years
	Tveter and Bråthen (2015)	Varying commuting effect with small initial effect.
	Øresund Trends (2012)	Significant instant effect, but much larger effects after seven years.

3.1 Static and dynamic agglomeration mechanisms

The relative importance of the static and dynamic agglomeration mechanisms in delivering productivity gains can be analysed by looking at the literature that seeks to distinguish between the urban wage premium (static effect) and the urban wage growth premium (dynamic effect). The urban wage premium is usually thought of as primarily gains from labor market matching. Meaning a higher quality of the worker-firm match. The urban wage *growth* premium, on the other hand, is usually thought of as effects that come from learning effects. Since learning effects, usually are thought of as the accumulation of human capital it

occurs—almost by assumption—only gradually. The attempts of separating the long-run agglomeration benefits into an instantaneous and a growth part is therefore interpreted as a way of separating matching (static) and learning (dynamic) effects.

The literature that attempts to separate the urban wage premium and the urban wage growth premium finds different results. Carlsen et al. (2016), Korpi and Clark (2017) and Roca and Puga (2017) reports an urban wage growth premium and interpret this as evidence of faster human capital accumulation in cities. In general, their findings suggest that about 60 percent of the total agglomeration effect occurs gradually. According to the results form Carlsen et al. (2016), the effect of experience follows an inverse U-shape and reaches a plateau after approximately a 10-year period. While the immediate effect—interpreted as matching effects—contributes to 40 percent of productivity uplift. In other words evidence of the learning mechanism. D'Costa and Overman (2014)—in contrast—finds no evidence of an urban wage growth premium. They do however find evidence that learning in a city gives leads to faster productivity growth than learning in a rural area.

Whilst this evidence gives support that agglomeration impacts will appear over time with learning impacts taking up to ten years to fully appear in the economy, it does not inform us how quickly productivity in an agglomeration will increase following a transport improvement. This is because this empirical strand of literature follows workers who move between cities, rather than examining workers who remain in a city which has received a transport improvement. We turn to this other strand of the empirical literature in the next section.

3.2 Long and short-run productivity impacts

Our evidence on the long and short-run productivity effect draws on studies using two different approaches. The first are studies using differences between places to estimate agglomeration benefits. The second, are studies that use a particular project (an ex-post case analysis) to estimate productivity effects.

Studies that utilise differences between places, after controlling for differences between workers, capture the long-run productivity effects from agglomeration. This is because the places in which the workers reside are well established cities. Combes et al. (2008) identifies the agglomeration effects (primarily) by estimating the effects for individuals that moves between cities of different sizes (this approach is thought of as the best empirical strategy to identify the causal agglomeration effect). Other studies that arguably estimate the long run impacts include those based on UK data by Graham (2007) and Graham et al. (2009). The latter form the basis of the agglomeration elasticities in the Scottish Transport Appraisal Guidance (STAG) and WebTAG. There is now a large evidence base of these elasticities, with typical estimates of the long-run agglomeration elasticities of between 2 and 5 percent (Melo et al., 2009; Rosenthal and Strange, 2004).

However, to say anything about impacts from transport improvements in the short-run we need analysis that identifies the impacts using transport changes by analysing changes in the overall transport network, such as Gibbons et al. (2012); Isacsson et al. (2015); Sanchis-Guarner (2014). These short-run productivity estimates are lower than the long-run estimates, and, in some cases, even statistically insignificant. Isacsson et al. (2015), for example, use changes in the Swedish transport network and individual wage-data to estimate the impacts of accessibility improvements. The estimate that is closest to our idea of proximity gains is the fixed-effects estimates when focusing on only workers with a fixed place of residence and using only changes in the transport network as variation in accessibility. In this case, the

effect is low and statistically insignificant. Similar evidence is found in both Gibbons et al. (2012) and Sanchis-Guarner (2014).

An alternative to estimate the short run productivity effect uses case studies. Cambridge Systematics (2008) is the only contribution (we are aware of) that both conducts an ex-post analysis and provide evidence on how productivity is affected over time. This report studies the economic impacts of the Appalachian Highway system in the US and estimates the impacts in the Appalachian counties by comparing them to “un-treated” twin-counties with similar characteristics. They report that it takes between five and eight years before any statistically significant effects are found. The effects in the following years show different patterns: in some case effects that are increasing, while in others they are decreasing. We do, however, not give much weight on these long-run impacts as the validity of the twin-county approach is less credible over a long time-span.

This evidence base on short term productivity impacts, whilst very small, does point towards difficulty in identifying anything sizeable. Possibly this is down to the data and empirical strategy adopted, or possibly it is because frictions, such as search and transaction costs, slow down the speed at which the static agglomeration mechanisms can operate. To understand if frictions are at play we turn to evidence on firstly traffic build up post a transport intervention, and then commuting behaviour post a transport intervention. If either of these are slow to react to the presence of a transport improvement then we will have good reason to believe that this ex post evidence on small short run productivity impacts is due to frictions being present, rather than being a result of poor data.

3.3 Traffic lags

Before any productivity effect can occur, because of a transport improvement, there must be an interaction effect between people or firms located in different places. The standard effect on traffic after transport improvements are a sizeable initial traffic increase the first year after opening, but research shows that it usually takes some years before the full impact on traffic is visible. This delayed impact is often labelled traffic ramp-up.

Most research shows clear evidence of a delayed traffic impact. Bain and Polakovic (2005) find no such effects, but George et al. (2003), Odeck (2013) and Welde et al. (2017) reports significant higher traffic growth in the years after the opening of transport schemes. For example, reports Odeck (2013) reports a yearly underestimation of traffic growth of one percent, while the evidence from Welde et al. (2017) shows an even higher underestimation.

The relevance of the traffic impact for the type of interactions that give productivity benefits, can however, be discussed. The reason is that only a few travel purposes, such as commuting and business travels, are related to agglomeration benefits. For example, can travels for work-related purposes (commuting and travels when working) change instantaneously, while leisure travels adjust slower. In this case, the slow impact on traffic has no relevance to agglomeration economies.

3.4 Commuting lags

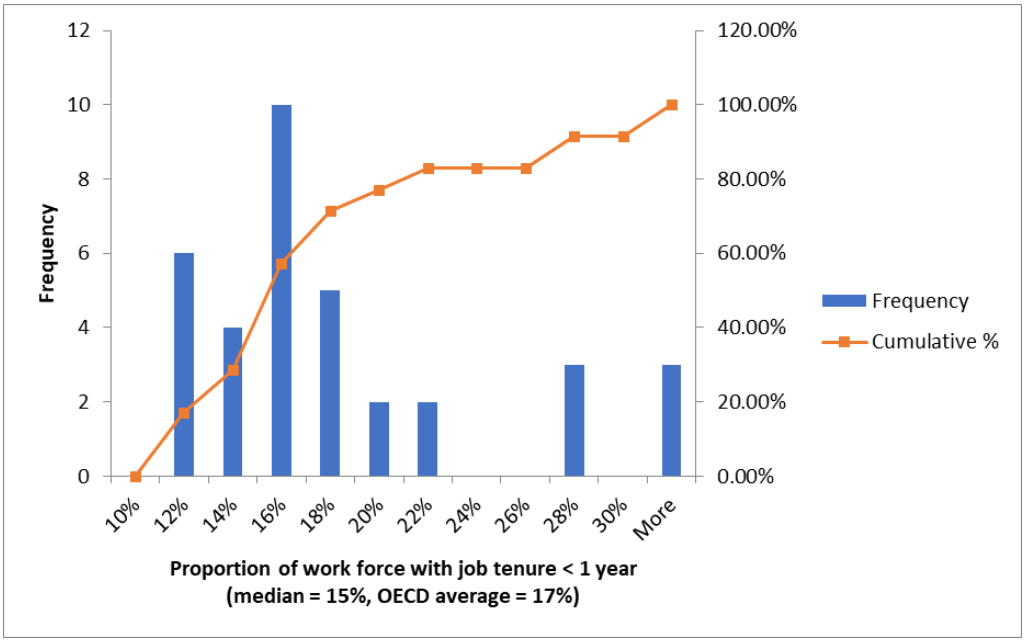
Probably the best indicator of labour market matching is commuting. Here we examine the speed at which commuting effects occur. By commuting effects, we refer to the changes in commuting behaviour brought about by a change in job. We are not referring to changes in mode, time of departure or route used to travel to work.

To our knowledge, only three studies investigate time lags of commuting. The first, Rotger and Nielsen (2015) examine the impacts of an improved public transport system in Denmark. They report that commuting effects are only statistically significant 3–4 years after the opening. Two Norwegian studies use fixed links (roads replacing ferries to islands) to estimate commuting impacts (Tveter, 2018; Tveter and Bråthen, 2015). The result from these studies suggests a slow commuting adjustment, although with some differences. In general, the results suggest that it may take five years before any effects are detectable, and the impact gradually increases even ten years after the opening of the fixed links. There are also several studies that examine changes in commuting patterns. Where leading examples are Baum-Snow (2007) and Baum-Snow (2010). Although relevant, these studies do not, however, examine the dynamic adjustment.

Commuter statistics over the Øresund bridge—connecting Sweden and Denmark—show an immediate effect and lagged effects. In the period 1999–2009 (the year before opening and the year when the number of commuters plateaued), commuters across the Øresund connection increased from almost three thousand to 19 thousand—an increase of almost 600%. The dynamics of the commuters follow similar dynamics as for traffic. First, there was an initial jump in commuters, and thereafter a substantial growth that levelled off after 10 years. Comparing commuting for the first whole year after opening to the whole last year before opening there was an increase in commuting of 50 percent (Øresund Trends, 2012). In the following years, the number of commuters increased by 350 percent. After that there was a significant growth in commuters that plateaued in 2007. After 2007 and to 2011 there has been a small decline—perhaps caused by the financial crisis and low economic growth.

Further indirect evidence on the speed at which we might expect workers to change jobs in response to more opportunities in a larger agglomeration come from job tenure rates. Figure 1 presents a histogram of the distribution of the proportion of the workforce who have been in their job for less than 1 year for thirty five OECD countries. As can be seen the median value is 15%. That is in any one year on average 15% of the workforce change jobs. With that sort of job change rate it would take many years for job matching effects to fully work their way through the workforce. The minimum it would be would be 7 years (≈100%/15%), but in all likelihood it would be longer as some workers change jobs quite frequently and others do not. Differences in the rates between countries would also suggest that the effect might be slower in some countries than others.

In summary, these few examples indicate that commuting effects—at least the most substantial ones—are detectable after five years. The total effect, however, may take 10–15 years before it fully materialises. Job tenure rates in developed countries correspond with this view, as they indicate that a significant lagged effect will occur for the matching mechanisms. Interestingly they also show differences between countries, probably reflecting labour market variations, but also probably indicating national variations in the speed at which matching may occur.



Source: OECD Data on job tenure: https://stats.oecd.org/Index.aspx?DataSetCode=TENURE_AVE

Figure 1 Frequency distribution and histogram of proportion of workforce in each OECD country with job tenure less than 1 year (2016 data)

4 Policy implications

From our review of the evidence, we conclude that it most likely takes time before agglomeration impacts materialize. Our best estimate is that the instantaneous effect is small—perhaps non-existent—and it takes several years before any effects are detectable. First, it appears that there are substantial frictions because it takes time before people start interacting in the way that it is believed to give rise to the agglomeration productivity effects. We base this on our view that changes in travel behaviour are necessary for the interactions, that stimulate the gains in productivity from increased agglomeration, to occur. Our review shows that it takes 4–7 years before interaction effects in the form of commuting are detectable. This result supports ex-post studies that show small immediate productivity impacts. Examining job tenure shows that about 15% of workers change jobs a year, with the result that improved matching will take some time to work its way fully through the labour market. Second, the productivity uplift of these changes seems to start slowly and build up, with a maximal effect after 5–10 years (not including economy frictions). Linking these together, our best estimate is that most of the agglomeration benefits from learning and matching have materialised after 10–15 years. Unfortunately, we do not have any evidence on how fast the sharing mechanism operates. Our only guidance comes from our theoretical discussion in 2.1 where we showed that some of the sharing mechanisms probably work fast, while some of them operate slowly. In total, our small evidence base points in the direction of agglomeration impacts that take 10–20 years to fully materialize.

The importance of the overestimation bias also depends on the specific implementation of the cost-benefits analysis. Both the appraisal period and the discount rate are important factors. The longer the appraisal period, the less important is the overestimation bias – since the proportion of the appraisal period in which the efefcts have fully materilised will be larger the longer the appraisal period. A high

discount rate will, however, increase the overestimation bias, since the years of the appraisal period with full impacts will be given less weight in the present value calculation.

To show the consequence of different cost-benefit analysis practices, we calculate the overestimation bias using the guidelines for UK, New Zealand, and Australia. The UK uses the longest appraisal period (60 years) and the lowest discount rate (3.5 percent until 2049, thereafter 3 percent). New Zealand comes in the middle with an appraisal period of 40 years and a discount rate of 6 percent. Australia, though it does not yet include agglomeration benefits[i], uses the shortest appraisal period (30 years) and the highest discount rate (7 percent). To make the calculations comparable, we assume the same productivity growth of 2 percent per annum—approximately in line with the UK guidelines—throughout the appraisal period in all calculations.

Table 4 presents the overestimation bias. We calculate the overestimation using different adjustment speeds, different appraisal periods, and discount rates. Given the adjustment speed, the highest overestimation is for Australia, while it is lowest for the UK. For Australia, the percent overestimation varies between 50 and 30 percent, depending on the adjustment speed. For the UK the overestimation bias is much lower in all cases. Even for the longest adjustment period of 20 years the additional benefits are lower than for the fastest adjustment for both New Zealand and Australia. Hence, the guideline differences cause much higher differences than the different assumptions regarding adjustment speed.

Table 4 Overestimation of agglomeration benefits by country guidelines and adjustment speed

	Adjustment speed		
UK*	20-year	15-year	10-year
Benefits (sum)	104.14	107.36	110.37
Benefits (discounted)	52.68	54.76	56.94
Overestimation	10 %	8 %	5 %
Overestimation (discounted)	15 %	12 %	8 %
New Zealand**			
Benefits (sum)	49.41	52.64	55.65
Benefits (discounted)	11.97	13.53	15.29
Overestimation	20 %	15 %	10 %
Overestimation (discounted)	40 %	32 %	24 %
Australia***			
Benefits (sum)	29.18	32.41	35.42
Benefits (discounted)	7.96	9.36	10.97
Overestimation	71 %	78 %	86 %
Overestimation (discounted)	49 %	40 %	29 %

Notes: The table displays benefits and overestimated agglomeration benefits under different assumptions. Both summed and discounted. Overestimation is defined as actual benefits under the different timeframe assumptions relative to benefits with full impacts the whole period. All calculations include an underlying productivity growth of 2% per year.
* 60-year appraisal period, 3.5% discount rate until 2049, thereafter 3%
**40-year appraisal period, 6% discount rate
***30-year appraisal period, 7% discount rate

5 Conclusion

A consensus exists that firms are more productive in larger cities. It is then only a small conceptual step from this observation to the conclusion that improvements in transport networks could improve

productivity. Improvements to transport networks bring firms closer to each other and firms closer to workers improving productivity at the micro level. We therefore find that across the world the productivity effects of agglomeration are being incorporated into national appraisal guidelines for transport investments.

Evidence remains limited, but enough now exists to examine in more detail the veracity of the conceptual step from transport project to productivity gains through agglomeration. Our view is that evidence exists to indicate that transport investments do lead to the changes in interactions between e.g. workers and firms that will allow these productivity gains to be realised. However, they are not instantaneous. Drawing together different strands of evidence these gains may take between ten and twenty years to materialise. From a transport appraisal perspective, where appraisal periods are short and discount rates are high this can lead to a significant overestimation of agglomeration impacts.

The evidence base upon which our conclusions are based remains thin. Further work is needed to expand it with ex-post analysis being central. There is a need to understand the ability of transport investments to deliver productivity gains through agglomeration looking ideally at timeframes of up to twenty years. This area of study has proven difficult in the past, and more promising avenues might be to gather more evidence of the timeframe over which travel behaviour changes of commuters and importantly of firms, that underpin agglomeration economies, occurs. With potential long periods of adjustment before all the productivity gains from agglomeration materialise, it is also important to understand what frictions these delays arise from, and whether transport or broader economic policy can influence the timeframe.

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[i] Australia is currently consulting on the incorporation of agglomeration benefits in the appraisal of transport schemes in its cities.