The influence of market imperfections on the evaluation of investments - a SCGE model approach

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Abstract

This paper investigates an influence of pecuniary market imperfections upon the welfare benefits of transport infrastructure improvements using a Spatial Computable General Equilibrium (SCGE) model for Norway. Empirical analysis is performed for Cournot oligopoly and monopolistic competition under different assumptions about initial number of firms in the market. The model results demonstrate that impact of market imperfections should be taken into account in case of large infrastructure improvements and in the presence of high market power. However, in other cases market imperfections contribute relatively little to the total infrastructure welfare benefits.

Keywords: market imperfections, general equilibrium, transport investments

1. Introduction

There is a firmly held belief among the politicians that investments in transport infrastructure promotes economic development and that the welfare benefits of transport infrastructure provision as measured traditionally by direct transport cost reduction using conventional cost-benefit analysis (CBA) are significantly diminished since other possible effects are omitted.

There exist a number of simulation studies investigating the consistency between CBA welfare measure and the true benefits of infrastructure investments including Hussain (1996), Venables and Gasiorek (1998), Newberry (1998), Nordmand (1998) and Rowendal (2002). These researchers use theoretical general and partial equilibrium models in order to illustrate the importance of market imperfections for the correct estimation of transport welfare benefits. Most of them use hypothetical data for empirical simulations. The difference between CBA and true benefit measures estimated by the researchers depends strongly upon the assumptions made about the parameters of the models and the form of market imperfections. In general, the artificial data set chosen for the simulation analysis drives the results.

The present paper differs from the existing literature in that it uses real data set for Norway for the empirical analysis. The data set is used to calibrate the SCGE model and test whether the results of conventional CBA differ a lot from true welfare benefits estimated from the model in the presence of pecuniary market imperfections. Analysis is performed for cases of Cournot oligopoly and monopolistic competition.

Under these market imperfections transport infrastructure improvements enhance the efficiency of the economic system because they increase competition. Transport facilitates trade and commerce by widening the area of goods markets, which, in turn, leads to greater competition. The removal of trade barriers results in higher productivity and raises the purchasing power of population. It can therefore be argued that factors of economic growth such as economies of scale, structural adjustment or the diffusion of technological processes are all affected by transport.

The existence of all these possible effects leads to the situation, where the traditional CBA methods used for the analysis of transport infrastructure benefits do not capture all important economic effects and hence there is a need to develop and use partial and general equilibrium models with retroactive effect between explanatory variable in order to perform empirical analysis of the relations between transport infrastructure provision and regional economic development.

The present paper is constructed as follows. Section 2 discusses direct and indirect welfare benefits of infrastructure provision. Section 3 gives description of welfare measure used under the general equilibrium approach. Section 4 presents general structure of the SCGE model for Norway. Section 5 presents simulation results results. Section 6 concludes the paper.

2. Direct and indirect welfare benefits of infrastructure provision

Conventional Cost-Benefit Analysis (CBA) tries to measure the welfare effects of carrying out different policy measures such as tax changes or infrastructure investments, for example. Consumers are the only agents in the economy which experience welfare, hence CBA should estimate the effects of a particular policy measure on consumers in their different roles of buyers of consumption goods, suppliers of production factors, receivers of external effects etc. If the policy measure concerns consumers directly, there is no need to estimate its effects on other economic agents. However in many cases a policy measure concerns both consumers and other actors. In this case the effects of policy measure reach consumers only after one or more intermediate steps, for instance because the measure lowers the cost of an input for an industry producing a consumer good. CBA measures the indirect effects on consumers as the direct effect on other economic agents, hence treating direct effects on non-consumers, as they were effects on consumers. In case, when price of input good is affected by the policy measure, the indirect effects are measured by the Marshallian consumer's surplus of the demand for the input whose price changes.

For instance, in case of the improvement in transport infrastructure one usually tries to estimate the effect of this measure on the demand for trips for various purposes and approximates the benefits by means of the change in area under the relevant demand curves. This means that trips for business purposes are treated in the same manner as the individual trips. Direct effects on firms measure the indirect effects on persons.

The use of CBA is justified in the framework of Arrow-Debreu economy characterised by constant returns to scale and perfect competition implying that all prices are equal to marginal costs (MC). Every change in the economy that every change in the economy that leads to lower unit costs of production automatically leads to lower prices and this means that such cost reductions are completely passed through to the consumers of the firm's products and ultimately to the consumers.

However, in the situation when either imperfect competition and /or (dis)economies of scale are present in the economy, the equality between direct and indirect effects of a policy measure does not hold and, hence, the use of CBA is not justified.

Several researchers have investigated the problem of inconsistency between the welfare benefits estimated by CBA technique and the true ones. Venables and Gasiorek (1998) provide simulation results that suggest that in such an economy the results of transport improvements might be substantially larger than estimated using CBA. On the other hand, Newbery (1998) provides examples that show that in some situations conventional CBA might overestimate the welfare gains of public investment.

An interesting research performed by Rouwendal (2002) uncovers some reasons for the conventional CBA to be biased. By using a simple theoretical model he demonstrates that the equality between indirect effects of consumers and direct effects on firms holds under perfect competition and constant returns to scale, in case when the appropriate demand function for input is used for the analysis. Such demand function should incorporate not only the effects of substitution but also the effect of change in demand for industry's output. He further shows that the conventional CBA underestimates welfare effect of a policy change in case of monopoly. The model results, however, differ between the different forms of monopolistic competition. When modelled according to the Dixit-Stiglitz model the presence of monopolistic competition results in CBA underestimating the true welfare benefits, while in the case when logit model is used, CBA overestimates the true benefits of policy measure. Rouwendal agues that the details of demand specification are important for the conclusions. He also tresses the absence of systematic relationship between the size of direct and indirect benefits in situations of monopolistic competition.

The simulation analysis performed by Nordman (1998) using the SCGE model developed by Hussain (1996) clearly demonstrates that if increasing returns to scale is introduced to the model, the link-related CBA welfare measure tends to underestimate the true benefits of transport infrastructure improvement.

Although the performed simulation and theoretical analysis clearly indicates that CBA welfare measure deviates from the true welfare benefits under the presence of market imperfections and (dis)economies of scale, the estimated size of deviation varies from study to study and depends upon the parameters chosen by the researchers. Hence, there is a clear need to estimate direct and indirect effect of given policy measure using real data for a particular country.

3. General equilibrium and welfare measure

The traditional way to measure welfare changes in a partial equilibrium framework is to examine consumer, producer surpluses, external costs and governmental revenue. These measures however do not provide fro a unique monetary evaluation of the welfare, but is depending on the specific data used when measuring them, and hence called path-depended.

Hicks (1943) have proposed two alternative measures of welfare, which can be viewed as forms of path-independent willingness-to-pay measures, compensating (CV) and equivalent (EV) variations. Today these measures constitute a solid fundament for welfare evaluations in the context of general equilibrium modelling.

The equivalent variation for the representative consumer in a particular region is obtained by calculating the difference between the expenditure function of the new level of utility with original prices and the expenditure function in the pre-policy change case. The total benefits to the economy are obtained by aggregating the separate effects to each of the regions. The sum of EV over the set of regions in the model is then used as the total welfare measure.

Just et al. (1982) have discovered that general equilibrium effects, as a result of policy changes in a single market, could be fully measured in the market itself, provided that the other markets are free from price distortion mechanisms and under the assumption that the public sector budget remains unchanged. However, if there already were distortions in the rest of the economy and those were held constant and unchanged, the effects due to price distorting policy still could be measured in the actual market alone. This result only is valid under the assumptions that (a) price is set equal to marginal cost, (b) there are no price limitations in the rest of the markets and (c) the budget of the public sector remains unchanged. In the situations there these terms are not fulfilled, the effects on other markets have to be added to the effects on the link.

In order to compare CBA welfare measure with general equilibrium welfare measure the “true Benefit Multiplier” (TBM) from Hussain(1996) is used. The multiplier is defined as the quotient between general equilibrium welfare measure and CBA welfare measure. The unitary value of the multiplier means that CBA welfare measure cover the total welfare benefits from policy implication, while the more it diverges from unity the worse can CBA measure capture the total welfare benefits.

4. A SCGE model for Norway

4.1 Model structure and database

This section presents PINGO, a SCGE model for Norway. The model is static and is formulated as a non-linear mixed complementarity problem. A Mixed Complementarity Problem (MCP) consists of a system of (linear or non-linear) equations that are written as inequalities and are linked to bounded variables in complementarity slackness conditions. For details see Rutherford (1995).

The model is characterised by an explicit representation of a geographic space in the form of freight transport costs between its regions. There is no explicit representation of savings or unemployment in the model, factors are immobile and the government sector is quite simplistic. The mixed-complementarity formulation of the model allows it to be easily implemented using GAMS modelling system[1]. Table 1 shows the full mathematical formulation of PINGO.

The country is divided into 19 separate domestic regions[2], each of which includes region-specific households, factors, commodity-producing and goods-transporting agents. All economic agents follow standard utility- and profit-maximization behaviour. Households' incomes consist of factor payments and governmental transfers and are fully spend on consumption. Households' utilities have Cobb-Douglas functional forms and differ between the regions. Productions of commodities are performed using region-specific production factors in combination with intermediate commodity inputs according to constant returns to scale Cobb-Douglas production technologies. The government collects indirect taxes and redistributes the tax revenue to households in the form of lump-sum transfers.

Interregional trade in PINGO is modelled according to the so-called pooling concept. Each region in the model includes economic agents who are responsible for the transport of a particular type of good from all domestic regions and from the rest of the world using freight transport services. The value of transport services used by an agent is proportional to the value of the transported good and depends upon the type of good. After being transported, the good is merged into a region-specific pool. The good from the pool is delivered to the intermediate and the final consumers within that region. The pooling process is represented by a constant elasticity of scale (CES) production technology. Regional commodities are supposed to be imperfect substitutes and the degree of homogeneity within a sector is represented by a CES elasticity of substitution.

Freight transport services are produced by a national transport sector. This sector uses regional factors and commodities as inputs according to a constant elasticity of scale Cobb-Douglas production technology.

The investment activity in PINGO is modelled with the help of regional investment sectors. These sectors produce investment capital using commodity inputs according to constant elasticity of scale Cobb-Douglas production functions. Hence, capital in the model is region-specific and its price varies across domestic regions.

Commodity and factor prices are determined in regional markets with perfectly competitive economies. Commodity trades between different domestic regions and with the rest of the world generate demand for freight transport

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[1] PATH solver for GAMS is based on Newton's method.

[2] These regions correspond to the counties in Norway

services according to a fixed-coefficient formulation. Prices of these services are endogenously determined in the model. The country is assumed to be a price-taker in the international trade. Hence, import prices are exogenously fixed. For any domestic region, trading with the rest of the world, import prices exceed export prices. Similarly, differences in commodity prices between domestic regions reflect the pattern of domestic trades and the level of transport costs.

Finally, the model includes a budget constraint for the payments to and from the rest of the world. The country's earnings from exports plus government revenue are equal to the country's expenditures on imports plus transfers to households.

PINGO is calibrated to reproduce a benchmark equilibrium data consistent with the Social Accounting Matrix (SAM) for the year 1999. The SAM matrix is constructed using accounts data for 19 Norwegian regions, the regional import-export data, the domestic interregional flows of goods, estimated by a gravitation approach, and good-specific freight transport costs from NEMO. Table 2 shows the structure of the data used for the calibration of the model. The values of elasticity of substitution for CES functions have been taken from GODMOD-3 model for Norway (Jensen and Eriksen, 1997).

4.2 Some preliminary remarks on the model

PINGO has been calibrated using transport costs derived from NEMO for the year 1999. NEMO includes elaborate representations of national transport networks and allows carriers to perform mode and route choice decisions based on a cost-minimization principle. Good-specific transport costs derived from NEMO depend on the network representation and link-based operation costs, specified for each transport mode. Any changes in the transport infrastructure of Norway may be translated into respective changes in good-specific transport costs using NEMO. Transport costs can be calculated at different levels of regional detail and in particular for each pair of regions in PINGO. Annual relative changes in freight transport costs are calculated using NEMO and can be used in PINGO in order to assess the economic and welfare effects of certain transport infrastructure improvements. Relative changes in transport costs calculated with NEMO are good-specific, in contrast to the transport services produced by the national transport sector in PINGO.

For simulations with PINGO, transport infrastructure improvements are represented as changes in the fixed good-specific quantities of transport services used per unit of transported good, $\theta^{g}_{trr'}$ (see Table 1). This representation allows for the utilization of the transport costs derived from NEMO. It also allows one to account for good-specific aspects of transport infrastructure.

Let us denote the costs of transporting one unit of good g from region r to region r' before and after transport infrastructure improvements by $H^{0}_{grr'}$ and $H^{1}_{grr'}$, where $H^{1}_{grr'} < H^{0}_{grr'}$. In order to produce these changes in PINGO, coefficients $\theta^{g}_{trr'}$ are updated in such a way that their new values

${\theta^{g}_{trr'}}^{new} = \theta^{g}_{trr'} \dfrac{H^{1}_{grr'}}{H^{0}_{grr'}}$. Additional transport infrastructure investments result in lower prices and higher demands for transport services D_{tr}, which are translated into higher production values, lower prices of consumption goods and changes in tax revenues received by the government (see Table 1).

Changes in economic variables resulting from a certain transport infrastructure improvement are transformed into regional specific welfare gains measured by means of the Hicksian Equivalent Variation (EV) measure. The national or overall welfare gains are the sum of EV measures over the domestic regions.

5. Estimation of "True Benefit Multiplier"

In this section the presented SCGE model for Norway is used in order to estimate the Hussain's TBM for different types of market imperfections including Cournot oligopoly and monopolistic competition. Elasticity of substitution is assumed to be equal 4. Calculations are performed under different assumptions about initial number of firms in the market and for different types of infrastructure improvements. Results of the simulations are presented at Tables 3 and 4.

The calculated Hussain's TBM (see Table 3) is lower then those reported by other simulation studies. This difference is explained by strong distinctions in underlying assumptions between the studies including changes in transport costs, chosen levels of elasticities and other technological parameters of the production functions. The present study utilises rather modest decrease in transportation costs in comparison with others using decrease in transport costs ranging from 30% to 50%. However, real investment projects carried out in countries with the developed transport infrastructure quite rarely exceed 5% decrease in transport costs.

Results of calculations presented at Table 3 clearly demonstrate that the level of transport cost reductions is positively related to the level of Hussain's TBM. Hence, assumption about the level transport costs savings is crucial to the results of welfare analysis. In case of large cost decrease market imperfections are becoming more and more important and should be taken into account while estimating welfare benefits of infrastructure projects. Table 4 shows that monetary value of additional welfare gains attributed to market imperfections are also increasing with the level of cost reductions and cannot be neglected in case of large transport improvements.

The chosen functional form of imperfect competition influences the simulation s results. The calculated Hussain's TBM is much larger in the case of Cournot oligopoly then in the case of monopolistic competition. Moreover, in case of Cournot oligopoly the value of TBM is decreasing with the initial number of firms at the market (see Table 3). In case of monopolistic competition, on the other hand, its value is independent upon the number of firms (see Table 3). According to Table 4, the difference between CBA and true welfare measures increases more with each additional percentage of cost savings in case of small initial number of firms at the market.

As demonstrated at Table 4 despite the small value of TBM the difference between CBA and true welfare measures in monetary value is quite large for the case of high market power and significant infrastructure improvements and, hence, should not be neglected. However, in other cases market imperfections contribute quite little to the total benefits of infrastructure provision.

6. Conclusions

An influence of market imperfections upon the value of welfare benefits of transport infrastructure projects is highly contentious issue, which attracts attention of both politicians and researchers. A number of existing simulation studies including those by Hussain (1996), Venables and Gasiorek (1998), Newberry (1998), Nordmand (1998) and Rowendal (2002) illustrates the importance of market imperfections using theoretical partial and general equilibrium models. Both assumption and results of those studies differ a lot, which illustrates the importance of chosen assumptions about technological parameters, functional forms and level of transport cost savings.

The focus of the present paper is on influence of imperfect competition. It uses real data set for Norway in order to calibrate the SCGE model. It further uses the model to estimate Hussain's TBM for cases Cournot oligopoly and monopolistic competition. Empirical analysis is performed for different types of infrastructure improvements.

Results of model simulations demonstrate that the level of TBM estimated using Norwegian data set is lower then in other existing studies and its value is positively related to the level of transport costs reductions. Calculated TBM is much higher in the case of Cournot oligopoly then in the case of monopolistic competition. In case of Cournot oligopoly TBM is positively related to the level of market power represented as an initial number of firms at the market.

Despite quite low estimated value of Hussain's TBM, the monetary value of difference between CBA and true welfare measures is quite significant, especially in case of large infrastructure improvements and high market power. Hence, market imperfections should be taken into account while estimating welfare benefits of infrastructure improvements in these cases.

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Table 1

Mathematical formulation of PINGO model

Sets	
$g \in G$	goods
$t \in T$	transport services
$s \in S$	services other then transport ones
$f \in \{l,c\}$	factors (labour and capital)
$k \in K$	goods and services other then transport ones (commodities) / production and service sectors
$i \in I = f \cup G \cup S$	factors, goods and services
$r \in R$	regions
Parameters	
$\alpha^{i}_{k\,r}$	share of input *i* per unit of output of sector *k* in region *r*
$h^{g}_{r\,r'}$	share of good *g* shipped from region *r* to region *r´* per unit of good *g* consumed in region *r*
$h^{g}_{imp\,r'}$	share of good *g* shipped to region *r´* from the rest of the world per unit of good *g* consumed in region *r*
$\theta^{g}_{t\,r\,r'}$	quantity of transport service *t* used per unit of good *g* transported from region *r* to region *r´*
$\theta^{g}_{imp\;r}$	quantity of transport service *t* used per unit of good *g* transported to region *r* from the rest of the world
σ	elasticity of substitution between goods transported from different regions and from the rest of the world
ψ^{c}_{r}	share of commodity *c* in households consumption in region *r*
γ_{r}	share of governmental transfers to households in region *r*

P^{imp}_{g}	import price of good *g*
η^{g}_{r}	share of good *g* exported to the rest of the world from region *r*
$\tau_{k\,r}$	rate of revenue tax for sector *k* in region *r*
$\alpha^{I}_{T\,r}$	share of input *i* from region *r* per unit of activity of a national transport sector
β^{t}_{T}	share of output *t* per unit of activity of a national transport sector
η_{T}	rate of revenue tax for a national transport sector
$\alpha^{g}_{c\,r}$	share of input *g* per unit of output of an investment sector in region *r*
L_{r}	endowment of labour in region *r*

Variables

$P_{k\,r}$	price of commodity *k* produced in region *r*
$Z_{i\,r}$	price of commodity or factor *i* consumed in region *r*
P_{t}	price of transport service *t*
A_{T}	level of activity for the national transport sector
$Q_{g\,r\,r'}$	quantity of good *g* transported from region *r* to region *r*′
$Q^{imp}_{g\,r'}$	quantity of good *g* transported to region *r*′ from the rest of the world
$D\,k_{r}$	quantity of commodity *k* demanded by household in region *r*
$Q^{exp}_{g\,r}$	quantity of good *g* exported from region *r* to the rest of the world
$D_{t\,r}$	quantity of transport services *t* demanded in region *r*

$Q_{k\,r}$	quantity of commodity k produced in region r
$I_{i\,r}$	quantity of commodity or factor i demanded as input in region r
$Q_{c\,r}$	quantity of investment capital produced in region r
Q_{t}	quantity of transport services produced by national transport sector
TR	total transfers from government to households
Y_{r}	income of a household in region r

#	Equation	Domain	Complementarity constraint	Description
1	$I_{i\,r} = \Sigma_{k\in K} Q_{k\,r} \cdot P_{k\,r} \cdot \alpha^{i}_{k\,r} / Z_{i\,r} + Q_{c\,r} \cdot R_{c} \cdot \alpha^{i}_{c\,r} / Z_{i\,r}$	$i \in I \quad r \in R$		Input demand
	$+ A_{T} \cdot \alpha^{i}_{T\,r} / Z_{i\,r}$			
2	$D_{t\,r} = \Sigma_{g\in G} Q_{g\,r\,r'} \cdot \theta^{g}_{t\,r\,r'}$	$t \in T \quad r \in R$		Transport service demands
4	$Q_{t} = A_{t} \cdot \beta^{t}_{T} / P_{t}$	$t \in T$		Output of transport services
5	$Y_{r} = Z_{l\,r} \cdot L_{r} + TR \cdot \gamma_{r}$	$r \in R$		Households' incomes
6	$D_{k\,r} = Y_{r} \cdot \psi^{c}_{r} / Z_{k\,r}$	$k \in K \quad r \in R$		Households' demands
7	$\Sigma_{i\in I} (Z_{i\,r}) \wedge \alpha^{i}_{k\,r} \geq P_{k\,r} \cdot (1-\eta^{k}_{r})$	$k \in K \quad r \in R$	$Q_{k\,r} \geq 0$	FOC for profit maximization
	$\Sigma_{i\in I} \Sigma_{r\in R} (Z_{ir}) \wedge \alpha^{i}_{T\,r} \geq \Sigma_{t\in T} (P_{t}) \wedge \beta\, t_{T} \cdot (1-\eta_{T})$		$A_{T} \geq 0$	
	$\Sigma_{g\in G} (Z_{g\,r}) \wedge \alpha^{g}_{c\,r} \geq Z_{c\,r}$	$r \in R$	$Q_{c\,r} \geq 0$	

8	$Q_{g\,r'\,r} = (I_{g\,r} + D_{g\,r})\cdot(P_{g\,r'} + P_t\cdot\theta^{g}_{t\,r'\,r})^{-\sigma}$ $\cdot(\Sigma_{r''\in R}\, h^{g}_{r''\,r}\cdot(P_{g\,r''} + P_t\cdot\theta^{g}_{t\,r''\,r})^{1-\sigma})^{\sigma/(1-\sigma)}$	$g\in G \quad r,r',r''\in R$		Quantities of transported goods
9	$Q^{imp}_{g\,r} = Q_{g\,r}\cdot\eta^{g}_{r}$	$g\in G \quad r\in R$		Imported goods
10	$Q^{exp}_{g\,r} = I_{i\,r}\cdot h^{g}_{imp\,r}$	$g\in G \quad r\in R$		Exported goods
11	$Z_{g\,r} = (\Sigma_{r'\in R}((P_{g\,r} + P_t\cdot\theta^{g}_{t\,r'\,r})/h^{g}_{r'\,r})^{\sigma/(\sigma-1)}$ $+((P^{imp}_{g} + P_t\cdot\theta^{g}_{imp\;r})/h^{g}_{imp\,r})^{\sigma/(\sigma-1)})^{(\sigma-1)/\sigma}$	$g\in G \quad r\in R$		Link between regional commodity prices
	$Z_{s\,r} = P_{s\,r}$	$s\in S \quad r\in R$		
12	$Q_{g\,r} \geq \Sigma_{r'\in R}\, Q_{g\,r\,r'} + Q^{exp}_{g\,r}$	$g\in G \quad r\in R$	$P_{g\,r} \geq 0$	Market equilibrium
	$\Sigma_{r'\in R}\, Q_{g\,r'\,r} + Q^{exp}_{g\,r} \geq I_{g\,r} + D_{k\,r}$	$g\in G \quad r\in R$	$Z_{g\,r} \geq 0$	
	$Q_{s\,r} \geq I_{s\,r} + D_{s\,r}$	$s\in S \quad r\in R$	$P_{s\,r} \geq 0$	
	$L_r \geq I_{l\,r}$	$r\in R$	$Z_{l} \geq 0$	
	$Q_{c\,r} \geq I_{c\,r}$	$r\in R$	$Z_{c} \geq 0$	
	$Q_{t} \geq D_{t\,r}$	$t\in T$	$P_t \geq 0$	
13	$\Sigma_{k\in K}\Sigma_{r\in R}\, Q_{k\,r}\cdot P_{k\,r}\cdot\eta^{c}_{r} + \Sigma_{t\in T}\, Q_t\cdot P_t\cdot\eta_{T}$ $+\Sigma_{g\in G}\Sigma_{r\in R}\, Q^{iexp}_{g\,r}\cdot P_{g\,r} = TR + \Sigma_{g\in G}\Sigma_{r\in R}\, Q^{imp}_{g\,r}\cdot P^{imp}_{g}$			Governmental balance

Note: sign ^ denotes the power operator

A mathematical model statement is given in Table 1. In the table, the row of each inequality includes a lower bound of zero for the variable that is linked to the inequality in a complementary-slackness relationship. As a reflection of Walras law, one of the equilibrium conditions follows from the other equations and may be dropped.

Table 2 Structure of the data used for calibration of PINGO

	Regions 1 - 19	National level	Border
Households	One	None	None
Factors	Labour, capital	None	None
Activities	10 goods sectors 2 service sectors investment sector	Government	None
Transport	None	Transport sector	None
Trade	10 transporting agents	None	Import; export

Table 3 Estimated Hussain's True Benefit Multiplier

Decrease in transportation costs	Cournot oligopoly with 20 firms	Cournot oligopoly with 5 firms	Monopolistic competition
2%	1.000045	1.00022	1.00000058
4%	1.000084	1.00042	1.00000091
6%	1.000119	1.00059	1.00000107
8%	1.000150	1.00080	1.00000113
10%	1.000179	1.00098	1.00000112
12%	1.000208	1.00121	1.00000111

Table 4 Difference between CBA and true benefit welfare measures in mil Euro per year

Decrease in transportation costs	Cournot oligopoly with 20 firms	Cournot oligopoly with 5 firms	Monopolistic competition
2%	1.70	8.18	0.022
4%	3.15	15.82	0.034
6%	4.45	22.28	0.040
8%	5.63	30.07	0.042
10%	6.70	36.86	0.042
12%	7.79	45.31	0.720

Figure 1 Norwegian counties: 01 Østfold, 02 Akershus, 03 Oslo, 04 Hedmark, 05 Oppland, 06 Buskerud, 07 Vestfold, 08 Telemark, 09 Aust-Agder, 10 Vest-Agder, 11 Rogaland,12 Hordaland, 14 Sogn and Fjordane, 15 Møre and Romsdal, 16 Sør-Trøndelag, 17 Nord-Trøndelag, 18 Nordland, 19 Troms, 20 Finnmark