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On the development of raem: The dutch spatial general equilibrium model and it's first application to a new railway link

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**ON THE DEVELOPMENT OF RAEM:
THE DUTCH SPATIAL GENERAL EQUILIBRIUM MODEL
AND ITS FIRST APPLICATION TO A NEW RAILWAY LINK**

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ABSTRACT

This paper describes the development of a spatial computable general equilibrium model aimed at estimating the indirect economic effects of major transport infrastructure projects on Dutch regions. The RAEM model is based in the so-called new economic geography literature. It employs monopolistic competition for fourteen sectors as the basic market form, and calibrates most of its coefficients on recently constructed bi-regional input-output tables for the Netherlands. The general outline of the model is described and the way it fits in with evaluation schemes presently adopted by the Dutch government and the European Commission. A first version of the model has been applied to a base scenario for the year 2020 and has been used for evaluating the indirect economic effects of a new railway link between Amsterdam and Groningen. The paper describes the results of this exercise and discusses the way the RAEM model will be developed further in the near future.

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1. INTRODUCTION

In many countries procedures have been developed for transportation project evaluation (see i.e. Morisugi and Hayashi, 2000). In the Netherlands up to very recently such a standardized method did not exist. In 2000 the Dutch Minister of Transport published a guideline (Eijgenraam et al, 2000) for the evaluation of infrastructure projects, based on the results of a study in which a number of Dutch research institutes combined their common knowledge and experience in this field.

This guideline (abbreviated as the OEEI guideline) describes the way external and internal effects, direct and indirect effects of transport infrastructure projects can be estimated. In some fields such as the description of indirect economic effects this guideline is rather vague because at present we lack a model that adequately describes these indirect effects. It is indicated that the best way to fill in this gap is by building a spatial equilibrium model. It is argued (see Oosterhaven, Sturm and Zwaneveld, 1999) that the spatial computable general equilibrium models (SCGE models) is a more promising alternative in comparison with existing interregional infrastructure and land use- transportation models (LUTI).

In this paper we will first summarise the present methods available for evaluating major infrastructure improvements (section 2) and compare the SCGE model with other models (the LUTI model especially). The general structure of such a model is described in section 3, before we present the first results of an application for the evaluation of the indirect effects of a new infrastructure link in the Netherlands in section 4. In section 5 it is indicated how we plan to develop this model further.

2. PRESENT METHODS FOR EVALUATING INFRASTRUCTURE

When considering the economic effects of transport infrastructure, first, one has to make a distinction between direct and indirect effects, temporary and permanent effects, and market and non-market or external effects (see Table 1).

Table 1. Type of effects of transport infrastructure investments.

		Temporary	Permanent
Direct	via markets:	Construction effects	Exploitation and time saving effects
	external effects:	Environmental effects	Environmental, safety etc. effects
Indirect	via demand:	Backward expenditure effects	Backward expenditure effects
	via supply:	Crowding-out effects	Productivity and location effects
	external effects:	Indirect emissions	Indirect emissions etc.

Temporary economic effects will occur during construction, both directly and through demand effects also indirectly. Less discussed, but equally important, are indirect supply or crowding-out effects, both through the capital market as a consequence of the need for finance and through the labour market as a consequence of drawing on specific spatial and occupational segments. Besides temporary economic effects, there will be direct temporary external effects, such as noise and environmental disturbances during construction activities, and indirect temporary external effects, such as emissions due to backward economic effects (far) away from the actual construction sites.

Permanent direct economic effects of course include exploitation cost, and transport cost and time benefits for people and freight. These user benefits, mostly, are the prime reason for investing in infrastructure projects. When that is the case, one speaks of a *passive infrastructure policy*, meaning that investments primarily follow the growing demand for transportation, where it occurs, and attempt to avoid or mediate the costs of congestion. Passive infrastructure policy decisions typically will be made only on the basis of a positive net national total of users' benefits minus investment, exploitation and external cost.

Besides direct effects, there will of course also be permanent indirect economic effects. First, these relate to the backward expenditure effects of the exploitation and use of infrastructure. Second, these relate to the so-called programme or *induced effects*, which are defined as the consequences of the reduction in transport cost for production and location decisions of people and firms, and the subsequent effects on income and employment of the population at large (Rietveld and Nijkamp, 2000). Naturally, these supply-driven effects will on their turn also have demand effects.

When attaining these cost-induced effects is the main objective of investing in infrastructure, one speaks of an *active infrastructure policy* that tries to influence location and production decisions of firms and thus tries to induce private investments. Besides, hopefully, a positive net national total of benefits and cost, active infrastructure policy decisions typically will be made either on the pattern and the size of the regional re-distributive effects and/or on the expected size of the national generation effect.

Besides these permanent economic effects there will of course also be permanent effects that are external to the market, such as noise, safety, emissions and environmental disturbances (see Rothengatter, 2000). Moreover, the indirect economic effects also cause indirect external effects that need to be incorporated in the analysis when a fair valuation of investments in alternative transport systems is concerned (see e.g. Bos, 1998, for the indirect energy use and emissions of different freight transport systems).

There is a large amount of literature on the economic impacts of infrastructure (see Blonk, 1979, Vickerman, 1991, Rietveld van Bruinsma, 1998, for overviews) as well as a large variety of methods to estimate these impacts (see Oosterhaven, Sturm and Zwaneveld, 1998, Rietveld and Nijkamp, 2000, for overviews). The methods most used are the following:

- micro surveys with firms,
- estimations of quasi production functions,
- partial equilibrium potential models
- macro and regional economic models,
- land use/transportation interaction (LUTI) models, and
- spatial computable general equilibrium (SCGE) models.

We will concentrate on the last 2 because they are considered to be the best suited to indicate the effects of major infrastructure projects that a likely to have an impact of the economic structures in a given area (Oosterhaven & Knaap, 2000).

LUTI models consist of linked transportation models and "land use" or better location models. They mostly employ a system dynamics type of modelling and are primarily developed to predict future growth and to analyse policy scenarios for large urban conglomerations. There is a whole series of such models for different conglomerations. LUTI models have a decades long history of gradual development and are nowadays typically very disaggregated with numerous spatial zones, sectors, household types, transport motives, modes of transportation, etc. (see DSC/ME&P, 1998, Wilson, 1998, for overviews).

SCGE models typically are comparative static equilibrium models of interregional trade and location based in microeconomics, using utility and production functions with substitution between inputs. Firms often operate under economies of scale in markets with monopolistic competition of the Dixit-Stiglitz (1977) type. The few empirical applications of this approach are Venables and Gasiorek (1996) and Bröcker (1998). Interesting theoretical simulations with a SCGE model with a land market are found in Fan (et al. 1998). A recent Dutch application will be discussed in the next section. These models are part of the new economic geography school (Krugman, 1991, Fujita, Krugman and Venables, 1999) and have been around for less than a decade. In other words, we are comparing a mature methodology, possibly at the end of its life cycle, and a new methodology that is still in its infancy.

The practical feasibility of LUTI models is large, which for a mature methodology with heavy investments in its empirical implementation is not too surprising. Especially the transportation sub-models are known to be rather adequate in estimating all kinds of transportation price and quantity impacts of policy measures in the transportation sector itself. Given the scientific uncertainty around the location behaviour of firms, this does not hold to the same degree for the impact of transport measures on the location of firms. In view of the decrease of the relative cost of freight transportation over time, this is not too surprising. The relative cost of passenger transportation, however, has been increasing over time, mainly because of the increase in time costs due to increases in congestion and increases in real income. For this reason, the location of service activities can be explained much better than the location of industrial activities. As the location of most service activities primarily follows that of people and industrial activities, it mainly plays a role on the intra-urban level.

Consequently, the power of LUTI models in estimating the interregional location effect of transport measures is much less than that of estimating the impact on intra-urban location decisions, let alone the impacts within the transport sector itself that are generally covered quite well. Besides, LUTI models in general, but especially the land use sub-models, traditionally contain many fixed input-output and other type of ratios and prices. Hence, the estimation of the (location) impacts of new transport infrastructure becomes especially unreliable when major projects or far-reaching measures are at hand.

Finally, most LUTI models are not well able to translate the estimated impacts of transport and infrastructure measures into estimates of consumer benefits, as is needed in a sound welfare theoretically underpinned cost-benefit analysis (CBA). This ability mainly depends on how consumer and producer behaviour is modelled and estimated. In the best LUTI models consumer choices relating to transportation and location decisions are usually modelled and estimated by means of a discrete random utility approach. Producer location decisions,

however, are seldom modelled by means of discrete profit maximising behaviour, whereas producer production and price decisions are practically always modelled using some kind of fixed ratios. As a consequence, most LUTI models will provide reasonable estimates of transport user benefits. Sometimes they will provide reasonable estimates of consumer benefits in as far as the latter are based on discrete choice behaviour. The existing LUTI models, however, are not able to estimate transport benefits that are based on continuous consumer choices or discrete and continuous producer choices.

SCGE models, typically, are theoretically well suited for this evaluation task (see also Venables & Gasiorek, 1998). The SCGE modelling problem, at the moment, is not theoretical in nature, but empirical and computational. The consistent estimation of all the necessary consumers' and producers' substitution elasticities is problematic, if only because of the lack of adequate data and the lack of a tradition of estimating such elasticities at the regional level. Moreover, the calibration of these models such that they reproduce recent history and simultaneously provide plausible (i.e. stable) projections is problematic too, especially because of the highly non-linear character of the behavioural equations.

Whether LUTI models can easily incorporate imperfect markets, and internal and external economies or diseconomies of scale, is doubtful. The strength of most LUTI models lies in their segmentation and detail, i.e. they usually contain many different zones, transport modes, households type, firms type, and so on. The benefit of having such detail lies in the homogeneity of behaviour and the assumed stability of relations at that level. But this detail is achieved at the cost of mathematical and theoretical simplicity, such as perfect competition, absence of scale economies, fixed ratios and linear relations.

The present, still young SCGE models have opposite properties, namely a lack of detail and sound empirical foundation, but a sophisticated theoretical foundation and rather complex, non-linear mathematics. The latter is precisely the reason why SCGE models are able to model (dis)economies of scale, external economies of spatial clusters of activity, continuous substitution between capital, labour, energy and material inputs in the case of firms, and between different consumption goods in the case of households. Moreover, monopolistic competition of the Dixit-Stiglitz type allows for heterogeneous products implying variety, and therefore allows for cross hauling of close substitutes between regions. Finally, SCGE models lead to a direct estimation of especially the non-transport benefits of new infrastructure, which is absent in most LUTI models.

Whether a further piecemeal improvement of the theoretically handicapped, but in practice successful LUTI models is preferable to the implementation of a theoretical superior, but yet untested alternative, is essentially a matter of taste and belief. DSC/ME&P (1998) confess to the piecemeal improvement strategy. The further segmentation they call for may be necessary for the "best" estimation of the impacts of transport policies, but it is not sufficient for the "best" estimation of the transport benefits as in a CBA. The latter requires modelling, not only of discrete choice, but also of continuous responses of consumers and producers based on, respectively, utility maximising and profit maximising assumptions. Our experience in model-building tells us that the introduction of additional causal mechanisms or additional actors produces much more differences in the outcomes than a further differentiation of already present relationships and actors. We would rather like to stress the potentially dead-end

character of that approach, and would like to advocate the more promising but also more risky start of empirically based SCGE modelling.

Two problems, however, remain to be discussed. LUTI models are inherently more dynamic than the comparative static SCGE models. The latter, for the moment, are only able to compare the outcomes of different equilibrium states, such as:

- Benefits of generalised transport cost reductions due to changing prices, production, consumption and trade, while holding the number of firms and the number of workers per region constant; showing what could be labelled as the *short-run* effects.
- Benefits of transport cost reductions when the number of firms per region is allowed to change; showing *medium term* effects.
- Benefits when the number of workers is allowed to change too; showing the *long-run* effects of new transport infrastructure.

A truly dynamic SCGE approach is possible but raises a whole new series of issues (see Knaap and Oosterhaven, 2000).

3. DESCRIPTION OF THE BASIC FORM OF RAEM

In this section we present the basic form of the spatial equilibrium model RAEM that we have developed and applied in the Netherlands. The model is still under construction but in its basic form it can be seen as a good example of the SCGE models discussed in the previous section.

In the RAEM model we assume that all markets are of the monopolistic competition type and each firm in each industry produces one and only one variety of the product of that industry. In all production and utility functions the varieties x_i are added to an aggregate Q_j with the following CES-function (see Dixit and Stiglitz, 1977):

$$Q_j = \left(\sum_{i=1}^n x_i^{1-1/s} \right)^{1/(1-1/s)} \quad (4)$$

In (4) s represents the elasticity of substitution among the n different varieties of industry j . All utility and production functions have a Cobb-Douglas specification. The production function only uses intermediate inputs and labour:

$$Y_j = L_j^a \left(\prod_{i=1}^m Q_i^{g_i} \right)^{1-a} \quad (5)$$

In (5) parameter a controls the division between labour and the total of the intermediate inputs and g_i gives the relative weight among the intermediate inputs from different sectors.

In the equilibrium all prices are a function of all other prices. In this solution the complement of the quantity aggregate (4) is the following price index function:

$$G_j(p_{1j}, \dots, p_{nj}) = \left[\sum_{i=1}^n p_{ij}^{1-s} \right]^{1/(1-s)} \quad (6)$$

In (6) p_{ij} is the price of variety i in sector j . This price index varies across different regions, as these purchasing prices are inclusive of the transport and communication cost of delivering the product.

In the monopolistic competition equilibrium, prices are a mark-up over marginal costs, including the transport costs. Thus, the way in which transport costs are included in the prices is decisive for the functioning of our model. We have followed standard practice and introduce transport costs as a mark-up over the regular f.o.b. price. Specifically, in view of the problem at hand, RAEM uses a new bi-modal (people/freight) transport cost mark-up:

$$p^* = [f_g(d_g)]^p \cdot [f_p(d_p)]^{1-p} \cdot p \quad (7)$$

In (7) p gives the importance of freight transport for the transportation costs of the sector at hand. Information on this parameter proved to be scarce. Hence, expert judgement was used to 'guestimate' the 14 sectoral p 's needed. In (7) f follows the usual specification of *iceberg* transport cost (see e.g. Bröcker, 1998):

$$f(d) = 1 + J \cdot d^w \quad (8)$$

In (8) u and w are parameters to be estimated and d is the distance between the producer and the customer. For freight, simple road kilometres used as distances do not change in the application. A new railway link is modelled as a decrease in 'people-distance' d_p .

4. RESULTS OF RAEM TO EVALUATE DUTCH RAIL PROPOSALS

Some of the capabilities and problems of SCGE models may be illustrated with the recent construction and application of such a model to evaluate six alternative Dutch rail projects (see Elhorst et al 2000, for the whole study).

Early 2001 the Dutch government will decide how the relatively rural Northern Netherlands (containing the provinces of Groningen, Friesland and Drenthe) will get a faster rail connection to the heavily urbanised Randstad (containing the cities of Rotterdam, the Hague, Amsterdam and Utrecht, and their connecting surroundings). The faster rail connection should run through the new reclaimed land-province of Flevoland, which used to be part of the former Zuiderzee. At present the rail connection between Groningen City and Schiphol Airport runs around the former Zuiderzee. Hence, rail travel distances and time will be shortened considerably, but car distances and time will hardly change as even a doubling of the modal share of rail will reduce the modal share of cars only little. The six different rail alternatives are summarised in Table 2.

Table 2. Description of the rail variants and their travel times Groningen-Schiphol (in minutes)

REF	Reference scenario or zero-alternative, including the so-called Hanzeline from Lelystad to Zwolle, which is not yet constructed	118
HIC	Hanzeline intercity, the only difference with REF is its higher speed	102
HHS	Hanzeline high speed, including rail shortcuts and a TGV only calling at major stations	71
ZIC	Zuiderzeeline intercity, a new rail track from Lelystad to Groningen with conventional trains	89
ZHS	Zuiderzeeline high speed, as ZIC but including a TGV only calling at three major stations	65
MZM	Transrapid metro, a new magnetic levitation rail system from Schiphol to Groningen calling at all 6 intermediate stations 6 times per hour	59
MZB	Transrapid high speed, as MZM but calling at the 6 stations 2 times, at the 3 major stations 2 times, and running a shuttle 2 times from Schiphol to Almere in Flevoland	45

For details on the Dutch SCGE model (RAEM) model we refer to Knaap and Oosterhaven (2000). Here we will discuss only some of its most salient features and some of the problems in its implementation and application.

RAEM models demand, output and trade of 14 industries in 548 municipalities with one (presently) immobile household sector. For people, transport costs vary between the infrastructure variants (see Table 2). The travel times between municipalities are a weighted average between times for cars, slow traffic (bikes etc.) and public transport. In the simulations only the last travel times change, along with the modal shares. Both types of changes were derived outside RAEM from an existing transport model (LMS, see NEI, 2000, Elhorst et al, 2000).

The estimation and calibration of RAEM proved to be complicated: a situation that is quite common with both spatial and non-spatial CGE models. In fact, three types of parameters were used:

- Parameters ‘guestimated’ by experts. These include (per sector) the relative importance of freight as compared to transport of people, the weight of non-transport location factors as compared to transport cost, and share of non-tradeables per industry.
- Parameters derived from recent Dutch bi-regional input-output tables (RUG/CBS, 1999). These include the input cost shares for industrial sectors and household sector per region.
- Econometrically estimated parameters. The latter include all substitution elasticities and the remaining parameters of the transport cost functions.

The econometric estimation was done for all 18 unknown parameters simultaneously. They were chosen to minimise the sum of squared differences between actual and the predicted log-trade flows between regions. The estimation uses the 588 observations on trade flows that could be derived from the IO tables (namely 3 flows, on exports, imports and intra-regional deliveries, for 14 sectors in 14 regions).

The results indicate the following: when all transport costs relate to freight, prices rise with 21% after 100 km. When all transport relates to people, prices rise by 15% after 100 minutes of travel. With an average elasticity of 12, total sectoral output halves after 21 km of freight transport and after 22 minutes of people transport.

After estimating all parameters, RAEM was calibrated on a projection of the Dutch economy for the reference EC-scenario in 2020 (CPB, 1997), introducing an ‘unexplained productivity’ parameter per sector per region to make sure the calibration and the reference scenario were exactly the same. Not surprisingly, these parameters were especially high for service industries, since SCGE models as yet are not capable of projecting structural shifts in industry shares per region.

Besides, this first Dutch SCGE model had to interact with a labour migration model and an IO expenditure model for labour migrants (see Elhorst et al. 2000). Consequently, certain variables such as population and the number of firms had to be kept constant. This, unfortunately, meant that (internal) scale economies and (external) cluster economies could not be detected yet. Only the *short run* responses were estimated. Tables 3 and 4 show a summary of the outcomes.

First, Table 3 shows the spatial redistribution of jobs over the Netherlands after executing each of the variants separately. Regions at the end of the line (the Randstad and the North) together with the region along the line (Flevoland) profit at the cost of the rest of the country. The rest of the country experiences a relative deterioration in its competitive position, especially with respect to the economically largest market in the West of the country. Clearly the effect of speed is decisive, but also the trajectory of the variant plays a role. The Hanzeline variants HIC and HHS only increase the speed along an almost unchanged trajectory. Hence, especially the economic core area (the Randstad) hardly profits from this improvement, whereas it profits clearly more from the four other variants that involve new trajectories to the North.

The aggregate outcomes in Table 3 hide a substantial redistribution of jobs at the lower spatial level of the 40 regions shown. The underlying material at the level of 14 sectors and 548 municipalities, of course, even shows larger differences. From this last material, for instance, it can be deduced that the bulk of the employment effect in the North relates to the services sector in the city of Groningen, where the new line would terminate. This is not too surprising as only business travel times improve, while Groningen is by far the largest (service) city in the North and also enjoys the largest %-gain in travel time to the largest sub-market of the Netherlands, that is the Randstad. Other sub-regions in the North, such as those to the east and south of the city of Groningen, in fact, show negative employment effects as their relative competitive position deteriorates compared to northern cities closer along the new infrastructure.

Table 3. Change in jobs per region per infrastructure variant compared to REF (EC-scenario 2020).

Δ Jobs	HIC	HHS	ZIC	ZHS	MZB	MZM
Northern Netherlands	650	1800	900	2000	3500	3100
Randstad	250	400	1200	1800	2200	2500
Flevoland	350	600	400	900	2100	2500
Rest of the country	-1250	-2900	-2500	-4700	-7800	-8100

Besides these regional (re-distributive) effects, there are also important national (generative) effects, shown in Table 4. This is a little surprising, as economies of scale are not yet allowed. There is a minimal decrease in national employment (not shown), because labour becomes relatively more expensive compared to total intermediate inputs. Total output, however,

increases as savings in transport costs lead to lower prices and more demand. Most of the lower prices are passed on to consumers who also enjoy their own direct transport cost savings, which result in an overall reduction of consumer prices (CPI).

Besides lower prices, consumers also enjoy a greater variety of available consumption goods. In fact, people along the Transrapid line will be able to go to the opera in Amsterdam and return the same evening, something that is hardly possible today. Because of the explicit utility function(s), RAEM, as any other SCGE model, is able to translate the utility gain in the equivalent income increase that would have been necessary to reach the same change in utility (welfare). In the case of the Transrapid these gains amount to over half a billion yearly, which has to be compared with an investment cost of 11-13 billion DFL.

Table 4. Changes in output, prices and consumer welfare per infrastructure variant in EC 2020.

		HIC	HHS	ZIC	ZHS	MZB	MZM
Δ output	(in %)	0.004	0.010	0.004	0.010	0.016	0.016
Δ CPI	(in %)	-0.02	-0.06	-0.02	-0.05	-0.09	-0.09
Eqv. Δ GDP	(in mln. Dfl.)	142	345	124	337	578	554

Finally, there is the interesting phenomenon that the increase in output is much, much smaller than the decrease in the CPI. Part of this difference is explained by the peculiar implications of using iceberg type transport costs. Reducing iceberg type of transport costs does not free-up transport sector inputs, such as labour and intermediate inputs. Instead it results in less products being “melted away” during transportation. This implies that the supplier needs to produce less to satisfy the same level of demand on the part of these customers. Hence, the consumption of non-transport products is able to increase more than the production of non-transport products. This unwarranted fact went unnoticed in the literature until now.

When a macro SCGE is used, this property does not pose a serious problem as the macro economic output is inclusive of transportation output that does (implicitly) reduce. In a multi-sectoral SCGE, however, this iceberg type transport cost imply a serious *mis-specification* as they lead to an underestimation of the output effects in the non-transportation sectors, especially in those sectors for which transport cost reduce most, whereas the opposite should be the case. RAEM, in fact, found the largest positive output effects in the public utility sector that only indirectly uses the transportation of people.

5. FURTHER DEVELOPMENT OF THE MODEL

The model as is described in section 3 and which application is shown in section 4 is not complete in the sense that at present we have left out some elements that should be incorporated if we aim for a complete integrated spatial equilibrium model that is consistent and omits the risk for double counting.

The ultimate aim is to construct a model that describes the direct and indirect effects of major infrastructure improvements, through their impact on the transport prices and accessibility improvements on the price levels, the level of employment and production per sector and region, also taking into account the availability of land per region.

Despite the fact that the application of CGE models in the field of transport policy opens new doors towards project evaluation, this goal is clearly an ambitious one. As we proceed with applying these models, new opportunities for research emerge as well, that will need to be addressed to safeguard the future accuracy and robustness of model results. One category of model improvements concerns the truthfulness of the description of real world transport, logistics, trade and location processes. First of all, we believe we should incorporate the effects of migration of workers. Constraints in the regional availability of labour may have a dampening effect on regional development, both by constraining growth and by increasing the cost of labour at locations. Also, firms are not always flexible in their location; industries that are not footloose may suffer from changes in location of other, connected firms. On the other hand, cluster synergies or non-additional network benefits may emerge from groups of firms that become more closely connected. Finally, the relation between transport costs and the regional or sectoral production functions could be detailed much further than is presently the case. The classical assumptions may be too rigid for our purposes, especially as the improvements we are evaluating lie exactly in the transport system. These kinds of more subtle impacts are not considered yet in our analyses, but might be shown to be extremely relevant from the perspective of competitive power of the industry.

An illustration of the complexity of such a model, which integrates the above aspects, is given below. Basically, beside the relations between systems of production, consumption and trade, this model includes passenger mobility related systems of labour, migration and commuting. Especially for evaluations of transport policy, this model would uncover relations that cannot be treated with the present set-up.

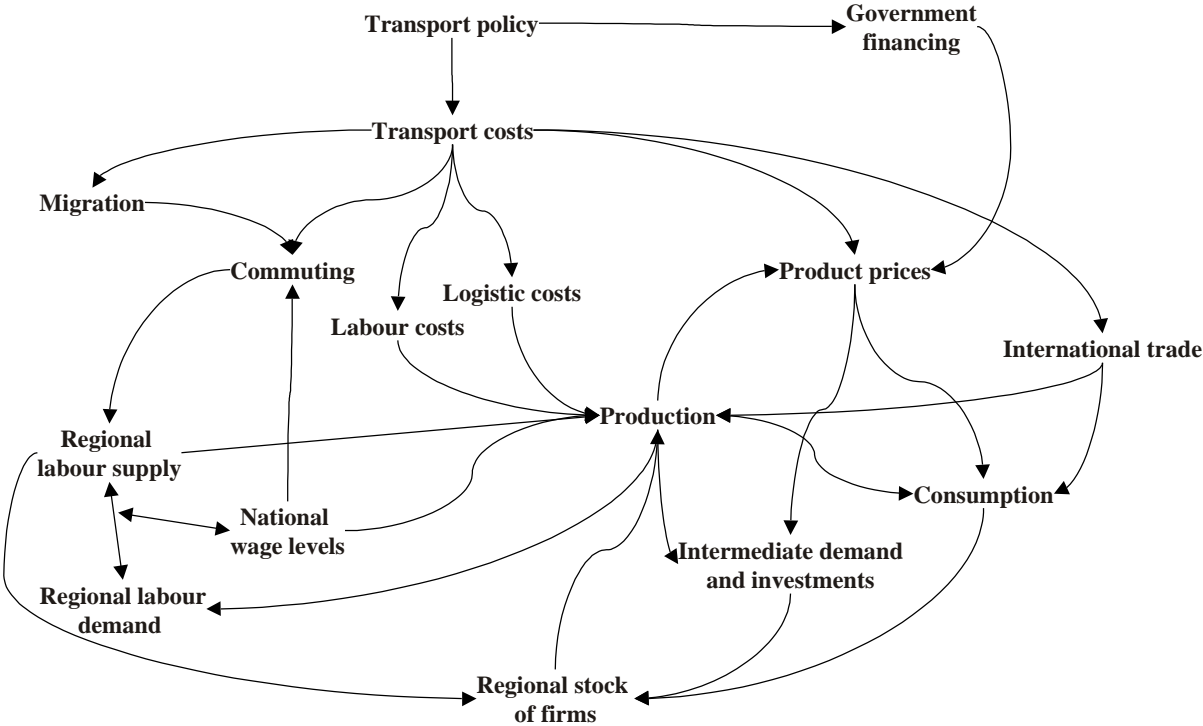


Figure 1: Illustration of an equilibrium model including labour, migration and commuting

“*International repercussions*” is a second category of impacts that was relatively little studied until now. A recent study (Bröcker 1999) indicates that to a significant extent the impacts of the TEN projects occur outside the country where projects are implemented. Considering that the benefits and costs are different by country, as is their valuation from a national macro-economic perspective, there is a clear need for identifying the impacts by country as objectively as possible. This includes distinguishing the stakeholders as they suffer or benefit, by as many categories as is needed to allow a valuation of impacts by as many different standards as apply in these countries.

In addition, the evaluation of the *environmental impacts* of projects is a crucial issue. Formally, this should not form part of a spatial equilibrium model, unless there is a clear and shared understanding of the economics of these impacts, and how they relate to the finances of industrial production, which is now the starting point for these analyses. However, as was already demonstrated, these effects can *be included formally inside input-output analysis*, and there is no reason to believe that an equilibrium perspective would not apply (within the right framework of premises, of course) or that a spatial element could not be introduced.

Finally, a number of issues related to error structure and reliability of results need to be resolved. In some instances one can experience that the new equilibrium solution is unstable, especially for smaller infrastructure improvements. The many dimensions of the model that needs to be solved and the type of algorithms that are applied to calculate these solutions apparently cannot guarantee that the equilibrium is global. Especially for smaller projects (and arguably, most of the projects evaluated with these methods will be small), new generations of approaches will be needed to approximate spatial equilibria instead of re-evaluating them completely. Also, we have to improve our insight as to the propagation of errors in these schemes of calculation. This may result in new standards for the accuracy of certain steps in the calculation. We expect that an accurate estimate of the impact of transport timesavings upon sectoral production will be critical.

The further extension of the RAEM model along the above lines is expected to take place in the next years, firstly for the Netherlands, but later on also for the European context. In this respect it is worthwhile to mention that we have started the project IASON³ for the 5th framework program of the European Commission, in which the ideas that have been presented in this paper will be implemented for Europe.

The two models that are applied here for evaluating European transport projects and policies concern the SASI model and the CGEurope model. While the latter is a true spatial equilibrium model, the SASI model can be characterised as a location potential model (LUTI). In the light of their application for project evaluations the two are clearly complementary. While the CGE is the platform for comparative static analyses, the SASI model can provide estimates of future GDP, regional employment and so on. These models were applied many times individually, but not in this conjunction before. It will be interesting to see to what we

³ The project “Integrated appraisal of socio-economic and network effects of European transport investments and policies” aims at developing broad guidelines for social cost-benefit analysis.

can learn from this application, and what recommendations will result for project evaluations in the specific case of Europe.

Within the context of social cost-benefit analysis, the above issues are but examples of the complexities that arise when a SCGE model is applied at the European level. Beside cross-border issues, at European level, transport distances are larger and trade flows smaller, which places higher demands on the models' accuracy. Moreover, there is an enormous heterogeneity in socio-economic characteristics of different regions, which has consequences for the parameterisation of the model and the associated data requirements. The development of an integrated SCGE model as pictured above would form an interesting challenge in this respect, where local, regional and European objectives (like e.g. 'cohesion') will all have to be reconciled.

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