Essays on Spatial Economies and Organization

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Abstract

This thesis concerns both static and dynamic modeling in a spatial computable general equilibrium setting. First, we have applied a static framework for the assessment of economic impacts of the Öresund bridge. Secondly, we make an attempt to enhance the static framework through the introduction of economic dynamics. Third, we introduce the STRAGO model, incorporating monopolistic competition, dynamics and additive transport costs. STRAGO is applied to the analysis of effects from a kilometer tax on freight. The last paper presents a framework for studying the division, or fragmentation of production. This framework uses the standard theory of monopolistic competition, with a production chain extension, through a recursive view of markets. The optimal level of fragmentation in such industries is studied.
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List of papers:

(I) Sundberg M, Economic Effects of the Öresund Bridge - A spatial computable general equilibrium analysis.

(II) Sundberg M, Dynamic Spatial CGE Frameworks - Specifications and simulations.

(III) Sundberg M, The Development of STRAGO - With application to a kilometer tax.

(IV) Sundberg M, Fragmenting Production in Monopolistically Competitive Industries.
1 Introduction

Spatial aspects of economic activities have become a center of attention within the field of economics. This important role for transports, in economics, was recently acknowledged by means of the 2008 Nobel Prize in economics\textsuperscript{1}. In this thesis we will primarily focus on the interplay between economic activities and transport costs. Spatial economies, as stated in the title, refers to the fact that economic activities that take place at different locations and interact through trade, will typically incur transport costs. Things are moved across space. The movement of goods, as well as people, requires resources. Resources which we may represent through transport costs in an economic environment.

Transport costs will in turn affect how different economic activities are organized, not only at which location a certain activity takes place, but also which activities are pursued in the first place. The effects of transport costs on the organization of different economic activities, as well as the reorganization of those activities as transport costs change, are at the heart of this thesis.

Our vehicle of choice, for analyzing relationships between the economy and transports, is spatial computable general equilibrium models, SCGE models in short. Three out of the four papers presented in this thesis are concerned with the development and application of such models. Typically we view the spatial economy through a regionally divided, or disaggregated, representation of the economy. Each region in the economy is considered to shelter a number of actors, such as households and different types of firms. Then, as these actors interact through trade, they will also require transports. We consider transport demand as a derived demand from these trade activities.

We will soon return to the motivations for using the SCGE approach. Before that, we should introduce the final contribution of the thesis. The fourth paper is closely related to the question of why there is trade, at all. By exploring forces for production to fragment into production chains, we try to explain why there is trade in intermediate goods, i.e. why there is trade between firms. The question of why there is trade is clearly fundamental to economics. Also, considering transports as a derived demand from trade puts trade in focus in this thesis. Let us therefore tell a brief story of some classic lines of thoughts on this matter.

\textsuperscript{1}The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel. In 2008, Paul Krugman was awarded this prize for his contributions in international trade and economic geography, see [46].
1.1 Why is there trade?

There are many different reasons for trade to occur. A mutual wish to have what others possess is one basic component of explaining trade. Behind such a wish one may find differences in abilities to produce different goods and services. From a production perspective, it may be more efficient for different actors to specialize in certain tasks through a division of labor, and then trade the outputs between each other. Differences in production technologies or differences in the endowments in production factors may cause such division. From a demand perspective, a wish to have access to a wide variety of outputs can also cause division of production, and thus trade. All the above-mentioned reasons for trade are in line with traditional explanations for trade, which we will return to. But, let us now turn to an important contrasting example, where no trade occurs.

Starrett’s [44] work on location choices in perfectly competitive settings resulted in what is usually referred to as the spatial impossibility theorem. In a discussion on the progressions in the fields of new economic geography, urban economics and location theory, Fujita and Thisse [20] summarize this theorem as:

"Consider an Arrow-Debreu economy with a finite number of agents and locations. If space is homogeneous and transport is costly, then there is no competitive equilibrium involving transportation."

Without dwelling on the exact premises of this result, we will focus on the basic intuition. Starrett studied production, exhibiting constant returns to scale. Both firms and households are assumed free to move to any location. Households and firms wish to locate themselves in order to avoid transport costs. Then, as production is perfectly divisible, each region will become self-sufficient and act as an autarky. There will be no trade between different locations, and hence no transports. If we wish to study the relationships between transports and the economy, we have to depart from the combination of assumptions made by Starrett.

How then, do we explain trade? We may assume that different countries, or locations, have different production technologies, which are not mobile. This assumption was adopted by David Ricardo. Ricardian explanations of trade are based on the idea of comparative advantage. Each country has production technologies, and those technologies differ between countries. Thus, a specific country may have a comparative advantage, is relatively more efficient than other countries, in the production of some goods. Typically this
will induce trade, as countries export goods in which they have a comparative advantage in production.

Heckscher and Ohlin dismissed the comparative advantage explanation for trade, in favor of an explanation based on differences in factor endowments. Rather than focusing on differences in production technologies, they utilize differences in endowments such as capital and labor. Those endowments are assumed to be immobile, they do not relocate between countries, contrasting to the assumptions of Starrett. Typically, each country will export goods that make extensive use of the factor in which the country is well endowed. For an overview of both the theoretical and empirical relevance of the Ricardian and Heckscher-Ohlin models, see Feenstra [17].

Both the Ricardian point of view, and that of Heckscher-Ohlin, build upon arguments for trade from a production perspective, either through production technologies or through production factors. Armington [4] on the other hand, takes a demand perspective on trade by assuming that products are distinguished by place of production. Goods produced at different locations may be similar, but they are not perfect substitutes. Thus, regions that have such mutual demand for the others’ produce, will trade with each other.

More recent trade theory takes the assumptions of monopolistic competition as their point of departure. Monopolistic competition in its most widely used form originate from Spence [43], and, Dixit and Stiglitz [15]. This theory was adopted by Ethier [16], explaining trade in intermediates, and by Krugman [33] and [34], in international trade and economic geography. From the demand perspective, the goods that are provided are viewed as substitutes. Also, a wide variety of such goods is demanded. On the margin, increasing the variety, the number, of goods is more satisfying to those who demand products than increasing the amount of each good. This property is called ‘love of variety’. From the demand perspective, a very small amount of a great variety of goods is preferable. From the production side we have increasing returns to scale, which balance the demand force for varieties. Production is not efficient on small scales. As these forces balance each other, a certain number of varieties and a certain amount of each variety will be produced. It turns out that each variety is produced by a single monopolist. This monopolist has a location for production. Compared to the Armington approach, where products are demanded by location of production, multiregional versions of monopolistic competition model are similar in feel. Yet, it is not the location itself that drives demand, but it is the uniqueness of the product. A product produced by a single firm, which has an address in space. Then, if production takes place at different locations, there will be a mutual demand for products between regions. We get trade.
Different abilities to produce different goods and services may explain specialization, and division of labor. People specialize according to skills. The products are then exchanged, or traded. These ideas are evident in the following passage from Adam Smith [42]:

"It is the great multiplication of the productions of all the different arts, in consequence of the division of labor, which occasions, in a well-governed society, that universal opulence which extends itself to the lowest ranks of people. Every workman has a great quantity of his own work to dispose of beyond what he himself has occasion for; and every other workman being exactly in the same situation, he is enabled to exchange a great quantity of his own goods for a great quantity, or, what comes to the same thing, for the price of a great quantity of theirs."

According to Smith, it is the division of labor which generates great multiplication of the productions, which in turn is transformed into wealth of workmen through the trade of goods. It is also important to note that Smith recognized that the "multiplication of the productions", due to the "division of labor", is limited. In his own words, "the division of labor is limited by the extent of the market".

In the light of the previous passage by Smith, it is interesting to note that models of monopolistic competition lend themselves to rather classical interpretations. Labor is divided between firms, producing different varieties. Those varieties are all demanded by the households. Even though each individual household may be thought of as working only at one firm, they demand the produce of others; they trade. Through the love of variety, there is multiplication in the wealth generated from productions of the different varieties of goods.

Finally, Young [49] introduces the ideas of roundabout methods of production, meaning that production is divided into successive stages. Earlier stages produce capital goods employed in the later stages. If we make a loose interpretation of those capital goods as intermediates, we will have trade in intermediates between the successive stages. Also, successive stages of production induce another dimension to the division of labor. People and firms specialize, but they also make use of the fact that others specialize too, in their own production. Young notes:

"...over a large part of the industry an increasingly intricate nexus of specialized undertakings has inserted itself between the producer of raw materials and the consumer of the final product".
1.2 Why use SCGE models?

There has been a large increase in the interest in spatial computable general equilibrium (SCGE) models. One of the reasons for this increase is the demand for tools that may assist in the assessment of policies. In particular for the assessment of the economic impacts of infrastructure investments and other transport related policies. One question to be answered is what are the economic impacts of changing accessibility? SCGE models are specifically designed for and have been used for this type of policy assessment. Two reports that indicate this demand for SCGE models are the feasibility study of SCGE models commissioned by the Swedish Institute for Transport and Communications Analysis, and a report commissioned by the UK Department for Transport [22]. The EU has also demonstrated its interest in the SCGE approach by funding the IASON\textsuperscript{2} project, for documentation see e.g. [7] and [8].

There are numerous ways of approaching the assessment of infrastructure and transport policies. Different approaches such as cost benefit analyses, multi-regional input-output analyses and econometric analyses are all used in assessments. Multi-regional input-output models are the closest relatives to SCGE models, since they attempt to model the economy. Yet, they are not able to fully capture price and quantity effects, as they do not allow for substitution effects in the economy. Lowered transport costs due to infrastructure investments tend to stimulate the actors in the economy to take advantage of the cost reduction in production and consumption. These types of effects are difficult to capture within the input-output setting. The strength of input-output models is that they allow a high degree of disaggregation, representing many different regions and many types of firms.

If we think of the demand for transports as a derived demand, transport is not necessarily a good in itself but may be a byproduct of the need to move people and goods in space. Treating transports as a derived demand calls for an economy from which to derive it, where essentially the differences in locations of supplies and demands for goods and services incur transports. Then, if we wish to analyze the effects of different economic policies on transport demand, SCGE models provide means for such an analysis. Given the dual relationship, where the economy affects transports, and transports affect

\textsuperscript{2}IASON - Integrated Appraisal of Spatial economic and Network effects of transport investments and policies.
the economy, we may also ask the reverse question. What are the economic impacts of transport policies?

One of the strengths of SCGE models is the use of underpinning micro-economic theory for modeling the economy. The SCGE framework represents a theoretically and mathematically consistent approach to describing the economy, and it allows us to perform policy assessments and investigate scenarios within this consistent framework, where the interactions between the economy and transports can be studied.
2 Aspects of Modeling

This section discusses different aspects of modeling. Starting with some particular model development issues that are dealt with in the papers, then moving toward discussing more general aspects of modeling, such as the probing of the assumption-space and what we may learn or explain through models.

2.1 Modeling of transport costs

Later, in Section 3, we will discuss a range of applied models, where transport costs are represented in different ways. In many models, both analytical and applied, the costs of transports are represented by adopting Samuelson’s iceberg approach [41], a way of modeling transport costs without an explicit representation of a transport sector. As goods are moved, parts of them disappear, they melt. The cost of movement is thus represented through this waste of goods. The popularity of this approach is explained in Fujita, Krugman and Venables [19] p. 7, when they state that "There turns out to be a tremendous synergy between the assumption of iceberg transport costs and the Dixit-Stiglitz model, in the sense that combining them causes many potentially nasty technical complications simply to, well, melt away". These complications are dealt with in Paper III of this thesis, as we depart from the iceberg approach through the introduction of a transport sector.

Due to criticism, such as provided by [45], to the use of the iceberg approach in applied computable general equilibrium modeling, iceberg costs are nowadays found more rarely in applications. Rather, transport sectors are explicitly represented and transports are used, complementary to the goods and services that are traded. The transport costs are added to the price of purchasing goods and services from different regions. In some models, the basic approach is to make use of a transport network model external to the SCGE model in providing these transport costs. As shown in Figure 1 in a simplified manner, a scenario or policy may be implemented and the resulting effects in the transport network model on e.g. transport costs may be fed into the SCGE model, which may produce results regarding transport demand, that are fed back to the transport model. The idea is to do this in an iterative manner until an equilibrium between the two model systems is achieved. Yet, it should still be recognized, trade costs in the form of Samuelsonian icebergs still play an important role in analytical work.

An alternative approach was described theoretically by Friesz, Sou and Westin [18], where a freight network model and an SCGE model were combined into a simultaneous model. This may be accomplished by formulating
2.2 What about time?

In static frameworks, temporal aspects are most commonly not addressed. The usual procedure in the application of a static model is to calibrate the model to data for a benchmark year yielding a benchmark equilibrium of the model. Then, policy analysis is performed by applying the policy in the model and computing a counterfactual equilibrium. The results from the two static equilibria are compared to reveal the implications of the policy.

One natural candidate to the ceteris paribus, all else being equal, approach is to construct a basecase scenario with a corresponding basecase forecast equilibrium to be compared to a forecast equilibrium with the intended policy included. In a dynamic setting, not only the basecase scenario would matter, but the temporal ordering and timing of different policies make a difference for economic transitions. In principle, if we think of two hypothetical policies A and B, implemented in sequence, where policy A is to keep

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Figure 1: Typical interaction patterns between a transport network model and an SCGE model in policy assessment.

both the economic equilibrium and the network equilibrium as a simultaneous mixed complementarity problem. This approach was implemented in a test model by Ivanova [28], where network models for car transports and public transports as well as a freight network model were merged with an SCGE model.
households' welfare constant over ten years and policy B is to increase the households' welfare by ten percent over ten years. Then, households would be better off having policy B implemented before policy A than vice versa, as they achieve the higher level of welfare during the implementation of policy A. First increasing welfare for ten years, then keeping the welfare constant at this higher level for the next ten years. This highly simplified example illustrates the importance of ordering of changes or policies in a temporal economy.

Another aspect of time in economic modeling is the time it takes for the modeled economy to adjust toward an equilibrium, a steady state. In static models this question is dealt with by adjusting the assumptions made in the model to fit the intended time range in which the model is applied. For example, in a short term model the assumption of immobility of the labor force between regions may be adopted, whereas in a long term model the labor force may be assumed mobile between regions. One question is then, how shall we interpret short and long term? Usually this question is left to the modeler's intuition and judgment. Without making any statements for the real economy, when simulating dynamic models, we can test how transition times toward equilibrium are affected by e.g. mobility assumptions. Then it is primarily an empiric question which assumptions we should adopt and which model fits real world data the best. The example given, where mobility assumptions have temporal consequences, highlights the interrelations between spatial and temporal aspects of modeling the economy.

2.3 Markets with gravity

In the introduction, we have already touched upon the implications of different market forms on trade. In the case of perfectly competitive markets we may adopt the Armington assumption, where products are demanded with respect to their place of production. In the case of monopolistic competition, we get trade as a consequence of demand driven by a love for variety. In both cases, the demand structures can be represented by very similar mathematical representations. We employ functions exhibiting constant elasticity of substitution, CES functions. Fujita, Krugman and Venables [19] comment on their own book on the spatial economy saying, that it should perhaps be named "Games You Can Play with CES functions". In this thesis, we also utilize this functional form extensively.

The close relationship between CES functions and gravity models is well known, see Anderson [1] and Bergstrand [5]. CES functions generate gravity-like trade flows. Then, Anderson and van Wincoop [2] start out their empirical discussion on trade flows, with: "The gravity equation is one of the
most empirically successful in economics”. This empirical success of gravity equations lends support to the use of CES functional forms, together with transport costs, as they generate gravity-like trade patterns. At least, we will generate trade patterns close to the empirical findings.

The gravity feel is especially strong in the case of monopolistic competition. Big markets demand a lot, and through their love of variety, their demand is extra strong for goods from locations which supply a lot. This property also explains why the field of spatial economics has gravitated toward the use of monopolistic competition. Together with trade costs, this market form has the power to explain agglomerations of economic activity – agglomerations which not only affect which goods are produced at certain locations, but also affects the trade patterns between locations through specialization and concentration.

### 2.4 Validation

For transport model systems Lundqvist and Mattsson [36] divide model validation into four parts:

- **Practical validation.** What is the system level? Which mechanisms are exogenous and which are endogenous?

- **Theoretical validation.** What is the theoretical foundation? Does the system use an equilibrium or dynamic approach? Are the various causal relationships reasonably well modeled?

- **Internal validation.** How good are the models at reproducing the data on which they have been estimated? Is the responsiveness to changes in explanatory variables reasonable?

- **External validation.** Can the model system reasonably well reproduce other independent data? How well can the model system reproduce a future year (forecasting) or a previous year (backcasting)?

In terms of these classifications, the strength of computable general equilibrium models pertain to particularly theoretic validations. One of the main aims of CGE models is to rely on economic theory to model causal relationships in the economy. In doing this, most models represent the economic actors in an aggregate fashion. For representing heterogeneous households in an aggregate fashion, preferences must satisfy the Gorman form, see [48]. There are similar results for representing firms in an aggregate fashion, and with regard to these results on aggregation Hansen and Heckman [23] note:
"These results give examples of when simple aggregate relations can be deduced from relations underlying the micro behavior of the individual agents, but they do not justify using the constructed aggregate relations to evaluate fully the welfare costs and benefits of a policy". Ideally the results from an aggregate model should be disaggregated back to the individual agents. This task is quite demanding, and in practice we may have to rely on aggregate results.

Internal and external validations are scarcely employed, at best, within the field of SCGE modeling. Most models, to our knowledge, are calibrated to data in such a way that the parameters of the models are just identified. That is, calibration makes use of as many observations of data as there are parameters in the model. Hence there is usually little knowledge of the uncertainties in calibrated parameters. Due to this uncertainty a common approach is to perform a sensitivity analysis with respect to the calibrated parameters, yielding the sensitivity of model results to variations in parameters, see [10] for an example. McKitrick [38] performs a type of internal validation of CGE models when he tests the role of functional forms in the models. He finds that the model results are sensitive to the functional forms chosen to represent the agents in the economy, this result being one of his platforms for questioning the empirical relevance of CGE models. This type of criticism highlights issues that need to be addressed within the field of CGE modeling. One example of external validation can be found in the work by Kehoe [32]. He performs ex post evaluations of a number of CGE forecasts, made with different models assessing the economic impacts of NAFTA (the North American Free Trade Agreement). More studies of this sort are called for, as they may provide information on model weaknesses and directions for model improvements.

2.5 Exploring the assumptions

Models in economics are often stated in a form that allows analytical deduction in the form of mathematical proofs. Given the premises of the model, the results presented through analytical methods are true. Proofs are typically stated with the aim to say something general about the model, e.g. to characterize all possible solutions for a model throughout its parameter space. Given such a proof we have received knowledge about the types of results the model can display. Knowledge of this type, based on analytical methods, comes at a price. The wish to achieve analytically tractable results constrains the scale and complexity of models amenable to analysis and hence puts a restriction on the possible results achievable.

In an analytical method, the premises and deduction is the basis of the
2.5 Exploring the assumptions

Explanation of the result. Numerical methods or simulations, on the other hand, are mechanized methods used to provide results from models i.e. the implications of the premises are reached through mechanized deduction. The mechanized deduction decouples the premises from the results in terms of explanations. Rather than explaining the results, the premises are stated and we observe the results provided by the mechanized deduction.

In this thesis we use both analytical and numerical methods to generate results. Given the discussion above, it might seem that we consider analytical methods to be superior in terms of providing explanations and results. This is not completely true. Both approaches are subject to the criticism of McCloskey [37]. She questions the strong focus on theorizing in economics, exploring how different assumptions may lead to different conclusions. In summary, she finds economic theorizing to possess "Great rigor in the middle", but to be "touchie-feelie on the ends". She calls for more empirical testing, economists are not considering the basis and interpretations of the premises sufficiently. Therefore, an analytical model, on loose grounds, may provide less relevant explanations than simply observing the results of simulations.

Conversely, such exploration of assumptions have been defended. Gibbard and Varian [21] discuss models in terms of caricatures – caricatures of a complex reality. As such they isolate some particular aspects, hopefully relevant, and use them to explain and roughly depict some feature of the world. They also argue that the relevance of such explanations may be determined depending on whether the features found are robust to changes in the caricature. Similar ideas are put forward by Mäki [39], as he compares models to experiments. Models provide an experimental setting, through which the scientist may explore the consequences of different assumptions. Models differ from experiments in one aspect, though, they provide more efficient isolations from the complex reality. In Mäki's words, p. 309: "Given the difference in means of control, it is not surprising that theoretical models are capable of effecting isolations more stringently than material models. In theoretical modeling, one simply assumes away all disturbances and complications". Cartwright [9] discusses the interpretation of models as parables, in contrast to fables. Fables come with an abstract lesson, which is not required for parables, which may require an interpretation from the outside. She concludes, p. 8: "...models are more like parables than fables. So constructing the model and deriving its consequences are just a small step toward drawing a lesson from it. In order to know what a parable means we need to study a great deal of text, reading both the theory that imbeds the model and reading the world itself". It seems that she is suggesting that economic theorizing is not necessarily bad, because it is "touchie-feelie on the ends".
but it does require interpretation in the end.
3 Related Models in the Literature

The models presented in this section are all computable general equilibrium models that have been implemented and used in policy assessment. The first two models: Pingo and CGEurope are examples of static SCGE models with an emphasis on the interplay between transports and economics. The MONASH model and the Diao & Somwaru model are dynamic multi-regional models where the economic actors in the model optimize intertemporal decisions. GTAP has a suite of models, both dynamic and static, focusing on international and interregional trade. The RAEM model is a recursively dynamic SCGE model with a focus on transports and locational issues through migration. In all the models described below, except the Diao & Somwaru model, transport costs are included in actions of trade. In CGEurope the costs of transports are represented by adopting Samuelson’s iceberg approach. In Pingo, RAEM and MONASH the transport sectors are more or less explicitly modeled, and the transport costs are added to the price of purchasing goods and services from different regions. In the cases of Pingo, CGEurope and RAEM the basic approach is to make use of a transport network model external to the SCGE model in providing these transport costs.

This is by no means a complete list of models, but rather a selection of applied models that are relevant to the thesis.

Pingo

The Norwegian model Pingo [29] was developed with the aim of providing forecasts for regional and interregional goods transports. The model uses the assumption of a small open economy with Norway being represented by 19 regions and one rest-of-the-world region, allowing exports and imports. Trade between regions is supported by an explicitly modeled transport sector incurring transport costs. Origin-destination (OD) matrices combined with transport costs from the Norwegian transport model NEMO have been used in order to construct a social accounting matrix, used for calibration of the model. The model distinguishes between 9 types of production sectors, one service sector and one investment sector, where the sectors act according to the assumption of perfect competition. Through interaction with the transport model NEMO, forecasts are made for mode specific OD matrices, transport costs, transport volumes etc. Pingo is a static type model, where forecasts are driven by changes in exogenous variables such as policy variables and projections of regional populations.
3 RELATED MODELS IN THE LITERATURE

CGEurope

Earlier versions of the CGEurope model were extended within the IASON project funded by the Fifth Framework RTD Programme, see [8]. This model suite represents one of the largest developments in terms of the number of regions covered, where the whole world is represented, but where most of the regions represent parts of Europe, with a total of more than one thousand regions. Firms producing tradable goods are modeled in the Dixit-Stiglitz fashion of monopolistic competition [15], while local goods are assumed to be produced under perfect competition. One of the distinctive features of the latest version of CGEurope is that households demand private passenger travel in accordance with utility maximization. Furthermore, freight costs for goods, international trade barrier costs, and business travel costs are included in the transaction costs of the firms. Similar to the idea in Pingo, transport costs are derived from the separate transport model SCENES, which is a model providing forecasts of freight and personal travel costs. The principal aim of the CGEurope model is to provide spatially distributed welfare effects linked to changes in accessibility within and between regions.

RAEM

The Dutch model, RAEM, by Thissen [47] and later extended by Ivanova [27], is a model or framework under development. After some preliminary experience with early versions of the model, a number of issues with regard to model assumptions were raised, and ideas of how to resolve these issues have led to model development. In [45] these issues are put forward as "1) interfacing problems between transport and SCGE models, 2) the modeling of the influence of transport costs on sectoral production, 3) the interpretation of the conventional, micro-level specification of product variety in aggregate applications and 4) the problem of irrational agglomeration effects in economic activities". The first issue refers to problems with different definitions of transport costs in SCGE and transport models and problems with regard to the transport accounts of firms that are typically not represented in the data to which SCGE models are calibrated. The second issue is a critique of the commonly used iceberg approach [41] to model transport costs. It is argued that this approach may suffice in aggregate models but may lead to serious mis-specifications of transport costs in sectorally disaggregated models. The last two problems arise from assumptions of monopolistic competition in the Dixit-Stiglitz fashion [15]. With this approach agglomeration effects can be studied, but there are issues to address regarding problems of 'irrational agglomeration effects'. These aspects are not fundamental problems to the
approach taken in the development of RAEM, but rather constructive critique of shortcomings with the approach, where possible ways of dealing with these issues are reported in [45]. In RAEM, commuting between regions was earlier implicitly modeled through applying Pissarides search model, e.g. see [35], in describing the labor market, where searching for jobs in other regions than the region of residence creates a commuting pattern. Nowadays trips and migration are modeled through gravity formulations. The latest version of the model also incorporates recursive dynamics with static and adaptive expectations.

MONASH

The MONASH model represents a long tradition of CGE modeling at the Center of Policy Studies and Impact Project at Monash University, Australia. The model is an extension of the earlier developed static ORANI model, which dates back to 1977. MONASH is a multi-regional, multi-sectoral, dynamic CGE model system, which allows for different choices of the levels of sectoral and regional disaggregation. For an overview see [14]. Also, the model can be applied with different assumptions regarding the dynamic behavior of economic agents, including the assumptions of perfect foresight or static expectations. The transport sectors are identified as margin sectors which are required for trade of goods and services in the model, where the costs imposed by the margin sectors are included in the purchase price of tradables. Both firms and households are assumed to make intertemporal decisions, where firms maximize their values by investments in their capital stocks and act in a perfectly competitive environment, and households make consumption versus savings decisions. Another feature of the MONASH system is that it allows for different types of closures. This means that depending on the situation where the model is used, different assumptions regarding which variables are exogenously given and which are endogenously determined within the model can be adopted.

Dixon and Rimmer [14] state the ideas that: "(a) CGE models can be used in forecasting; and (b) forecasts matter for policy analysis", and they note that assessment of possible policies requires realistic base case scenarios. This need for realistic forecasts is supported by the fact that in the dynamic setting the order and timing of different exogenous changes and policies matter for the transition path of the economy.
Diao & Somwaru

The Diao & Somwaru model [13] was constructed to analyze effects of the MERCOSUR (Southern Common Market including four South American countries). This model is a multi-regional, multi-sectoral, dynamic CGE model which is an extension and application of the model presented in [12]. In principle these models adopt the same assumptions of intertemporal optimization by firms and households as is used in the MONASH model. Yet, the descriptions of these models are more accessible, and we have found them inspirational for developing the spatial dynamic model tested in this thesis. Even though the Diao & Somwaru model is multi-regional, it is not spatial, since there are no transport costs inferred on trade, in contrast to all the previously described models.

GTAP

GTAP (Global Trade Analysis Project) is a project coordinated by the Center for Global Trade Analysis at Purdue University. The project has a focus on providing data, encouraging collaborations between researchers, and also to maintain and develop trade models. For documentation on the standard GTAP framework see Hertel [24], and for the recursively dynamic extension of the model, see Ianchovichina and McDougall [25]. As the GTAP project has spawned a large number of research papers, technical reports, and working papers, we suggest the interested reader to visit their homepage for further information.
4 The Papers - Summaries and Remarks

Figure 2: The four papers and the differences in their assumptions.

This section provides summaries and remarks to all the papers included in the thesis. In Figure 2 we have displayed the different papers in relation to the assumptions made in the different models. The models differ in one more relevant assumption, which is that all models except STRAGO uses the iceberg approach to trade costs. In STRAGO, there is an explicitly represented transport sector, and transport costs are additive. Earlier versions of the first two papers, on the Öresund bridge and dynamical prototypes, were part of the author’s licentiate thesis.

4.1 Paper I

In paper I we apply a static spatial computable general equilibrium model to assess the economic impacts of the Öresund bridge. In this application we have primarily addressed two issues in the development of the model, the first being how to construct a useful data set for calibrating the model, and the second issue being how to implement a cross strait trade barrier in the model.

Concerning the construction of data, different approaches could be considered. Either a regionalized social accounting matrix, describing economic activities for all regions in a disaggregate fashion, or an input-output matrix describing the economy on a regionally aggregated level, could be used for
calibration. The former approach requires trade data for both inter- and intra-regional trade, data that were not available in the Öresund case. The latter requires data for the modeled economy as a whole, or regionally aggregated, and rests on assumptions of equal preferences of households and equal technologies of firms across regions. This type of data was also not available for the Öresund region. Therefore we used a methodology to construct the needed data, using matrix balancing methods. In doing this we were able to set up two sets of data allowing us to identify differences in preferences and technologies between the Danish and Swedish side of the Öresund region, retaining the assumption of equal preferences and technologies across regions within the respective countries.

When introducing the trade barrier between Sweden and Denmark to the Öresund model, we need to identify the meaning of this barrier. Some possible foundations for barriers to trade within the Öresund model are: distance dependent trade costs that are not accounted for, differences in legislation, language and culture or other trade related costs. The model uses euclidean distances between regions to represent the distance related costs of trade. This means that the extra cost of crossing the Öresund strait is not accounted for in the distance related trade cost of the model. Since the extra cost of relying on ferries, for cross strait trade, is not accounted for in the distance dependent costs of the model, these costs may be captured by the modeled barrier. Differences in legislation, language and culture are examples of barriers that may incur frictions to trade. Finally, other trade related costs, not represented in the model, are costs due to logistics, personal travel and business travel. All these different factors may be accounted for by the introduction of the trade barrier in the model. The modeled barrier was consistently calibrated within the SCGE framework such that cross strait trade coincides with an observation of the cross strait trade pattern on an aggregate level. In paper I we provide resulting effects of reducing this trade barrier. It is clear that these results need to be interpreted with some caution, as we are not able to identify different parts of barrier costs. We have no means of distinguishing between the trade costs that are not accounted for and parts of the trade barrier due to differences in language for example. Hence the results concerning removal of the trade barrier can be viewed partly as a sensitivity analysis of the model to the trade barrier and partly as describing the potential economic impacts of removing such a barrier.

4.2 Paper II

In paper II we make a first attempt to address issues of time within an SCGE framework. As discussed earlier, temporal issues may be important both for
forecasting and policy analysis. Our approach has been that 'small is beautiful'. Therefore we have stated a small scale test model where we merge a static SCGE framework [6] with a classical framework for intertemporal consumption/savings modeling [40]. Previous static type SCGE models typically take the capital stocks used for production as exogenous to the model. In doing this they implicitly assume away the possibility to study investment effects, and welfare effects thereof, due to infrastructure improvements for example. Within the developed framework this is one possible issue that can be addressed, i.e. the formation of capital due to different policies.

Apart from understanding how to model the temporal economy and stating the model, we aim to test the behavior of the model with regard to different but commonly used assumptions. A sensitivity analysis in assumptions is provided. We have focused on studying the dynamic behavior of the economy with respect to different assumptions on capital mobility and consumer behavior. Consumers are modeled both as agents acting according to perfect foresight and static expectations. In the perfect foresight specification we can separate the time of announcement and the time of implementation of policies allowing the households to react to the implications of future policies. In the static expectations specification this type of anticipation can not be studied, as the households only react to a policy when it has been implemented. An alternative to perfect foresight or static expectations is extrapolative expectations. This represents a way of letting expectations of the future be derived from the history of the economy, a specification we have not yet tested. As the model tested is a small scale first attempt toward stating a dynamic SCGE, it is clear that the model can be extended.

4.3 Paper III

Paper III presents the development of STRAGO, together with an application of a kilometer tax on freight. The developed model provides a dynamic SCGE model, where households act with perfect foresight. Production is modeled as monopolistically competitive, but with a twist. By merging the Armington approach with that of monopolistic competition, we are able to provide a parametrization between perfect and monopolistic competition. Thus, we may set the level of competition in each sector. The relevance of this parametrization is investigated by Ardelean [3], who estimates the strength of the love for variety. She states that this strength is typically overrated in the standard monopolistically competitive setup. Thus, guided by these results, we reduce it in our implementation of STRAGO. Furthermore, we model the transport sector explicitly, and transport costs enter in an additive fashion to the price of traded goods. Because of these additive transport costs,
the elasticities of demand, facing the monopolists, are no longer constant. They become an endogenous part of the description of the equilibrium. This induces an extra dimension to the results generated by the model, as the monopolists will experience increasing competitiveness on the markets as transport costs are lowered. This effect is not present in monopolistically competitive models using the iceberg approach. The model is calibrated to input-output data, aggregated from the national accounts. Also production-consumption data are used, providing the regional distribution of production for the different sectors. Transport costs are calibrated in order to coincide with those of the Samgods transport model.

The simulation of a kilometer tax is performed in order to analyze both sectoral and regional effects from such a policy. The motivation of such a tax is usually given in terms of reductions of externalities generated by heavy freight vehicles. Such externalities are road wear, noise, pollution and accidents.

The effects of the policy are discussed both in terms of welfare measures and in terms of value added for different sectors in different regions. We find centrally located regions coping well in terms of welfare implications from the policy. The policy basically increases the transport costs. Therefore, the actors of the economy tend to shift their demand toward more locally produced goods. Central regions have more close neighbors, and therefore are not as negatively affected as peripheral regions. From a sectoral perspective, we find that sectors using both transport intensive inputs, as well as being subject to a large markup on their own prices due to the tax, are those that suffer the most. Yet, it is interesting to note, that the industry for unprocessed lumber is not especially affected. This is argued to be an effect of this industry’s small export base.

Regional and sectoral results are summarized through the use of localization, concentration and specialization indices on entropy form. The indices we use are discussed by Cutrini [11]. These entropy indices lend themselves to an intuitive, dual interpretation of specialization and concentration. Regions can only be specialized, if some industries are concentrated. In terms of regional specialization, the middle north (Norra Mellansverige) is the most affected region, requiring the largest restructuring of industrial composition.

4.4 Paper IV

Paper IV analyzes fragmenting production in monopolistically competitive industries. In the introduction of the thesis, we discussed the adoption of roundabout methods of production as a way of exploiting the division of labor, and as an explanation to trade in intermediates. People do not only
specialize in certain skills, they also use the produce of others who have specialized, as inputs to their own production. In the paper we utilize the standard theory of monopolistic competition as a tool to describe the emergence of such production processes. By adopting a recursive view on the production process, we are able to provide a simple description of all the active production stages in an optimally organized industry. Analytical results regarding the length of the production chains as well as prices, quantities, and the number of firms, active at any particular stage of production, are provided. In our model, it turns out, that the level of roundaboutness, or fragmentation of production, is limited by the extent of the market. The level of fragmentation increases in the primary input factor, labor, and decreases in transport costs.

Ideas on fragmentation production has been the focus of many studies, starting with the work by Jones and Kierzkowski [30] and later [31]. The main idea presented is built upon the assumptions that fixed costs of overall production increase with the overall level of fragmentation, while the marginal costs decrease. Then for a certain level of total output there is an adequate degree of fragmentation. The model presented in our paper will provide such a cost structure, generated in a monopolistically competitive economy. It provides a micro foundation.

Taking the framework into a two-country environment, where locations of productions are taken exogenous, we find vertical specialization between countries in industries that engage in long enough production chains. It is better to agglomerate upstream production in one country and downstream production in the other, than to engage in a symmetric structure between the countries. If one has many stages in the production chain, each stage operating in each country, and cross-hauling the products in each stage, then eventually, with enough stages, it will become more productive to agglomerate into a vertically specialized pattern of production. A pattern, which allows us to avoid trade costs.

One goal of the paper is to achieve an analytical description in which fragmentation is generated. In pursuing this goal we have made strongly simplifying assumptions. Yet, our hope is that the model accommodates some interesting properties. We may have fragmentation and vertical specialization of production, in a framework that uses a very simple description of each individual firm.
5 Conclusions

So, what have we learnt? Given the rather crude treatment of data when implementing the models in this thesis, we have to apply some caution in the interpretation of the results. As we stand, we do not provide prognoses of the economy. What we do provide is an analysis of different scenarios. In Paper I and III we perform scenario analyses regarding infrastructure improvements, and a transport policy respectively. The scenarios are implemented in the models through changing exogenous parameters such as transport cost parameters or tax levels. This can be seen as a form of sensitivity analysis, investigating which parts of the economy will respond to what degree as a consequence of the policy. In Paper II, the roles of different but commonly used assumptions are examined. We may then contrast these models with different assumptions in order to learn something about the robustness of our conclusions. A sensitivity analysis in assumptions is made. All these three papers may be considered to provide caricatures, and to use models as experiments, in the sense of Gibbard and Varian [21], and Mäki [10]. Paper IV, on fragmentation, takes on a slightly different role. We wish to explain a phenomenon. Production is divided, or fragmented, among firms. As noted, Cartwright [9] suggests that we may think of such models as parables – parables telling a story, but really, being an instantiation of an abstract thought on a higher level. The model is only one instance, out of many possible, which may provide the message. Also the message told needs interpretation from outside the model. Simply put, the work on fragmentation may be seen as a starting point from which we may explore, further, the role of fragmentation for production.

In Paper I and II, we use the Samuelsonian iceberg approach to model transport costs. This way of modeling transport costs gained its popularity mainly because of its simplifying nature in analytical work. As we are applying numerical methods to solve for computable equilibria, this motivation loses its merit. Therefore we move into modeling a transport sector which produces the transport services required to sustain trade. This is done in Paper III. Trade costs are taken to be strictly additive to the purchase price of products. This approach is clearly more intuitive, and much easier to sell to the transport society. The introduction of additive transport costs in the monopolistically competitive economy induces an effect on the competitiveness of markets. Competition increases as transport costs are lowered. Also, removing perfect for monopolistic competition, allows us to capture agglomeration forces. Through a parametrization between the Armington approach and that of monopolistic competition, we have the possibility to set the level of strength of these forces. In Paper IV we reinstate the use of the iceberg
approach due to analytical tractability.

By the introduction of dynamics in our SCGE models, we can consider
dynamic aspects of different policies. The dynamic formulations that we have
used are the simplest possible form of introducing perfect foresight dynamics
into the models. Only households make intertemporal consumption and in-
vestment decisions. Yet, these models let us study investment effects caused
by the policies. As transport costs change, the return on capital is affected
as well as the costs of assembling capital, and either causes investments or
divestments in capital stocks.

In the SCGE models we take fragmentation of production as a given. We
use input-output data, which represent the intersectoral dependencies, for
calibration of the models. The underlying cause of this industrial structure
is not pursued. This begs the question, why is there such a structure in the
first place? Answering, or suggesting one mechanism causing such a structure
is the focus of Paper IV. We do this by studying the role of fragmentation
in a simple model with monopolistic competition. We find fragmentation to
be limited by the extent of the market, both when it comes to the number
of active firms active at any particular stage of production, and the number
of successive stages involved in production.

From a policy perspective, Paper I investigates the role of the Öresund
bridge, both in terms of lowered transport costs and by studying a trade
barrier. The trade barrier is calibrated such that cross-strait trade coincides
with observations. We find that the removal of the trade barrier may have
significant effects on the cross-strait trade. Paper III analyses different effects
from a kilometer tax on freight. By utilizing entropy measures describing
the level of concentration of industries, and the level of specialization of
regions, we are able to discuss locational effects from the policy. We find that
industries that use transport intensive inputs and whose output is subject to
a large tax induced markup are the most affected. Then, regions specialized
in those sectors are also more affected than others. Also, as transport costs
increase, demands are shifted to locally produced goods, and central regions
cope well.
6 Future Work

Continuing the work on fragmentation, extending it into a framework with endogenous location of the firms would constitute interesting future work. There has been a strong, and well justified, focus on agglomerations of the economy, but fragmentation can also be of importance. The possibility to fragment production may work in either way in terms of agglomeration, which may occur through vertical or horizontal specialization along production chains. However, fragmentation may also generate diffusion of production, and it may allow production to take place at different locations, utilizing differences in factor prices, endowments, the agglomeration of others, or simply removing trade costs.

The STRAGO model has already been used in other applications, outside this thesis. The model was used in providing regionally disaggregated scenarios for ITPS\(^3\), see [26]. Taking the national scenarios provided by the Ministry of Finance, which where generated with a national CGE model, as the premises for analysis. By calibrating STRAGO to these scenarios, such that the model replicate results on a national level, we were able to provide regionally disaggregated but nationally consistent results. The results from STRAGO were then further disaggregated through the use of the rAps model system. More work of this sort may be interesting, for instance about how to aggregate and disaggregate results between different models, with different spatial and sectoral representations. A stronger integration with transport models, both regarding freight and travel, would also constitute interesting further work.

Another project that has already been financed relates to the study of marginal costs of public funds (MCPF). STRAGO will be used in order to analyze distortionary effects from taxation. The MCPF may play an important role in the application of Cost-Benefit analyses, a tool commonly used in the assessment of infrastructure projects and transport policies. In the project we will work on extending the model in terms of the representation of the tax system and labor market modeling.

Calibration and data issues always have to be dealt with when a model is implemented. The availability of relevant data puts restrictions on what may and what may not be modeled. Moving toward estimation of SCGE models is another area which could be addressed.

Other areas where further model development may be of interest are the treatment of land use and further work on dynamics. Our dynamic models use a simple way of representing investments, and only households make

\(^3\)Swedish Institute for Growth Policy Studies
decisions over time. An alternative approach would be to incorporate Tobin’s q-theory of investments. Having firms optimize the returns of their capital, and households owning the firms.
References


REFERENCES


