

De relevantie van geïnduceerd verkeer: gemak dient de rijdende mens?

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Samenvatting

Bij het ontwerpen van nieuwe wegen en het verbreden van bestaande verbindingen ten behoeve van het vergroten van de capaciteit, is 'geïnduceerd verkeer' een fenomeen waarmee rekening gehouden moet worden. Geïnduceerd verkeer is verkeer dat niet aanwezig was, en waar geen rekening mee werd gehouden vòòr de aanleg of de verbreding van wegen, maar ontstaat door beter bereikbare bestemmingen, omdat de stremmingen ten gevolge van een ontoereikende capaciteit zijn afgenomen. De 'wet van Behoud van REistijd en VERplaatsingen (BREVER)' zoals geformuleerd door Hupkes (1978), gaat ervan uit dat de reizende mens, onafhankelijk van woonplaats of levenssituatie, graag een bepaalde hoeveelheid reistijd per dag incalculeert. Deze wet maakt dat een reiziger besluit voor het kiezen van een bepaalde route, of het op reis gaan naar een bepaalde bestemming, afhankelijk van de tijd die het kost. Kost het minder tijd om een bepaalde route te kiezen of reis te ondernemen, doordat de capaciteit is toegenomen, zal de verkeersvraag op de route weer toenemen nadat deze een tijd minder is geweest. Het gevolg is dat, ondanks dat de capaciteit van wegen is toegenomen, de capaciteit weer ontoereikend kan zijn en er weer stremmingen plaatsvinden op de aangepaste locatie. Het aanleggen of verbreden van wegen dient dus het gemak van de rijdende, calculerende, mens.

Ondanks dat het bestaan van 'geïnduceerd verkeer' algemeen onderschreven wordt, is er weinig overeenstemming over de grootte en het belang van dit fenomeen. Daarom is er literatuuronderzoek verricht waarin bronnen van verschillende origine zijn vergeleken, zoals wetenschappelijke artikelen, overheidsdocumenten en krantenartikelen.

Het blijkt dat er grote verschillen zijn in opvattingen, zelfs in wetenschappelijke artikelen, over hoe geïnduceerd verkeer dient te worden gemeten, in zowel de omvang als de tijdsduur waarover dient te worden gemeten. Er is consensus in alle onderzochte artikelen dat geïnduceerd verkeer inderdaad voorkomt, maar tot welk niveau is geen overeenstemming te vinden. Sommige artikelen geven aan dat voor elke procent extra wegcapaciteit, een procent nieuw verkeer wordt gegenereerd. Andere stellen dat voor deze procent extra wegcapaciteit slechts 0,3% extra wegverkeer wordt gegenereerd. Deze grote verschillen zijn niet behulpzaam voor beleidsmakers in het besluiten van het aanleggen of verbreden van wegen, noch in communicatie tussen overheid en publiek, dus aanbevolen wordt verder onderzoek te doen op een gestandaardiseerde manier.

In dit artikel worden alle literatuurbevindingen op een rijtje gezet, als een startpunt voor verder onderzoek, bijvoorbeeld naar een voorstel voor standaardisatie voor het meten van geïnduceerd verkeer. Het artikel is gebaseerd op het bachelor afstudeerwerk van Erblich (2021).

1. Introduction and problem statement

The design of the motorways in a network is closely related to the demand, and whenever congestion arises, due to insufficient capacity, the question arises whether it is necessary to widen roads by adding more lanes, or to add new roads to the network. Before the Covid-situation changed the demand (since working at home became advisable) in the Netherlands, the majority of the congestions in the peak hours was due to insufficient capacity to cater for the demand in these rush hours. However, also outside the rush hours, the traffic jam size increased over the years. (Rijkswaterstaat, 2019).

The travel time loss and costs related to the congestion urges for a redesign to extend the motorway network, either by adding lanes, or adding or extending roads. In the Netherlands, in the last couple of decades, the usual road extension or widening has primarily been focused on solving bottlenecks: if congestion would arise at a certain point, the road would usually be widened or a detour would be constructed, and the point of trouble should, in theory, be free from congestion again (Taale, 2021).

However, after these capacity extensions, the demand might increase to a higher level than before had been assumed. With the Law of Constant Travel time (Hupkes, 1978) in mind, travellers who previously were reluctant to take a certain route because of congestion and the related time loss, now choose to take the bottleneck-free route. This will cause an increased demand, the so-called 'induced demand'. This increased demand might result in the congestion returning.

In literature, there is a large spread considering the significance of induced demand. For example, in certain cases, the IDE, 'Induced Demand Elasticity', e.g. the percentage of extra traffic related to the added road capacity will be near or even above 1 (Duranton & Turner, 2009). In contrast, van der Loop (2014) found an IDE around 0.4.

Other, largely diverging, results can be found in other literature. In this paper, the various points of view considering the significance of the induced demand phenomenon will be analysed, which will try to help to answer the following research question: "*What is the significance of the induced demand phenomenon with road widenings?*" In order to obtain the answer to this research question, an analysis will be carried out considering various sources of literature (scientific papers, documents from governments, articles from newspapers) that discuss the induced demand phenomenon. In section 2, the methodology is explained with which the literature has been reviewed. In section 3, the results of the literature review are presented. Section 4 contains the discussion section. Finally, the conclusions are given in section 5. This paper is based on a TU Delft Bachelor thesis (Erblich, 2021).

2. Literature Review – the methodology

As a starting point the paper on literature reviews from Snyder (2019) is considered. This paper states that there are three types of literature reviews: systematic, semi-systematic and integrative reviews. The systematic review is most suited for comparing similarly natured literature in detail, whereas the semi-systematic review is more suited for a broader topic that might have been described in different ways. Lastly, the integrative review aims to create new concepts by merging several perspectives found.

The aim of the review carried out in this thesis is not to create any new concepts, it merely compares different points of view. Also, the literature considered consists of different types of resources. Therefore a semi-systematic review has been used.

2.1 *Literature search*

The types of literature that have been considered are:

1. PM: 'Popular media', this is information meant for the general public. This could include newspapers as well as articles on websites that clearly have the goal to inform the general public without pre-knowledge about traffic and road design.
2. SL: 'Scientific literature': papers, journal articles etc., which have been through a peer-review process and are meant for scientific or research purposes.
3. O: 'Other': literature that cannot be placed in either of the aforementioned categories, e.g., reports from Rijkswaterstaat, or from advisory boards of the government. These are meant for neither of the aforementioned purposes, at least not in the first place: their goal might be to inform other professional parties about current states of affairs.

The key words in the search have been 'induced demand', 'congestion' and 'road design'. For literature of type 2 and 3, the key words 'filebestrijding' (fight against traffic jams) and 'file beleid Rijkswaterstaat' (traffic jam policy Rijkswaterstaat) were used as well. Literature has been searched by supplementing the building block approach (combining many search terms into one search query in order to get to the desired available literature as efficiently as possible) with the snowball method (once a relevant publication of any form has been found, use the cited literature contained in that publication to get to other relevant publications) (Vrije Universiteit Amsterdam, 2021).

2.2 *Thematic analysis*

A thematic analysis is a form of qualitative analysis in which the main focus is on analysing and recognising 'themes', i.e., certain patterns, within the literature that will be compared.

The standard framework for a thematic analysis from this literature is taken from (Braun & Clarke (2006), see listed below:

1. Familiarising with data (here: the literature): thoroughly reading the data and getting familiar with its contents.
2. Generating initial codes, where 'codes' can be described as the most basic 'elements' of meaningful information that the data provides.
3. Searching for themes within the codes that have been established in Step 2, the themes in this research are related to the research question.
4. Reviewing themes: some themes will be found to be more relevant than others, or the data supporting them could either be too diverse or too scarce.
5. Defining and naming themes: i.e., which aspects of the data are being captured, and what do the themes contribute to the understanding of the data.
6. Reporting: placing the results in context and creating a coherent conclusion.

Some sorting will be applied to the found literature beforehand, in order to create an overview within the list of found literature. To achieve this, the literature will be sorted in a table, which will list the title, author, year and the type of literature.

3. Literature review – the results

In this section relevant literature is listed, a short description of the literature is given, a thematic analysis is made and the IDE (Induced Demand Elasticity) is compared.

3.1 Literature overview

In Table 1 an overview is given of the reviewed literature. The literature is mentioned in the References of this paper. The type of the literature is indicated according to the abbreviations in section 2.1. If no level of IDE is found in the literature, this entry is left open.

Reference	Title	Type	IDE
Goodwin (1996)	Empirical evidence on induced traffic: a review and synthesis	SL	0.5 -1.0*
Noland (1999)	Relationships between highway capacity and induced vehicle travel	SL	0.69-0.83
Noland et al (2000)	Induced travel : a review of recent literature and the implications for transportation and environmental policy	O	0.3-1.0
Cervero (2003)	Road Expansion, Urban Growth and Induced Travel: A Path Analysis	O	0.238
Duranton et al (2009)	The Fundamental Law of Road Congestion: Evidence from US Cities	O	0.82 - ±1
Van der Loop (2014)	De latente vraag in het wegverkeer	PM	0.4
Mann (2014)	What's Up With That: Building Bigger Roads Actually Makes Traffic Worse	SL	1**
Van der Loop et al. (2016)	New findings in the Netherlands about induced demand and the benefits of new road infrastructure	PM	0.2-0.4
Kuiken (2016)	Niet realistisch: de files oplossen met 1200 kilometer extra asfalt	PM	
Bleijenberg (2017)	Het Filemonster	PM	
Verkade (2018)	Meer asfalt leidt altijd tot meer files. Toch geven we er elk jaar een miljard euro aan uit	SL	1**
Hymel (2019)	If you build it, they will drive: Measuring induced demand for vehicle travel in urban areas	PM	0.89-1.06
Verhoef (2018)	Inflatie van reistijd	PM	
Houtekamer (2019)	NRC checkt: 'Meer rijstroken beste bestrijding fileleed'	O	1**
Rijkswaterstaat (2020)	File-aanpak 2018-2021	O	

*: 0.5 on short term, 1 on the longer term; **: simplified reference to Duranton et al (2009).

Table 1 Literature overview. 'Type' as given in section 2.1, 'IDE' (Induced Demand Elasticity) as found in the paper.

3.2 Literature summary

Goodwin (1996) measured traffic counts rather than VKT (vehicle kilometres travelled), defines induced traffic as “all extra traffic other than reassignment” and mentions “an elasticity of traffic volume with respect to travel time” of -0.5 in the short term and -1.0 in the long term, for a speed change which saves 10% of travel time. Concludes that “an average road improvement” will generate 10%-20% of additional traffic, however, it is not specified how much of this additional traffic is considered to be induced traffic.

Noland (1999) – Definition used here: ‘induced VMT’ (vehicle mean traffic), being “any infrastructure change that results in either short run or long run increases in VMT”. Results show elasticities of vehicle mean travelled vs. changes in lane mile of 0.713 for interstate highways, 0.69 for arterial roads and 0.826 for collector roads. With a two-year lag, the values are between 0.2 and 0.5. The effect persists the longest with arterial roads.

Noland et al (2000) – ‘Induced travel’ definition used: “the increase in VMT attributable to any transportation infrastructure project that increases capacity”. It is stated that much of the disagreement about the existence of induced travel originates from traffic engineers’ traditional assumption that total travel will be constant, despite changes in travel price (or: time cost), as well as the assumption that travel growth will be caused by exogenous factors. Statistic research from the US shows that “lane mile elasticities (with respect to VMT)” (of which the definition is not fully outlined) are between 0.3-0.7 on a county-scale and 0.7-1.0 on a metropolitan scale.

Cervero (2003) states that “most” studies study growth in VKT as a function of lane-mile additions. This article adds an intermediate step: road improvements make travel at higher speeds possible, and it is this that subsequently causes demand to grow. Discerns ‘induced demand’ (merely new traffic) from ‘induced travel’ (which might also include diversions in route or time) and uses the latter. Using this two-step model, an induced travel effect was found with an elasticity of 0.238. This lower elasticity than in many other models is attributed to the different way of modelling.

Duranton et al (2009) examined “the effect of lane kilometers of roads on vehicle kilometers travelled (VKT)”, using data from the United States MSA’s (Metropolitan Statistical Areas). The exact definition of ‘effect’ is missing, however, the modelling used suggests that this is the eventual correlation between the two mentioned parameters. The general result is a correlation coefficient between 0.82 and 0.86 for interstate highways outside of urbanized areas. Major roads in urbanized areas yield similar results. However, interstate highways inside of urbanized areas seem to suggest correlations around or even higher than 1.

Van der Loop (2014) – Uses ‘latente vraag’ (latent demand) to be investigated in this report and defines it as “the increase in car use over the entire day on the entire road network (in terms of vehicle kilometres travelled) arising as a result of road extensions”. The Dutch main road network was extended by 9%. Its usage increased by 16% between 2000 and 2012. Around 4% is estimated to be new traffic, of which half is estimated to be originating from other roads and half is estimated to be latent demand. It is especially

occurring during peak hours: in the morning peak, the traffic increase is 10% and in the evening peak, it is 12%. Extant research has on average shown an elasticity of 0.3-0.5, which is in line with these findings of around 0.4. In the traffic models used in the Netherlands, the Landelijk Model Systeem (National Modelling System) and the Nederlands Regionaal Model (Dutch Regional Model), latent demand is incorporated by modelling an infrastructure extension by means of changes in the choice for time, route and transport mode. When travel times decrease, more traffic is attributed to that route. However, possible effects on urban developments are not incorporated into the model.

Mann (2014) – Discovery over the last decades: “you can’t build your way out of congestion” and claims that the ways of trying to solve traffic jams are “fruitless”. Reference to Duranton et al (2009) wherein an elasticity of 1 was found. Mentions the possible causes: when creating the ability to travel, people will travel more, e.g., by moving out of a town, or making more car trips than previously. Also, a good road network attracts companies that need roads, bringing more traffic. Public transport merely adds more movements, it does not relieve congestion.

Van der Loop et al (2016) - The definition of induced demand used in this paper is: “the increase in car use per day on the total network, in terms of the vehicle kilometres resulting from road expansion (new roads or adding lanes)”. Other causes of extra car use, like economy or population growth, as well as route and time adaptations after road expansion, are not considered. A large study considering the Amsterdam ring road concluded that one year after opening the last ‘missing gap’, the total amount of trips had increased by 8% (of which 5% is considered to be induced demand). A total of 25% of car users changed their route, whereas 31% changed departure time, seeming to suggest a shift from off-peak hours to peak hours. Another study performed by the KiM in the Netherlands in the period of 2000-2012 found the amount of extra traffic in terms of extra vehicle kilometres to be around 4%, for a capacity increase of about 10% in those years. This study also found that car use increased by 10-12% in peak hours on road stretches with new lanes, partially from what van der Loop (2016) defines as induced demand, but also from time and route shifts. The proportion of these is not specified. Increases in car use during peak hours (which does not qualify as induced demand) should not be confused with new car use due to new infrastructure (which does qualify as induced demand).

Kuiken (2016) – According to the advisory commission ‘Loendersloot Groep’, 1,200 kilometres of asphalt would be required for solving the extant road congestion problems completely, on average two lanes for the morning peak and one lane for the evening peak. According to this Loendersloot Groep, those extra kilometres would not be too prone to new traffic/congestion. The reason mentioned: the number of travellers currently taking the train but preferring the car would merely fill up the equivalent of half a lane. A more acute problem would be the requirement for proper distribution of all cars into cities and parking spaces.

Bleijenberg (2017) – The economic damage of traffic jams is estimated at €3b/y. In 1988 a plan was made by Rijkswaterstaat to reduce traffic jams to a third of the proportions. Instead, the traffic jams have tripled in size up to 2010. There is too little understanding of the origins. The problem of not being able to solve traffic jams is especially apparent around freeways in urban environments, the reason being: a large route shift from roads inside of cities to roads outside of cities. This might lead to a slightly higher average travel speed inside of cities, however, traffic jams reoccur on the new freeways. Also contributing is an increase in travelled distance when being able to travel faster. Finally, well reachable areas are attractive for new urban activities. Solutions for this problem: larger and more densely built cities, making shorter travelled distances viable, and increase transport speed inside those cities, using a smart combination of cars, public transport and bicycle.

Verkade (2018) – For 50 years, the need for road widenings seems to be fed by fear that within years, all roads will be congested (NOS, 2016) (Dujardin, 2017), (Kegel, 2018). Public appreciation for these measurements is helped by using large terms like 'traffic infarct' (suggesting a parallel to health) 'delta plan' (suggesting a parallel to flood defences). For 30 years, there have been large discrepancies between calculated and eventual traffic numbers, which have always turned out much larger than expected. Induced demand is created by the appeal of areas that are better reachable after solving congestion problems, which will attract extra traffic (Bleijenberg, 2015). Reference to Duranton et al (2009), also claiming a correlation of 1.

Hymel (2019) – In this article, the 'induced demand elasticity' is measured and defined as the causal link between an increase in vehicle miles travelled per capita and highway capacity extensions. Measuring induced demand elasticity is difficult due to statistical reasons, as well as likely unobservable factors. Also, some effects take many years to be observable (e.g., a commuter who might move or change job due to faster travel speeds). The article discards and does not specify any causes of this induced demand: new travels or shifts of peak. The result of the investigation was an elasticity in the range of 0.892 to 1.063.

Verhoef (2018) – In politics and media, the solving of traffic jams is a major issue. In the current policies, solving points of conflict (i.e., sections of road that are prone to congestion) has become the norm and the average person is used to this way of communicating. However, the caveats mentioned here do include a form of induced demand: "Expansion of road capacity offers relief for a short amount of time, but subsequently attracts new mobility, resulting in traffic jams again".

Houtekamer (2019) - Also mentions Duranton et al (2009) as a source, claiming a similar elasticity. Mentions an investigation of the KiM: a 9% increase in road capacity leading to 4% extra traffic of which half was completely new, this is more or less in line with Van der Loop et al. (2016). Mentions the Rapportage Rijkswegennet from Rijkswaterstaat, which found that out of 7 widened roads, 4 resulted in shorter travel times, 2 remained equal and one got longer. Uses the BREVER law (Hupkes, 1982, Peters et al. (2001)) to explain that when travel speeds are faster, people will tend to travel larger distances.

Rijkswaterstaat (2020) - This report proposes solutions to traffic jams in several ways (focussing on mitigation, prevention and avoidance), at a header 'Improving infrastructure at conflict points', the following sentence is found: "The adjustments to the infrastructure are one-off, the effects for traffic flow are lasting". No form of possible extra traffic attraction is mentioned.

3.3 Themes found

Definition used

Although most literature reviewed covers in a way the induced traffic theme, there seems to be little consensus on the exact way of measuring it. The most common way seems to be a relation between the total amount of vehicle kilometres travelled and kilometres of new infrastructural expansions, which is used by Noland (1999), Noland et al (2000), Durantou et al (2009), Van der Loop et al. (2016) and Hymel (2019).

Other definitions and ways of measuring found are a relation between traffic counts on a certain road after an expansion which has cut back travel time. The relative extra number of vehicles that passed the road is then linked to the amount of travel time the road expansion has made possible (Noland, 1999). Cervero (2003) uses an intermediate step to first determine the relationship between infrastructural expansions and higher travel speed, after which this higher travel speed is related to the amount of extra travel on the expanded road sections.

Timespan for measuring the IDE

As induced demand is a phenomenon of which the full effects will only become apparent after several years, accurately defining the time stretch over which measurements are taken is crucial for a right comparison. In the Amsterdam ring road study mentioned by Van der Loop et al. (2016), effects are observed one year after opening a road stretch. Another study mentioned by Van der Loop et al. (2016) observes effects over a 12-year timespan, combining all extra traffic and all roadworks, making it impossible to discern between. Hymel (2019) mentions the measured effects are split up between 'short-term' effects and effects measured after 5 years.

Durantou et al (2009) apply a 20-year study period, using data from two consecutive spans of 10 years. Noland (1999) uses immediate effects as well as effects with a 2-year and a 5-year lag. Goodwin (1996) makes a distinction between 'short term' and 'long term' effects, without measuring the exact number of years. Cervero (2003) measures effects over a period of 15 years.

Size of IDE

The various researches which link the number of kilometres of new infrastructural expansions to the total amount of vehicle kilometres travelled, end up with elasticities of 0.4 (or even 0.2) (Van der Loop et al., 2016), between 0.892 and 1.063 (Hymel, 2019), 0.82-0.86 for highways outside of urban areas and major roads in urban areas, and around 1 for highways inside of urban areas (Durantou et al, 2009), 0.713 for interstate highways, 0.69 for arterial roads and 0.826 for collector roads (Noland, 1999). Other found elasticities are 0.238 by Cervero (2003), although this is measured in a different manner, see the Definition above.

Are any areas more sensitive to induced traffic?

Most literature reviewed does not point to any areas being more prone to induced demand effects. However, Duranton et al (2009) makes a distinction between highways vs. major roads inside urbanized areas vs. highways outside of urbanized areas. With this distinction, the highways in urban areas seem to stick out with elasticities close to or just above 1, whereas other roads seem to have an elasticity of 0.82-0.86. This observation is in line with Bleijenberg (2017), which also mentions a possible cause for this effect, being a large route shift from roads inside of cities to roads outside of cities.

Influence of public transport

A common thought is that public transport could help relieve traffic levels by means of travellers shifting mode. This might lead to less new demand on roads, in case public transit facilities would be improved whilst widening roads. Duranton et al (2009) conclude that additional provision of public transport has no influence on the number of vehicle kilometres travelled, which is also mentioned by Mann (2014). The exact opposite effect (people switching from public transport to road travel), however, has been proved to exist, albeit only 3% on a 27% trip increase (Van der Loop et al., 2016). According to Kuiken (2016), the number of public transport travellers who would take the car without traffic jams is about equal to 'half a lane' of traffic, however, no further details are given on the nature of that calculation.

Influence of fuel prices

This subject is covered to the most extent in Noland et al (2000), stating that the elasticity of fuel prices in relation to the number of vehicle kilometres travelled is between -0.45 and -0.9 for the United Kingdom. Noland et al (2000) also states that these elasticities will be larger in the United States (-0.56 in the short run and -1.18 in the long run and concludes that in regions with lower fuel prices, more behavioural changes can be expected from changes in travel speed (which would be one of the effects of road widenings), assuming a constant 'budget' for travelling, including a value for travel time. To quote Noland et al (2000): "if fuel prices are low, then more of a behavioural response can be expected from changes in travel speeds".

However, Noland et al (2000) comes to a totally different conclusion, stating that "our calculation is not sensitive to the assumptions made for vehicle operating costs. Even a tripling of fuel prices would make little difference here." According to Noland (1999), a fuel price vs. vehicle kilometres travelled elasticity between -0.126 and -0.192 is found. Goodwin (1996) summarizes various results from previous studies by stating an elasticity of -0.1 to -0.5 and subsequently uses -0.15 for further calculations.

Origins

Although the *effects* of induced demand can be measured relatively easily in terms of route shifts, mode shifts or completely new travel, the origins of this induced demand are a subject that is not always discussed in detail. The main origin mentioned in Noland et al (2000), Duranton et al (2009), Verkade (2018), Mann (2014), Bleijenberg (2017), Noland (1999) and Cervero (2003) is that extra road capacity will cause changes in accessibility within urban areas. These could subsequently result in changes in spatial allocation. In other words: with the facilitation of higher travel speeds, the likelihood of spatial reallocations is increasing, both in commercial (businesses) and private

(residents) sectors. Another origin that is repeatedly mentioned (in Noland et al (2000), Mann (2014), Bleijenberg (2017) and Houtekamer (2019)) has its roots in the alleged constancy of travel time which is best known in Dutch literature as the BREVER law (Hupkes, 1982, Peters et al., 2001). This law states that the amount of time that a person spends travelling per day is more or less constant over the entire world. Following this law, more travels would be made when traveling speeds, due to road capacity extension, increase. Other causes mentioned include possibly larger shifts than foreseen from public transport to road traffic. This would be caused by fewer people travelling by public transport because of road capacity increases, which may subsequently force public transport operators to reduce operational frequencies or increase fares, which will generate even more traffic Noland et al (2000).

Finally, it should be noted that in all these findings, there seems to be little research done into the proportions of these origins of induced demand, in other words: how much these individual origins contribute to the total. An exception is in Duranton et al (2009), which examines and calculates the proportions of several possible origins of induced demand. These include: the migration of both people and economic activity, individual behavioural changes, increases in the commercial transportation sector, and traffic diverting from other roads. One of the results from this that could be most relevant is that commercial transportation seems to be the most elastic to road capacity increase, with elasticities that are sometimes above 2, i.e.: for every percent of road capacity added, commercial transportation would increase with two percent.

4. Discussion

The ways of measuring the amount of induced demand as well as the resulting induced travel are hugely diverse. This makes it considerably hard to compare viewpoints found in the diverse literature. It also minimises the possibilities for comparing the amounts of induced demand in different countries, as the measurement methods are of such diversity. A few notable viewpoints will be discussed here. In the paper of van der Loop (2014), mode and route shifts are discarded in the definition of induced demand (which most other literature does as well). Eventually, the paper gives an elasticity in the range of 0.3 to 0.5 as a result, meaning in this case that every percent of road capacity added will generate approximately 0.4 ± 0.1 percent of completely new traffic. The paper concludes that this is a 'relatively low' amount. However, as the elasticity of 0.4 is merely considering completely new traffic, it might be questioned whether one can really speak of a 'relatively' low amount.

Another remarkability found in the literature review is that most research focuses merely on new traffic and does not go into too much detail on route and time shifts caused by new infrastructure. However, with some research (Duranton & Turner, 2009) already suggesting elasticities of a total amount of vehicle kilometres travelled vs. added lane kilometres being close to 1, it might very well be that the elasticities of *total* additional traffic (i. e., *including* route and time shifts) could end up well above 1. It might be interesting to also execute research into these total traffic numbers.

For the Dutch situation, it might be expected that the induced demand phenomenon will be well under the attention of Rijkswaterstaat. However, it seems as if the effect is currently not getting too much attention, based on (Taale, 2021) as well as the document on Rijkswaterstaat's policy on solving traffic in the period 2018-2021

(Rijkswaterstaat, 2020). In the latter document, the fact that road widenings could attract extra traffic is not mentioned at all.

On the other side, various 'popular media' meant for informing the general public seem to report about the phenomenon in sometimes slightly erroneous ways. For example, while the often-cited research of Duranton & Turner (2009) suggests induced demand elasticities of around 0.85 for most types of roads, which can get close to or slightly above 1 for highways in urban areas, this result has often been found to be simplified to "a perfect one-to-one match" (Mann, 2014) or "for every percent of road widening that you perform, traffic eventually will increase with one percent" (Verkade, 2018). It could also be argued whether this "road widening" (used by Verkade, 2018) really is the same as the very quoted research which focused on capacity extension (Duranton & Turner, 2009). This distinction could be of extra importance because merely widening roads in one spot or solving bottlenecks could only lead to shifting the capacity shortage problems to other areas, such as the inner parts of cities where capacity or parking extensions are harder to realise (Kuiken, 2016).

Another newspaper article mentions that the current traffic congestion problems on Dutch freeways can be solved by adding 1200 kilometres of lanes and subsequently states that these lanes will not be prone to congestion again (Kuiken, 2016). However, neither exact calculations nor explanations of this statement are added. More nuanced information about the phenomenon meant for the general public has not been found.

5. Conclusion

The majority of literature does seem to suggest that induced demand phenomena are real and occurring. Although the exact amounts of induced demand claimed are varying greatly, conclusive evidence pointing against the existence of induced demand has not been found, in either type of literature. Some literature suggests that relations between extra road capacity added and new traffic generated might be close to, or, in some situations, even above 1 (Duranton & Turner, 2009). However, almost all literature also suggests that this subject is in need of more research.

This paper, therefore, relays the suggestion that more research be done into the induced demand phenomenon with road widenings. However, almost more importantly, a recommendation is added that the research method be more standardised, in terms of what is exactly measured, and after how much time the effects of road widenings are evaluated. With more standardised research performed in the future, it might also contribute to eliminating ambiguous messages that the general public reaches. At this moment, it appears there is a large gap between what is communicated by authorities and other stakeholders, who have demonstrated that induced demand is of high importance on one side, and the exaggerations that most of the popular media researched have been found to make (e.g., generalising the results of research to strengthen their point) on the other side. If the research methods would become more standardised, more consensuses can arise between policymakers and the public, and the steps taken to overcome road congestions can be more successful. A more standardised approach would also enable a better tracking along the world of possible developments regarding the significance of induced demand, which is especially relevant given the rapid changes occurring in the world at this moment (e.g., the COVID-19 pandemic, which

caused a surge in the number of people working from home), allowing for a better and swifter adaptation worldwide to momentary travel demands.

- de auteur(s);
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