Appeared in Tijdschrift Economische en Sociale Geografie 2003

INDIRECT ECONOMIC EFFECTS OF NEW INFRASTRUCTURE: A COMPARISON OF DUTCH HIGH SPEED RAIL VARIANTS

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ABSTRACT

New transport infrastructure has a myriad of direct and indirect effects. The indirect effects on population and economic activity are most difficult to estimate. This paper introduces three different models to estimate the impacts of new infrastructure on labour supply and demand, and carefully explains how the interaction between the models and their outcomes should be handled. The methodology is applied to a possible magnetic levitation rail system from Schiphol across the Afsluitdijk to Groningen. Next, this benchmark is used to derive a qualitative assessment for alternative trajectories and slower type of new rail infrastructure, all across the Afsluitdijk. The paper concludes with a summary of the remarkable differences in outcomes with the official Maglev proposal that runs through the polders of the former Zuiderzee.

Keywords: transport infrastructure, magnetic levitation, indirect effects, labour market effects, Afsluitdijk, the Netherlands

1 INTRODUCTION

Soon, the Dutch government will decide on a major infrastructure project involving the construction of a new rail link between Amsterdam/Schiphol Airport and the City of Groningen in the North of the country. Amsterdam is part of the Randstad region, the economic core of the Netherlands. By contrast, the North is considered an economically lagging region. Attempts to stimulate the northern economy with infrastructure, investment premiums and relocation of central government offices have not solved the problem yet. Although declining, the unemployment rate is still relatively high and part of the once-relocated government offices return to the Randstad after privatisation (see Oosterhaven, 1996, for an overview).

The construction of a shorter and much faster rail link between the Randstad and the North is thought to help solve the economic problems in the North as part of the new policy program “Kompas voor het Noorden”. Arguments in favour of this link focus on its indirect economic effects. Six possible variants of this rail link have already been studied (see Elhorst *et al.* 2000). All trajectories took the southern *route* through the Flevoland polders (in the former Zuiderzee, see ZZL in figure 1). Alternatives along the *northern* route using the Afsluitdijk have not yet been studied thoroughly. The northern alternative was rejected in an early stage, mainly because of environmental reasons (V&W, 2000). However, besides connecting the Northern Netherlands with the Randstad, this alternative also runs through the North of North-Holland, a region having economic problems of its own. In this article the impacts of new rail infrastructure along the Afsluitdijk will be estimated and compared.

In section 2, the selection of stations and specification of trajectories of six possible alternatives across the Afsluitdijk will be discussed. Section 3 gives a description of the models used and the results for the indirect economic effects of the magnetic levitation (Maglev) variant through the West of the Province of North-Holland, which is chosen for the quantitative investigation. Section 4 gives a qualitative comparison between the indirect economic effects of all six possible variants using the chosen western Maglev across the Afsluitdijk as a benchmark. In section 5 the indirect economic effects of this benchmark are compared with the indirect economic effects of the comparable Zuiderzeeline variant investigated earlier. Section 6 concludes.

2 TRAJECTORIES AND STATIONS OF THE AFSLUITDIJK VARIANTS

2.1 Description of all six variants

This section gives a description of six of the possible rail connections between Schiphol and Groningen across the Afsluitdijk. Two different main trajectories can be identified: a route through the West of North-Holland, with a main station in Alkmaar, and a route through the East of North-Holland, stopping in Purmerend and Hoorn. Within these two main spatial variants three types of transport techniques may be used: an intercity railroad (IC), a high-speed railroad (HS) or a Maglev system (ML).

Each of these types of techniques has it's own characteristics. The IC-variants are relatively slow (a maximum of 160 km/h) and will mainly use existing tracks. The HS-variants are faster (about 300 km/h) but need modifications of existing tracks to reach higher speeds, while new tracks should be relatively straight with few stops in order to reach the maximum speed. A problem of these two systems is that they need relatively long distances to reach their maximum speed and to slow down again. Especially for the high-speed variant this means that only few stops should be planned in order not to increase the overall travel time unnecessary. The ML-variant is the fastest of the three (over 400 km/h) and is capable of fast acceleration and deceleration. Moreover it allows for sharper curves, enabling a better bundling with existing infrastructure. This makes it suitable for both fast short and fast long distance transportation. A major disadvantage of the Maglev, however, is its high investment cost since existing rail infrastructure can not be used.

The detailed choice of the trajectories and stations for each of the six variants (see figure 1) is based on a qualitative evaluation of the trade-off between the use of existing tracks (= cost advantage), picking up extra passengers (= revenue and time gain), and causing extra travel time for other passengers (= revenue and time loss). For example, the HS- and IC-variants in Friesland are not lead via Drachten, as this would require unnecessary large investments in entirely new tracks between Leeuwarden and Groningen compared to just upgrading the existing tracks via Buitenpost. Furthermore, the Western IC- and HS-variant are assumed to follow a different route in the North of North-Holland. The ICW-variant passes through Schagen in order to pick up passengers from Den Helder and to use the maximum of existing tracks, whereas the HSW-variant passes through Wieringerwerf in order the reach the maximum speed on the longer distances (for further details see Romp and Oosterhaven, 2001).

Of these six variants the MLW-variant is chosen as the variant to be studied quantitatively. With the MLW the older economic centres of Alkmaar (directly) and Den Helder (indirectly) are being served, offering a better opportunity of independent economic development, whereas serving the eastern, mainly suburban cities of Hoorn and Purmerend would have resulted, relatively more, in accommodating commuters' trips. To create a benchmark for the qualitative comparison the Maglev system is chosen, as this system is certain to produce the largest effects on the working population and the employment in the various regions (compare Elhorst *et al.* 2000, for the Zuiderzeeline variants).

2.2 Detailed description of the western Maglev variant

This section therefor describes the MLW variant in more detail. The route is planned from Groningen via Drachten, Leeuwarden, Alkmaar, Zaandam, Amsterdam-Sloterdijk to Schiphol Airport (see figure 1). The reason to stop in the larger cities of Leeuwarden, Alkmaar and Zaandam is evident as the passenger potential of these cities is relatively large (see table 1). Not stopping would clearly hamper the profitability of the line.

The decision to stop at Drachten is based on the fact that Drachten does not yet have a railway station and has a passenger potential of about 130 thousand people. When offered an alternative for travelling by car, there is not much chance of substitution with existing railroads. Moreover, the alternative route over Buitenpost is already served with traditional rail. The decision not to assume a ML-station in Harlingen while passing it is based on opposite reasons. It already has a (regular) rail connection with Leeuwarden, whereas its passenger potential is small. Stopping would increase the travel time between other stations more or less unnecessary.

The choice for Schiphol Airport as the terminal station and not Amsterdam-CS is important. It implies that the Maglev is assumed to pass Amsterdam along the western side and to stop at Amsterdam-Sloterdijk instead of Amsterdam-CS. One reason is that the Sloterdijk/Schiphol combination promises far more passengers than just Amsterdam-CS. Another reason is the data and outcome comparability with the Zuiderzeeline study (Elhorst *et al.* 2000).

The final choice is not to pass the MLW by Schagen. This is based on the following evaluation. On the one hand, an extra station at Schagen will increase the line’s distance by 10 kilometres. This extra distance and the extra time necessary for accelerating, decelerating and stopping will produce an extra travel time of 7 minutes. This applies to all trips to and from a relevant population around the four stations in Friesland and Groningen of about 733 thousand (see table 1). On the other hand, an extra station at Schagen will reduce travel times for passengers to and from the North of North-Holland. Their alternative boarding station would be Alkmaar. This will increase their travel time by about 17 minutes, either by regular existing rail (from Den Helder, Anna Paulowna or Schagen) or by regular car (from all of the “Kop” of North-

Holland”). This time gain applies to the trips to and from a population of about 136 thousand. The percentage increase in travel time to and from the northern stations is smaller than the percentage reduction to and from the “Kop” of North-Holland”, but weighted with the population at hand there is a considerable difference in potential timeloss and timegain in favour of *not* stopping in Schagen.

The MLW-trajectory thus chosen runs along 207 kilometre. The schedule will be of a Metro type, i.e. six times per hour stopping in all five intermediate stations, to be as comparable as possible with its Maglev Zuiderzeeline competitor. A metro schedule leads to minimal waiting times at the intermediate stations and gives a total travel time Groningen-Schiphol of about 61 minutes as compared to 60 minutes for its ZZL competitor (see table 2 for details).

3 INDIRECT ECONOMIC EFFECTS: METHODOLOGY

3.1 Introduction and overview

There are two main indirect economic effects and two derived indirect economic effects, which will be estimated here (see figure 2). The two main effects both start with the exogenous changes in travel time (for details on the construction of the travel time matrices, see Romp & Oosterhaven, 2001).

The first main effect is related to the commuting behaviour of workers. With a fast rail link, commuters can choose dwellings with more room at lower prices with more green in the countryside further out, keeping their current jobs (housing migration). This will increase the demand for locally produced goods and services as a result of which a multiplier process is started that leads to subsequent shifts in regional production and employment (consumption-induced employment).

The second main effect is related to changes in economic activities that are brought about by transport cost reductions that make both imports and exports cheaper. Both consumers and producers will buy goods and services from firms and regions further away, while producers will sell their outputs to markets further away. Both consumers and producers can thus choose from a wider variety of suppliers, fitting their production and consumption needs better. The resulting shifts in economic activity (transport cost-induced employment) will then induce labour supply to move with the jobs (labour migration).

Next, the working of models used will be discussed in more detail as well as the way in which the effects are calculated. The latter is done sequentially such that the endogenous outcomes of the first model precisely serve as the exogenous input for the next model in a consistent way, without double counting the impacts.

3.2 Housing migration

Reducing travel times affects the commuting behaviour of workers. With faster transport they can relocate to regions that allow for more space in and around the worker's own house. Research shows that a majority of workers prefer this (Elhorst *et al.* 1999, VROM, 2000, Rouwendal & Meijer, 2001). Other research shows that the average commuting time does not change over time, while the distribution around the average is relatively stable (Hupkes, 1977, Zhavi & McLynn, 1983, SACTRA, 1999, p.118, Small & Gómez-Ibá az, 1999, p.1941). This implies that the percentage of commuters travelling a certain amount of time per day may be assumed constant in the longer run, which is the relevant timeframe when estimating indirect effects of infrastructure projects. These two basic assumptions are combined in a *commuter location model* that (re)allocates workers around fixed regions of employment. The approach is comparable to the assignment models used to allocate commuters to a transport network (see White, 1999). It is different in that the residential locations are not fixed.

Employment per region is determined outside the commuter location model. The workers are assigned to rings of regions further and further out around the region of employment, using a commuting travel time distribution table (for details, see Elhorst & Oosterhaven, 2002). The actual table uses the shares of workers travelling in 25 different time classes and three modes of transportation: car, public transport and slow transport. The latter distinction is made to capture the largest differences in shares between different time classes. In the lower time classes, the share of the slow transport is relatively large. In the higher time classes public transport and private cars dominate. The actual commuting time and mode matrix will not only capture the heterogeneity of the preferences of the working population with respect to commuting and transport mode, but indirectly also aspects related with them, such as the heterogeneity of housing preferences. Besides, the model also differentiates between the four largest municipalities, municipalities with a railway station and municipalities without a railway station. This second distinction is made because the commuting behaviour of people working in these different municipalities differs for supply reasons, such as differences in congestion levels and availability of public transport.

The actual commuter location model (CLM) allocates the working population of 548 municipalities of employment from the baseline projection for 2020 (E_{base}, see further TNO *et al.* 2000) to 548 municipalities of residence, both with the baseline peak hour times (T_{base}) and with the project-specific faster peak hour times of the MLW variant (T_{MLW}). The difference between the two allocations is the estimate of the (avoided) migration of the working population (ΔW) caused by the faster commuting times of the MLW:

$$\Delta W_{housing} = CLM(E_{base}, T_{MLW}, etc.) - CLM(E_{base}, T_{base}, etc.) \qquad (1)$$

It should be noted that an increase in the working population of a region compared to the baseline projection does not imply that workers actually are immigrating from another region. Most of the shift may be caused by *avoided* emigration already accounted for in the baseline projection. For example, students from Leeuwarden entering the job market will no longer move to e.g. Amsterdam, but will instead commute with the Maglev to Amsterdam, thus increasing the working population in Leeuwarden and decreasing that of Amsterdam compared to the baseline, without moving.

3.3 Employment due to travel time reductions

A new fast rail link also implies reductions of off-peak hour business and shopping travel times between several regions, both along and further out from the end of the line, which generally leads to lower cost or lower prices for products sold on markets further away. Thus, exports become cheaper, which leads to higher output and employment. On its turn this leads to a larger demand for intermediate inputs. Besides, a reduction of transport cost leads to lower prices for products from regions further away. Thus, imports become cheaper too and will partly substitute for more expensive local goods, which may lead to a reduction of production and employment. Other local producers that use these imports, however, can reduce their output prices and sell more. Besides these price and volume effects, geographically larger markets will also lead to an increase of supply of comparable products in all regions affected (variety effects).

The effects of faster infrastructure on production and location decisions of companies and the consumption decision of households will thus be complex. To estimate these effects a *spatial computable general equilibrium model* (SCGE model) is used. The actual model fits in the new economic geography line of research (see Fujita *et al.* 1999). In all these models the impact of geographically larger markets, and their subsequent price, volume and variety effects, are modelled by assuming increasing returns to scale, heterogeneous products and monopolistic competition per market (see Dixit & Stiglitz, 1977). The actual model extends the variant with intermediate sales between sectors first introduced by Venables (1996) (see also Bröcker, 1999). Our approach is new in that the transport cost function distinguishes between freight cost and travel time for households and business people. The actual model furthermore distinguishes 14 different sectors and 548 regions (municipalities). The trading relations between the production sectors in different regions are estimated with the recent Dutch bi-regional input-output data (RUG/CBS, 1999). For further details we refer to Knaap & Oosterhaven (2001).

The SCGE model computes the employment in all municipalities for the baseline projection for 2020 and the project-variant. The difference is used as an estimation of the transport-induced change in labour demand (ΔE_{SCGE}). The model baseline is used instead of the exogenous employment per municipality used in the calculation of the housing migration. In this way only the employment effects due to travel time reductions are measured, excluding possible forecasting errors of the SCGE model:

$$\Delta E_{SCGE} = SCGE\,(T_{MLW}, W_{base}, \text{etc.}) - SCGE\,(T_{base}, W_{base}, \text{etc.}) \qquad (2)$$

3.4 Labour migration

The above housing migration results from reduced travel times with a *given* employment per region. The SCGE model estimates the *changes* in employment per region. These employment changes of course also affect the size of the regional working population. The first effect has been labelled housing migration and the second effect is here labelled labour migration. The difference between the two lies in the migration motive; housing migration results from changes in travel times, labour migration results from changes in employment opportunities.

The residential locations of the labour migrants can and are also estimated with the commuter location model (CLM). To determine housing migration, the employment per region in the baseline projection was fixed in (1). To estimate labour migration we use the new employment per region due to the MLW-variant as calculated with the SCGE model in (2) (E_{SCGE}) holding the new commuting time matrices (T_{MLW}) constant, as follows:

$$\Delta W_{labour} = CLM\,(E_{base} + \Delta E_{SCGE}, T_{MLW}, etc.) - CLM\,(E_{base}, T_{MLW}, etc.) \qquad (3)$$

The *total* migration of workers per municipality as a result of the new rail link (ΔW_{total}), is simply calculated as the sum of both housing migration and labour migration. Consistency can easily be verified by adding (1) and (3). See figure 3 and table 3 for the outcomes.

3.5 Consumption-induced employment

The total migration of workers induces a regional redistribution of purchasing power within the Netherlands. A new rail link will also reduce consumption prices and increase the market reach of, especially, the top-services such as premier league football and opera. This will reduce the consumption-induced employment in regions with a less varied supply of services. This effect, the increase in service areas, is already incorporated in the production shifts of the Dutch SCGE model. This section deals with employment effect of the regional redistribution of purchasing power.

This last effect is not estimated at the level of the 548 municipalities as were the three earlier effects, but at level of the 40 so-called corop-regions with the aid of a 40x40 employment multiplier matrix of working migrants. This multiplier matrix is based on the bi-regional input-output tables of the 12 provinces of the Netherlands and the two mainports, Groot-Rijnmond (corop 29) and Groot-Amsterdam/NZKG (corops 20-23) (RUG/CBS, 1999, Eding *et al.* 1999). From these tables, 14 Type II intra-regional employment multipliers are calculated and 14 Type II interregional employment spillover effects with regard to the rest of the Netherlands (see Miller & Blair, 1985). The lacking intra-regional multipliers for the corop-regions were derived from a regression on the available ones at the provincial and mainport level. The lacking interregional spilovers at the corop-level were calculated through desaggregation of the available spilovers by means of second order distance decays (see Elhorst *et al.* 2000, or Oosterhaven, 2001, for further details).

The input-output multiplier matrix (IOM) is applied to the total migration of workers aggregated to the 40 corop regions, which gives the consumption-induced change in employment for the 40 corop regions (ΔE_{IOM}):

$$\Delta E_{IOM} = IOM\,(\Delta W_{housing} + \Delta W_{labour}) \qquad (4)$$

The *total* employment effect is calculated consistently as the sum of (2) and (4). See figure 3 and table 3 for the outcomes.

4 EMPIRICAL RESULTS FOR THE WESTERN MAGLEV VARIANT

Table 3 gives a quantitative summary of the estimated effects for the western Maglev variant across the Afsluitdijk (the MLW, see figure 1), with an aggregation of the corop-regions that are least affected. Figure 3 gives a view of the spatial distribution of the effects for all 40 corop-regions. More detailed results can be given, but in view of the uncertainty involved in these kind of estimations this is not justified.

Table 3 and figure 3 show that the main *housing migration effects* occur in the Alkmaar region and in Friesland. Besides a greater accessibility as regards the employment concentrations in the northern wing of the Randstad, the Frisian housing market also strengthens its accessibility as regards the employment in the city of Groningen. The latter occurs at the cost of the rest of the province of Groningen and northern Drenthe. The improvement of the accessibility of the Alkmaar region mainly regards the Amsterdam and Schiphol employment concentrations, and occurs at the cost of a deterioration of the relative accessibility of housing in the city of Amsterdam itself and in regions further to the south, such as Utrecht and South-Holland. Thus, the main housing migration impacts occur along the middle sections of the MLW-variant.

Interestingly, however, the main *travel cost-induced employment effects* occur at the ends of the new line. There the larger concentrations of firms get the largest improvement in accessibility as regards the larger population and employment concentrations. Although both consumers and producers in Groningen will buy more in the northern wing of the Randstad, the positive effect of increased accessibility on the output of firms in Groningen dominates. Producers in Groningen and also in Friesland will get better access to the largest market in the Netherlands (the Randstad region) and that gain far outweighs the loss of part of their local customers to firms in the Randstad. The effects at the other end of the line, within the province of North-Holland (NH), are not negligible either. Firms in NH not only will get better access to the smaller markets in the northern Netherlands, but they will also get better access to each other's markets.

These gains in absolute market access along the line, of course, result in a loss of *relative* access and competitiveness of firms in the rest of the Netherlands. They will loose market shares, both in the large market of the northern wing of the Randstad, but also in the smaller markets in the northern parts of NH and in the northern Netherlands. These losses will be largest in the regions close by, as these have the larger market shares to loose. Hence, we find the larger negative effects in Utrecht and Gelderland, and percentage-wise smaller negative effects in the southern Netherlands. Within the close-by province of South-Holland, the negative effects in the subregions with poor connections to Schiphol and the MLW just dominate the positive effects in the Rotterdam- and Leiden-regions that have good connections to Schiphol and the MLW. In the case of Rotterdam the good connection relates to its planned future direct high-speed rail to Schiphol (HSL-Zuid) that is part of the baseline projection in 2020.

The *labour migration effects* of course largely follow the spatial pattern of the employment effects (see especially figure 3). The main difference is that the (partly avoided) labour migration effects in Groningen and the Amsterdam region are considerably smaller than their employment effects. The reason is that not every labour migrant will want to live in these relatively crowded and expensive employment centres. In stead, partly using the MLW, they will spread out over the surrounding regions. This is why the labour migration effect in the "Kop" of North-Holland is +400, whereas its own employment effect is only +100. In the case of Drenthe the difference is even more remarkable. Its own main employment effect is negative due to the loss of its relative competitiveness, whereas its labour migration effect is positive due to the spill-over of labour migrants into especially the northern part of this province (see figure 3).

The *consumption-induced employment effects* of course follow the pattern of total (partly avoided) migration. Naturally, in terms of jobs, the consumption effects are smaller than the number of migrating workers that cause these effects. The spatial pattern is also a little different as consumption expenditure effects spill over into surrounding regions and have a tendency to concentrate in the regions with the relatively larger shopping centres. This is most clear in the case of the Amsterdam-region. This region has a negative net migration effect, but due to consumption spillovers from migrants into adjacent regions, it has a positive “shopping” effect. In the Alkmaar- and the greater Zaan-region almost the opposite happens. They receive large numbers of migrants, but only capture a relatively small part of their consumption expenditures.

Finally, it is of interest to briefly look at the total migration and total employment effects, which will be the base for the qualitative comparison in the next section. The total migration of workers is relatively largest for the small Alkmaar region (+5000) and absolutely largest for the province of Friesland (+7000). To get the impact on *total population*, the number of working migrants has to be multiplied with the future average household size corrected for double-income earners. Hence, the population effects will be roughly *twice as large* as the migration numbers in table 3. Clearly, for total population the effects are larger in the middle sections of the new line than at the end of the line. The opposite is the case the impact on *total employment*. This hold especially for the northern end of the MLW in Groningen and Friesland, but also for its southern end where the largest effects are found in the Amsterdam-region (see also figure 3).

5 QUALITATIVE COMPARISON OF ALL SIX AFSLUITDIJK VARIANTS

Table 4 contains a qualitative comparison of all six variants for a rail link across the Afsluitdijk (see figure 1). The scores result from down-scaling the total effects of the MLW-variant with the lower speeds and the different locations of the stations of the other variants. Besides reckoning with speed and trajectory differences, use has been made of the differences between the impacts of comparable variants from the Zuiderzeeline study (i.e. between ZIC, ZHS and MZM in Elhorst *et al.* 2000). Extrapolating from this experience, however, was not straightforward, as the length of the new tracks is much smaller. In the case of the Zuiderzeeline IC- and HS-variants, new tracks run over 115 km from Lelystad all the way to Groningen. In the case of the Afsluitdijk new tracks are restricted to 71 km between Harlingen and Hoorn in the case of the eastern variants, and to almost the same distance plus the small 12-km stretch from Alkmaar south along the A9 in the case of the western variants.

This smaller length of new tracks and the consequently smaller time gains dominate the differences between the impacts for the Maglev variants, and the impacts for the IC- and the

HS-variants. For Groningen and Friesland the down-scaling of impacts needed to be smaller as they benefit more from the new tracks than the regions in the province of North-Holland (NH). Groningen and Friesland still get a faster rail connection to the economically heavy Amsterdam-region, but the regions within NH using the IC- and HS-variants only get a better access to the economically lighter weight Northern Netherlands.

The exceptions to the general size-relations between the impacts described above are only few. In the case of the western route we expect the HS-variant to still have slight positive population effects in the case of the North of NH and the Alkmaar-region due to the better access of their housing markets for commuters from the Amsterdam area. For the eastern HS-variant, this of course only applies to the North of NH and not to the Alkmaar region. Furthermore, these small positive effects only hold for population and not for employment. In the case of employment only the Amsterdam-region profits measurably from the better access to northern firms and consumers, both because of the own size of its economy and because of the variety of the supply of its services.

Finally, there will of course be important differences between the western and the eastern variants. These are most clear when the two Maglev variants are compared. The MLE will induce effects in the Hoorn/Purmerend region, whereas the MLW will induce effects in the Alkmaar region. In the case of housing and labour migration, the effects in these two eastern cities will be more of less comparable in size with the +5000 for the Alkmaar-region (see table 3). In the case of employment, the effects will be smaller and less comparable. We do not expect sizeable employment effects for Hoorn/Purmerend and relatively small effects for the Alkmaar region (+1700, see table 3). In the case of the slower IC- and HS-variants, there will be no significant differences between the eastern and the western variants within North-Holland since mainly existing tracks will be used.

6 AFSLUITDIJK VERSUS ZUIDERZEELINE MAGLEV VARIANTS

As noted in the introduction, the official alternatives for a rail link between the Randstad and the North all run through the province of Flevoland, part of the former Zuiderzee. Of the official alternatives, the magnetic levitation system with a metro schedule is favoured by regional and local authorities as it promises the largest indirect employment and population effects (see the MZM-variant in Elhorst *et al.* 2000). This alternative has a projected frequency of six trains per hour, runs from Schiphol to Groningen and has six intermediate stops (see figure 1 and table 2). By design our Afsluitdijk MLW is most comparable with the official ZZL Maglev Metro proposal, except for its different trajectory. This makes a comparison not only politically interesting, but also geographically as most intermediate stops are located in quite different regions.

In table 5 the differences between the Afsluitdijk MLW and the ZZL Maglev are shown. As could be expected, the Afsluitdijk MLW is more positive for the regions in the province of North-Holland. With the MLW, they represent attractive housing options for employees from the northern wing of the Randstad, while their accessibility gain results in an increase in relative competitiveness, production and employment. Especially the Alkmaar-region benefits from a much faster connection with Amsterdam, resulting in an increase of its working population of 5,000 instead of a loss of 350 with the ZZL Maglev. The employment raises to 1,700, whereas in the MZM-variant there is a loss of also 350.

More surprising is the difference in gain in the northern part of the Netherlands. Although the ZZL Maglev also connects these regions with the Randstad better, this region as a whole gains more by the implementation of the Afsluitdijk MLW. The province of Groningen for instance attracts 2,600 more employees and 1,500 more jobs than with the ZZL Maglev. Even for the province of Drenthe, which is not directly linked-up by the Afsluitdijk MLW, the result is clear-cut. This province attracts 1,000 more employees, and 700 more jobs compared to the ZZL Maglev.

The explanation of this remarkable difference is found in the Province of Flevoland. For the northern Netherlands this is a more serious competitor on the markets in the northern wing of the Randstad than the Alkmaar- and the Zaan-regions. Flevoland clearly gains from the ZZL Maglev, especially in term of working population (+13,000), but also in term of employment (+4,200). In the case of the Afsluitdijk MLW it looses these gains not only to the Alkmaar- and Zaan-regions, which have a comparable spatial position to Amsterdam, but also to the northern Netherlands, which is located further away, but nevertheless picks up part of the loss of Flevoland.

Comparable, but much smaller effects hold for Gelderland, South-Holland, Utrecht (and Gooi) and the rest of the Netherlands.

7 CONCLUSION AND CAUTION

It should be noted that all above results are subject to a series of qualifications (see Elhorst *et al.* 2000, for details). The housing migration results may represent an over-estimation, as the Dutch commuter location model does not yet take the probably higher ticket prices into account. The employment results, on the other hand, most probably represent an under-estimation as the Dutch SCGE-model does not yet take agglomeration economies into account.

Evidently, only looking at the size of the indirect employment and population effects, the Maglev variants are to be preferred above the intercity and the high-speed rail variants. Looking only at these effects, the only choice seems to be that of the trajectory. When the economic development of the North is the main objective, the conclusion is clear: the Afsluitdijk trajectory is to be preferred above the official Zuiderzeeline trajectory. The present analysis, however, is too feeble to come to a conclusion when comparing the western with the eastern Afsluitdijk trajectory.

Furthermore, it should be noted that the indirect economic effects, although important, only represent one of the many effects of new infrastructure. In fact, the indirect effects studied here mainly relate to the interregional re-distribution of jobs and people. Whether or not this redistribution is such that a *net* national employment or output effect occurs is not studied here. Also the investment and environmental cost are not taken into consideration here. One thing is sure, however, the Maglev variants produce by far the largest indirect effects, but they are also by far the most expensive in terms of investment cost. Hence, a serious conclusion can not be drawn without an integral social cost-benefit analysis (cf. Elhorst & Oosterhaven, 2001, for a cost-benefit analysis of the ZZL, see SACTRA, 1999, CPB/NEI, 2000, for transport CBA in general). Crucial inputs for such an analysis, however, has to come from the type of integral indirect impacts approach developed in this article.

ACKNOWLEDGEMENTS

This article is an offspring of a research project commissioned by “Kop en Munt” (Economic Development Initiative for the North of North-Holland) with the support of the Province of North-Holland and Novem (Netherlands’ Initiative for Energy and the Environment). See Romp & Oosterhaven (2001) for the full report. We thank three anonymous referees for their constructive criticism.

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Table 1. Passenger potential per station.

Station	Potential[1]	Station	Potential[1]
Schiphol Airport	472,567	Schagen[2]	136,201
Amsterdam-Sloterdijk[3]	430,468	Harlingen[2]	47,246
Amsterdam-CS[3]	382,914	Leeuwarden	191,071
Zaandam	282,115	Drachten	128,915
Alkmaar	284,793	Groningen	365,982

1. Calculated as the total population of the municipalities within 10 kilometres. When a municipality is within 10 kilometres of two or more stations its population is added to the most accessible station.

2. The values for Schagen and Harlingen are calculated as *marginal* values. The *total* values are a little higher since their service areas overlap with the areas of Alkmaar and Leeuwarden.

3. The values for Amsterdam-CS and Amsterdam-Sloterdijk are the numbers of passengers that prefer that station. When either CS or Sloterdijk is chosen, that station takes the total of both as its potential.

Table 2. The MLW across the Afsluitdijk compared with the Zuiderzeeline Maglev.

From:	To:	Distance (km.)	Travel time (min.)
Schiphol	A'dam-Sloterdijk	12	7
A'dam-Sloterdijk	Zaandam	7	7
aandam	Alkmaar	26	10
Alkmaar	Leeuwarden	105	21
Leeuwarden	Drachten	26	9
Drachten	Groningen	31	7
	Total MLW Afsluitdijk	207	61
Schiphol	A'dam-WTC	9	5
A'dam-WTC	Almere	31	11
Almere	Lelystad	24	9
Lelystad	Emmeloord	33	10
Emmeloord	Heerenveen	37	9
Heerenveen	Drachten	19	7
Drachten	Groningen	33	9
	Total Zuiderzeeline	186	60

Table 3. Indirect economic effects per region for the western Maglev variant (MLW).

Region (corop-numbers)	Housing migration	Labour migration	Total* migration	Trp. cost induced employ.	Consum. induced employ.	Total* employ.
North of North-Holland (18)	-300	400	150	100	50	150
Alkmaar region (19)	4,400	700	5,000	1,000	700	1,700
Greater Zaan region (20-22)	400	800	1,200	800	200	1,000
Greater Amsterdam (23)	-2,300	2,000	-250	2,900	150	3,100
Groningen (1-3)	-300	3,200	2,900	4,200	600	4,800
Friesland (4-6)	4,300	2,600	7,000	2,600	1,400	4,000
Drenthe (7-9)	-600	150	-400	-600	-50	-700
Overijssel (10-12)	-50	-1,700	-1,700	-1,900	-300	-2,200
Gelderland (13-16)	-500	-3,800	-4,300	-3,600	-800	-4,400
Flevoland (40)	-700	-400	-1,100	-500	-150	-600
Utrecht and Gooi (17+24)	-3100	-1700	-4800	-2600	-800	-3400
South-Holland (25-30)	-1200	50	-1100	-50	-250	-300
Southern Netherl. (31-39)	-150	-2,500	-2,600	-2,500	-600	-3,000

* Because of rounding off the effects individually, the separate effects do not always add up to the total.

Table 4. Qualitative effects of all six Afsluitdijk variants.

Population effects	ICW	HSW	**MLW**[1]	ICE	HSE	MLE
North of North-Holland	0	0 / +	**0**	0	0 / +	0
Alkmaar region	0	0 / +	**+ +**	0	0	0
Hoorn & Purmerend[2]	0	0	**0**	0	0	+ +
Zaanstreek, IJmond & Haarlem	0	0	**0 / +**	0	0	0 / +
Greater Amsterdam	0	-	**0**	0	0 / -	0
Groningen & Friesland	+	+ +	**+ + +**	+	+ +	+ + +
Rest of the Netherlands	-	- -	**- - - - -**	-	- -	- - - - -
Employment effects	**ICW**	**HSW**	**MLW**[1]	**ICE**	**HSE**	**MLE**
North of North-Holland	0	0	**0**	0	0	0
Alkmaar region	0	0	**0 / +**	0	0	0
Hoorn & Purmerend[2]	0	0	**0**	0	0	0
Zaanstreek, IJmond & Haarlem	0	0	**0 / +**	0	0	0 / +
Greater Amsterdam	0	0 / +	**+**	0	0 / +	+
Groningen & Friesland	+	+ +	**+ + +**	+	+ +	+ + +
Rest of the Netherlands	-	- -	**- - - - -**	-	- -	- - - -

1. The results in this column correspond to table 3. The other columns are derived from this one.

2. Hoorn & Purmerend are taken from, respectively, the corop-regions 18 & 23 (see table 3).

Table 5. Total effects of the Afsluitdijk (MLW) and the Zuiderzeeline (ZZL) Maglev variants.

Region (corop-numbers)	Total migration effects			Total employment effects		
	MLW	ZZL	Differ.[2]	MLW	ZZL	Differ.[2]
North of NH (18)	150	-600	750	150	-450	600
Alkmaar region (19)	5,000	-350	5,400	1,700	-350	2,100
Greater Zaan region (20-22)	1,200	-2,000	3,200	1,000	-650	1,700
Greater Amsterdam (23)	-250	-450	200	3,100	2,200	900
Groningen (1-3)	2,900	250	2,600	4,800	3,300	1,500
Friesland (4-6)	7,000	5,000	1,800	4,000	2,000	2,000
Drenthe (7-9)	-400	-1,400	1,000	-700	-1400	700
Overijssel (10-12)	-1,700	-2,600	900	-2,200	-2,500	300
Gelderland (13-16)	-4,300	-4,100	-200	-4,400	-3,800	-600
Flevoland (40)	-1,100	13,000	-14,000	-600	4,200	-4,800
Utrecht and Gooi (17+24)	-4,800	-3,600	-1,200	-3,400	-1,400	-2,000
South-Holland (25-30)	-1,100	-700	-400	-300	950	-1,300
Southern Netherl. (31-39)	-2,600	-2,500	-150	-3,000	-2,200	-800

[1] ZZL effects are taken from the MZM-columns in tables 4.2 and 5.3 of Elhorst (et al. 2000)

[2] Because of rounding, this column may not precisely match the difference between the other two.

Figure 1. Trajectories of the six Afsluitdijk-variants and the Zuiderzeeline

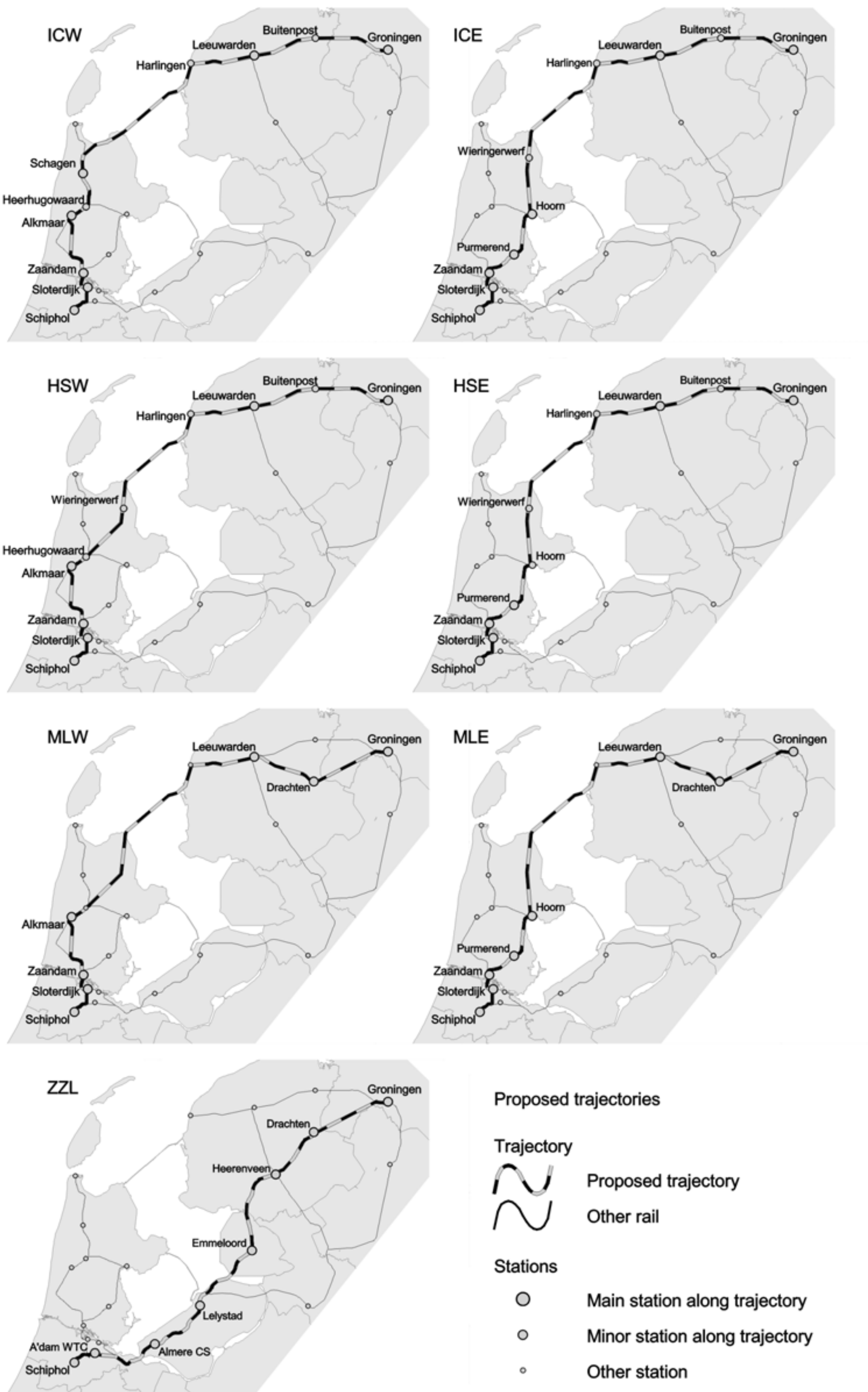

Figure 2. The relationship between the different indirect economic effects.

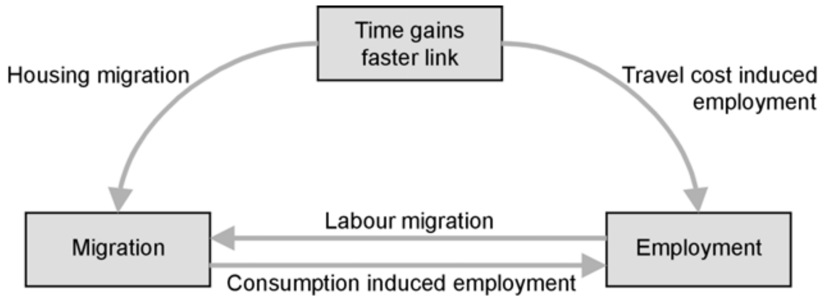

Figure 3. Indirect effects of the western Maglev variant across the Afsluitdijk (MLW), per corop-region