Jukka Ruotinen

Essays in trade in services

difficulties and possibilities

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To my parents

Abstract

This dissertation focuses on the trade in services and examines it from different perspectives to improve the existing knowledge on the matter. Considering trade negotiations, the first two essays handle controversial issues, whereas the third papers' topic enhances countries to promote trade.

In the first theoretical essay, we study liberalization of health services. By liberalization we mean removing restrictions on doctor mobility between two countries. Because of the nonexistence of a useful model, we also receive results from constructing a health service model. The results state that when the government is faced with a minimum treatment requirement, it is also efficient to provide patients a limited amount of treatment by the public sector. In a two-country model, with a minimum treatment requirement, liberalization of health services increases welfare only, if at least one of the countries has a very limited amount of doctors.

In the second essay we use a computable general equilibrium model to first estimate tariff equivalent reactions to exogenous increases in trade in transport services. After that welfare gains from liberalization of these barriers are analyzed. Independent of the assumption how much transport services are increased, the largest decrease of tariff equivalents needed for the corresponding increases are in the sea and air transport services. Vice-versa, this means that liberalization of given tariff equivalents in the other transport service sectors leads to a higher increase in trade than liberalization in the sea and air transport sectors. Judgemental total liberalization of transport, finance, and business services shows a moderate increase in global welfare.

In the last essay, we study empirically trade-related technology spillover effects. The existing literature has focused on spillover effects through trade in goods and FDI-flows. This paper concentrates on services, and shows that spillover gains can be received also with trade in services. Our results show that service flows contribute to total factor productivity in both developed and developing countries. Especially in developing

countries the effects of spillovers through services are comparable with spillovers through goods. We find no evidence for indirect spillover benefits through trade in services, but for goods the indirect effects are significant. Our results are consistent with trade theory, and with papers that analyze spillover effects through trade in goods.

Keywords: trade in services, health services, tariff equivalents, spillovers

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Chapter 1

Introduction

Background

This dissertation focuses on the trade in services. It examines trade in services from different perspectives to improve the existing knowledge on the matter. Statistics show the significance of services for economies, and the growing importance of trade in services. According to the World Trade Organization (WTO) the share of services is over 65 % of total output in industrialized countries. The importance of services increases as income rises; in developing countries the share is around 38 %. From the trade perspective, globalization was rapid in the 90's. Trade in goods and services nearly doubled within that period, even though the latter is faced with high trade barriers.

% of WE	Merchandise	Transp.	Travel	Oth. Serv.
1990	82	5	6	7
1995	81	5	6	7
2000	81	4	6	8
2006	81	4	5	9
% of WE growth				
1990	77	5	9	9
1995	80	4	7	8
2000	81	3	6	10
2006	82	4	4	10

Notes: Data Source WTO (www.wto.org); total world trade (including trade in Merchandise and total commercial services) was in 1980 $ 2,4 trillion and in 2006 $ 15 trillion; World export growth measured by growth in the last 10 years

Table 1: World export (WE) growth

In table 1 we introduce the development of world trade between 1980-2006. According to the WTO, world trade is now about sevenfold higher than 28 years ago. Thus in absolute terms trade in services has been increasing rapidly; yet the relative significance of trade in services has remained constant. The service trade to total trade ratio has remained under 20 % during the last observable 26 years. In the service sector other commercial services have gained some advantage over transportation and travelling.

In the aspect of globalization a "great leap forward" was taken in 1994. The leap was the establishment of WTO, an international organization in its own right[1]. However, the gains from introduction of the General Agreement on Trade in Services (GATS) remain a question mark. Statistics show that the increase of trade in commercial services was considerably higher in the first half of the 20th century than the latter. According to Hoekman (1996), the Uruguay Round did not deliver any actual liberalization and GATS was limited to partial "locking in" of policies that had already been implemented by member states. According to Adlung and Roy (2005), progress after 1995 has been limited to commitments in the telecommunication sector. This progress has been in contrast to the increase of world GDP. At the same time consumers have become more eager to consume services (as income has been rising) and countries have been reluctant to liberalize trade in services. Why is that?

The main arguments against free trade often include individual and environmental aspects. Considering the latter argument trade in transport services and travelling is presumed to be environmentally harmful. Still considering other services, one has to take into account the intangibility of services which should make them environmentally friendly. Considering the individual aspects and specifically, individual protection a main issue is the quality question. How can countries e.g. avoid receiving unqualified

[1] According to Bhagwati (2004), with the conclusion of the Uruguay Round an astonishing capture of the WTO took place. The three legs of the tripod were GATT (General Agreement on Tariffs and Trade), GATS (General Agreement on Trade in Services) and TRIPS (Trade-Related Aspects of Intellectual Property Rights). The first two legs belonged in the trade body, where TRIPs was the introduction of a cancer cell into a healthy body.

doctors from other countries? One main argument in economics is that to avoid spillover effects and to achieve maximum welfare, measures should be targeted to the root of the problem. And free trade is not the problem.

One of the key empirical findings is that rising income leads to trading in a greater number of varieties and higher quality. The empirical results of Hummels and Klenow (2002) show that greater exports and imports are associated with larger set of goods indicating larger selection for consumers. Still papers that show a positive link between trade barriers and product quality do exist[2]. Krishna (1990) shows that theoretically trade barriers can increase the quality of the imported product. This is due to the fact that trade barriers remove consumers with a low valuation of quality, who purchase low-quality products. Still the results do not indicate that total welfare would increase. One issue is how increasing trade affects competition. Kranton (2003) argues that when quality is unobservable to consumers prior to purchase, price competition may eliminate profits necessary to induce firms to produce high-quality goods.

The barriers to trade in services remain high. For many developing countries, where the barriers are the highest, the coverage of specific commitments is well below 50 percent of all services supply. This means that the welfare gains to be achieved by liberalization are extensive, but a lot of effort has to be put in place. Multilateral trade negotiations are needed to secure market access for committed countries, and to attract new countries to join the negotiations. Especially developing countries would gain from the liberalization, as they have high barriers to trade in services.

Due to doubts of the liberalization process, countries have set bound tariffs[3] under

[2]One empirical example is how in the USA and Canada trade barriers in automobiles affected Japan's trade and investment flows. Japan's car exports were restricted in 1981 by a VER (a quota on trade imposed from the exporting country's side; still usually imposed at the request of the importing country's government). According to Stern (1989), Japanese car makers responded to the VER by improving car quality. Feenstra (1984) estimated that two-thirds of the increase in imports of Japanese cars after the introduction of the VER was due to quality improvement between 1980-1984. Japanese car makers also increased FDI flows and opened up subsidiary production plants in the USA.

[3]During tariff negotiations (known as rounds, the most recent of which was the Uruguay Round), countries set ceilings on their tariff rates. This is known as the bound rate and refers to the highest allowable rate, in contrast to the rate that is actually applied, which is referred to as the effective rate. WTO negotiations on tariff reductions concern bound tariffs, not applied tariffs.

the GATS. Applied tariffs are usually equal to the bound tariffs in developed countries, but bound tariffs often exceed applied tariffs in developing countries; a phenomenon known as tariff overhang. In many cases the applied tariffs are lower than the bound tariff rates. Due to the intangibility of services, barriers do not generally take the form of tariff barriers. Instead they often consist of prohibitions, quotas, and government regulation. Hoekman and Braga (1997) divide barriers to trade in services into four categories: quantitative restrictions, price-based instruments, licenses or certification requirements, and discriminatory access to distribution and communication systems. The different types of trade barriers can be applied to restrict trade in different kinds of services. Most progress has been achieved with the liberalization of business and financial services and tourism.

The liberalization of trade in transport services has remained up to bilateral negotiations. The explanation for the slow liberalization of transport services is that air and sea transportation enterprises are in many countries state-owned or highly subsidized sectors. They are also considered as part of the infrastructure, and this is one reason why they are highly protected. Transport, energy, and telecommunication services are examples of infrastructural service sectors; only the liberalization of energy and telecommunication services has risen on the agenda.

The liberalization of trade in health services has also been a difficult task. The lack of liberalization is most probably due to government interference in this sector[4]. Governments may find it hard to combine structural economic reforms and achieve social objectives. Thus finding a balance between preserving regulatory freedom and benefits from liberalization of trade is needed. Technological change is affecting the possibilities of liberalization, for which telecommunication services are a leading example.

From the theoretical point of view, a consistency exists between trade in goods and services. The H-O-S theory states that a country will concentrate on production that re-

[4]GATS define services as "any service in any sector except services supplied in the exercise of governmental authority" (GATS Art. I:3(b)). The problem with this commitment is how governments can commit to access conditions in some segments without compromising their ability to exercise their "governmental authority" in others.

quires factors that countries are relatively abundant with. Produced items can be either goods or services. Neither did Richardo distinguish between the two when illustrating that trade is based on different technologies of production. Specialization (utilizing economies of scale and improving quality) is in general welfare increasing and beneficial for countries, and technological change increases the possibilities of specialization.

Mundell (1957) showed that the flow of factors of production could substitute trade in goods if trade in final goods is restricted. This is also relevant for services. If trade in services is restricted e.g. due to consumer protection, factor movement may subsidize this if mode-substitution is not possible[5]. Considering services the question then is about trade in services versus migration. Trade theorists have suggested that liberalization of trade in services could be a partial substitute for migration.

In addition, trade flows are nowadays hard to treat due to problems in distinguishing between goods and services. Production of goods requires the usage of services. This is why services also play indirectly a great part in world trade (Francois and Reinert 1996). Allowing importation of services may therefore have also considerable effects on the countries' production and exportation of goods.

Yet an analysis of trade in services is needed. The interesting feature of trade in services that distinguishes it from trade in goods arises from the various ways in which services can be traded. Sampson and Snape (1985) divide services into four modes that are also used by the WTO for distinguishing different types of services in GATS-negotiations:

- Mode 1 – Cross-border trade – Covers services supplied from the territory of any other member (e.g. services through telecommunication or postal infrastructure: consultancy, market research reports, tele-medical advice)

- Mode 2 – Consumption abroad – Covers services supplied in the territory of one member to the service consumer of any other member (e.g. tourists, students, or patients consuming abroad services)

[5]By mode-substitution we mean substitution of the way trade is performed. E.g., cross-border trade or presence of natural persons can be replaced by commercial presence.

- Mode 3 – Commercial presence – Covers services supplied by a service supplier of one member, through commercial presence, in the territory of any other member (e.g. locally established affiliate, subsidiary, or representative office of a foreign owned and controlled company: bank, hotel group, construction company)

- Mode 4 – Presence of natural persons – Covers services supplied by a service supplier of one member, through the presence of natural persons of a member in the territory of any other member (e.g. consultant, health worker)

Services are intangible and are often consumed as produced. Technological development has changed this picture as services can be in a digital form. Transfers of e.g. databases enable services to be produced in the traditional way (mode 1). To distinguish between the four modes of service trade we take health services as an example. Doctors do not need to meet patients in order to provide treatment. Health related consultancy is increasing, which highlights mode 1. Mode 2 could be a much more important factor than it currently is. For instance, due to the lack of portable health insurance people who retire while living abroad are often forced to come home to obtain affordable medical care (Hoekman 2006). In the health sector FDI-flows have remained limited, but their role is slowly increasing (mode 3). In mode 4, instead of buying service production, countries try to persuade doctors from other countries to immigrate. This substitution holds true for the high skilled as for the low skilled workers. If trade in services was more open, the pressure for tempting cross-border workers could be lower. In general, the lack of understanding in health services holds for all types of health services trade (Hoekman 2006).

Trade in services differs from trade in goods where production and consumption are separated. Another important difference between trade in goods and services concerning trade theory is how goods and services reflect to the law of one price. This law states that in the absence of transportation and other transaction costs, competitive markets will equalize the price of an identical good in two countries. The law of one price does not apply to locally produced services. Also traded services that require local factor

inputs are not associated with the law of one price. As services are often bundled with goods, the liberalization of trade in goods may not result in an integrated market either (Horn, Shy 1996).

Baumol (1967) was one of the first papers that explicitly analyzed the service sector[6]. It is definitely one of the most important studies, even though its implication that services hinder growth is not as valid as it used to be. The conclusion holds only if the stagnant industries produce final products. For intermediate services the conclusion does not hold (Francois 1990a, Oulton 2001). Oulton (2001) argues that e.g. business services are intermediate products that enjoy technical progress and benefits from productivity growth. Also indirect benefits exist as the manufacturing sector uses these business services. This is a very important outcome since among the most rapidly expanding service industries are financial and business services, which are intermediate services. The USA has shown that productivity growth can be led by services (Jorgenson, Ho & Stiroh 2003). Due to the properties of technology and trade, inventions in one country can increase productivity also in other countries. This can occur through direct and indirect trade flows or foreign direct investments (FDI). Still the understanding of the magnitudes and direction of spillovers resulting from trade in services and FDI has still remained very moderate (Hoekman 2006).

As said, many services have an intermediate role in the production process. The importance of these services is increasing due to their role in the continuing specialization process through outsourcing in companies. Consumer demand for variety and quality

[6]Baumol effect (known as Baumol's cost disease) was described by William J. Baumol and William G. Bowen. Their original example of a "problem" existing in the service sector was conducted for the performing arts sector; they pointed out that the same number of musicians was needed today to play a Beethoven string quartet as were in the 1800s. So the productivity of Classical music performance had not increased. At the same time wages of musicians have increased (as competition for employees exists) and this causes a dilemma against the theory in classical economics that wages are always closely tied to labor productivity changes. Still world GDP and consumer salaries have been growing increasingly due to productivity growth. Technological innovations in the industrial sector have also benefited people working in the service sector. And if productivity is not increased in the future in labor intensive services, service sector workers have to be compensated by e.g. keeping tax rates constant. One interesting feature is that the share of services to GDP increases as income rises. This means that despite the Baumol effect people are more eager to pay for services even (because of) productivity growth would remain sluggish in the service sector.

of services is increasing, and the same is occurring in industrial enterprises to increase productivity. Another important aspect of the intermediary role of services is the costs they provide. We take transportation and financial services as examples. According to Djankov, Freund and Cong (2006) international transport and related transaction costs are a major factor determining the competitiveness of potential exporters. Francois and Wooton (2001) have shown that welfare gains achieved by tariff reduction in the export market remain considerably smaller if the shipping lines are not competitive. The financial service sector is important due to its intermediate role in production, but also due to its direct effects on consumers' welfare. Trade literature shows a positive link between financial sector openness and economic growth performance (Hoekman 2006).

Empirical research on trade in services and its liberalization effects have remained limited due to the lack of (reliable) data. Researchers have not been able to utilize computable general equilibrium models (CGE) to their full potential. Data problems cover both trade flows and policies restricting trade. According to Hoekman (2006), the difficulty of quantifying and identifying the barriers reflects historical nontradability of services. Another aspect is that services are often bundled with traded goods and separating them is difficult.

With the following essays we will contribute to the research on trade in services. The first two essays concentrate on two service sectors, health services and transportation, in which liberalization has been a difficult task for policy makers. The outcomes of the first two papers do not concentrate on giving much support for the slowly ongoing liberalization of trade in services. They will merely contribute to the existing literature of trade in services. The third essay reflects the ambitions of countries (spillovers) and gives support for trade in services liberalization. The lack of data, a concern shared with all researchers, is also a problem of the two empirical essays, and making assumptions cannot be avoided. Still, the assumptions do not ruin our results; instead, the lack of data was a motivating factor for the second essay.

Trade in services is analyzed from a macroeconomic perspective. The essays are

heterogeneous in the way issues are researched. The first essay is a theoretical one and the second and the third essay are empirical studies. Economic welfare and growth effects are studied in trade literature by econometric studies and CGE analysis. In the second paper calculations are performed with a CGE-model, and the third paper is a cross-country econometric study.

Overview of the essays

The first essay "Publicly provided health services in a two-country model" (chapter 2) focuses on health services. From the trade perspective health services is a difficult subject, and one example of the difficulty is the EU service directive, which does not include health services. As represented in chapter 2 subsection 1.1, an outcome of the inability of countries to agree on health services liberalization is the mobility of doctors between countries (Mundell 1957). The objective of the first essay is to introduce a theoretical Nordic country type health care model and study welfare effects from liberalization of health services between two Nordic countries. We jump from the theme of trade in services to factor movement, as we find the latter issue to be more relevant.

The essay includes an introduction until we are prepared to analyze the mobility of doctors (as a substitute for trade in health services). Despite remarkable papers[7] that include many important aspects of health care provision, a suitable model for analyzing doctors' mobility between countries was hard to find[8]. The most suitable papers that model health service supply in the Nordic countries are Hoel and Saether (2003) and Iversen (1997). However, a problem with these papers is that they assume an exogenously given waiting time in the public sector before treatment is provided. We make use of the way the waiting time is modelled. Contrary to the existing papers, the waiting time in our model is endogenous, and we specify it as treatment quality that is determined by the relative amount of doctors to the amount of patients.

[7] See Arrow (1963), Rothschild and Stiglitz (1976), Weitzman (1977) and Poterba (1994).

[8] This holds especially for models that formalize health services as provided by Nordic countries, where the role of the public sector is important. Health services are mainly provided by the public sector due to assure the wellbeing of people, externalities and the problems of asymmetric information that personal insurance include (Rothschild and Stiglitz 1976).

A reason for the government intervention in the health sector in the first place is the potential externalities in the form of infections. To avoid infections, the government sets in the model a minimum amount of treatment that has to be provided to all patients. In our model this provision is modeled by offering public services free as consumed. The publicly provided health services are financed in the first model with a welfare maximizing lump-sum tax and in the second model by targeting taxation on patients visiting private doctors. The decided tax rate determines the wage and number of doctors working in the public health sector. Patients choose between the public and the private health sector according to their valuation of treatment quality[9]. Doctors choose between the sectors according to their entrepreneurial skills.

The liberalization of health services is modelled in a traditional way by assuming two similar Nordic countries that are different in one aspect. We assume that this aspect is the amount of doctors in a country. The potential for welfare benefits of the liberalization is obvious because one country has a comparative advantage in doctors desiring to work in the private sector and the other in public sector doctors. Still the several factors in the model make the benefits unobvious. When countries cooperate in wage setting and total welfare increases from liberalization, but the welfare of the other country decreases, that country can be compensated. Even when countries do not cooperate, the losing country has a comparative advantage in utilizing another factor of production than doctors.

The first essay leaves many questions unanswered and motivates further discussion and research. Still it gives insight to one of the most difficult subjects in world trade / factor allocation. The framework that is built up enables with simple changes to study the issue further[10]. Considering first the one-country model, the first essay shows

[9]It should be noticed that we are not saying that doctors working in the public sector have higher skills than doctors in the private sector. In the private sector the doctors have only more time for analyzing patients due to one doctor can spend more time on a patient.

[10]It would be also possible to study explicitly trade in health services with the model (according to gats-classification mode 4), but as mentioned we consider that factor movement is at the moment a more important subject considering health services. And still it is a substitute for trade in health services.

that it is optimal for a country to have a dual health care system where health services are provided both publicly and privately. Assuming this framework for a country, we introduce a second country into the model.

One result that we obtain is that both countries end up issuing doctors working in the public health sector at an equal wage even if they would not cooperate in wage setting. This is based on the fact that a country offering a lower public sector wage rate would not receive any public sector doctors. When offering a higher wage it would receive all public doctors. The model shows that if both countries finance health services with a lump-sum tax the total welfare of the countries will increase if at least one of the countries has a low number of doctors compared to the amount of patients. The reason why it may be the case that countries would not benefit from liberalization is that the welfare of patients decreases if both countries have a high number of doctors, who are allowed to move between countries. The government in our model is unable to tax the moving doctors, and welfare losses cannot be avoided if mobility is allowed.

If public health services are financed with targeted taxation, instead of lump-sum taxes, the quality of public provided services does not change. This is why liberalization does not affect patients going to the public sector, and liberalization is always welfare increasing.

The second essay "Welfare effects of trade in transport services liberalization" (chapter 3) discusses another difficult subject for the policy makers, namely transport services. The growth of trade in international transport services has decreased to almost zero percentage a year as discussed in chapter 3 subsection 1.1. Air transport services are generally protected from foreign competition, and they are not included in GATS negotiations. Bilateral negotiations have also remained limited, as have maritime negotiations, especially in the case of domestic coastal transportation. Theoretical examination, however, shows obvious liberalization benefits (Francois, Wooton 2001).

The welfare effects resulting from the liberalization of trade in services has been analyzed by using Hoekman's "quesstimates" on tariff equivalents[11]. Our focus is especially

[11] See Brown, Deardorff and Stern (1996), Dee, Gaisler and Watts (1996) and Robinson, Wang and

on the transportation sector as a whole. We use a computable general equilibrium model (CGE) GTAP[12] to perform our calculations. We begin by simulating international region based tariff equivalents for air transports, sea transports and all other transports as a group. These tariff equivalents are then used for tariff reduction simulations. To get a clearer picture of liberalization benefits that can be gained from intermediate service sector liberalization, we add at this stage tariff equivalent estimated by Francois (2001) for the financial and the business service sectors.

Using tariff equivalents, we study welfare effects from multilateral liberalization of trade barriers. We have especially a developing country focus in this paper, and bring out the results for Africa. In addition we show how the liberalization affects exportation and importation of goods from different regions. We have aggregated the GTAP-database for our simulations into 6 regions and 8 sectors[13]. Only cross border service trade effects are discussed, and FDI:s are not considered.

We use systematic sensitivity analysis to estimate the reliability of the results we obtain from the reduction of the chosen trade barriers. When trade is liberalized between regions in the model, the elasticity of substitution factors determines how this affects production. When domestic production is substituted by foreign production it is up to the elasticity of substitution factors how large these substitution effects are.

Estimating the tariff equivalents for the transport services, we obtain some interesting results. Independent on the assumption of how much trade in the different transport services is increased, the largest decrease of tariff equivalents needed for the corresponding increases in trade are in the sea and air transport services. These two sectors react quite similarly. Vice-versa, this means that the reduction of given tariff equivalents leads in all other transport services to a higher increase in trade than reduction in sea and air transport services. This is probably because actual tariff equivalents

Martin (2002).

[12]The GTAP model is developed at University of Purdue in Global Trade Analysis Project.

[13]The regions are: Industrialized countries, Central and South American countries, South Asia, Africa, and the rest of the world. The sectors are: food, other primary products, manufactures, and services (where the studied service sectors are taken separately).

for the sea and air transport services are higher than for all other transport services. From this would follow that higher reduction of tariffs are possible in the sea and air transportation sectors.

The welfare effects of liberalization of trade in transport, financial and business services are measured by three indicators: regional equivalent variation (EV), regional household utility, and quantity index for regional gross domestic product (GDP)[14]. The results we obtain remain modest, and indicate that liberalization of the chosen intermediate services alone will not lead to large increases in welfare. If a judgmental increase of 80 % in transport services trade is possible, and financial and business services are liberalized as a whole, (Francois 2001 estimates) regional GDP increases by 0,17 % on average. What should be noted is that if large increases of trade in transport services are possible, all chosen regions will benefit from the liberalization. As shown by trade literature (Hoekman 2006), liberalization of transport services alone will not lead to large increases of welfare[15].

Measuring welfare by GDP changes, the most benefiting region is Africa. Measured by EV, the most benefiting regions are the industrialized countries and countries in South Asia. The liberalization of trade is most beneficial in other transport services and air transport services. The benefits of the liberalization of trade in sea transport, financial and business services remain low. By introducing systematic sensibility analysis, we find that positive welfare effects of liberalization are uncertain in two regions: Central and South America and the group of all other countries.

The third essay "Technological diffusion and trade in services" (chapter 4) differs from the first two essays, as its topic enhances countries to promote trade. As noted by Solow (1957), technological change can sustain economic growth. Physical and human

[14]EV is a compensation payment that in the absence of the economic change (price decrease) moves the consumers of a region to the welfare associated with the change. The regional household utility (u) is a percentile change of the equivalent variation. Changes in GDP reflect shifts in the economy's production possibilities frontier owing to the improved allocation of a fixed resource base (Hertel, Tsigas 1997).

[15]Still one should notice, that GDP's will be every year 0,17 % higher. If one calculates the net present value of this, it is not insignificant.

capital accumulations alone are not able to explain the large variation of growth rates in various countries (Easterly, Levine 2001). The properties associated with technology and knowledge (non-rival, excludable) increase the possibility of countries to benefit from foreign R&D investments. According to Eaton and Kortum (1999) and Keller (2002), the major sources of technological change leading to productivity growth in the OECD countries do not originate from domestic investments but from foreign investments. Countries are familiar with the benefits of absorbing technology, and this motivates countries to enhance imports.

The existing literature has focused on spillover effects through trade in goods and FDI-flows. The path-breaking paper in this field is Coe and Helpman (1995). The third essay shows that spillover gains can also be reached by trade in services. Analyses of services are unexploited in this field; even one can expect the benefits from technological diffusion occurring through trade in services to be significant. This is due to the fact that with person-to-person contacts it can be very difficult for the inventor to prevent knowledge spillovers (Keller 2004). The main reason for the lack of research in this field is most probably related to data problems. We sidestep this problem by utilizing data provided by GTAP (section 3).

There are important papers that have discussed the way spillover effects through trade should be modeled. We take advantage of three papers in our calculations: Lichtenberg and van Pottelsberghe de la Potterie (1998), Lumenga-Neso, Olarreaga, and Schiff (2001) and Coe, Helpman, and Hoffmaister (1997). The first paper is used for analyzing only direct spillovers, which is the traditional way for analyzing spillovers. After that we take advantage of the second paper and repeat our regression with a specified model by introducing indirect spillovers[16]. The last paper concentrates in studying whether countries with higher spending on post secondary education have been able to gain more from direct service spillovers.

As explained, technological change is the main factor behind economic growth in

[16] Indirect spillover is defined in Lumenga-Neso, Olarreaga, and Schiff (2001). It is based on the idea that country A can benefit through trade from R&D investments in country C even if it is not trading with that country. This is the case if both countries A and C are trading with country B.

the long run. Technological change is equal to total factor productivity (TFP), which measures changes in output with respect to changes in inputs (labor and capital) used in production. TFP can be promoted by increasing R&D-investments. These investments can be performed in the home country or imported (spillovers). In this essay we have calculated how changes in these stocks affect TFP[17]. We include 50 countries[18] from 3 income groups, and the observed years are 1990-2000. The critical assumption in our calculations is that bilateral service shares have been close to the shares in 1997. Foreign goods and service R&D-stocks are based on stocks of 16 high-income economies. For most of the low-income countries the domestic R&D-stocks were assumed to be zero.

Not surprisingly, our results show a positive effect of domestic R&D investment on TFP. The effects of investments are higher in high-income economies. A one percentage unit increase in domestic R&D investment in the high-income economies leads to a 0,16 % increase in TFP. A one percentage point increase in the foreign service R&D stock increased directly TFP by 0,02-0,05 % independent on the country income level. Indirect service spillovers had no effect on TFP.

Investments into post-secondary education were not found to have any positive impact on countries' ability to benefit from other countries' investments into service R&D stocks. When adding indirect trade flows into our calculations, the picture of foreign good R&D stock effects through trade changed. A one percentage unit increase in foreign goods R&D-stock lead indirectly to a 0,5 % increase in TFP. When separating high-income economies, we found that high-income economies were also able to benefit from direct spillovers.

Concluding comments

The focus of this dissertation is on three issues in trade in services that are analyzed to a minor extent in trade literature. The issues are analyzed from a macroeconomic

[17] However, it should be noted that the relationship between imports and productivity is complicated. Productivity growth triggers economic growth and increases income. This, in turn, leads to an increase in imports. Also increased productivity in an import-substituting industry crowds out imports from the domestic market and thus has a negative impact.

[18] 22 of the countries are high-income, 20 middle-income, and 8 low-income countries.

perspective. The first topic is to solve implications of the present state of trade in health services. The second issue is the magnitude of barriers to trade in transport services and their liberalization implications on other sectors and welfare. The third essay focuses on the explicit benefits, form and magnitude, of spillovers through trade in services.

Our key finding from the first essay is that if two countries finance public health services with a lump-sum tax, the total welfare of the countries will increase if at least on of the countries is faced with a low amount of doctors compared to the amount of patients. The second paper states that reduction of given tariff equivalents in sea and air transport services leads to a similar and higher increase of trade in these sectors than an equal reduction in other transport services. The welfare effects of liberalization of trade in transport, financial and business services alone remain modest. Still, if large increases of trade in transport services are possible, all regions will benefit from liberalization. According to the results of the third essay, countries have befitted from direct spillovers through trade in services independent on the country's income level. Indirect service spillovers show no impact on total factor productivity (TFP).

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Chapter 2
Publicly provided health services in a two-country model

1 Introduction

In most European countries health services are mainly financed by the public sector and its share of health care expenditure is over 70% (OECD 2005)[1]. In the Nordic countries the share is even higher. Switzerland and the USA are examples of countries where the role of private financing is higher. Also in some developing countries private financing plays a notable role in financing health services (Hanson, Berman 1998). In addition to humane reasons, the existing literature supports public financing of health services due to economic reasons. One classic explanation are externalities which arise when individuals do not take into account the possibility of infecting others. Important arguments for government intervention in health care are market failure and redistribution (Poterba 1995)[2]. Arrow (1963) analyses sources of market imperfections, which include asymmetric information between patients and providers of health services, and the uncertainty of future needs for medical treatment. The first imperfection would lead without government interfering to undesired outcomes. The response of markets to the second imperfection is health insurance. Still insurance include a problem of

[1] These figures include government spending into research which makes it difficult to analyze by these figures the share of government spending on health services supply.

[2] We do not discuss aspects of redistribution in this paper.

asymmetric information (Rothschild, Stiglitz 1976). Adverse selection makes it undesirable to have only privately financed health care, because only those with high risks of needing treatment or wealthy people would buy insurance. By compelling individuals to get insurance, the government is able to increase total welfare.

Another issue with insurances in common is moral hazard. Health insurances include problems such as how the actions of people affect the probability of treatment needed and how much treatment individuals demand or doctors provide. Considering the latter argument, in the private sector action is based on profit maximization, and patients are also eager to demand the best possible treatment if they are covered by insurance. The outcome of this is expensive insurances. To avoid moral hazard problems, it may be more difficult for the government to affect privately offered insurances, than to offer insurance or provide health services. (Poterba 1995) divides government intervention into subsidies, mandates, and government provision. As mentioned, the USA mainly follows the first strategy by subsidizing health insurance, where insurances are partly provided by the government. Subsidies are given in the form of reduced insurance fees and tax deductions. Nordic countries rely mainly on government provision.

Weitzman (1977) analyzes which one, the price system or rationing, is more effective in matching up the limited supply of a deficit commodity amongst those who need it the most. His results can be utilized in analyzing health services provision. Weitzman (1977) shows that rationing is more effective if needs for the deficit commodity is uniform and/or there is high income inequality. The inverse conditions hold for efficiency of a price system. Despite Weitzman's (1977) results, public provision of health services has disadvantages. One question is whether governments should "make or buy" services. To maximise efficiency, the government can contract-out services. Already the possibility of competition may increase the productivity of the public sector. The government also has to decide how to finance the public supply. Lump-sum taxation is an efficient way of financing, but also user fees can be used. Public provision can reduce individuals' ability to choose desired health service providers. Lack of competition can be the outcome of public provision. Still a low amount of competition can also be a problem with the

private sector. Independent of the type of health service supply, one important factor is the utilization of new technologies[3]. This can be easier for the public sector (in the developed countries) due to major resources.

In their path breaking papers, Hoel and Saether (2003) and Iversen (1997) analyze health services in the Nordic countries. We make use of these papers, and especially how the waiting time (patients need to wait to see a doctor) is modelled in these papers. We also take into account two crucial aspects in public financing of health services in our Nordic country health service model that have not, to our knowledge, been analyzed before. One issue is the desire of health service providers (doctors) to work for the private sector. If a highly subsidised public sector exists and demand for private health services is low, this can lead to low provision of private services. In our model, private health service providers face costs from establishing private practices. Another factor are externalities that arise from the existence of a dual supply model of health services (queuing, treatment quality). When health service providers or patients move between the public and private sector this affects other patients and doctors. We concentrate especially on these two points when constructing a health care model. The results from our model are compared with those of Weitzman (1977). The main reason for constructing a new model is that we desire to take a global aspect into health service analyses, and we were unable to find a suitable model for this.

Globalization can affect health care and health service provision in various ways. We include a trade aspect into our model. The H-O-S theory suggests that countries concentrate on factors that they are relatively abundant with. Still if trade in final goods is restricted, the flow of factors can substitute trade in goods (Mundell 1957). A similar analysis can be done for services[4]. Trade in health services can include many factors. Relating to WTO modes, trade in health services can be combined with all of them. Examples of these are education of doctors or operations on patients in

[3]The usage of new technologies is a difficult subject in health care. First installing them in an efficient way is difficult, and the disuse of them also leads to trouble (Baumol 1967).

[4]Among others Francois (1990), Sampson and Snape (1985) and Francois and Wooton (2001) examine the difference between trade in goods and trade in services.

foreign countries, investments into health care providing firms in foreign countries, and temporary mobility of doctors. Combining the trade issue with our former aspects in health care provision, the most important factors for us are the behavior of health service providers and patients. In addition we conclude that the mobility of patients in large amounts is unlikely, so we rely on Mundell (1957) and enable the mobility of health service providers in our model. One aspect that is taken into account in analyzing the global benefits of the liberalization of health service providers' mobility is the possibility for countries to cooperate.

In section 2 we present a one-Nordic country health care model. First, we introduce a model which takes into account some important factors of health care that, to our knowledge, have not been analyzed before. With this model we study two ways of financing health services. After that we include the second Nordic country into our analysis and study the welfare effects of the liberalization of health services production. Section 3 is for conclusions. The appendixes include proofs of lemmas.

2 The Model

In this model the reason for the government to interfere with the health services market is based on externalities. The first externality is infections, so the government is faced with a minimum treatment requirement. The second externality originates from the ability of doctors and patients to choose between the private and the public health care sector. The second externality is explained in detail in subsubsection 2.1.3. The supply of health services (the amount of health care provided by doctors) is assumed to be scarce, so that all patients are not able to get perfect treatment. Because the government is willing to avoid infection, it is unable to set a user fee to match up the limited supply of health services. The government can set a lump-sum tax to finance public health services, or it can set a targeted tax on private health sector visits.

After introducing a one-Nordic country model, we enlarge our analysis to contain two countries. In the two-Nordic country model we study the effects of factor (doctor)

mobility between two Nordic countries. We assume that doctor mobility occurs because there is no possibility of trade in services by which we mean patients getting treatment in a foreign country. We assume two identical Nordic countries which differ only in their amount of doctors. The object of the two-country model is to study the welfare changes after allowing doctors' free mobility.

2.1 A one-country model

Hoel and Saether (2003) and Iversen (1997) assume an exogenous waiting time in the public health sector before treatment is performed. This waiting time then determines how people polarize between the public and the private sector. We make use of the way waiting times are modeled in these papers. Contrary to the existing models, the "waiting time" is in our model an endogenous factor, and we specify it treatment quality as explained in subsubsection 2.1.3. Our focus is on basic health care, by which we mean people visiting doctors because of basic diseases or minor trauma. We assume that all patients are faced with the same "baggage" of medical illnesses. To get well, all patients require the same exogenous determined amount (time) of basic health care in the examined period. Patients visit a doctor once. Private doctors work as entrepreneurs in our model. All doctors put in an equal amount of working hours and are able to examine during that time an equal amount of patients in the given period. Next, we introduce the demand and supply of health services and then consider government behavior.

2.1.1 Demand of health services

The allocation of patients between those who visit the public health care sector and the private sector is determined endogenously in the following way. The benefit of visiting the public sector is $a_g\theta - t - p_g$ where a_g is the relative amount of health care provided to health care demanded in the public sector. θ is the valuation of treatment quality, and people have different valuation for health because of different income levels. a_g

is dependent on the share of treatment hours provided by the doctors working in the public sector to treatment demanded by public sector patients (equation (5)). The valuation θ is dependent on the income of people. t is a lump-sum tax set by the government.

We assume that to avoid infections the government assures that $a_g \geq \underline{a}_g$, where $\underline{a}_g$ is the minimum amount of treatment guaranteed by the government. Because of this the public sector user fee is $p_g = 0$. The benefits of visiting the private sector is correspondingly $a_p\theta - t - p$, where a_p is the relative amount health care provided to health care demanded in the private sector and p is the cost of a private visit. If the following condition holds, it is optimal for a patient to visit the private sector

$$(a_p - a_g)\theta > p \tag{1}$$

where θ is uniformly distributed between $[0, 1]$. We denote the cumulative distribution function by F. From equation (1) follows that the share of patients visiting the public sector is

$$F(\dot{\theta}) = \frac{pN}{(a_p - a_g)} \tag{2}$$

where p is the equilibrium price in the private sector, and $\dot{\theta}$ is treatment quality valuation of the indifferent patient. We denote the total amount of patients by N, and set $N = 1$.

2.1.2 Supply of health services

Before calculating equilibrium conditions, we explain the behavior of doctors. Doctors can choose between working in the public or in the private sector. Doctors have skills λ, which are uniformly distributed between $[\underline{\lambda}, \overline{\lambda}]$. To start private practices, doctors need a skill level of $\bar{\lambda}$. This factor contains the entrepreneurial skills private doctors have to be able to handle. When deciding to become a private entrepreneur, the doctor is able to earn $\frac{p}{a_p} - (\bar{\lambda} - \lambda)$, where $\bar{\lambda} - \lambda$ is the amount of extra effort a doctor has to put due to low skills. By working for the government doctors receive a payoff w_g. The

condition for deciding to work as a private doctor is

$$\frac{p}{a_p} - (\overline{\lambda} - \lambda) \geq w_g \tag{3}$$

where λ is uniformly distributed between $[0, 1]$. We set $\underline{\lambda} = 0$ and $\overline{\lambda} = 1$. For equation (3) to be satisfied $\lambda \geq 1 - (\frac{p}{a_p} - w_g)$, from which follows that $\frac{p}{a_p} \geq w_g$. We denote the cumulative distribution function by G. From equation (3) follows that the share of doctors working in the public sector is

$$G(\dot{\lambda}) = 1 + w_g - \frac{p}{a_p} \tag{4}$$

As assumed in subsection 2.1 all doctors are able to examine an equal amount of patients. The maximum amount of patients that can be "properly" examined is L, which is dependent on the amount of doctors. $\dot{\lambda}$ is the skill-level of the indifferent doctor.

2.1.3 The government behavior and rationing

In addition to infections, a second type of externalities exists in this model. This arises when doctors make a decision to start private practices, and at the same time they decrease treatment hours per patient in the "public sector" (a_g). By issuing a public wage w_g the government can keep some doctors in the public sector. Patients also create externalities when choosing between sectors.

The medical attention time per patient in the public sector can be denoted by

$$a_g = \frac{G(\dot{\lambda})L}{F(\dot{\theta})} \tag{5}$$

The medical attention time per patient in the private sector a_p differs from the public sector because of different amount of patients and doctors. One question is why there would be any incentive for people to visit private doctors if public treatment is given for free, as we assume. The motivation comes from different treatment times in

the two sectors[5]. When $a_g = a_p$, there is no motivation for patients to go to the private sector. Yet, if the government sets $a_g < a_p$, some people are eager to visit private doctors. All patients get treatment, but the more there are patients compared to the amount of doctors in the public sector, the shorter the time of treatment per patient is[6].

Contrary to existing papers, we do not study the emergence of a waiting time in the public sector. We assume that all public sector patients are treated to some extent in the public health clinics. The motivation for some people to visit private doctors is an outcome, as mentioned, of reasons based on treatment quality. A short medical attention time per patient in the public sector means that doctors are not given an ordinary amount of time to treat patients[7]. However, one should notice that when there is no shortage of medical treatment ($L = N$) from this follows that $a_g = 1$, and no private sector is required.

2.1.4 The game

There are three players in this model: the government, patients, and doctors. The model equilibrium is solved as a game with four steps. First the government sets the public wage w_g. Then at the second step doctors decide the sector they will work for (λ) and at the third step the private sector visiting fee (p) is determined. At the final step patients choose between the public and the private sector (θ). We use backward induction for solving equilibrium. Before solving the optimal public wage we focus on the third step, where doctors set p. The equilibrium of supply and demand of medical treatment in the public and in the private sector are given by the following equations

[5] When analyzing waiting times a could be considered as the probability of getting treatment when requested.

[6] According to equation (2) and the definition of θ ($U[0,1]$), we are aware that $a_g \leq a_p - p$. From this it follows that $a_g < a_p$, when $p > 0$.

[7] This could lead to an increasing amount of visits by people, or to the existence of more sick people in the society. We do not model the dynamic effect of a low a_g on N.

$$LG(\dot{\lambda}) = F(\dot{\theta})a_g \quad (6)$$

$$L(1 - G(\dot{\lambda})) = (1 - F(\dot{\theta}))a_p \quad (7)$$

where equation (6) determines the allocation of doctors and patients in the public sector and equation (7) in the private sector. By combining equations (2),(4),(6), and (7) we can solve the market equilibrium price for a private visit

$$p = (a_p - L) \quad (8)$$

We have found a connection between the attention time per patient in the private sector a_p and the private sector fee p. We are also able to show why $a_p = 1$ and $p = 1 - L$ is an equilibrium and the only equilibrium. Assume first that all doctors set $a_p = 1$. By assumption $a_p = 1$ denotes perfect treatment, and no patient desires to get more treatment. If one doctor tries to set the price of a private visit to p' so that $p' > p$ he would receive no patients and no income. Instead by setting $p' < p$ and giving treatment a'_p so that $a'_p < a_p$ the answer of this actions profitability is more complicated. For some θ it must be that $a'_p\theta - p' \geq \theta - p$ so that a patient would prefer the deviating doctor, and from this follows that $p' \leq p - \theta(1 - a'_p)$. Studying first the patients in the private sector, the maximum price p' the deviating doctor can ask for is $p' \leq p - \dot{\theta}(1 - a'_p) = p - \frac{p(1-a'_p)}{1-a_g}$, and the total profit would be $\frac{1}{a'_p}[p - \frac{p(1-a'_p)}{1-a_g}] < p$. Because p is the profit of the doctor if it will not deviate, we conclude that deviating by attracting private sector patients is not profitable. Trying to attract patients from the public sector would give a maximum profit of $\frac{p(a'_p-a_g)}{a'_p(1-a_g)} < p$, which is not profitable.

Next we have to show that $a_p = 1$ is the only equilibrium. First we assume that $a_p > 1$. From this would follow that the expected income of private doctors would be $\frac{p}{a_p}$. Assuming that one doctor would instead charge p, $p - \epsilon$ (where $\epsilon \approx 0$ is a small positive number) and still offer perfect treatment ($a'_p = 1$), the expected income

would be $p - \epsilon > \frac{p}{a_p}$, because all private patients and some patients from the public sector would try to receive treatment from this doctor. From this follows that $a_p > 1$ is no equilibrium. Considering next that $a_p < 1$. Assume that the deviating doctor would set $a_p = 1$. The maximum price he/she could ask for treatment would be $p' = \theta(1 - a_p) + p = 1 - a_p + p > \frac{p}{a_p}$ (see equation1)) where the right hand side would be the profit from acting as other doctors. So $a_p > 1$ is no equilibrium.

Now we have shown that $a_p = 1$ and $p = 1 - L$ is the only equilibrium. The treatment time per patient in the public sector is

$$a_g = 1 - \frac{(1 - L)}{1 - (1 - L - w_g)L} \tag{9}$$

where $a_g < 1$ when $p > 0$, which follows from the assumption that $L < N$. Next we solve the optimal public sector wage.

Lemma 1 *It is optimal for the government to introduce a public health care sector when public services are financed by a lump-sum tax. The optimal wage level paid by the government is*

$$w_g = \frac{p}{2} \tag{10}$$

when $a_g(w_g = \frac{p}{2}) \geq \underline{a}_g$.

Proof. See appendix 1. ■

The public health service supply is based on rationing, and we end up with a dual health care system with public and private supply of health services. When the needs for the deficit commodity are uniform and there is a high income inequality we should end up according to Weitzman (1977) with rationing. Still our results show that when health services are financed with a lump-sum tax, it is optimal to have both rationing and a price system. Weitzman (1977) also shows that it is always optimal to choose either one of the two ways to supply a deficit commodity.

The assumption behind equation (10), a dual system, is that the government is able to increase the welfare of those patients not visiting private doctors by persuading more doctors to the public sector with a higher public sector wage. From equation (9) we see that $\frac{\partial a_g}{\partial w_g} > 0$, which indicates the increase of the welfare of patients visiting the public sector. The welfare of doctors also increases when public wages become higher. However, under lump-sum taxation increasing public wages is only beneficial to some point because increasing taxes reduces welfare. If $a_g(w_g = \frac{p}{2}) \geq \underline{a}_g$, the government can act optimally without infections.

2.1.5 Targeted taxation

In the presented model, the government is unable to finance public health sector visits with a user fee[8]. By doing this, the government would be unable to avoid infections. Acting irrationally, the government can still choose to tax only patients visiting the private sector. We call this targeted taxation. From this would follow that some patients would move from visiting private doctors to the public health sector, but all patients would get treatment and infections would not exist.

Those patients who now visit a public sector doctor receive a utility of $\theta \underline{a}_g$ and those who visit private doctors receive $\theta - p - t$, where $a_p = 1$ as before and t is taxation targeted at private health sector visitors. If the following condition holds it is optimal for the patient to visit the private sector

$$(1 - \underline{a}_g)\dot{\theta} > p + t \tag{11}$$

The share of patients visiting the public sector is $F(\dot{\theta})$. $\dot{\theta}$ is the treatment quality valuation for the indifferent person. By following equations (6) and (7), we are able to solve the connection between the private sector user fee p and targeted tax t

$$p = 1 - L - t \tag{12}$$

[8]In reality, user fees do exist in the public sector, but they are not based on optimization. They are mainly set to avoid unnecessary visits, which we do not have in our model.

In addition we are aware that $(1-\dot{\theta})t = \dot{\lambda}Lw_g$ which is the budget constraint and following equation (4) that $\dot{\lambda} = 1+w_g-p$. By combining this information with equations (6), (7), (11) and (12) we are able to solve that

$$w_g = [A/L - L]\frac{L-A}{L} \tag{13}$$

where $A = \frac{(1-L)\underline{a}_g}{1-\underline{a}_g}$. The targeted tax is $t = A(\frac{A/L-L}{A+1})$, from which follows that $p = 1 - L - A(\frac{A/L-L}{A+1})$.

The interpretation of equation (13) is straightforward. When there are more doctors (higher L) in a country, competition between doctors decreases the price of a private sector visit. Doctors also desire a lower compensation in the public sector and lower taxes are required to pay the doctors' salaries. If a country is willing to give better treatment to all patients in the country, (increase $\underline{a}_g$) it has to set higher taxes and pay higher wages in the public sector. This decreases the amount of patients willing to use private doctors and competition will bring private sector visiting fee (p) down. Compared to the lump-sum tax- model with targeted taxation we end up with higher welfare (assuming same $\underline{a}_g$). This is due to the fact that with targeted taxation the price of a private visit decreases.

2.2 A two-country model

In this subsection we consider the welfare effects of doctor mobility between two Nordic countries, d (domestic) and f (foreign). We assume that doctors face no expenses from moving, and that doctors are free to move due to our assumption that the government has no possibility for screening. We assume lump-sum financing of public health services (targeted taxation) in both countries and distinguish between noncooperative and cooperative wage setting of governments. The results show under what conditions it is profitable to allow doctor mobility. When the mobility can be shown to have a negative welfare effect, countries will not permit liberalization. Taking only the total international welfare effect into account is rational because a doctor-losing country can

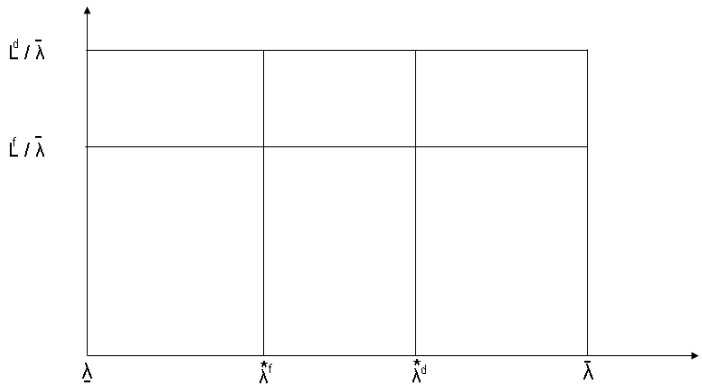

Figure 1: Supply of doctors in countries d and f with public health care provision.

be compensated when countries cooperate[9]. Another reason is that the country losing doctors has a relative shortage of another factor of production than doctors (e.g. engineers), and therefore no compensation is needed.

The supply of doctors and the demand for health care in the public and the private sector can be obtained for countries d and f as in the one-country model. The supply of doctors in both countries is illustrated in figure 1. The difference between the two countries is assumed to be only the amount of doctors; the amount of doctors is higher in the domestic country, $L^d > L^f$. From this assumption follows that the price of private visits is before the possibility of mobility higher in the foreign country, $p^f > p^d$. The share of doctors working for the public sector is in equilibrium before mobility higher in the domestic country, $\dot{\lambda}^d > \dot{\lambda}^f$[10]. In figure 1, the total amount of public doctors in country d is $\frac{L^d}{\bar{\lambda}}\dot{\lambda}^d$.

[9] Unfortunately this compensation rarely happens. China is still an good example of a country benefiting from skilled workers moving back to China.

[10] Another way of proceeding would be to assume the income levels to be different in the two countries. From this would follow that patients would differ in the two countries in their willingness to pay for health services.

2.2.1 Lump-sum taxes and cooperation between countries

When countries cooperate it is optimal for them to set the same public sector wage and share doctors. After the possibility of mobility, doctors with skills $0 \longrightarrow \dot{\lambda}$ work in the public sector, and doctors with skills $\dot{\lambda} \longrightarrow 1$ work in the private sector; $\dot{\lambda}^f < \dot{\lambda} < \dot{\lambda}^d$. The possibility for global gains from free mobility of doctors can be studied with the help of figure 1. With cooperation more private doctors can be taken from country d instead of country f which is profitable.

Because of both countries offer the same wage rate and doctors are by assumption indifferent between the two countries, both countries acquire an equal amount of doctors. The treatment equilibrium in the public sector has the following form for both countries (the amount of treatment given equals treatment received)

$$\frac{L^d + L^f}{2} G(\dot{\lambda}) = F(\dot{\theta}) a_g \tag{14}$$

The private sector treatment equilibrium is now

$$\frac{L^d + L^f}{2} (1 - G(\dot{\lambda})) = (1 - F(\dot{\theta})) a_p \tag{15}$$

Based on the arguments of subsubsection 2.1.4, we are able to solve that it is optimal for the private doctors to set

$$p = \frac{(2 - L^d - L^f)}{2} \tag{16}$$

where $p^d < p < p^f$.

Following appendix 1, we are able to calculate the optimal wage rate as before. The optimal public sector wage that both countries now offer can be shown again to be $w_g = \frac{p}{2}$ when $a_g(w_g = \frac{p}{2}) \geq \underline{a}_g$.

International trade models show that benefits can be gained from factor mobility. According to figure 1, country d has a comparative advantage in producing private sector doctors and country f public sector doctors.

Lemma 2 *International benefits can be gained from free mobility of doctors if* $(L^d + L^f) < \frac{4}{3}$ *when public services are financed with a lump-sum tax*

Proof. *See appendix 2* ■

As explained in subsubsection 2.1.2, L is the total supply of health services and dependent on the amount of doctors. According to our results, countries that cooperate in wage setting cannot gain from the liberalization of doctors' mobility, if both countries have a high amount of doctors. In this case both L^d and L^f are close to $N(N = 1)$. When countries cooperate and the supply of health services is rationed, global gains from liberalization can only be achieved when there is a shortage of treatment provided in both countries or in the country (f) with a low amount of doctors. We assume that in both countries patients get the minimum amount of treatment when setting $w_g = \frac{p}{2}$.

It is crucial that with the liberalization also the wage rates paid to doctors' change, both in the public and in the private sector. This affects the mobility of patients and doctors between the two sectors and the welfare of patients and doctors. The government is unable to have an effect on the mobility of doctors after the liberalization; it is unable to prevent the doctors from moving or to tax the moving doctors. This is why the welfare losses from the externality born by the free mobility can not be avoided.

In this model, the total share of doctors working in the private sector increases compared with no liberalization. If we increase exogenously the amount of doctors, the share of doctors working in the private sector rises, and the expenses from achieving entrepreneurial skills increase. From the patients' point of view, the more patients there are in the private sector, the higher the price for a private visit is.

2.2.2 Lump-sum taxes and noncooperative strategies

With no cooperation between countries in wage setting is more complicated for the government. When the government sets the public sector wage, it has to take the welfare maximizing process into account the action of the other country, of the doctors

and of the patients. The game has four stages

1. The government of country d and country f choose the public sector wage w^d/w^f
2. Doctors choose between the private and the public sector, and between countries d and f
3. Doctors set the private sector visiting fee
4. Patients choose between the private and the public sector

Backward induction is used for solving the optimal wage.

Lemma 3 *When countries use a lump-sum tax, it is optimal for both to set* $w_g = \frac{p}{2}$ *even when countries do not cooperate.* $w^d = w^f = \frac{p}{2}$ *is the only equilibrium.*

Proof. See appendix 3. ■

Taking into account the patients' mobility between sectors (stage 4), the doctors choose between the private and the public sector and set the private sector visiting fee (stage 3). As a result we can argue that it is optimal for private sector doctors to set the same fee when there is a private sector in only one country or in both of them. Private sector doctors are indifferent between the countries considering where they set private practices.

When governments set public sector wages their priority is to get public doctors (a_g>0). They also have to base their decision on the reaction of the other country's government. By choosing the wage rate in a optimal manner, ($w_g = p/2$) the other will not take all public sector doctors and welfare gains for one country are the highest.

2.2.3 Targeted taxation and two countries

In this model the governments of both countries finance public health services by taxing private health sector visits. When countries cooperate in setting wages, they will only make sure that the minimum treatment requirement $\underline{a}_g$ will be satisfied. Some patients

will move between the public and the private sector. In country d, where the price of the private sector visit p will increase, some patients will move from the private to the public sector. In country f the opposite will occur.

When countries do not cooperate in wage setting we will end up with the same result as when countries cooperate. Following subsubsection 2.2.2 and keeping in mind that countries only make sure that $\underline{a}_g$ will be satisfied and do not optimize welfare, bot countries will set w_g as with cooperation. If one country would set $a_g \geq \underline{a}_g$, the other country would follow in the fear of losing all public doctors. Still, it would not be in the countries' interest to increase $\underline{a}_g$.

Lemma 4 *When public health services are financed with targeted taxation, governments will set* $w_g = \frac{A/L-L}{A+1}$, *where* $A = \frac{(1-L)a_g}{1-a_g}$ *and* $L = \frac{L^d+L^f}{2}$.

Proof. See subsubsection 2.1.5 where we only replace L with $\frac{L^d+L^f}{2}$. ■

The total welfare of countries should increase by liberalization because of two reasons. One reason is doctors' specialization; after liberalization more skilled doctors will work for the private sector. The other reason is the patients' mobility between sectors. As known, the new price of private visits is exactly the average ($\frac{p^d+p^f}{2}$) of the prices in the two countries without liberalization, where $p^f > p^d$. After liberalization the price of a visit decreases in country f and increases in country d. However, those patients that now visit a doctor in country f give a higher value for treatment than those in country d that do not visit a doctor anymore. Patients visiting the public sector still receive $\underline{a}_g$.

Lemma 5 *Global benefits can be gained from liberalization when countries finance their public health services with targeted taxation.*

Proof. *See appendix 4.* ■

3 Conclusions and further discussion

Societies support financial assistance for medical treatment due to the possibility of infections or other political reasons. With the existence of these, we show with our model that it is optimal to have a dual medical care system where health services are provided both privately and publicly. Public health services are financed with a lump-sum tax. Another way for the government to finance private health services is a targeted tax, where patients using private health services are taxed.

Cooperation between countries does not affect the possibility of achieving global benefits from liberalization of health services (free mobility of doctors) in our model. When countries use lump-sum taxes, they benefit from the liberalization only when there is in at least on of the countries a very limited amount of treatment that can be provided. When targeted taxation is used, the countries benefit from liberalization.

However, it should be noted that we have not included costs that the government has to face when constructing public health services (in our model). First of all building up the infrastructure (health centers and hospitals) is expensive. The second issue is the collection of taxes if the government is unable to set user fees. Also lump-sum taxation may be impossible, and more important for our analysis, collection of taxes causes expenses. Taking the cost factors into account would affect our results reducing the optimal size of the public health sector. At the extreme, with no minimum treatment requirement, when these costs are too high, we would be left with only the private sector.

Another issue for the two-country model is how we differentiate the two countries. We assumed a different amount of doctors in the two countries. Another starting point would have been to allow patients in the two countries to differ in their treatment quality valuation. This would be an interesting issue, especially from the patients' point of view. With a user fee, the amount of patients getting treatment would reduce in the country with lower valuation for treatment. With a lump-sum tax this could mean that in the country with lower valuation the amount of doctors would decrease and the

amount of patients would increase in the public sector. In both cases doctors would move from the lower to the higher treatment valuating country. The higher valuating country would receive doctors, and therefore the total welfare of the two countries could increase. This starting point could be a good way to analyze countries with unequal wealth. Especially with this starting point a proper discussion for compensation of the loosing country would be needed.

The fourth issue that we leave open for further discussion is the patient distribution function in our model, which is assumed to be uniform.

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4 Appendixes

4.1 Appendix 1: Proof 1

Total surplus (S) of a country from health services is

$$S = S_p + S_d$$

where

$$S_p = \int_0^{\dot{\theta}} (\theta a_g - t) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p - t) dF(\theta)$$

$$S_d = L \int_0^{\dot{\lambda}} w_g dG(\lambda) + L \int_{\dot{\lambda}}^1 (p - (1 - \lambda)) dG(\lambda)$$

S consists of patients' surplus S_p and doctors' surplus S_d. The public health care is financed with a lump-sum tax. We assume that the collection of taxes creates no costs. The object of the government is to maximize S subject to the budget constraint.

$$\left\{ \begin{array}{c} \max\limits_{w_g, t} \{S\} \\ s.t. t = \dot{\lambda} L w_g \\ a_g \geq \underline{a}_g \end{array} \right\}$$

$\Longleftrightarrow$

$$\max_{w_g} \left\{ \int_0^{\dot{\theta}} (\theta a_g) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p) dF(\theta) + L \int_{\dot{\lambda}}^1 (p - (1 - \lambda)) dG(\lambda) \right\}$$

$\Longleftrightarrow$

$$\begin{aligned}\frac{\partial S_{tot}}{\partial w_g} &= \frac{\partial}{\partial w_g}[\frac{1}{2} - \frac{p}{2} - \frac{p(p-w_g)L}{2} + \\ &(p-1)L + \frac{L}{2} - \frac{2(p-1)(1+w_g-p)L}{2} - \\ &\frac{(1+w_g-p)^2 L}{2}] = 0\end{aligned}$$

From the maximization we receive that $w_g = \frac{p}{2}$ and $\frac{\partial^2 S_{tot}}{\partial^2 w_g} = -2 < 0$. This result holds for $a_g(w_g = \frac{p}{2}) \geq \underline{a}_g$.

4.2 Appendix 2: Proof 2

When doctors are allowed to move and countries cooperate, the total surplus of one country with mobility (S^m) is

$$\begin{aligned}S^m &= \int_0^{\dot{\theta}} (\theta a_g - t) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p - t) dF(\theta) + \\ &[\frac{L^d + L^f}{2}] \int_0^{\dot{\lambda}} w_g dG(\lambda) + [\frac{L^d + L^f}{2}] \int_{\dot{\lambda}}^1 (p - (1-\lambda)) dG(\lambda)\end{aligned}$$

By following maximization in appendix 1 and by taking the budget constraint ($t = \dot{\lambda}(\frac{L^d+L^f}{2})w_g$) into account we receive again that in optimum $w_g = \frac{p}{2}$.

For receiving global gains from free mobility of doctors, we must have

$$2S^m > S^d + S^f$$

$\Longleftrightarrow$

$$2[\frac{1}{2} - \frac{p}{2} + \frac{2(L^d + L^f)p^2}{16} - \frac{(L^d + L^f)p^2}{16}] > S^d + S^f$$

$$\iff$$

$$\frac{1}{32}[(2-L^d-L^f)^2(L^d+L^f)-4(1-L^d)^2L^d-4(1-L^f)^2L^f>0$$

$$\iff$$

$$\frac{(L^d-L^f)^2}{32}[4-3(L^d+L^f)]>0 \tag{17}$$

Condition (17) holds when

$$\frac{4}{3(L^d+L^f)}>1$$

4.3 Appendix 3: Proof 3

We are going to proof lemma 3 in the following steps

1. We calculate the private sector price level in equilibrium
2. Study the reaction of a country to a positive public wage offer by the other country
3. Conclude that both countries set public wages equal to $\frac{p}{2}$

(Step 1) Taking into account that as before (subsubsection 2.1.4) that $a_p=1$, it follows always that $p=\frac{2-L^d-L^f}{2}$, . When $w^d=w^f$ we have for both countries

$$(\frac{L^d+L^f}{2})G(\dot{\lambda})=F(\dot{\theta})a_g$$

$$(\frac{L^d+L^f}{2})(1-G(\dot{\lambda}))=(1-F(\dot{\theta}))a_p$$

from these we can show as before that $p=\frac{2-L^d-L^f}{2}$. When $w^d>w^f$ we have in country d for the public sector

$$(L^d+L^f)G(\dot{\lambda})=F(\dot{\theta})a_g$$

and for the private sector must hold that

$$(L^d + L^f)(1 - G(\dot{\lambda})) - (1 - F^f(\dot{\theta}))a_p = (1 - F^d(\dot{\theta}))a_p$$

where $F^d(\dot{\theta}) = \frac{p}{1-a_g}$ and $F^f(\dot{\theta}) = \frac{p}{a_p}$. This follows from the fact that there is no public sector in country f. Also now the outcome is that $p = \frac{2-L^d-L^f}{2}$. The latter result is equivalent for $w^d < w^f$. From step one follows (assuming that $w^d > w^f$) that when $w_g^d = p - \frac{1}{2}$ all patients in country d visit public doctors. One can notice that the private sector price increases in country d when doctors are allowed to move.

(Step 2) When country d sets $w_g^d > 0$, country f can set , $w_g^f = w_g^d$, or $w_g^f > w_g^d$. Notice that country f will not set $w_g^f = 0$ because of $\underline{a}_g > 0$. We compare at this step surpluses with the first two possible reactions (notice that the budget constraints are taken into account). The surpluses of country f are

$$\begin{aligned} S^f(w \quad | \quad w^f = w^d, w_g^d > 0) &= \int_0^{\dot{\theta}} (\theta a_g) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p) dF(\theta) \\ &\quad + [\frac{L^d + L^f}{2}] \int_{\dot{\lambda}}^1 (p - (1 - \lambda)) dG(\lambda) \qquad (18) \\ &= \frac{1}{2} - \frac{p(2p + (1 + w_g^d - p)(L^d + L^f))}{4} - \frac{(p - w_g^d)^2 (L^d + L^f)}{4} \end{aligned}$$

$$
\begin{aligned}
S^f(w \quad | \quad w^f > w^d, w_g^d > 0) &= \int_0^{\dot{\theta}} (\theta a_g) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p) dF(\theta) \\
&+ [(L^d + L^f) - \frac{L^d + L^f}{2(1-\dot{\lambda})}] \int_{\dot{\lambda}}^1 (p - (1-\lambda)) dG(\lambda) \qquad (19) \\
&= \frac{1}{2} - \frac{p(p + (1 + w_g^f - p)(L^d + L^f))}{2} - \frac{(p - w_g^f)^2 (L^d + L^f)}{2} \\
&+ \frac{(p - w_g^f)(L^d + L^f)}{4}
\end{aligned}
$$

The maximum surplus from the latter equation (19) can be received with $w_g^f = \frac{2p-1}{4}$ or $w_g^f = 0$ if $2p - 1 < 0$. Assuming that $2p - 1 > 0$ it follows that

$$
\begin{aligned}
S^f(w \quad | \quad w^f = w^d) &> S^f(w \mid w^f = w^d + \epsilon), if \\
w_g^d \quad &> \quad \frac{2p-1}{4}
\end{aligned}
$$

and

$$
\begin{aligned}
S^f(w \quad | \quad w^f = \frac{2p-1}{4}) &> S^f(w \mid w^f = w^d), if \\
0 \quad < \quad w_g^d &< \frac{p - \sqrt[2]{p^2 - 8(\frac{2p-1}{4})^2}}{2}
\end{aligned}
$$

If $2p - 1 < 0$ it is profitable for countries to set $w^f = w^d$ because of $w_g^d > 0$.

(Step 3) Country d is aware that if $2p - 1 < 0$, country f is going to set $w^f = w^d$. If $2p - 1 > 0$, country f sets $w^f = \frac{2p-1}{4}$ only if $w_g^d < \frac{p - \sqrt[2]{p^2 - 8(\frac{2p-1}{4})^2}}{2}$. Because of $\underline{a}_g > 0$, country d has to have doctors in the public sector. It is optimal for country d to set $w_g = \frac{p}{2}$, because it knows that country f will set $w_g^f = w_g^d$ and by setting $w_g^f = w_g^d = \frac{p}{2}$,

welfare gains are the highest.

4.4 Appendix 4: Proof 4

When doctors are free to move between countries, we are able to show that

$$S_p + S_d = \frac{L(1-L)(1-\dot{\lambda})}{2} + L\dot{\lambda}(1-\dot{\lambda}/2) \tag{20}$$

where $\dot{\lambda} = \frac{(1-L)A}{L}$, $A = \frac{(1-L)a_g}{1-a_g}$ and $L = \frac{L^d+L^f}{2}$.

We can derive equation (20) from solving

$$\begin{aligned} S_p + S_d &= \int_0^{\dot{\theta}} (\theta a_g) dF(\theta) + \int_{\dot{\theta}}^1 (\theta - p - t) dF(\theta) \\ &\quad + [\frac{L^d + L^f}{2}] \int_0^{\dot{\lambda}} w_g dG(\lambda) + [\frac{L^d + L^f}{2}] \int_{\dot{\lambda}}^1 (p - (1-\lambda)) dG(\lambda) \end{aligned}$$

by taking into account the budget constraint $(1-\dot{\theta})t = \dot{\lambda}(\frac{L^d+L^f}{2})w_g$, the equilibrium of supply and demand of medical treatment in the public and in the private sector: equations (6) and (7), the share of doctors working in the public sector: equation (4), and the share of patiens going to the public sector: equations (11) and (12), we will receive equation (20).

The welfare shown in equation (20) is the same for both countries. To be sure that welfare increases by liberalization of doctor mobility we have to be able to show that

$$
\begin{aligned}
& 2 * [\frac{L(1-L)(1-\dot{\lambda})}{2} + L\dot{\lambda}(1-\dot{\lambda}/2)] \\
& -\frac{L^d(1-L^d)(1-\dot{\lambda}^d)}{2} + L^d\dot{\lambda}^d(1-\dot{\lambda}^d/2) \\
& -\frac{L^f(1-L^f)(1-\dot{\lambda}^f)}{2} + L^f\dot{\lambda}^f(1-\dot{\lambda}^f/2) \\
> \; & 0
\end{aligned}
$$

$\Leftrightarrow$

$$
\begin{aligned}
& 2 * [\frac{(L+b)(1-L)(1-\dot{\lambda})}{2} + \frac{L\dot{\lambda}}{2}] \\
& -[\frac{(L^d+b)(1-L^d)(1-\dot{\lambda}^d)}{2} + \frac{L^d\dot{\lambda}^d}{2}] \\
& -[\frac{(L^f+b)(1-L^f)(1-\dot{\lambda}^f)}{2} + \frac{L^f\dot{\lambda}^f}{2}] \\
> \; & 0
\end{aligned}
$$

where $b = \frac{\mathrm{a}_g}{1-\mathrm{a}_g}$ and $L\dot{\lambda} = (1-L)b = \frac{L^d\dot{\lambda}^d}{2} + \frac{L^f\dot{\lambda}^f}{2}$.

$\Leftrightarrow$

$$
\begin{aligned}
& (L^d+b)[\frac{L^d-L^f}{2} + \frac{(L^d-L^f)b}{2} - \frac{(L^d-L^f)b}{L^d(L^d+L^f)}] + \\
& (L^f+b)[-\frac{(L^d-L^f)}{2} - \frac{(L^d-L^f)b}{2} + \frac{(L^d-L^f)b}{L^d(L^d+L^f)}] \\
> \; & 0
\end{aligned}
$$

$\Leftrightarrow$

$$\begin{aligned} & \frac{(L^d - L^f)^2}{2} + \frac{(L^d - L^f)^2 b}{2} + \frac{(L^d - L^f)^2 b^2}{L^d L^f (L^d + L^f)} \\ > \; & 0 \end{aligned}$$

□

Chapter 3

Welfare effects of trade in transport services

1 Introduction

One important step in the multilateral trade liberalization process was taken during the Uruguay Round in 1995. It was the establishment of the World Trade Organization (WTO), an international organization in its own right. The most important difference to its former, the General Agreement of Tariffs and Trade (GATT), is that member countries are more tightly tied to its agreements. To assure the commitment of countries into the agreements, the dispute settlement mechanism (DSM) was established. Another important step taken in 1995 was that also services were included in multilateral trade negotiations under the General Agreement of Trade in Services (GATS). However, until now the realized multilateral liberalization of trade in services has been very limited. The increase in internationally provided services has been due to increasing foreign direct investments (FDI) and increasing travelling. The growth of international trade in transport services has slowed down to almost zero percent a year.

The need for multilateral organized service negotiations is obvious. The arguments are familiar from the liberalization negotiations of trade in goods. The main argument is the potential economic gain from liberalization. Compared to bilateral negotiations the advantage of multilateral negotiations is that they can secure market access for committed countries, and attract new countries to join the negotiations. 136 countries have left conditional commitments for the WTO on liberalization of trade in services

in different service sectors. Most progress has been achieved with the liberalization of business and financial services. The transport service sector liberalization has proceeded more slowly. In the group of countries that are most committed to conditionally liberalize their service sectors nearly all are developed countries. The least committed countries are the poorest developing countries. As in the liberalization of trade in goods, countries that could gain the most from the liberalization process are at least at the beginning of the negotiations going to stay out of the process.

Computable general equilibrium (CGE) models have been used for analyzing the welfare gains from the liberalization of trade in services. Most of the papers focus on total welfare gains from the liberalization of trade in services or increasing FDI-flows. These papers mainly use Hoekman's (1995) criticized "guesstimates" on tariff equivalents, and by decreasing these tariffs they receive welfare increasing results (Brown, Deardorff, and Stern 1996; Dee, Geisler and Watts 1996). The paper that most closely relate to our study is the paper by Robinson, Wang, and Martin (2002). They focus on the implications that liberalization of trade in services can have on other sectors. However, they use Hoekman's (1995) "guesstimates" in their paper, and they focus especially on the shipping margin reduction impacts.

In this paper we are going to first simulate international region based tariff equivalents for transport services with a CGE-model. This is done by studying tariff equivalents that are consistent with specified increases of trade in services ceteris paribus. These tariff equivalents are then used for tariff reduction simulations, which is not possible to do just by increasing trade in services exogenously. The tariff equivalents for the financial and business service sectors are taken from the gravity-model estimates by Francois (2001). The main issue is to study the potential gains for developed and developing countries from multilateral liberalization of different service sectors. We study only cross border service trade effects of the chosen service sectors, so FDI-flows are left outside our discussion[1]. The main interests are the total welfare gains that

[1] Especially in the case of financial services, FDI-flows are a remarkable part of international services flows (Verikios, Zhang 2001). However in developing countries international banks do not enter these countries before international companies are represented there. Before that financial services are

developed and developing countries can achieve through multilateral liberalization of chosen service sectors. In addition to that we are interested in how the multilateral liberalization of services affects the exportation and importation of goods from and to selected regions. We have a developing country focus in this paper, and we bring out especially the results for Africa. Before calculating the liberalization effects, we have to simulate potential existing tariff equivalents for our chosen transport sectors. The simulation and further calculations are done with GTAP; a computable general equilibrium (CGE) model. From our selected service sectors, the transport sector is divided into three categories: air transport, sea transport and other transport services. Our selected regions are formed from the GTAP database considering regions and areas. The selected regions are the industrialized countries, Central and South America, South Asia, Africa, and the rest of the world (appendix 1).

The paper is organized in the following way. In section two we study potential gains from multilateral trade liberalization, trade in services data, and barriers to trade in services. Section three gives theoretical reasoning for liberalization of transport services, and in section four we briefly discuss the model and data used in this paper. Barriers to trade in transport services are estimated in section five. In section six we show trade liberalization results in chosen service sectors, and interpret these results. The last section is for conclusions.

2 Trade in services in general

2.1 Potential gains from liberalization of trade in services

A high variety of gains can be achieved from liberalization of different transport service sectors[2]. One argument for the liberalization of trade in services is, as in the case of liberalization of trade in goods, comparative advantage. Developing countries

provided through trade.

[2]Some of the following arguments can also be generalized to describe the benefits from liberalization of other service sectors than transport, finance, or business.

may not have a comparative advantage in the trade of capital- or knowledge-intensive service products. However, all countries have comparative advantage in some areas, and because of this, also developing countries can benefit from liberalization of trade in services. This can be the case even if developing countries are net importers of a particular service (Hodge, Nordas 1999).

Compared to the liberalization of trade in goods, the benefits of service sector liberalization are twofold. One argument is the direct effect mentioned above, but the indirect effect is also very important. An inefficient and expensive service infrastructure makes a barrier to trade in goods and in common is an obstacle for sectors which use services as an intermediate product. For example the agriculture sector in a developing country cannot become internationally competitive without efficient banking, insurance or transport services. Knowing this fact, the liberalization of trade in goods combined with the liberalization of trade in services has a more significant welfare increasing effect than liberalization of trade in goods alone. If the WTO Ministerial Conferences (Seattle, Cancún) will not be able to bring down the barriers of trade in goods, liberalization of trade in services could also be considered as an alternative way of increasing world trade in goods. The liberalization of intermediate services could make the barriers of trade in goods even more expensive for countries.

Markusen (1989) argues that free trade in inputs/services is superior to free trade in goods because of its significance for efficient production. Compared to trade in goods, the benefits from intermediate service sector liberalization can also be more efficient because the absolute barriers to trade in services are estimated to be higher. Services are the largest and fastest growing sector of the world economy, providing over 60 % of world output. This fact can increase the share of services world trade in the future. Similar to trade in goods, because of high trade barriers, trade in services has been increasing through FDI-flows. However large welfare gains can be gained through further trade liberalization especially in developing countries[3].

[3]The WTO has been worried about world trade in services because there has been no legal basis on which to resolve conflicting national interests.

There are also additional potential positive welfare implications from liberalization of service flows. One is the potential spillover that can benefit also developing countries through FDI-flows[4]. The macroeconomic implications discussed by Hodge (2001) are also important. First of all, increasing FDI-flows decreases the amount of domestic savings needed for particular investments, and domestic savings can be used for other purposes. This can increase the total amount of investments in the target countries[5]. Secondly, foreign capital flows may also increase the efficiency of domestic financial markets. This can decrease the need for foreign capital and again increase investments. When a broad range of services are liberalized, this can also lead to lower inflationary pressure within an economy as prices fall for a significant share of total output. This can increase savings and stimulate investment and growth. Domestic investments can also increase as competition in the liberalized sectors increases.

The total welfare effect of trade in services liberalization is most probably positive, but as in the case of trade in goods liberalization, there are also those who lose. Both in the case of growing imported services and FDI-flows competition increases, if the foreign competitors or companies do not take control in a particular sector. The domestic service producers and their employees can be the losers if the domestic company is not competitive. However, especially if services are produced through FDI-flows the laid off skilled employees may be able to join the new companies.

2.2 Trends in the trade of transport, financial, and business services

In the following CGE-model calculations we study only transports sold through exports, despite the fast increase of services sold through FDI. If we would be interested in the total international flows of services we should not concentrate only on exported

[4]It is specified in the GATS agreement in article XIX that developing countries can attach to their market opening commitments conditions that increase their participation in trade in services. This can make the link between FDI-flows and spillovers more probable.

[5]This is what has happened in East-European countries.

services. Especially services included according to the WTO classification in the third mode, commercial presence, are mainly provided through FDI-flows[6]. However focusing on transport, financial, and business services, it is reasonable to concentrate on the exportation of these services. Due to technological development, also financial and business services are nowadays profitable to export. The main reason for considering only services sold through exports is that we are especially interested in the welfare effects of eliminating import barriers.

Before going into the details of the barriers of trade in services, we discuss how trade in services has evolved. The share of services in developing countries is around 38 % and in industrialized countries over 65 % of total output (WTO 2002). The difference can be explained by the fact that people spend a higher amount of their income on services as their total income increases. Despite the absolute value of produced services has been increasing, internationally provided services as a share of total world trade is much smaller than the services output share; about 24 %. The main reasons for this are that merchandise goods are easier to export, and that barriers to trade in services are higher.

	Exports			Imports		
	91-95	95-01	91-01	91-95	95-01	91-01
World	8.8	3.2	7.0	8.2	3.0	6.4
North America	6.8	4.8	7.2	5.1	5.9	7.0
Western Europe	6.5	2.8	5.3	6.7	3.1	5.7
Asia	16.3	2.2	10.0	14.5	1.2	7.9
Latin America	8.8	4.5	8.1	9.2	4.4	8.2
Africa	7.1	3.0	5.8	4.4	1.2	2.9

Table 1: Growth in the world trade of commercial services by selected region, 1991-2001 (source: WTO 2002)

As with trade in goods, a great amount of services is traded between EU, USA and Japan. Their commercial service exports present 69 % of exported world services and

[6]There are four ways of supplying services internationally. These are called the four modes: cross-border trade, consumption abroad, commercial presence and presence of natural persons.

imports 65 % of total imports (WTO 2002). From table 1 we can see how the growth of commercial services exported and imported by different regions has evolved in the 1990's. The most obvious conclusion is that the growth of world trade in services has been much slower in the second half of the decade. The only region that has been able to increase trade in services has been North America. In absolute terms, the steepest reduction of the growth figure has been in Europe, and relatively in Asia and Africa.

For our purposes it is interesting to know, how international trade in services has evolved between different service sectors. In the WTO statistical database 2002, internationally traded commercial services are divided into three categories: transport (22,3%), travel (30,6%) and other commercial services (47%). Business and financial services are represented in the last category. Business services have an approximately 70 % share of the other commercial services, and financial services have a 10 % share (Maurer, Chauvet 2002).

Considering the world as a whole, the share of transport services of all internationally traded commercial services has reduced the most. In 1980 it was the most traded commercial service (37% of the total), but in 2001 transports were traded less than travel or other commercial services. Between 1990-1995, the annual increase of trade in transport services was about 4.7 % in industrialized countries, and 10.3 % in developing countries. Between 1995-2000, the annual world growth of transport services has slowed down to almost zero percent a year. In developing countries the growth of trade in transport services has actually turn negative after 1995. The slow growth of trade in services after 1995 has mainly been due to the slowdown of trade in transport services (table1). However, also after 1995 the total production of services and the total trade in services has continued to grow. In industrial countries this has been mainly due to the increase in trade in other commercial services and in developing countries also due to an increase in travel service exports. Financial services have increased slightly its share of trade in other commercial services, and the share of business services has not changed. From this we can conclude that trade in these service sectors has increased at least in the industrialized countries.

2.3 Barriers to trade in services

It is in often impossible to restrict a service crossing borders by setting tariffs. This comes from the simple argument that services are no physical items. Hoekman and Braga (1997) divide barriers of trade in services into four categories[7]. All of these restrictions can be used to limit trade in transport services. A country can limit international trade in financial and business services by licenses or certification requirements, or by setting quantitative restrictions. These kinds of barriers can also be used to limit FDI-flows.

Air transport services are not included in GATS negotiations. Domestic air transport services are generally protected from foreign competition and international transport service commitments have been made through bilateral negotiations. Maritime negotiations also have shown little progress. Also in the case of maritime transport services, especially domestic coastal transportation has remained protected. Considering our paper, most progress has been achieved with business and financial services. Ranked by the number of conditional WTO commitments given by member countries, financial and business services were the most committed sectors after travelling [8]. Transport services were in the middle of the order. Especially in the case of transport services, developing countries are the least committed to trade liberalization.

The main problem in examining barriers to trade in transport and financial services is that there are few estimates of the barriers. Also the reliability of these estimates can be doubted. Especially in the case of transport services these measures are rather "guesstimates" of tariff equivalents. Also developing countries are hardly represented in these calculations, although their barriers to trade in services are the highest. Stern (2001) divides the measures of barriers to trade in services into four types, the frequency, price-, quantity- and financial based measures. The first paper, which tried to estimate

[7] These are quantitative restrictions, price-based instruments, licenses or certification requirements, and discriminatory access to distribution and communications systems.

[8] Under the GATS a conditional commitment means in many cases that a country is committed to let foreign services offering companies to enter the domestic market under certain conditions. In the case of trade limiting tariffs countries commit to bound tariffs. In many cases the applied tariffs are lower than the bound tariff rates.

tariff equivalents for different service sectors, was the paper by Hoekman (1995). He used a judgmental benchmark tariff and a frequency ratio received by the number of commitment scheduled in the GATS by individual member countries for different service sectors to estimate tariff equivalents. The paper's objective was to illustrate the relative degree of restriction, and the results can not be taken as absolute ad valorem tariff equivalents. As pointed out by Hoekman (1995), because of the absence of data on barriers to trade in services, his calculations could be used in CGE-exercises to simulate liberalization effects. In section 5 we provide another method to estimate the tariff equivalents for trade in transport services. Our starting point is to estimate these barriers by studying the tariff reduction needed for chosen exogenous increases of trade in transport services.

3 Theoretical framework

Following Francois and Wooton (2001) we can give theoretical reasoning for liberalization of trade in transport services. We concentrate on the indirect benefit from liberalization of transport services discussed in subsection 2.1, which is also a crucial factor in the GTAP-model. In this model a primary good q is transported from one country to another. We assume that the primary good producers are small and perfectly competitive. The net supply curve for the primary good (the share of the production that is not consumed domestically) is assumed to be linear in producer prices p_p

$$p_p = a + bq \tag{1}$$

Consumers in the world market have a linear inverse-demand function for the primary good imported. The quantity of the primary good q consumed abroad depends on the price p_c

$$p_c = c - dq \tag{2}$$

The consumer price exceeds the producer price due to a transport margin m and a tariff t

$$p_c = (1+t)(p_p + m) \tag{3}$$

The total revenue of a representative transport company i is $(m - c_i)q_i$, where c_i is the marginal transport cost and q_i the amount of the primary good transported by i. We assume n identical transport companies that enter into Cournot competition. We further assume that $n'(t) < 0$. By solving the equilibrium amount of transportation we receive that

$$q_i = \frac{c - (a+c)(1+t)}{(n(t)+1)(d+b(1+t))} \tag{4}$$

From equation (4) we receive that $\frac{\partial(nqi)}{\partial n} > 0$ and that $\frac{\partial(nqi)}{\partial t} < 0$, so reducing t increases total transportation which leads according to equations (1) and (2) to a higher price for suppliers $\frac{\partial(p_p)}{\partial t} < 0$ and lower price for consumers $\frac{\partial(p_c)}{\partial t} > 0$[9]. According to this model, there is a great potential for at least global benefits to be achieved.

4 The model

4.1 The model in general

In this section we represent the basic structure of a standard multiregional computable general equilibrium (CGE) model[10]. In the following sections we use the GTAP—model (Hertel, Tsigas 1997), to simulate transport tariff equivalents and welfare effects of liberalization of trade in transport, financial, and business services. The GTAP—model is solved with the software package GEMPACK. The model is based on the Global Trade Analysis Project (GTAP) dataset, and despite data problems it has been commonly

[9] The effect of t on the transport margin m remains unclear. On the other hand it gives the transport companies an opportunity increase their margins. However reducing t can increase n and this reduces the margin.

[10] Applied general equilibrium models are discussed by El Mekki etc. (2000).

used to analyze multilateral trade liberalization questions[11]. We use in our estimates version 5 of the GTAP data base, which contains 66 regions and 57 sectors. Compared to version 4 also services are more properly included in this version. The data covers 15 service sectors, including three transportation sectors, and the financial and business sectors. However, the current version lacks estimates of barriers to trade in services, and this makes our simulation more challenging. The international tariff equivalent barriers for trade in financial and business services are taken from Francois' (2001) estimates. Mainly because of data availability problems, Francois' (2001) estimates do not include barriers to trade in transport services.

Considering different regions and nations, the model is based on input-output tables that link industries through different stages. The first stage consists of three primary factors: land, labor, and capital. Linking the primary factors with higher stages of production, adding the factors with intermediate processing, the model produces final products. This output is sold to consumers, government, the investment sector, other firms, or is sold abroad. On the output side taxes are set on primary factors, intermediate inputs, or output. Also final consumption and trade are taxed. The regions interact with each other through bilateral trade. In addition to trade flows data, the database covers information about the differences between world market prices and consumer prices. These differences contain information about trade limiting existing trade barriers including applied ad valorem tariffs, quotas and other non-tariff trade restricting measures. However trade barriers exist only for trade in goods, and because of the measuring difficulties barriers to trade in services are not included.

Francois (2001) summarizes the important aspects of the model as follows: (i) it covers all world trade and production, (ii) includes intermediate linkages between sectors, (iii) and allows for trade to affect capital stocks through investment effect.

[11] The usefulness and limitations of the GTAP—model for analyzing multilateral trade liberalization issues are discussed by Francois, etc. (2000).

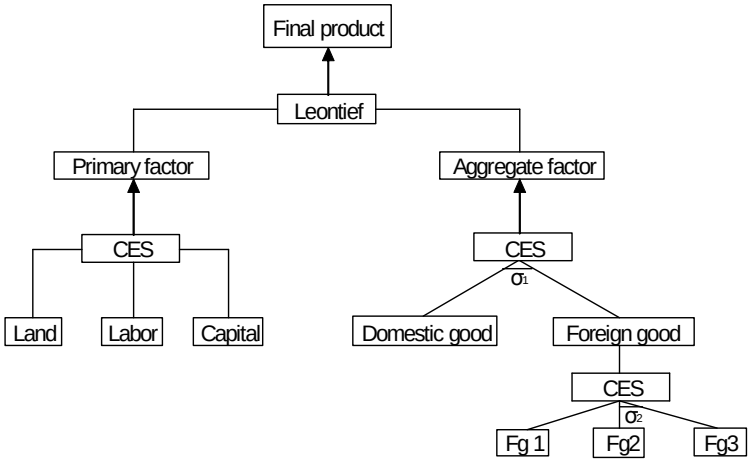

Figure 1: Production in the GTAP-model

4.2 Basic elements of the GTAP-model

On the demand side of the model, every region has a single representative household. The consumer receives income from selling primary factors which only he/she owns to firms, and finances its demand with this. The regional income is used to finance private consumption, public consumption, and saving. All of these get a fixed share of the income, determined by Cobb-Douglas preference function. Private demand of different aggregate products is divided by a constant difference of elasticity (CDE) function, and the aggregate products are divided into domestic and foreign product demands with a constant elasticity of substitution (CES) function. The public demand for aggregate products is determined as constant shares of demand by the Cobb-Douglas function, and the aggregate product consists of domestic and foreign goods determined by the CES function, as in private demand.

Total savings from different regions are collected into a global saving pool, a global bank. Regional investments are financed from this pool. The allocation of the investments depends on relative productivity of capital in different regions. The regions

where the relative productivity of capital grows get a higher share of capital. The global investments and savings are always in balance, but they do not have to be distributed equally between regions. Capital flows are assumed to be fixed. In every region there is one investment product. However in our static model the accumulation of the investments into the capital base cannot be taken into account.

As mentioned above, on the production side firms use domestic primary factors (land, labor, capital) and intermediate inputs (domestic and foreign goods) to achieve outputs (Figure 1). Final goods and services are produced in a cost minimizing manner that technology allows. The aggregate intermediate inputs and the aggregate primary products are used with constant shares for the production of the final product with the Leontief production function. The aggregate intermediate product is build up from domestic and foreign products by the CES function. The aggregate primary product is also build up from domestic primary factors by the CES function. Considering final goods, the production and demand are always in balance, and markets are perfectly competitive. The final goods differ by region. The different regionally produced goods can be used as substitutes to build up the aggregate intermediate products. However, consumers consider them as different products; making it possible that products of the same category are exported from and imported into a country.

Because of we are particularly interested in internationally traded transport services, we will next describe how they are modelled. The reconstruction of data on transport services differs from the other service sectors because other services are traded as goods in the model. The specific explanation of the transport service sector reconstruction is done by McDougall (2002), but here we explain the formulation in general.

As in the case of the global saving pool, the demand and supply of international transport services are also organized globally. This is done because otherwise there would be too many dimensions in the model. Starting from the usage of transport services, demand is determined by two factors: the country's total imports of transport services, and merchandise-trade-based margin value estimates. Imports are calculated as the difference between the cost, insurance and freight (cif) and free on board (fob)

value of each trade flow. The merchandise data is considered as more reliable, and this is why the service import values are adjusted to match them. The demand for transport services is satisfied by taking the services from a global pool. The transport services are collected into a global pool via a Cobb-Douglas production function from different regions. To equalize the demand and supply of transport services, the supply side is rescaled to agree with the usage of transportation.

From the total amount of traded transport services, transportation is divided into three subgroups: transportation nec (not elsewhere classified), sea transport and air transport. All of these groups include estimates of passenger, freight and other transportation. The estimated country usages of different transport services are based on regional and geographical factors.

4.3 Elasticity of substitution and the demand for imports

4.3.1 Formulation

In the previous subsection we illustrated the demand and supply side of the GTAP-model. However we did not discuss the elasticity of substitution that differentiates demand for goods produced domestically and aboard. Considering the decision to choose between domestic goods and imports, we have a two stage process when the aggregate product is built up (Figure 1)[12]. Starting from above we have the aggregate good built up from the domestic and the foreign good. If the price of the aggregate imported product falls, the elasticity of substitution $\sigma 1$ determines how this affects the demand for the domestic and the imported aggregate good. The aggregate import product is determined at the lower stage, and it is build up from differentiated goods imported from different regions. At the second stage it is also determined, how the fall of the price of one imported product affects the demand of the differentiated imported products, and their prices. The elasticity of substitution between varieties from different regions $\sigma 2$ determines this. So when for example import taxes are reduced in the model,

[12] The elasticity of substitution factors are as well important when we consider demand of final goods.

the different elasticity of substitution estimates has a large impact on the outcomes of this measure. We take this into account in section 6 when we estimate the impact of transport service sector liberalization on trade in goods.

4.3.2 Our calculations

The elasticity of substitution also has an effect on service production in different regions. When trade in services is liberalized between regions, the elasticity of substitution determines how this affects service production. This is why the estimates of the elasticities are crucial for our results. In the following section we are mainly interested in two things. First, we simulate barriers to trade in transport services, and then we study the effects of reduction of these barriers and liberalization of trade in financial and business services. To do the first step we simulate how the exogenous increase of trade in transport services affects the tax equivalent set to limit trade in transport services. Sensitivity analysis is not carried out at this stage.

At the second stage of our calculations in section 6 we set our own estimates and the estimates presented by Francois (2001) as base taxes to the model, and then we exogenously reduce these barriers to study their effects on different endogenous factors. The exogenous reduction of import taxes set on transport sector trade flows will lower the prices and increase the quantities of services imported. However, how great these effects are (what are the effects on other endogenous factors) depends largely on the elasticity of substitution factors. This is why systematic sensitivity analysis is needed.

4.3.3 Systematic Sensitivity Analysis[13]

As noticed before, we try to estimate the reliability of our results by doing systematic sensitivity analysis (SSA). The RunGTAP program is useful for this kind of calculations, and it can be used to determine how sensitive the results are with respect to changes in parameters or changes in shocks. With the results from these SSA calculations, one can get the mean and the standard deviation estimates for each endogenous

[13] We follow here the explanation of Vaittinen (2003), where a more detailed analysis can be found.

variable. In the last subsection we study the changes in the elasticity of substitution parameters, and estimate how these affect different endogenous variables in the model. The estimates are obtained by solving the model several times, and each time with different parameters. The different parameter values are chosen by using Gaussian guadrature (DeVyust, Preckel 1997). Gaussian quadrature produces estimates of means and standard deviations of the endogenous variables in the model, by viewing exogenous variables as random variables. The estimates are quite accurate, even though the model is solved a limited number of times. Of course the most reliable results could be received by using Monte Carlo analysis. However for a CGE-model, where the number of exogenous variables is large, Monte Carlo analysis becomes impractical. The parameters which vary are all symmetrically distributed.

Suppose we are given a continuous distribution for several variables. The Gaussian quadrature is a discrete distribution from this continuous distribution, and its first d moments are identical with those of the continuous distribution. The RunGTAP offers two Gaussian quadratures, which are the Stroud's and Liu's quadratures. They are of order three, which means that the first three moments are the same as in the continuous distribution. This allows the mean and standard deviation to be the same in both distributions. The quadratures are valid for distributions made up from one or more symmetric distributions which are varying independently. Suppose we have N elasticity of substitution factors varying independently. Stroud's quadrature has 2N points in it which means that the model has to be solved 2N times when SSA calculations are performed. The difference to Liu's quadrature, which we choose in our simulations, is that it chooses 4N points, so it can produce better approximations.

5 Simulation of trade barriers

5.1 The object

In this section we simulate the barriers to trade in transport services, which will be used in section 6 to analyze liberalization of these barriers. The most common way to do e.g. welfare analysis with the GTAP-model is to reduce existing barriers to trade and analyze the results. However, the main problem with services is that tariff estimates do not exist in the GTAP-database. Our chosen service sectors in this paper are transport, finance, and business. In the GTAP-model it is possible to set freely chosen tariffs to trade into the model. Yet barrier estimates of trade in our chosen service sectors are difficult to measure, and hardly any estimates have been presented. The transport service sector is especially difficult, and in most of the existing papers, estimated implications of liberalization of trade in transport service sector are performed with Hoekman's (1995) tariff "guesstimates". The estimates on barriers to trade in financial and business services chosen for this paper are based on Francois (2001) calculations.

To estimate exact barriers to trade in transport services would require a lot of effort. The estimation would probably turn out to be impossible because of the lack of data. Especially the barriers set by developing countries would be very hard to estimate by analyzing e.g. WTO negotiations. However, there is another way of analyzing the effects of increasing trade in services. What we do in this paper, is that we simulate how the increase of trade in different transport service sectors affects chosen endogenous factors in our model. Yet the problem is that we cannot do this directly with the GTAP-model. This is why we first need to simulate the barriers of trade in transport services.

5.2 The database

The GTAP-database Version 5 contains 66 countries and 57 sectors. 11 of the 57 sectors are service sectors. We have aggregated the GTAP-database for our simulations into 6

regions and 8 sectors (appendices 1 & 2)[14]. As noticed in the introduction section, our chosen regions are: industrialized countries (IC), Central and South American countries (CSA), South Asia, Africa, and rest of the world (ROW). These chosen regions already indicate that we have a developing country focus in this paper. The chosen aggregate sectors are food, other primary products (OthPrimary), manufactures, services, transport nec (not elsewhere classified), sea transports, air transports, and financial and business services (FandB). Because of our special focus on the transport sector, we have divided it into three sub- groups. The three transport service sectors differ in size and also in freight and passenger volumes, and their share of other transportation share they include. In the air transport sector, exports are mainly provided to transport people (McDougall 2002). Yet the other two transportation sectors offset air transportation, and freight transportation exports are twice as large as transport services provided for passengers[15].

Region	Transpnec	Seatransp	Airtransp
IC	74	62	71
CSA	5	10	7
SouthAsia	8	12	9
Africa	4	2	2
ROW	10	14	11

Table 2: GTAP-database estimates on selected regions share on exports and imports of different transport services

The shares of transport services used by different regions are illustrated in table 2. There are two main conclusions that can be drawn from the table. First the export and import shares of different transport services are very close to each other in all

[14]No more detailed information is needed, because of we are especially interested in global welfare effects.

[15]The share of freight transports is not insignificant to this paper. The better freight transports are represented in the model, the greater the possibility for us to get welfare implications from increasing trade in goods through liberalization of trade in transport services.

regions. This is mainly due to the fact that transport services are heavily traded within chosen regions. The second reason is the way the transport services data is formed in the GTAP-model. Another very obvious conclusion that can be drawn from table 2 is that industrialized countries are the main traders of transport services. Industrialized countries share of total air transport trade and of transport nec trade is over 70 percent and over 60 percent of sea transport trade.

5.3 Tariff equivalents for trade in transport services

Our primary object in this section is to study tariff equivalents that are consistent with specified increases of trade in transport services. Increasing trade in transport services exogenously in the GTAP-model from one country to another decreases the amount of transport services available in the country of origin. The problem is that it does not make the country to specialize itself in the production of a transport service[16]. In this subsection we present the results of tariff equivalents simulated with the GTAP-model[17]. The simulation is done to avoid the problem of high decreases of transport services available in the country of origin. The simulation is accomplished with the GTAP-model in the following order.

First, we set the increase of regional trade in transport services as an exogenous factor, and the tariff equivalents as endogenous factors. With the model we can study how the increase of the chosen exogenous factors affects the endogenous factors; especially tariff equivalents. One of the problems is that there are also other endogenous factors than the tariff equivalents reacting to the exogenous increases of trade in transport services. Yet we check that our results are relevant by setting the simulated tariff equivalents as existing tariffs into the model, and then examine that decreasing these tariffs will lead to demanded increases in transport services[18]. By doing the simulation

[16] Also the increase of transport service production in the country of origin will not bring us to desired final results.

[17] The tariff equivalents in this paper are estimates of total barriers to trade in transport services. They are illustrated as import barriers set by different regions.

[18] In the first estimation round this does not lead into demanded increases in transport services. This is why the estimation has to be repeated a few times. This is done by increasing the amount

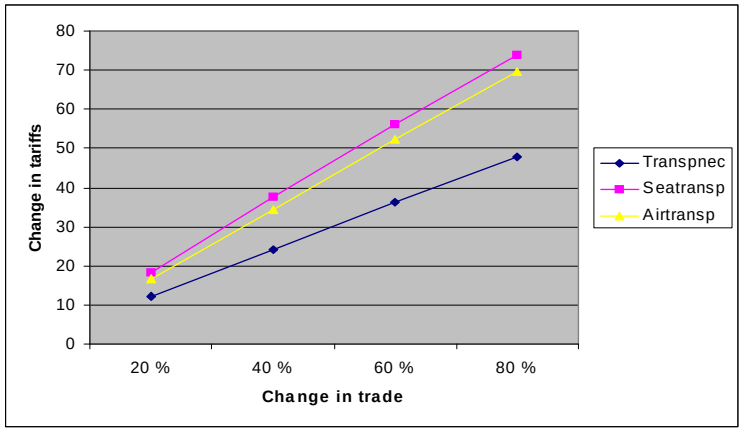

Figure 2: Tariff estimates corresponding to increases in trade of different transport services

and with the help of the estimated tariff equivalents we can study in section 6 how the increase of global trade in transport services in a chosen amount affects e.g. regional welfare, or international trade in goods. The other benefit of our calculations is that we can study the increases of trade in transport services following the removal of tariffs. Our calculations illustrate the effects of liberalization of barriers to trade in transport services.

The final results of the calculations are presented in appendix 3, and the region specific tariff equivalent estimates can be found there. In figure 2 we have left the country dimension away, and tariff equivalents are shown here as country averages[19]. From figure 2 we can see that if we want to estimate the economic effects of a 60 % increase of trade in chosen transport services, the corresponding tariff equivalents are on average 36 % for transport nec, 56 % for sea transports, and 52 % for air transports. Independent of the assumption, how much we want to increase trade in transport services, the largest decrease of tariff equivalents needed for the corresponding increases

of transport services with the difference of demanded increases and increases achieved from the first round.

[19] As one can notice from appendix 3, there are high variations of tariff equivalents between countries. In section 6, we use the exact tariff equivalents for our calculations.

are in the sea and air transport services. Vice-versa this means that the liberalization of given tariff equivalents leads in the transport nec sector to higher increase in trade than liberalization in sea and air transport sectors. However most probably the actual tariff equivalents for the sea and air transport services are higher than for the transport nec services.

It may not be relevant to analyze over 80 % increases of trade in transport nec services. Referring to Hoekman's (1995) "guesstimates" and Robinson, Wang, Martin (2002) we can conclude that tariff equivalents of around 70 % are relevant estimates of true tariff equivalents in the sea and air transport sectors. In the other transport sectors (transport nec) the relevant country averages are between 30-50 %. Especially in developing countries the tariff equivalents can be even higher than the estimated country averages. Taking into account that our chosen regions are mainly developing countries, increasing trade in transport services by 80 % can be considered to be the most relevant case.

In the following section we will introduce implications from increasing trade in transport services. Implications of four cases are considered. In the first three cases trade in transport services is increased by 20 %, 40 % and 60 %. The last case, considered as the most realistic case, is the total liberalization of trade in transport, financial, and business services. In the last case trade in transport services is increased by 80 %, and in addition Francois' (2001) estimates of financial and business service tariff equivalents are included and reduced to zero.

6 Trade liberalization effects

6.1 Total welfare effects

The total economic welfare effects of the liberalization of trade in transport services that lead to desired increases in trade in transport services are measured by three factors. These factors are regional equivalent variation (EV), regional household utility, and

quantity index for regional gross domestic product (GDP). The EV is a compensating payment that in the absence of the economic change moves the consumer to the welfare level associated with the change. It is a fixed price measure of the difference in consumption possibilities of consumers before and after the introduction of policies (price decrease). The regional household utility (u) is a percentile change of the equivalent variation. The quantity index GDP is a measure of growth for chosen regions. Changes in GDP reflect shifts in the economy's production possibilities frontier owing to the improved allocation of a fixed resource base (Hertel, Tsigas 1997). There is no doubt that removing barriers to trade in transport services would lead to increasing welfare in the world as total. Table 3 represents total estimated welfare gains from increasing world trade in transport services with a given amount.

	20 %	40 %	60 %	80 %
IC				
Δ EV	4.671	11.780	20.504	31.910
% -Δ u	0.02	0.06	0.1	0.16
% -Δ GDP	0.02	0.04	0.08	0.13
CSA				
	-0.399	-0.260	0.203	0.779
	-0.02	-0.01	0.01	0.04
	0	0.02	0.06	0.09
SouthAsia				
	0.925	2.163	3.545	5.393
	0.05	0.12	0.2	0.31
	0.03	0.07	0.12	0.19
Africa				
	0.074	0.324	0.682	1.223
	0.02	0.07	0.14	0.25
	0.02	0.07	0.13	0.22
ROW				
	-0.926	-0.921	-0.373	0.302
	-0.06	-0.06	-0.02	0.02
	0.01	0.06	0.12	0.2
Total				
	4.349	13.633	25.236	39.305
	0.002	0.036	0.086	0.156
	0.016	0.052	0.102	0.166

Table 3: Estimated welfare effects of increases in trade in transport services

The total liberalization of trade in transport, financial and business services increases the world total welfare by almost 40 billion dollars. On average, the EV increases by 0,16 %, and the regional GDP grows by 0,17 %. Considering different increase categories

of trade in transport services, the marginal value of the total EV is increasing slightly. If large increases of trade in transport services are possible (high barriers do exists), high welfare gains can be achieved[20]. Measured by EV, the regions benefiting the most from increasing trade in transport services are the industrial countries and countries in South Asia. Consumers in Central and South America lose the most if trade does not increase more than 40 % and in ROW if trade is not totally liberalized. We come up with two possible explanations for the negative results of EV. The first is that in these two areas exports increase relatively to imports, and the second is that total terms of trade decrease (figure 6). In relative terms the largest increases in consumption possibilities (u) are achieved in South Asia. Measuring welfare by GDP, the region that gains the most is Africa, especially if trade increases in large amounts. The changes in GDP are positive for all regions.

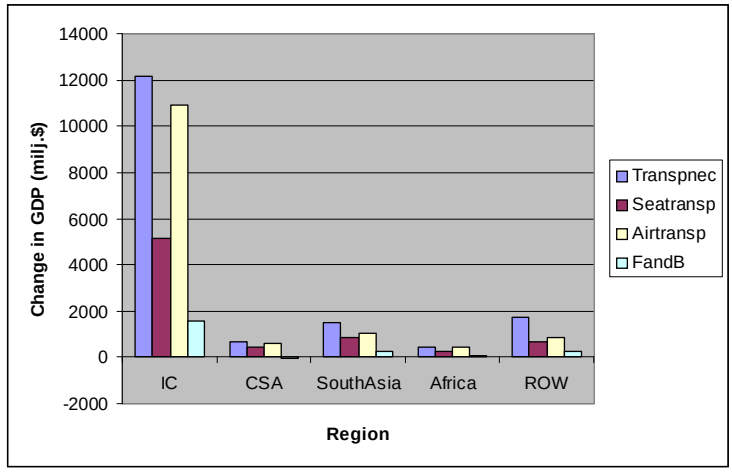

Figure 3: Regional change in the GDP with the liberalization of trade in different service sectors

In figure 3 we illustrate how the absolute GDP reacts to the total liberalization of

[20]It should be noted that as mentioned in subsection 2.2, before 1995 the annual increase of trade in services was over 10 % per year in the developing countries. This shows that increases of trade in transport services are possible to achieve.

trade in different transport services, and in financial and business services in different regions. The responses to changes in different categories of transport service increase are presented in appendix 4. As can be seen in figure 3, all countries benefit from the liberalization of trade in different transport services. Industrialized countries benefit most in absolute terms from the liberalization of all four service sectors. Most beneficial for all the regions is the liberalization of trade in transport nec services. The liberalization of trade in air transport services is almost as beneficial as the liberalization of transport nec, but benefits from liberalization of trade in sea transportation remains lower. The total liberalization of trade in financial and business services is beneficial for all other regions than Central and South America. The total gains from global liberalization of trade in financial and business services remain low.

In relative terms Africa gains the most from the liberalization of trade in different transport services. This outcome is independent of the assumption of how much we increase trade. In the case of total liberalization of trade in transport services, Africa's GDP increases by 0.08 % from liberalization of transport nec, by 0.05 % from liberalization of sea transportation, and by 0.07 % from liberalization of air transportation. Also the liberalization of trade in financial and business services increases Africa's GDP by 0.02 %.

6.2 Effects on trade in goods

One interesting question is, how the increase of trade in transport services (i.e. how the liberalization of trade) affects trade in goods between regions. This subsection gives an answer to that, and at the same time explains how the welfare effects presented above are achieved. We are mainly interested in three questions: how large are the changes of trade in certain groups of goods exported or imported from and to chosen regions, in which goods are the changes of exports or imports highest for chosen regions, and what are the effects on total terms of trade for chosen regions. The second question will also give us some information about the question in which production sectors do

certain regions have a comparative advantage.

In the following subsubsections we concentrate on the developing countries. The product groups we examine are food, other primary products (OthPrimary), manufactures (Mnfcs), and services (Svces). We take Africa as an example region for our considerations, and we compare all other regions with it. More detailed information about export or import data can be found in appendix 5.

6.2.1 Goods exports

Figure 4 illustrates the relative changes of exports from Africa, when transport services trade is increased. From figure 4 it can be noticed that exports of other primary products increases much less than exports of other goods from Africa. This is also true for other regions, and especially for ROW (appendix 5). The small increase in exports of other primary products in ROW is mainly due to the fact that it concentrates heavily on exportation of other goods. The main reason for the small increase in the exports of other primary products in the developing regions is that they are the only group of goods in which exportation from industrialized countries increases.

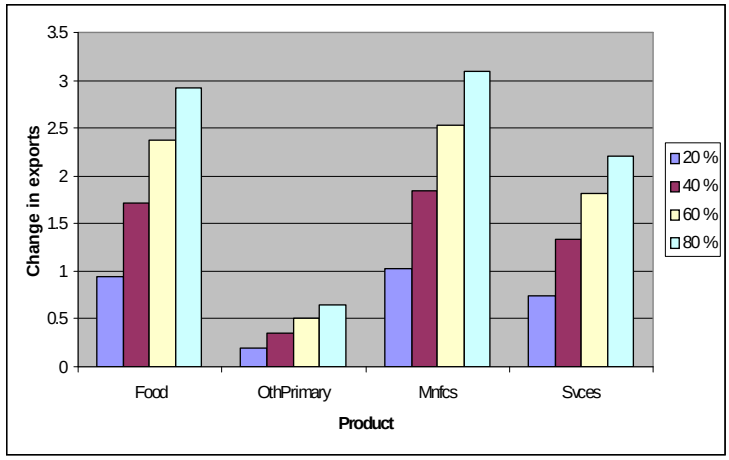

Figure 4: Changes in exportation of chosen products from Africa with the increase of trade in transport services.

Exports increase relatively most in ROW, where the exports of manufactures (a 3.4 % increase) and services (a 2.9 % increase) increase most after the total liberalization of the chosen services. In Africa and CSA the increases of exports in those two sectors are also high; the increase of manufactures is about 3 % and the increase of services about 2.2 % for both regions. With the exception of manufactures, the changes of exportation from South Asia are positive, but relatively low. The maximum increase in manufactures is 2 %, and in services 1.1 %. Considering exportation of other primary products (a 0.23 % increase), or food (a 0.17 % increase) the increase of exportation of these goods from South Asia remains low. The exportation of food from Africa and South Asia increase almost as much as exports of manufactures with different increases of trade in transportation. In Africa the increase of food exports reaches at highest 2.9 % and in CSA 3.0 %. Comparing the exportation of food and manufactures it is worth noting that traditionally Africa has been exporting food, so there is a greater potential for the increase of trade in manufactures. E.g. a 3 % increase in exports of a certain good from Africa is not high if the base level of exportation is close to zero. However, there remains no question about the sector where Africa has the comparative advantage in.

6.2.2 Imports of goods

As in the case of exports, other primary products show a different outcome in imports than other goods. The large increase of other primary products imports to developing countries is due to exportation of these goods by industrialized countries. Also industrialized countries increase their imports of other primary products, but measured in relative terms the increase remains much lower than in the developing countries. However, industrialized countries are relatively large importers of other goods and services. The outcome of this is, that increases of EV are large in the industrialized countries, because people have more products to consume through the increasing importation. In developing countries the importation of certain products falls in certain regions. With the exception of East Asia, the fall of importation of services is relatively high.

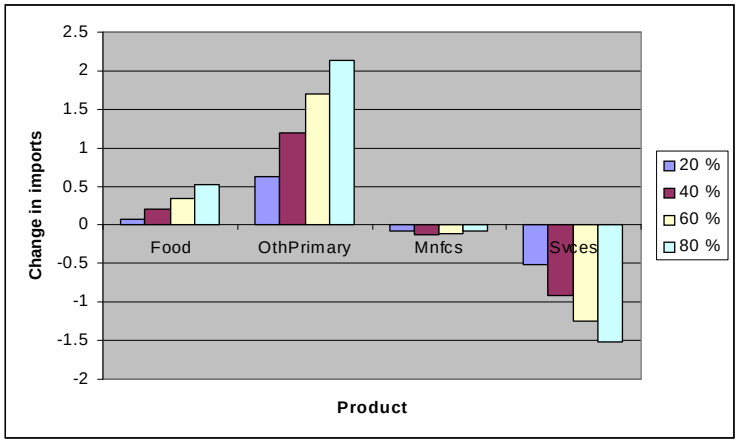

Figure 5: Changes in importation of chosen products from Africa with the increase of trade in transport services.

Imports of food and manufactures differ between regions. In Africa, ROW, and Central and South America manufactures imports decrease, but the decrease is small in all three regions. In South Asia manufactures imports increase for all increase categories in transport service exportation. Also food imports increase in South Asia, and this can be the reason why EV increases there. With the total liberalization of trade in transport services, imports of food increases in South Asia by 1.6 %. As can be seen in figure 5, the increase of food imports remains low for Africa. It increases at most only by 0.5 %. The increase in food imports is even smaller in Central and South America (a 0.3 % increase at most) and is negative for ROW (not significant).

The small amount of importation and high exportation of goods explains increases of EV in developing countries. If exports increase relative to imports, it is also straightforward that GDP increases in these regions.

6.2.3 Total terms of trade

In this subsubsection we analyze shortly the changes in terms of trade (tot) for the chosen countries. Figure 6 illustrates the changes in terms of trade corresponding to the

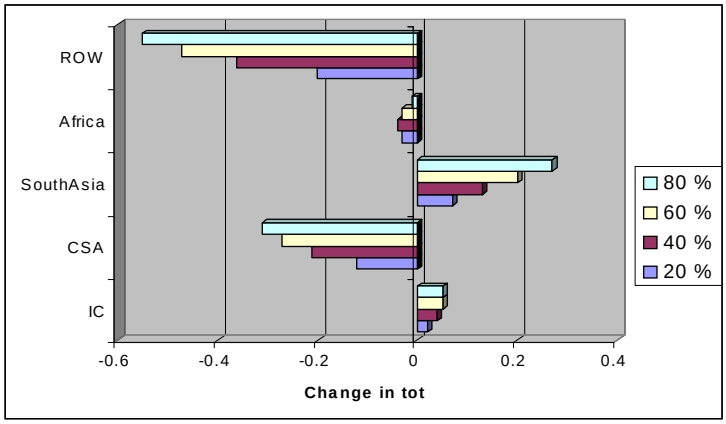

Figure 6: Change in the total terms of trade

amount of increase in transport service exportation. Only Africa makes an exception to the smooth correlation of total terms of trade and increase of transport exportation. In all other regions the increase of transport services strengthens the effect on the change in terms of trade. In Africa terms of trade decrease first more when transport services are increased from 20 % to 40 %; after that the more transport services are increased, the lower is the decrease in total terms of trade.

Specific explanations for the increase or decrease of terms in trade are hard to state. For example, if we assume that the terms of trade is significantly dependent on how the imports and exports develop, we also have to assume that the prices of e.g. different manufactures are equal. This is what we cannot do, and this fact also makes it difficult to analyze changes in terms of trade. However with this assumption, the terms of trade for South Asia can be explained. As can be seen from figure 6 the terms of trade increase in South Asia the more transport services are liberalized. This is possible due to the fact that exportation of manufactures increases greatly in South Asia. Considering the other regions, we cannot explain their terms of trade changes with the changes in exports or imports of manufactures. One explanation for the increase of terms of trade in industrialized countries and the decrease in Africa, Central and South America and

ROW is that the prices of other primary products decrease less than the prices of other products with increasing trade.

6.3 Sensitivity analysis

As mentioned in subsection 4.3 the results presented before are dependent on the elasticity of substitution factors. In subsubsection 4.3.1 we represented (figure 1) how the elasticity of substitution between domestic and foreign goods and the elasticity of substitution between different foreign goods affect countries' decision-making when they choose the goods used for building up final goods. In this subsection we study the estimated mean values, and standard deviations of chosen endogenous factors. The elasticity of substitution factors are chosen with Liu's quadrature from a symmetric distribution function which are formed by multiplying and dividing the existing elasticity factors by 2.

We begin our analysis by looking more closely at the welfare factors (EV, GDP) and the total terms of trade factors (tot) after the liberalization of trade in transport, financial, and business services. In table 4 we have three results for each region and for both welfare and total terms of trade factors: the before sensitive analysis results (gtapsim), the mean value after sensitive analysis (80m1) and the standard deviation factor after the simulation (80sd).

Those results which make us uncertain about our realized outcomes are the most interesting ones. This is true for EV in ROW. The mean value is after the analysis 316 billion, but the standard deviation is 941 billion. This means that the change of the EV for ROW can also be negative after the liberalization; but also much higher than with the original elasticity of substitution values. The standard deviation (0.141) for Africa's total terms of trade is much higher than the eigenvalue of the estimated mean value (-0.047). This means that the change in the terms of trade for Africa might as well improve after the total liberalization of trade in transport, financial, and business services. There are also two other values which can be very close to zero. The increase

of EV for Central and South America could remain small, and the total terms of trade improvement could also be small for industrialized countries.

	IC	CSA	SouthAsia	Africa	ROW
EV					
gtapsim	30211.27	835.59	4948.76	1096.96	403.40
80m1	32151.10	775.83	4983.27	1088.80	316.17
80sd	6629.24	528.24	544.57	202.21	941.26
qgdp					
gtapsim	0.12	0.09	0.17	0.20	0.18
80m1	0.13	0.10	0.18	0.21	0.19
80sd	0.02	0.01	0.03	0.03	0.03
tot					
gtapsim	0.05	-0.31	0.27	-0.01	-0.55
80m1	0.06	-0.35	0.24	-0.05	-0.59
80sd	0.04	0.15	0.08	0.14	0.18

Table 4: Results of SSA

In table 5 we represent the effects on exports and imports from and to Africa. For Africa there is one outcome factor which sign is uncertain. The mean value of importation of manufactures is —0.121 for Africa, but the standard deviation is 0.259. This means that after liberalization, the importation of manufactures to Africa might as well increase. Also the importation of food to Africa is an uncertain factor. The mean value of imports is 0.48 and the standard deviation is 0.344. This means that the liberalization of transport services may as well have a nonexistent effect on importation of food to Africa.

Uncertainty is also associated with other regions than Africa's importation and exportation of goods. The most uncertain outcomes are briefly discussed here. Most uncertainty is associated with the exportation and importation of food. First of all in the industrialized countries the sign for exportation of food is uncertain. According to the before sensitivity analysis GTAP simulation, exportation of food increases (0.013). However, after the sensitivity analysis, the mean value shows a negative sign (-0.038). If we take the standard deviation (0.262) into consideration, we can only say that the

outcome is uncertain. Also the effect on exportation of food from South Asia remains uncertain. The mean value of the exports increase is 0.28, but the standard deviation is 0.317. The importation of food to Central and South America (0.224 / 0.256) might as well decrease and to ROW (-0.126 / 0.309) increase. Considering other sectors, one uncertain factor is still the exportation of other primary goods from ROW (0.127 / 0.144), where the exportation of these goods may also decrease.

Africa	Exports			Imports		
	gtapsim	80m1	80sd	gtapsim	80m1	80sd
Food	2.944	3.225	1.079	0.519	0.48	0.344
OthPrimary	0.638	0.66	0.135	2.145	2.264	0.507
Mnfcs	3.117	3.347	0.891	**-0.081**	**-0.121**	**0.259**
Svces	2.23	2.501	1.031	-1.507	-1.666	0.588
FandB	2.197	2.473	1.058	-0.912	-1.031	0.44

Table 5: Effects of SSA on exports and imports from / to Africa

7 Conclusions

Countries' commitment to liberalize trade in transport services has remained low despite services in general were included in multilateral trade negotiations in 1995. However, there are potential welfare gains to be achieved from the liberalization of services. Transport services are important especially due to the potential dual benefits. Comparative advantage can be used as an argument for transport trade liberalization, but transports' effect on trade in goods is also relevant. Analyzing potential benefits from the liberalization of transport services has been difficult due to a lack of estimates of trade barriers. This paper uses a computable general equilibrium model to first estimate tariff equivalent reactions to exogenous increases in transport services trade. After that welfare gains from the liberalization of these barriers are analyzed.

Independent of the assumption how much transport services are increased, the largest decrease of tariff equivalents needed for the corresponding increases are in the

sea and air transport services. Vice-versa this means that the liberalization of given tariff equivalents leads in the transport nec sector to a higher increase in trade than the liberalization in sea and air transport sectors. Yet, it is possible that actual tariff equivalents for the sea and air transport services are higher than for the transport nec services. From this would follow that higher reduction of tariffs are possible in the sea and air transportation sectors.

Following tariff equivalent estimates of Francois (2001) in finance and business services and choosing a judgmental possibility of 80 percent increase in transport services, we obtain the following welfare effects, which are limited. On average, regional GDP grows by 0,17 % and EV increases by 0,16 %. However, if an 80 percent increase is possible, the welfare of all chosen regions increases. Measured by EV, the most benefiting regions are the industrial countries and countries in South Asia. Consumers in Central and South America lose, if trade does not increase more than 40 % and in ROW if trade is not totally liberalized. We come up with two possible explanations for the negative results of EV. The first is that in these two areas exports increase relatively to imports, and the second is that the total terms of trade decrease. Most beneficial for all the regions are the liberalization of trade in transport nec and air transport services. Benefits from liberalization of trade in sea transportation remain lower. In relative terms, Africa gains most from liberalization of trade in different transport services. This outcome is independent of the assumption of how much we increase trade. By introducing SSA, it can be found that the welfare effects of liberalization are uncertain for Central and South America and for "ROW". All in all, the total liberalization effects remain moderate.

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8 Appendixes

8.1 Appendix 1: GTAP country aggregation

Region	Code	Region	Code
Australia	IC	Finland	IC
New Zealand	IC	France	IC
China	SouthAsia	Germany	IC
Hong Kong	IC	United Kingdom	IC
Japan	IC	Greece	IC
Korea	IC	Ireland	IC
Taiwan	IC	Italy	IC
Indonesia	SouthAsia	Luxembourg	IC
Malaysia	SouthAsia	Netherlands	IC
Philippines	SouthAsia	Portugal	IC
Singapore	IC	Spain	IC
Thailand	SouthAsia	Sweden	IC
Vietnam	SouthAsia	Switzerland	IC
Bangladesh	SouthAsia	Rest of EFTA	IC
India	SouthAsia	Hungary	ROW
Sri Lanka	SouthAsia	Poland	ROW
Rest of South Asia	SouthAsia	Rest of Central European Assoc	ROW
Canada	IC	Former Soviet Union	ROW
United States	IC	Turkey	ROW
Mexico	CSA	Rest of Middle East	ROW
Central America, Caribbean	CSA	Morocco	Africa
Colombia	CSA	Rest of North Africa	Africa
Peru	CSA	Botswana	Africa
Venezuela	CSA	Rest of SACU (Namibia,RSA)	Africa
Rest of Andean Pact	CSA	Malawi	Africa
Argentina	CSA	Mozambique	Africa
Brazil	CSA	Tanzania	Africa
Chile	CSA	Zambia	Africa
Uruguay	CSA	Zimbabwe	Africa
Rest of South America	CSA	Other Southern Africa	Africa
Austria	IC	Uganda	Africa
Belgium	IC	Rest of Sub-Saharan Africa	Africa
Denmark	IC	Rest of World	ROW

8.2 Appendix 2: GTAP sectoral aggregation

Product Description	Sector Code	Product	Sector
Paddy rice	Food	Leather products	Mnfcs
Wheat	Food	Wood products	Mnfcs
Cereal grains nec	Food	Paper products, publishing	Mnfcs
Vegetables, fruit, nuts	Food	Petroleum, coal products	Mnfcs
Oil seeds	Food	Chemical,rubber,plastic prods	Mnfcs
Sugar cane, sugar beet	Food	Mineral products nec	Mnfcs
Plant-based fibers	OthPrimary	Ferrous metals	Mnfcs
Crops nec	Food	Metals nec	Mnfcs
Cattle,sheep,goats,horses	Food	Metal products	Mnfcs
Animal products nec	Food	Motor vehicles and parts	Mnfcs
Raw milk	Food	Transport equipment nec	Mnfcs
Wool, silk-worm cocoons	OthPrimary	Electronic equipment	Mnfcs
Forestry	OthPrimary	Machinery and equipment nec	Mnfcs
Fishing	Food	Manufactures nec	Mnfcs
Coal	OthPrimary	Electricity	Svces
Oil	OthPrimary	Gas manufacture, distribution	Svces
Gas	OthPrimary	Water	Svces
Minerals nec	OthPrimary	Construction	Svces
Meat: cattle,sheep,goats,horse	Food	Trade	Svces
Meat products nec	Food	Transport nec	Transpnec
Vegetable oils and fats	Food	Sea transport	Seatransp
Dairy products	Food	Air transport	Airtransp
Processed rice	Food	Communication	Svces
Sugar	Food	Financial services nec	FandB
Food products nec	Food	Insurance	Svces
Beverages and tobacco products	Food	Business services nec	FandB
Textiles	Mnfcs	Recreation and other services	Svces
Wearing apparel	Mnfcs	PubAdmin/Defence/Health/Educat	Svces
		Dwellings	Svces

8.3 Appendix 3: Estimated tariff rates

Ttanspnec	IC	CSA	SouthAsia	Africa	ROW	Average
20 %	9.7694	13.19104	11.4635	11.88678	14.0927	12.08068
40 %	19.5105	26.43482	22.86174	23.75842	28.31806	24.17671
60 %	29.234	39.62464	34.2143	35.60536	42.5081	36.23728
80 %	38.7971	52.41268	45.28626	47.1755	56.21314	47.97694
Seatransp						
20 %	14.6947	23.23614	13.95156	12.65544	27.12062	18.33169
40 %	30.2089	47.67124	28.0571	25.4352	55.81458	37.4374
60 %	45.9555	71.50182	42.13408	38.28144	83.2919	56.23295
80 %	61.2575	93.3541	55.76068	50.89068	107.8233	73.81725
Airtransp						
20 %	11.2716	16.8741	19.95422	16.63656	19.17336	16.78197
40 %	22.6632	34.50586	41.13764	34.20012	39.5899	34.41934
60 %	34.1686	52.35274	62.454	52.17668	60.34672	52.29975
80 %	45.5281	69.67246	82.84498	69.85258	80.43558	69.66674

8.4 Appendix 4: Changes in the GDP due to liberalization of different service sectors

IC	Transpnec	Seatransp	Airtransp	FandB
20 %	1388	756	1386	
40 %	4106	2030	3904	
60 %	7798	3552	3904	
80 %	12178	5156	10934	1556

CSA	Transpnec	Seatransp	Airtransp	FandB
20 %	7.5	57	-60.5	
40 %	153.38	177.75	78.75	
60 %	390.5	322.38	78.75	
80 %	680.88	462.88	646.25	-22.5

SouthAsia	Transpnec	Seatransp	Airtransp	FandB
20 %	220	188.38	115.88	
40 %	573	405.88	384.25	
60 %	1015	632.38	384.25	
80 %	1501.25	852.88	1043	281.25

Africa	Transpnec	Seatransp	Airtransp	FandB
20 %	37.13	48.25	33.19	
40 %	141.13	110.19	131.06	
60 %	291	180	131.06	
80 %	466.88	253.44	409.81	104.81

ROW	Transpnec	Seatransp	Airtransp	FandB
20 %	103.88	93.88	-14.25	
40 %	488.25	284.25	196	
60 %	1051.13	498.25	196	
80 %	1730.88	651.75	876.63	233.13

8.5 Appendix 5: Change in the exports and import of products from chosen regions

Food	IC	CSA	SouthAsia	Africa	ROW
20 %					
Exp	-0.05	0.96	0.07	0.94	0.74
Imp	0.23	0.01	0.42	0.07	-0.1
40 %					
	-0.05	1.75	0.11	1.72	1.31
	0.43	0.07	0.83	0.2	-0.13
60 %					
	-0.03	2.41	0.14	2.37	1.75
	0.6	0.15	1.22	0.35	-0.11
80 %					
	0.02	2.97	0.17	2.92	2.11
	0.76	0.25	1.58	0.52	-0.07

OthPrimary	IC	CSA	SouthAsia	Africa	ROW
20 %					
	0.35	0.2	0.03	0.19	0.04
	0.05	0.48	0.58	0.63	0.48
40 %					
	0.69	0.39	0.08	0.35	0.07
	0.11	0.9	1.1	1.19	0.89
60 %					
	1.02	0.56	0.15	0.5	0.08
	0.17	1.27	1.57	1.69	1.24
80 %					
	1.31	0.72	0.23	0.64	0.11
	0.24	1.6	1.99	2.14	1.54

Mnfcs	IC	CSA	SouthAsia	Africa	ROW
20 %					
	-0.13	0.99	0.59	1.02	1.16
	0.12	-0.19	0.22	-0.08	-0.16
40 %					
	-0.22	1.79	1.11	1.84	2.07
	0.23	-0.33	0.43	-0.12	-0.25
60 %					
	-0.27	2.41	1.57	2.53	2.78
	0.33	-0.42	0.64	-0.11	-0.3
80 %					
	-0.31	2.93	1.97	3.09	3.37
	0.42	-0.48	0.83	-0.08	-0.32

Svces	IC	CSA	SouthAsia	Africa	ROW
20 %					
	-0.26	0.78	0.34	0.74	1.01
	0.08	-0.43	-0.17	-0.51	-0.51
40 %					
	-0.45	1.39	0.63	1.34	1.78
	0.14	-0.76	-0.3	-0.92	-0.88
60 %					
	-0.59	1.9	0.9	1.82	2.37
	0.2	-1.01	-0.4	-1.25	-1.14
80 %					
	-0.7	2.31	1.12	2.21	2.86
	0.24	-1.2	-0.48	-1.51	-1.33

Chapter 4

Technological diffusion and trade in services

1 Introduction

Solow (1957) was the first to argue that increasing investments in physical or human capital with a given rate of technological process do not lead to sustained economic growth. He stated that technological change is the main factor behind economic growth. Nowadays there is a consensus that physical and human capital accumulations alone are not able to explain the large variation of growth rates in various countries (Easterly, Levine 2001)[1]. Even if domestic resources are not invested into research and development (R&D) countries are able to gain from global investments into R&D. The well-known properties associated with technology / knowledge (non-rival, excludable) increase the possibility for countries to benefit from foreign R&D investments. According to Eaton and Kortum (1999) and Keller (2002), the major sources of technological change leading to productivity growth in the OECD countries do not originate from domestic investments but from foreign investments. Keller (2001) states that international diffusion of technology is the major determinant of per capita income in the world. In the case of developing countries, the possibility for technological diffusion is high because of the technological gap. If developing countries are able to absorb technology, diffusion provides them also an opportunity for economic growth.

[1] Of course this does not mean that e.g. the influence of education should be underrated. Considering developing countries, domestic technical inventions or benefiting from diffusion of technology are hard to achieve without domestic skills.

Keller (2001) divides the process of technological diffusion into two mechanisms: active and passive spillover. The main difference between these two is that in the first mechanism the importing country receives a blueprint that is used in the domestic production process. In the second mechanism domestic inventors do not get familiar with the technology associated with traded products; they only observe the manufactured outcome of it. This means that they have access to the outcome of the foreign R&D. Both cases entail positive spillover externality, which means that technological knowledge is cheaper than the original expenses to the inventor. In this study our focus is on passive spillovers. These can be related to international trade mainly trough trade in intermediate goods, and foreign direct investments (FDI) through subsidiaries by foreign owned companies. These two channels can also increase active spillovers by increasing the amount of products and skills to be used and refined. The possibility of these spillovers increased in the 1990's when globalization was again rapid. World trade in goods and services nearly doubled between 1990-2001 (WTO 2002). The growth of FDI between countries was especially strong between 1996–1999 when the growth rate was about 40% per year (UNCTAD 2001).

International technology diffusion has been studied traditionally by R&D spillover regressions (Mohnen 2001, Keller 2001). With these regressions one measures how dependent total factor productivities (TFP) or GDPs of different countries are on different variables; especially on domestic and foreign R&D stocks. Examples of papers that analyze technological diffusion through international trade are Coe and Helpman (1995, henceforth CH), Coe, Helpman, and Hoffmaister (1997), and Keller (1997)[2]. The common factors of these papers are that they calculate foreign R&D stocks by weighting R&D stocks of foreign countries with bilateral trade flows between the domestic and the foreign technology exporting country. Keller's (1998) results raise serious doubts about

[2]The complicated relationship between imports and productivity must be noted. Productivity growth triggers economic growth and increases income. This in turn leads to an increase in imports. Also increased productivity in an import-substituting industry can crowd out imports in the domestic market and thus have a negative impact. This means that causality remains unclear. One way we have been trying to overcome this problem is by lagging indirect R&D spillovers and finding out that the optimal lag is two years.

the validity of this procedure. He repeats CH's (1995) regressions with counterfactual 'import' shares, and finds similar high coefficients and levels of explained variation when these counterfactual import shares are used instead of the actual shares.

More criticism has been set on CH (1995) by Lichtenberg and van Pottelsberghe de la Potterie (1998, henceforth LP). They show that import-share weighting suffers from aggregation bias and is highly sensitive to potential merger between countries[3]. Their conclusion is that what really matters is the intensity of R&D investments, by which they mean the share of R&D investments in the exporting country to the exporting country's GDP. Luintel and Khan (2004) introduce a further issue to the discussion of spillovers. They show that there exists significant heterogeneity in the dynamics of knowledge diffusion across the G10 countries. In addition, one important paper among others is Lumenga-Neso, Olarreaga, and Schiff (2001, henceforth LOS). They argue that R&D spillovers can take place between countries that do not have bilateral trade. This can be due to "indirect" R&D spillovers. These indirect spillovers can occur because the knowledge-receiving country does not have to trade with the country from which it receives spillovers directly. Instead the receiving country can gain indirectly from a third country that has direct trade with a country that trades with the technology exporting country. By showing this they also explain why the results of Keller (1998) differ from the ones of CH (1995).

We follow in our calculations the proposition of LP (1998), and take into account the R&D investment intensity in selected OECD countries (section 3.1). We also take into account the possibility of indirect spillovers (LOS (2001)), and repeat the regression with a specified model by introducing indirect spillovers (section 3.2). Following these methods provides us a way to study trade-related spillovers in the 1990's.

In this paper we are especially interested in technological diffusion through trade in services. International trade in goods and FDI are usually connected with passive spillovers. To categorize trade in services is more difficult. According to WTO, trade

[3]LP (1998) point out that why should the foreign R&D stock of a receiving country increase when importing countries merge.

in services can be divided into four modes: cross-border trade, consumption abroad, commercial presence, and presence of natural persons. Due to the special characteristics of services, interaction between people is often included in trade in services. Because of the special characteristics of trade in services, both active and passive spillovers are possible. One can expect the benefits from technological diffusion occurring through trade in services to be significant. This is due to the fact that with person-to-person contacts it can be very difficult for the inventor to prevent knowledge spillovers from occurring (Keller 2004). The possibility for countries to benefit from spillovers occurring through service flows has been increasing during the 1990's with increasing trade in services. The annual export growth of commercial service was over 6 % per year during 1990-2000 (WTO 2000).

In section 2 we represent the theoretical framework of our paper. After introducing the models used in our regressions, we represent results in section 3. The following section 4 is for conclusions. In appendix 1 we represent data construction. Appendix 2 represents our data sources and appendix 3 the chosen countries according to their income status.

2 Theoretical Framework

As mentioned in the introduction section, technological change is the main factor behind economic growth in the long run. Technological change affects total factor productivity (TFP) which measures changes in output with respect to changes in inputs used in production. We use R&D stocks as a measure of technological change[4]. CH (1995) explain why cumulative R&D account for growth in TFP, and we follow here their argumentation. As discussed in appendix 1, TFP can be calculated using the following equation

$$\ln TFP = \ln Y - \alpha \ln K - (1 - \alpha) \ln L \tag{1}$$

[4] Also changes in educational expenditure play a role in our calculations.

The output of an economy can be given the following form

$$Y = K^{\alpha} D^{1-\alpha} \tag{2}$$

where K is the capital stock, and D a measure for linear homogenous function of employed intermediate inputs (goods or services) dependent on amount of labor L and a country's R&D efforts. D consists of a measure of available intermediate inputs (n) and the assortment of intermediate inputs(x). Intermediates are manufactured with a unit of labor per unit output ($L = nx$). All inputs are equally priced and equally employed in production. If inputs are horizontally differentiated it follows that $D = n^{\frac{1}{\sigma-1}} X$, where σ is the elasticity of substitution between inputs and $X = nx$ represents aggregate employment of inputs. σ is assumed to be larger than one; so the closer σ is to one the more comparability exists and new intermediates exist.

Inserting equation (2) into the TFP function, equation (1), leads to

$$\ln TFP = (1-\alpha) \ln(n^{\frac{1}{\sigma-1}})$$

where by definition $X/L = 1$. TFP is dependent on the amount of intermediate inputs n, which depends on the country's cumulative R&D efforts.

International trade can be included in the analysis. In a global world intermediate goods or services do not necessarily have to be discovered in the home country. Most of international trade in goods consists of trade in producer goods. As mentioned in the introduction section, trade in services has also increased in the 1990's. These trade flows can have remarkable effects on TFP in the importing country, because producer goods and services can increase the amount of intermediate inputs n. It follows that n depends not only on the cumulative R&D in the home country, but on the cumulative R&D in the world economy. Especially in developing countries foreign R&D flows can be the main sources of technological change. Trade of intermediate inputs can increase n and thereby increase productivity in the importing country. For empirical implementations we will still leave unanswered the question whether the productivity effects of domestic

and foreign R&D are the same and whether goods and services have same effects. We also note that our statements may suffer from causality problems.

As argued, changes in TFP can occur due to changes in domestic and foreign R&D stocks. The most referred equation (originally represented by CH (1995)) to explain TFP changes has the following form

$$\ln TFP_{c,t} = \alpha_c + \beta^d \ln R^d_{c,t} + \beta^f \ln R^f_{c,t} + \varepsilon_{c,t} \tag{3}$$

where we have $TFP_{c,t}$ of country c at time t, $R^d_{c,t}$ the domestic stock of R&D, $R^f_{c,t}$ the stock of foreign produced R&D, and $\epsilon_{c,t}$ an error term that is identically and independently distributed across countries and time.

Authors have been challenging the way foreign R&D stocks should be calculated. These papers criticize especially the use of weights given to domestic R&D stocks for the calculation of foreign R&D stocks (factor $a_{c,t}$ in appendix 1). Keller (1998) repeats the calculations of CH (1995) with counterfactual 'import' shares and not by actual import shares as in the original paper. He finds similar high coefficients and levels of explained variation when these counterfactual import shares are used.

The criticism of Keller (1998) leads us to study more carefully foreign R&D effects. Following the arguments of LOS (2001), the explanation for Keller's (1998) results is that his counterfactual import shares represent the total foreign R&D stocks. LOS (2001) also show that the total foreign R&D stocks can be the outcome of two kinds of sources: direct and indirect spillovers. This means that countries can gain directly from the trading partners' R&D stocks, but also indirectly from countries that the home country is in touch indirectly through its trading partners. They estimate the same equation as CH (1995), but they consider separately direct foreign R&D stock ($R^{df}_{c,t}$) effects and indirect flows $R^{if}_{c,t}$. The indirect foreign R&D flows are equal to $R^{if}_{c,t} = R^f_{c,t} - R^{df}_{c,t}$.

Another important criticism on the import shares of CH (1995) has been presented by LP (1998). They argument against the way direct spillovers are calculated in the

original paper. They conclude that what really matters are the R&D investment intensities in the foreign countries. They propose that the denominator of the weighting variable should be the foreign country's GDP instead of total imports of the home country used by CH (1995)[5].

In addition to taking into account the previous criticism, we introduce services into the original model of CH (1995). Instead of leaving goods out of examination, we also consider them. One interesting question is if TFP changes received from foreign service R&D stocks differ from goods R&D stocks. Another question is how large the effects of both stocks are. In CH (1995) good and service flows are assumed to have equal effects on TFP, and they do not take into account the possibility of spillover-effects through service flows[6]. As mentioned, we are going to use two approaches for studying spillovers. First, we consider only direct spillovers following LP (1998) when calculating foreign R&D stocks (appendix 1). This is done by following equation (3). In section 3.2 we also take the indirect effects into account. For this we use the following function

$$\begin{aligned} \ln TFP_{c,t} &= \alpha_c + \beta^d \ln R^d_{c,t} + \beta^{dg}_{c,t} \ln T^{dg}_{c,t} G^{df}_{c,t} + \beta^{ig}_{c,t} \ln T^{ig}_{c,t} G^{if}_{c,t} \\ &\quad + \beta^{ds}_{c,t} \ln T^{ds}_{c,t} S^{df}_{c,t} + \beta^{is}_{c,t} \ln T^{is}_{c,t} S^{if}_{c,t} + \epsilon_{c,t} \end{aligned} \tag{4}$$

which includes in addition to the domestic R&D stock $R^d_{c,t}$ the direct ($G^{df}_{c,t}$, $S^{df}_{c,t}$) and indirect ($G^{if}_{c,t}$, $S^{if}_{c,t}$) foreign R&D stocks received through trade in goods and services, and where $T_{c,t}$ is the share of imports to GDP of the importing country. We also include education $E_{c,t}$ into equations (3) and (4) in section 3 (appendix 1). This is done to study if countries with higher spending on post secondary education have been better able to gain from direct service spillovers. Following Coe, Helpman and Hoffmaister (1997) the regression coefficient included is $\beta^e_{c,t} E \ln S^{df}_{c,t}$. Another interesting object is to

[5] Also Henry, Kneller, and Milner (2002) follow these weighting schemes.

[6] This has been done most certain due to the fact that information on bilateral service flows has not been available, and that trade in services has been increasing first in the 1990's.

study if the regression coefficients differ between countries of different income groups. This will be studied in section 3.3 by introducing a dummy variable to separate income groups.

Data construction is available in appendix 1. Data sources can be received from appendix 2. The period to be considered is 1990-2000. Altogether 50 countries are taken into examination. 22 of them are high income countries, 20 middle-income countries, and 8 low-income countries (appendix 3). As explained in appendix 1, foreign goods and service R&D stocks are based on stocks of 16 high-income OECD countries. We allow time lags for two variables in our equation. One factor is education, in which case it can take several years for the investments to show results. It can also take time until the indirect service flows affect productivity in the spillover receiving country. By experimentation we find that 6 years for the education factor and two years for indirect service spillovers give the highest $R - squared\ adjusted$ figures. The results with time lags allowed are introduced in the following section.

3 Results

3.1 Direct technological diffusion

In table 1 we present the panel estimates of direct spillovers based on equation (3) in section 2, where we have followed the argumentation of LP (1998). We are interested in the fixed country effects, so we use within country estimation in all of our regressions performed (sections 3.1-3.3). In table 1 we include all 50 countries and our period of consideration is 1990-2000. We see from table 1 how the amount of domestic R&D (R), and the direct foreign goods and service R&D stocks (Gd, Sd) have affected TFP.

Multicollinearity exists between our variables. To get around this problem, we have assumed that the capability of a country to benefit from foreign spillovers depends on the domestic R&D stocks. To capture pure effects of foreign spillovers we have regressed first ($\ln G$) on ($\ln R$), and then ($\ln S$) on ($\ln R$). We then use the residuals as $\widehat{\varepsilon}_1 = \widehat{\ln G}$

and $\widehat{\varepsilon}_2 = \widehat{\ln S}$. This ensures orthogonality between domestic and foreign R&D stocks. However, we still face the problem of collinearity between the different foreign R&D stocks. Comparing equations (2) and (3) one explanation for the regression coefficient reduction of the term $\ln Gd$ is collinearity; still another explanation is that in equation (2) spillovers through goods try to explain also spillovers through services. The adjusted regression coefficient increases from 12% to 14% when we include services separately, which speaks for equation (3).

Studying first the domestic R&D stocks, the increase of R by 1% has increased TFP by 0,096%. The effect of a 1% increase in Gd has been 0,037% according to equation (3). In the case of Sd this effect has been very similar (0,036%). In equation (4) we have also included the education factor ($\ln ESd$). Our results show no significant effects of high investments into post secondary education[7]. There are several reasons why the adjusted $R - squared$ is only 14% at most. The main reason is that we have assumed that the domestic R&D stocks are equal to zero in low-income countries[8]. Another explanation is that all potential spillover flows between countries are not taken into account because of the lack of data. The third possible explanation is that we have not taken into account all variables that affect TFP. Still we can conclude that direct spillovers through trade in services contribute to TFP.

[7] If significant, the negative sign of the regression coefficient could be explained by the need for countries to give more resources for primary education (see definition for education, appendix 1).

[8] Coe, Helpman, and Hoffmaister (1997) also receive adjusted $R - squared$ figures below 20% when analyzing only developing countries. When performing our regressions for only high-income economies, we receive adjusted $R - squared$ figures over 50% that concur with the results of e.g. CH (1995).

lnTFP	[i]	[ii]	[iii]	[iv]
lnR	0,096	0,096	0,096	0,097
	(8.80)**	(9.13)**	(9.24)**	(9.20)**
lnGd		0,074	0,037	0,037
		(6.27)**	(2.42)*	(2.41)*
lnSd			0,036	0,04
			(3.67)**	(2.96)**
lnESd				-0,045
				-0,39
Constant	2,256	2,256	2,256	2,245
	(10.97)**	(11.39)**	(11.53)**	(11.35)**
Observations	550	550	550	550
Number of countries	50	50	50	50
R-squared	0,13	0,2	0,22	0,22
R-squared adj.	0,05	0,12	0,14	0,14
Absolute value of t statistics in parentheses				
* significant at 5%; ** significant at 1%				

Notes: Country and period dummies included in the table

Table 1: Direct spillover effects

3.2 Direct and indirect technological diffusion

Next we take also indirect spillover effects into account. We have the same countries as before, and we use the same period. The calculation of the direct and indirect foreign R&D spillovers is performed through equation (4) in section 2 by following LOS (2001). As explained in appendix 1, direct received foreign R&D stocks of goods and services are now calculated with a different approach than in section 3.1. In addition to capture pure effects of foreign spillovers as before, we also capture pure indirect trade -related R&D spillovers as represented by LOS (2001). We regress the indirect service R&D stock $\ln \mathrm{Si}$ on the direct stock $\ln Sd$ and use the residual as the 'indirect' trade-related R&D spillovers in the regression. The same operation is done for the goods.

The effects of changing the way foreign R&D stocks are calculated on the regression coefficients can be studied by comparing equations (1) and (2) in table 2 with equations (3) and (4) in table 1. The most striking difference is that direct goods R&D stocks lose

meaning in table 2. So according to these calculations, direct spillovers through goods have not affected TFP. Still indirect spillovers through goods are significant[9]. From equations (3) and (4) we see that a 1% increase in the indirect goods R&D stock (with a two year time lag) $Gi2$ increases TFP by over 0,54%. R and Sd show similar effects in table (2) to regression coefficients in table (1). Increasing R by 1% increases TFP in equations (1-4) by over 0,09%. Increasing Sd by 1% has an effect of 0,027%-0,037%[10]. We further conclude that foreign R&D received through indirect trade in services do not seem to have a significant effect on TFP. Adjusted $R-squared$ figures are again low; at highest it receives a value of 14%.

lnTFP	[i]	[ii]	[iii]	[iv]
lnR	0,096	0,096	0,095	0,093
	(8.96)**	(8.69)**	(7.12)**	(6.81)**
lnGd	0,002	0,002	0,009	0,009
	(0.11)	(0.1)	(0.44)	(0.41)
lnSd	0,029	0,027	0,037	0,028
	(3.80)**	(2.45)*	(3.20)**	(1.66)
lnESd		0,029		0,097
		(0.28)		(0.69)
lnGi2			0,542	0,547
			(5.81)**	(5.84)**
lnSi2			0,004	0,007
			(0.09)	(0.16)
Constant	2,256	2,268	2,273	2,31
	(11.17)**	(10.97)**	(9.02)**	(8.96)**
Observations	550	550	450	450
Number of countries	50	50	50	50
R-squared	0,17	0,17	0,24	0,24
R-squared adj.	0,08	0,08	0,14	0,14
Absolute value of t statistics in parentheses				
* significant at 5%; ** significant at 1%				

Notes: Country and period dummies included in the table

Table 2: Direct and indirect spillover effects

[9]The variable $\ln Gi2$ indicates indirect foreign R&D stock of goods with a time lag of two years. Also indirect R&D stocks of services ($\ln Si2$) were delayed by two years. This is done because indirect trade-related spillovers may take longer to affect TFP than direct ones. The decision of choosing a lag of two years is based on experimentation, and with two years we were able to find most significant regression coefficients.

[10]$\ln Sd$ is in equation (4) significant at 10%.

3.3 Effects within income groups

The countries we have included in our equations are heterogeneous. This raises the question of different effects of variables between different country groups on TFP. In table 3 we have separated high-income countries with a dummy variable hi[11]. The use of the dummy variable is based on the interest to study the effects on developed high-income economies and developing countries (low-income and middle-income economies) separately. In table 3 we have first taken equations (3) and (4) from table 1 and table 2, and enlarged them to contain the dummy variables (hi).

The most interesting question from our point of view is how the effects of foreign direct and indirect R&D service stocks change. As before, the indirect service R&D stocks seem to have no effect on TFP neither in developing or developed countries. Still there is again evidence that direct service spillovers affect TFP. In all other equations (than equation (1)), service R&D spillovers have a significant effect on TFP, even at the 1% level. In developed countries, there seems to be no significant additional effect on TFP through trade in services. Equation (4) implies that Sd could have had even a negative effect on high income economies. Still we conclude that this is probably due to the education factor that is eventually positive for the developed countries (but not significant at 5%).

All countries have gained from indirect goods spillovers from foreign goods R&D stocks, and there is no evidence that the spillover effects would have been different for developed countries. Still comparing the first and the latter two equations, there is a difference in the effects of direct foreign R&D flows. Our results indicate that developed countries would have gained from direct goods R&D stocks. Due to equation (2) giving resources to post secondary education in developing countries has diminished

[11] Considering all studied explaining variables in our previous equations, we have added dummy variables, denoted hi. This dummy variable hi is equal to 1 for the high-income economies, and equal to 0 for the remaining countries, considered as developing countries.

the possibilities to gain from spillovers through trade in services. Considering the domestic R&D stocks, we can conclude that domestic R&D investments have been more profitable for developed countries.

lnTFP	[i]	[ii]	[iii]	[iv]
lnR	0,061	0,061	0,06	0,058
	(4.61)**	(4.62)**	(3.28)**	(3.18)**
lnRhi	0,105	0,104	0,134	0,125
	(4.39)**	(4.24)**	(4.35)**	(3.91)**
lnGd	0,047	0,049	-0,007	-0,006
	(2.59)**	(2.70)**	(-0.31)	(-0.27)
lnGdhi	0,078	0,07	0,152	0,137
	(1.98)*	(1.69)	(2.91)**	(2.56)*
lnSd	0,021	0,042	0,037	0,05
	(1.74)	(2.83)**	(2.92)**	(2.54)*
lnSdhi	0,007	-0,028	-0,047	-0,103
	(0.31)	(-0.64)	(-1.55)	(2.08)*
lnESd		-0,329		-0,159
		(2.42)*		(-0.84)
lnEsdhi		0,445		0,487
		(1.41)		(1.47)
lnGi2			0,536	0,496
			(3.96)**	(3.44)**
lnGi2hi			-0,076	-0,006
			(-0.38)	(-0.03)
lnSi2			0,042	0,039
			(0.7)	(0.64)
lnSi2hi			-0,118	-0,097
			(-1.28)	(-1.03)
Constant	1,784	1,808	0,261	0,545
	(7.41)**	(7.35)**	(0.42)	(0.76)
Observations	550	550	450	450
Number of countries	50	50	50	50
R-squared	0,26	0,27	0,29	0,29
R-squared adj.	0,17	0,18	0,18	0,18
Absolute value of t statistics in parentheses				
* significant at 5%; ** significant at 1%				

Notes: Country and period dummies included in the table

Table 3: Spillover effects in developed and developing countries

4 Conclusions

In this paper we have studied the spillover effects through trade in services. This is done by following two approaches that are based on the original model by CH (1995). First we consider direct spillover effects only and then also take into account the possibility of indirect spillover effects. According to our knowledge, service flows have not been analyzed separately from goods in these kinds of models, but the data of bilateral service

flows allows us to do this. The critical assumption is that bilateral service shares have been close to the shares in 1997. The data consists of 50 countries from 3 income groups, and the observed years are 1990-2000.

Our results show that a 1% increase in the foreign service R&D stock has increased total factor productivity by 0,02%-0,05%[12]. The effects on total factor productivities in the developing countries have been at least as strong as in the developed world. We find no significant evidence of different spillover gains through trade in services for countries devoting resources into post-secondary education. Furthermore, indirect service spillovers have no significant effect on TFP. Domestic R&D investments contribute to TFP. Especially in the developed countries the effects are high, being over 0,16%. The evidence of the benefits of direct spillovers through goods is complex. We can only conclude that developed countries have likely benefited from direct spillovers through goods. The effects of indirect spillovers through goods are high and significant for both developed and developing countries.

[12]The causality of the results remains unclear.

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5 Appendixes

5.1 Appendix 1: Data construction

Total factor productivity (TFP) TFP was defined for each of the 50 countries as

$$TFP_{c,t} = \frac{Y_{c,t}}{K_{c,t}^{\alpha_c} L_{c,t}^{(1-\alpha_c)}} \tag{5}$$

where Y is GDP in constant 1995 \$, K is the total stock of capital, and L is the total amount of labor. All of these variables were defined for each country c for each year t. The coefficient α_c is defined as the share of capital income in GDP. The $\alpha-$coefficients were constructed by using the labor income share $(1 - \alpha_c)$ calculations of Harrison (2002). For most countries in this paper estimates of α_c were available up until the year 1995, and for some countries up until 1997. We used averages of these available years to represent the share of capital income in GDP for the whole examined period (1990-2000). For some low-income economies estimates of α were not available for the 1990's. For these countries we used Harrison's (2002) calculations of income categorized country averages of the years 1993-1996.

From figure 1 we can get an insight of TFP growth development in five different countries, representing our three different income groups. As expected, TFP growth has been relatively highest in China. It is followed by Uganda and Argentina due to a high growth rate in the beginning of the 1990's. In the USA the growth rate has been relative smooth, and in Japan close to zero during the examined period. From table 4 we see that the highest average growth rates have taken place in the high- and low-income economies in 1996-2000. Within the same period, middle-income economies have realized a fall in TFP. Between 1990-2000 TFP growth has been the highest in low-income economies (1,3%) followed closely by the high-income economies (0,94%).

Capital and domestic R&D stock The capital and the domestic R&D stocks were generated using the perpetual inventory method. The stock values were calculated

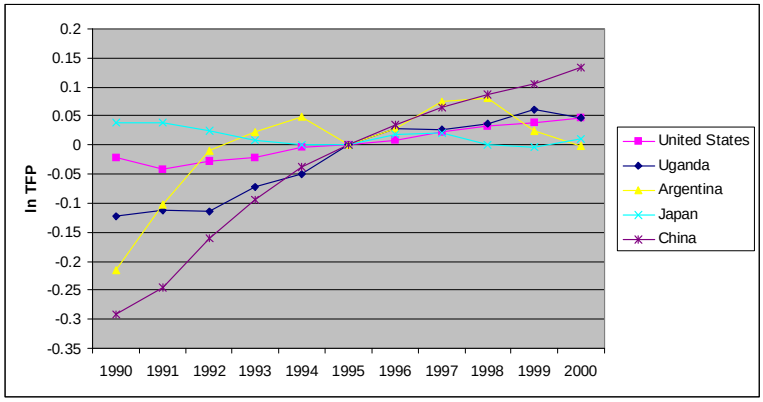

Figure 1: Total factor productivities

using the first available observations. For missing values of R&D investments, data was extrapolated forward / backwards for missing years by assuming that the R&D growth rate was the same in these missing years as on average in the studied period. If R&D data was available for the following and preceding years of the missing value, their average was used.

WDI (2003) gross fixed capital formation values were used for the capital stock calculations. The first observations were from the year 1960 for most of the high-income economies, and for some of the middle-income economies. The depreciation rate of the capital and the R&D stock was set equal to 10 per cent (Henry, Kneller, Milner 2003). The following equations were used

$$K_{c,t} = (1-\delta)K_{c,t-1} + KI_{c,t-1}$$

$$K_{c,0} = \frac{KI_{c,0}}{(g^K + \delta)}$$

where $K_{c,t}$ is the capital stock, δ the depreciation rate, $KI_{c,t-1}$ is the gross fixed capital investment, and g^K is the annual average growth rate of the investments. c is country index and t time index.

The total domestic R&D stocks ($R_{c,t}$, including both investments in manufacturing

and service sectors) were calculated as the capital stock values. The domestic R&D stocks were calculated by using research and development indicators from WDI (2003). The following equations were used

$$R_{c,t} = (1 - \delta)R_{c,t-1} + RI_{c,t-1}$$

$$R_{c,0} = \frac{RIc_{,0}}{(g^{RD} + \delta)}$$

where $R_{c,t}$ is the domestic R&D stock, δ the depreciation rate (10 %, Henry, Kneller, Milner 2003), $RI_{c,t-1}$ the R&D investment, and g^{RD} the annual average growth rate of the R&D investments. The R&D stocks of all low-income economies, except India, Indonesia, Philippines and Sri Lanka from the group of middle-income economies, were assumed to be zero[13]. Considering all high- and middle income economies, average growth rates of R&D spending were similar in these country groups. In table 4 we see that the growth rate was over 5 % for both groups in the examined period. The growth rates increased on average more in the first period. Our example countries do not show these kinds of differences between country groups. From figure 2 we observe that relative growth rates of domestic R&D spending were much higher in China and Argentina than in the USA and Japan. Still China can be considered as an exception in the group of middle-income economies.

The foreign R&D stocks In the theoretical framework section we introduced two approaches for calculating foreign R&D stocks. Now we explain in more detail the construction of the foreign goods and service R&D stocks, when indirect flows are taken into account and when not. First of all, the sources of spillovers through trade in goods and services are only 16 OECD countries[14]. The foreign R&D stocks were constructed

[13] Actually the R&D stocks of these countries were given a value of one, so we were able to take the logarithm of these values.

[14] The domestic business enterprise expenditure on R&D were available for 16 OECD countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Spain, United Kingdom, and the United States. Considering the target countries,

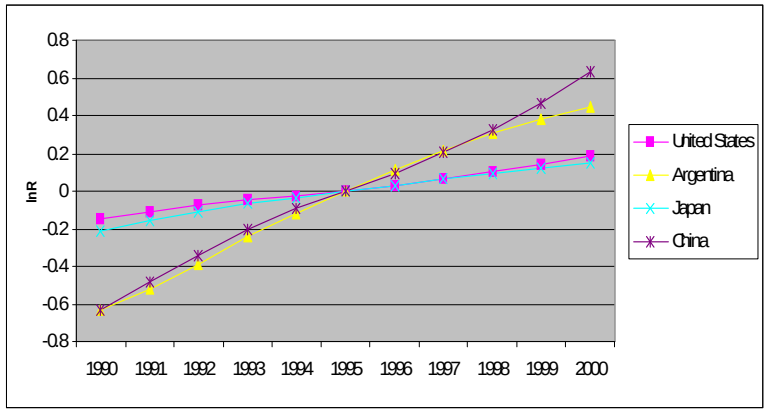

Figure 2: Domestic R&D stocks

by using SourceOECD data on business enterprise expenditure on R&D performed in goods and service industries. For construction we used the same assumptions as when defining domestic "total" R&D stocks. We followed the traditional way of building up the direct foreign goods and service R&D stocks (Keller 2001, Mohnen 2001).

$$FR_{f,t} = \Sigma a_{c,t} R_{c,t}$$

The traditional way to measure the foreign R&D stock ($FR_{f,t}$) is to sum up weighted "domestic" R&D stocks ($R_{c,t}$). There has been a great deal of discussion about the way these foreign R&D stocks should be constructed. First is the question of which stocks should be used to study the spillover effects from one country to another. As mentioned, in this paper we use stocks of both goods and services because of our interest to study spillovers occurring through both of the trade factors. Another subject is what weights should be given to these stocks. In subsection 3.1, when discussing only direct service flows, $a_{c,t}$ is defined as the share of imports to GDP of the exporting country[15]. LP

imports from these countries contain on average 47% of manufactures imports, and 66% of services imports.

[15] Bilateral manufactures and commercial service import shares were assumed to be constant during the 1990's. It is assumed that the share of imports country A received from country B is the same in 1990 and in 2000. The reason for this assumption is the lack of data. Our data source for the bilateral

(1998) propose that the denominator of the weighting variable should be the GDP of the exporting country rather than total import flows or the GDP of the importing country

$$FR_{f,c} = \sum \frac{MM_{cf}}{Y_{c,t}} R_{c,t}$$

where $FR_{f,t}$ is the foreign (importing country) R&D service stock, MM_{cf} the bilateral service flows, $Y_{c,t}$ the domestic (exporting country) GDPs, and $R_{c,t}$ the domestic service R&D stocks. LOS (2001), calculate direct service R&D flows in a similar way to LP with the difference that the denominator is the spillover receiving country's GDP (Y_d) instead of the country of origin (whereby they follow CH (1995))[16]. Indirect spillovers are calculated as the difference of total foreign R&D spending and direct spillovers. As proved by LOS (2001), total foreign service R&D stocks can be shown to be a simple sum of the R&D stocks in the country of origin. The indirect stocks are defined by LOS (2001) as

$$FR_{c,t} = \sum R_{c,t} - \sum \frac{MM_{cf}}{Y_{f,t}} R_{c,t}$$

The above explained formulation can be applied to goods (G) and services (S) separately. Considering the direct foreign R&D stocks, and following LP (1998), the growth rate of the foreign R&D stocks can be seen in table 4. The most obvious (but not surprising) result when comparing goods with services is that foreign service R&D stocks have been increasing much more rapidly than the foreign R&D stocks of goods. The average growth rates of foreign service R&D stocks were between 1990-2000 in high- and low income economies 11%, and in middle-income economies 15%. The average growth rates of foreign goods R&D stocks were below 3% in high- and low-income economies, and 9% in middle income economies. Both the foreign service and goods

import flows is Global trade analysis project 2001 (GTAP).

[16]LOS (2001) follow CP (1993) and define $a_{c,t}$ as the share of imports from the "technology exporting" country to total imports. Still we follow the approach where they multiply these $a_{c,t}$ weights with a factor of total imports to GDP of the technology receiving country (Factor $T_{c,t}$ in section 2 equation (4)).

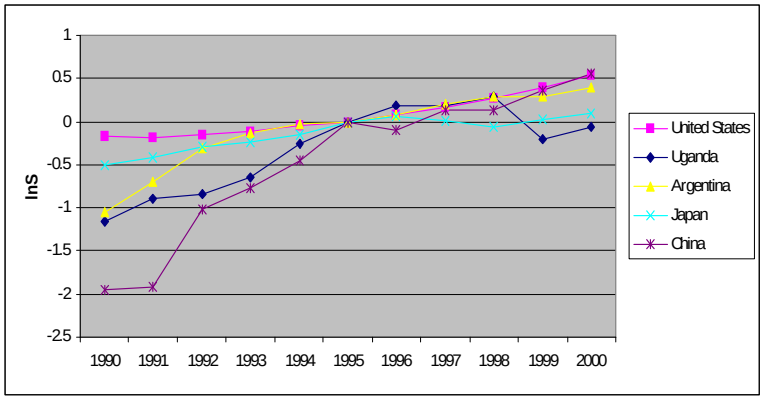

Figure 3: Foreign service R&D stocks

R&D stocks increased especially in the first period of the 1990's.

From figures 3 and 4 we can study the growth rates of the two different stocks in five countries. In the USA and Japan the growth rates of both the goods and services R&D stocks have been relative modest. Especially in Japan the foreign good R&D stock fell during the 1990's. The foreign service R&D stocks have been increasing relatively fastest in China. Also the foreign goods R&D stock has been increasing fast in China. Argentina has had fast growth rates in both stocks even the growth of foreign goods R&D stocks has been fluctuating quite strongly. The growth rates of foreign R&D stocks in Uganda were high in the first period of the 1990's.

Education The education factor is measured for all countries as the share of students getting post-secondary education to the total amount of students. One could assume that the highest level of education has the most significant effect on TFP at least in the high-income economies, so having a high standard of education could have a positive effect on productivity. Our data source for the education factors (Barro and Lee dataset) contains only data between five year periods. We use simple linear interpolation for generating figures for the missing years. We have a six year time lag for the education factor. The education factor is used to study if investments in education have affected

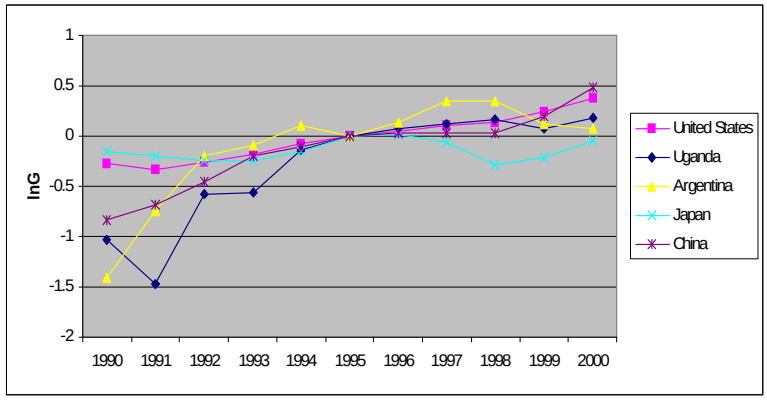

Figure 4: Foreign goods R&D stocks

the country's gains from service spillovers.

From table 4 we can study the average growth rates of the education factor in different income groups. In high-income economies the growth rate of the education factor has been higher in the second period of the 1990's. In the middle- and low-income economies, growth of investments into post-secondary education has been relatively lower. On average the growth rates in the different income groups have been 4%[17]. The growth rates of the post secondary educational investments of our five economies can be studied from figure 5. In countries with the highest relative amount of post-secondary education, USA and Japan, the growth of this education factor has also been growing relatively rapidly in the 1990's. Also Argentina has shown improvements in this factor. In China the factor has been increasing only slightly, and in Uganda there has been hardly any growth.

[17]For the Czech Republic and Slovak Republic we miss the education factors for the years 1984-1989.

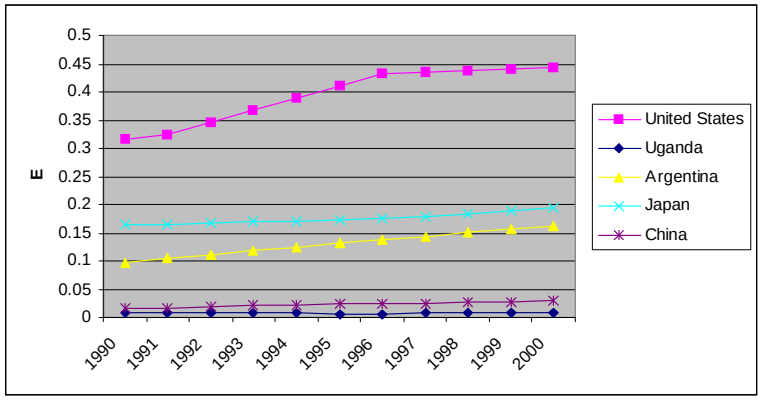

Figure 5: Post secondary educational investments

TFP	HI	MI	LI
1990-1995	0.004628	0.005219	0.005825
1996-2000	0.014108	-0.001410	0.019877
1990-2000	0.009368	0.001904	0.012851
R			
1990-1995	0.057348	0.064282	
1996-2000	0.055058	0.043637	
1990-2000	0.056203	0.053959	
G			
1990-1995	0.032798	0.142592	0.043533
1996-2000	0.010012	0.033068	0.012981
1990-2000	0.021405	0.087830	0.028257
S			
1990-1995	0.122097	0.212574	0.142299
1996-2000	0.089739	0.080167	0.073038
1990-2000	0.105918	0.146371	0.107669
E			
1990-1995	0.024868	0.044903	0.056841
1996-2000	0.048130	0.028755	0.016317
1990-2000	0.036499	0.036829	0.036579

Table 4: Average growth rates (%) of different variables in different income-groups.

5.2 Appendix 2: Data sources

World development indicators 2003 (WDI):

- GDP, (constant 1995 $)
- Capital stock; gross fixed capital formation (constant 1995 US$)
- Labor force
- Stock of domestic technical knowledge; Research and development indicators (% GDP)

Global trade analysis project 2001 (GTAP): GTAP Data Base Version 5

- Bilateral goods and commercial service imports, for the year 1997

International trade statistics 2000 & 2002, WTO

- World imports of goods and commercial services by selected economy

Barro & Lee dataset, NBER

- Human capital, Share of post-secondary educated of all educated in the group of population aged 15 and over

SourceOECD, Science and Technology Statistics, OECD

- Business Enterprise Expenditure on R&D (BERD) as a percentage of GDP
- Percentage of BERD performed in good and service industries

Network on science and technology indicators (RICYT)

- Stock of domestic technical knowledge; Research and development indicators for Latin-American countries (% GDP)

Harrison Ann E., Has Globalization Eroded Labor's share? Some Cross-Country Evidence

- The share of labor income in GDP

5.3 Appendix 3: Chosen countries[18]

High-income economies (23)

Australia	Greece	Singapore
Austria	Ireland	Spain
Belgium	Italy	Sweden
Canada	Japan	Switzerland
Denmark	Korea, Rep.	United Kingdom
Finland	Netherlands	United States
France	New Zealand	
Germany	Portugal	

Middle-income economies (20)

Argentina	Indonesia	Slovak Republic
Brazil	Malaysia	Sri Lanka
Chile	Mexico	Thailand
China	Peru	Turkey
Colombia	Philippines	Uruguay
Czech Republic	Poland	Venezuela, RB
Hungary	Romania	

Low-income economies (8)

Bangladesh	Malawi	Uganda
Botswana	Mozambique	Zimbabwe
India	Tanzania	

Table 5: Country groups by income (according to the World Bank Country Group-classification)

[18] Countries were chosen according to the availability of data in all variables. Data on domestic R&D and education spending make an exception. Domestic R&D spending is not available for Czech Republic, Indonesia, Philippines, Sri Lanka, and all low-income economies except India. Education spending is missing for 1984-1989 for Czech Republic, and Slovak Republic. The unavailable data is considered as missing data, and neither domestic R&D spending in low-income economies is considered to be zero.

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