Is car sharing a sustainable strategy?

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1. SYNOPSIS

Based on an integrated modelling approach, the economic, social, and environmental effects of an increase in car sharing in Germany are analysed.

2. ABSTRACT

In the sense of a comprehensive understanding of sustainability, the economic and social ramifications of car sharing are analysed in addition to its environmental consequences in an innovative way. An integrated input-output model is developed and applied to assess the impact of an increase in car sharing to 10 % of the licence holders in Germany until 2020 on pollution, production, sectoral changes, employment, job qualification, working conditions, and regional industrial concentration. The modelling approach complies with the idea of a life-cycle assessment, since indirect effects from inter-sectoral production relations are also taken into account.

The scenario results indicate that increased car sharing leads to small production gains since the reductions in the losing sectors such as car producers, garages, oil processing, or insurance services, are more than compensated by the production increases in the winning sectors such as car sharing services or public transportation. Since labour intensity is higher in the winning sectors than in the losing sectors, car sharing also leads to higher employment. In addition, increased car sharing tends to require average job qualifications but more flexible working times. It further results in a regionally more evenly distributed industry structure, but some regions face considerable pressure for adjustment. The shift in the modal split in favour of public transportation results in emission reductions for most, but not all pollutants.

Finally, insights from political economy theory suggest that measures to foster car sharing may not easily be attainable.

3. INTRODUCTION

Since the UNCED conference in Rio, *sustainable development* has emerged as a prime objective for policy making in industrialised nations. In a pragmatic interpretation, the rather abstract term 'sustainability' identifies environmental pollution and consumption of resources as limiting factors for sustainability, but simultaneously interprets the economic and social aspects of a sustainable, ecologically compatible development as additional requirements for economic and social acceptability. Usually, analyses of environmental conservation strategies such as end-of-pipe technologies, environmentally friendly production processes, intensifying product use (service use instead of ownership), recycling, or environmentally friendly products, focus on the ecological effect of these strategies. In contrast to the comprehensive meaning of sustainable development, the social and economic dimensions of sustainability are often neglected.

In this paper, we examine economic, social, and environmental effects of car sharing, which is among the most intensively discussed examples for intensifying product use. In addition, since car sharing is characterised by the expansion of car-sharing organisations, shifts resulting from the transition from new production of a durable good to service-like activities can also be explored.[1] In Germany, the transport sector is of particular importance, from an economic, a social, and an environmental point of view. On the production side, in the late 1990ies about 800,000 people were directly employed in the construction of vehicles (Statistisches _undesamt 2000), and another 537,000 in the trade sector (VDA 1999). Likewise, the construction of vehicles by itself accounts for about 3 % of GNP (Statistisches Bundesamt 2000). On the consumption side, since 1960 energy use in the transport sector has more than tripled and consumption levels are not expected to decrease (Prognos/ewi 1999). In 1997, the transport sector accounted for about 28 % of final energy consumption, with passenger cars accounting for about 80 % of final energy consumption in the transport sector (Wagner 2000). The environmental consequences are significant: road transport alone causes about 52 % of CO-emissions, almost half the NO_x-emissions and 20 % of CO_2-emissions in Germany. Thus, increasing car sharing for passenger transport may be a very effective measure to reduce environmental damages and congestion.

Car sharing means that several users share one vehicle. These users are members of a car-sharing club or company, which is responsible for the entire organisation including booking, co-ordination, purchasing, maintenance etc. In addition to a refundable entry deposit, and a small monthly service charge, users pay user charges for hours of use and for kilometres driven. Car sharing reduces the fixed costs of owning a vehicle (insurance, depreciation, taxes) to the individual user. Thus, car sharing is particularly cost effective for people with a low annual amount of kilometres driven, since for these people fixed costs are high relative to variable costs (fuel, repair, wear). Additional benefits accrue, since car-sharing members do not need a parking space, and may choose models to satisfy their varying transportation needs. Car-sharing organisations started in the US in the 1960ies, and the first car-sharing organisation in Germany was founded in 1988 in Berlin (Petersen 1995). Although by now, there are car-sharing organisations in every big city in Germany, it is still a niche market, and the potential is far from being realised. By the end of 1999, there were only about 35.000 car-sharing users in Germany, compared to 38.000 in Switzerland, although the potential market in Germany is ten times larger than in Switzerland. Besides economic reasons resulting from the amount of annual kilometres driven, barriers include transaction and hassle costs, that people may prefer immediate access to a vehicle, but also psycho-sociological reasons such as prestige, utility derived from ownership, or a lack of social acceptance of car sharing (Prettentahler and Steininger 1999). Apparently, Swiss car-sharing organisations were more successful than German companies in overcoming some of these barriers. Unlike in Germany, in Switzerland, car-sharing organisations have integrated years ago and are now organised as a single professional service provider, with a single marketing strategy, and a single customer platform. Also, Mobility has long been co-operating with other mobility providers such as the Swiss rail company and car rental companies, and charges lower entry fees than most German car-sharing organisations (Muheim 1998, Frick *et al.* 2000). Whether car sharing reduces private vehicle mileage depends on the relative strength of two effects. On the one hand, some users will reduce their mileage since, before becoming members of a car-sharing organisation they had access to a car either because they owned one, or because they could use the car of family members or friends. On the other hand, users who did not have access to a car prior to membership, will increase their mileage. The analyses of Baum and Pesch (1994) and Petersen (1995) suggest that the net effect is a significant mileage and fuel reduction between 42 % and 50 %. Fuel use accounts for approximately 60 % of the total life cycle energy consumption of about 637 GJ for an average passenger car (Ebersperger *et al.* 1998). The remaining 40 % stem from production, infrastructure and disposal. Over time, car sharing will not only result in reduced car production due to a lower annual vehicle mileage for users, but also because the higher use (and maintenance) intensity leads to an increase in total lifetime mileage for car-sharing vehicles. Additional fuel savings result from the above average fuel efficiency of these cars.

To assess the impact of car sharing not only on the environment, but - in the sense of an integral understanding of sustainability - also on socio-economic variables like production, sectoral changes, employment, job qualification, working conditions, and regional industrial concentration, an integrated input-output model is developed and applied. The modelling approach and key assumptions are presented in chapter 4. Results are shown in chapter 5, and chapter 6 summarises the main results, offers conclusions and provides some insights from political economy theory to assess the attainability of measures to foster car sharing.

4. MODELLING APPROACH AND KEY ASSUMPTIONS

Modelling approach

In combining top-down and bottom-up approaches, a medium level of aggregation has been chosen to analyse the impacts of an increase in car sharing (*meso level*). On the top-down side, an input-output model is used, which allows direct and indirect effects to be analysed on a branch or sector level, and to take diverse structural effects into account. On the bottom-up side, important input data for the model were gathered from expert interviews, additional literature sources, and statistical data bases. Contrasted s*cenario analyses* were carried out, since the aim of the study was not to predict the future, but rather to provide an empirical basis for decision making. Two scenarios were defined, a *reference scenario* and a *sustainability scenario*. The year 2020 was chosen as a reference point. To analyse these differences between the scenarios, the integrated model ISIS (Integrated Mesoeconomic Simulation System for Sustainability Assessment) was developed and applied, which permits in an innovative way a model-based, integrated analysis of the impacts of environmental conservation strategies on production, structural change, jobs, qualification structure, working conditions, regional structure and the environment. More specifically, the model consists of the following building blocks[2]:

- The *input-output model* is based on the most recent input-output table for Germany for 1995, in which the economy is divided into 58 production sectors and 6 final demand sectors. The table incorporates the economic transactions between the production sectors, and between the production and the demand sectors. Thus, not only direct effects are taken into account, but also the indirect effects resulting from the inter-sectoral economic relations. Also, estimated technological progress resulting in productivity changes until 2020 is incorporated in the model. The input-output model is used to explore the sectoral differences in production between the reference scenario and the sustainability scenario. The model results form the basis for subsequent analyses.
- In the *module for quantitative employment effects*, employment coefficients are used to calculate sector-specific differences in employment between the reference scenario and the sustainability scenario.[3]
- In the *module for qualitative employment effects*, the results from the input-output model are linked with data from the German micro census survey from 1996 to explore the impact of increased car-sharing on qualification requirements, job characteristics, and working hours.
- In the *module for regional effects*, the results from the input-output model are linked with data from the German employment agency. This data set includes the sectoral distribution of employees for each of the 181 labour office districts. Based on this module, differences between the reference scenario and the sustainability scenario on regional concentration of the industry sectors can be analysed. In addition districts, which benefit and lose from an increase in car sharing, can be identified.
- In the *module for environmental effects*, emission coefficients are used to calculate differences between the reference scenario and the sustainability scenario on primary energy consumption, the most important greenhouse gases, and air pollutants. Since indirect effects from inter-sectoral production relations are also taken into account, the modelling approach complies with the idea of a *life-cycle assessment (LCA)*. Furthermore, emission data for those processes responsible for the most important emissions are based on additional detailed analyses. Thus, in combining both the augmented input-output analysis and the LCA-type technology analysis, the advantages of both approaches are utilised (Duchin and Steenge 1999).

To adequately explore the impact of increased car sharing, it was necessary to create new input-output sectors called car-sharing organisations and public transport. The appropriate data on inputs, labour and emission characteristics for these new sectors was derived from expert interviews, literature, statistical sources, and emission models. To derive the economic effects in the input-output model demand impulses resulting from differences between the sustainability and the reference scenarios had to be quantified (i.e., less spending for own cars, more spending for car-sharing and public transport sectors). Then the net effects resulting from these positive and negative demand impulses could be calculated in the model. Expected increases in labour productivity up to the year 2020 were also taken into account.

Key assumptions

For both the reference scenario and the sustainability scenario, a set of economic, behavioural, demographic and technical assumptions has to be made. Following Prognos/ewi (1999), the number of private households is expected to increase from around 37 Mio. to over 39 Mio. The number of total passenger cars is expected to rise to 48 Mio., the majority of which, 43,5 Mio., belongs to private households, which will drive a total of 1,140 Bn. kilometres. In the reference scenario, 2.5 % of those owning a drivers licence are assumed to be members of car-sharing organisations. This share is supposed to increase in the sustainability scenario to 10 %. Measures to achieve this high share include improved public transportation, reserved parking spaces in cities, shopping centres, train stations, higher organisational efficiency and professionalism of car-sharing organisations, social acceptance, prestige, co-operation among car-sharing organisations, compatibility of booking systems, and co-operation with other public transport companies. Likewise, landlords could be exempted from the legal requirement to provide parking spaces in case the tenant is a member of a car-sharing organisation. On average, 20 users are assumed to share one car. Of the new car-sharing users in the reference scenario, 70 % are assumed to substitute car sharing for their own car, while 30 % did not own a car previously. While car sharing reduces kilometres driven in cars, total mobility is allowed to remain constant. That is, 95 % of the difference is satisfied through public transportation, and 5 % through biking and walking. The assumed occupation rate of a car is 1.6, and the assumed lifetime of a car-sharing car is 5 years. Following Prognos/ewi (1999) average fuel consumption of a car is supposed to decrease from 8.9 l/100 km in 1995 to 6.2 l/100 km in 2020. Since car-sharing organisations tend to use smaller and more efficient cars than average, the fuel consumption of a car-sharing car in 2020 is set at 5.2 l/100 km. Private demand for cars will be lower in the sustainability scenario compared to the reference scenario, but demand of car-sharing organisations will be higher. Reduced car sales are priced at the average factory price for a car produced in Germany, which is _ 14,620 (VDA 1997). The mark-up of retailers is estimated to be 20 % of the factory price. Demand for new cars by the car-sharing organisations was derived via depreciation. Car-sharing members not only save costs for purchasing, but also for keeping and maintenance like insurance, taxes etc. Data on these costs were gathered from consumer surveys (StBA 1998). Additional savings accrue from lower fuel costs. To close the model, it is assumed that any additional cost savings for new car-sharing members in the sustainability scenario are spent on general consumption.

For modelling the new input-output sector titled car-sharing organisations, it is assumed that by 2020, profitability, labour costs shares, profit shares, and depreciation of this sector resemble those of professional rental car companies. Data on other inputs like insurance, services, or maintenance could primarily be determined from interviews conducted with car-sharing organisations and from additional statistical data for operating costs of vehicles. A combination of the existing railroad and urban transport sectors was used to model the new public transport sector.

These assumptions result in the following differences between the reference scenario and the sustainability scenario:

Table 1. Major differences between the reference scenario and the sustainability scenario

	Difference
Increase in car-sharing users (Mio.)	3.26
Decrease in stock of private passenger cars (Mio.)	2.12
Increase in cars owned by car-sharing organisations (Mio.)	0.16
Reduction in kilometres driven by cars (Mio. km)	10,954
Increase in passenger kilometres by public transportation (Mio. passenger-km)	16,651
Demand for cars (Mio. _)	-2,062
Car keeping (Mio. _)	-1,671
Gasoline consumption (Mio. _)	-518
Car-Sharing-Dienstleister (Mio. _)	2,084
Public transport (Mio. _)	1,822
Sum (w/o sales taxes) (Mio. _)	-345
Net sales taxes[4] (Mio. _)	-8
Sum (Mio. _)	-353
Final demand compensation (Mio. _)	353

5. RESULTS

Starting with the results from the input-output model, production and quantitative employment effects of an increase in car sharing to 10 % of drivers' licence holders in the sustainability scenario versus the reference scenario are presented. Based on these findings, qualitative employment effects, regional effects, and environmental effects are subsequently presented.

Production and quantitative employment effects

An increase in car sharing to 10 % of drivers' licence holders results in a *modest increase in domestic production* of _ 750 Mio. and a net employment gain of 15,850 jobs. As can be seen from Figure 1 and Figure 2, there are significant differences between the various sectors.

Figure 1. Production effects from an increase in car sharing in 2020 (difference between reference and sustainability scenario)

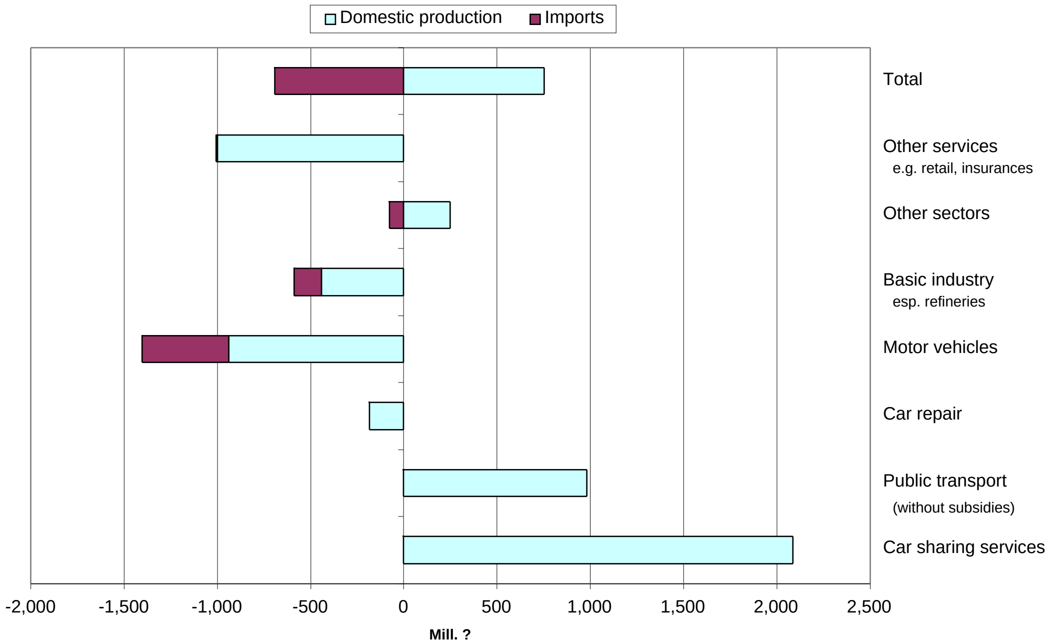
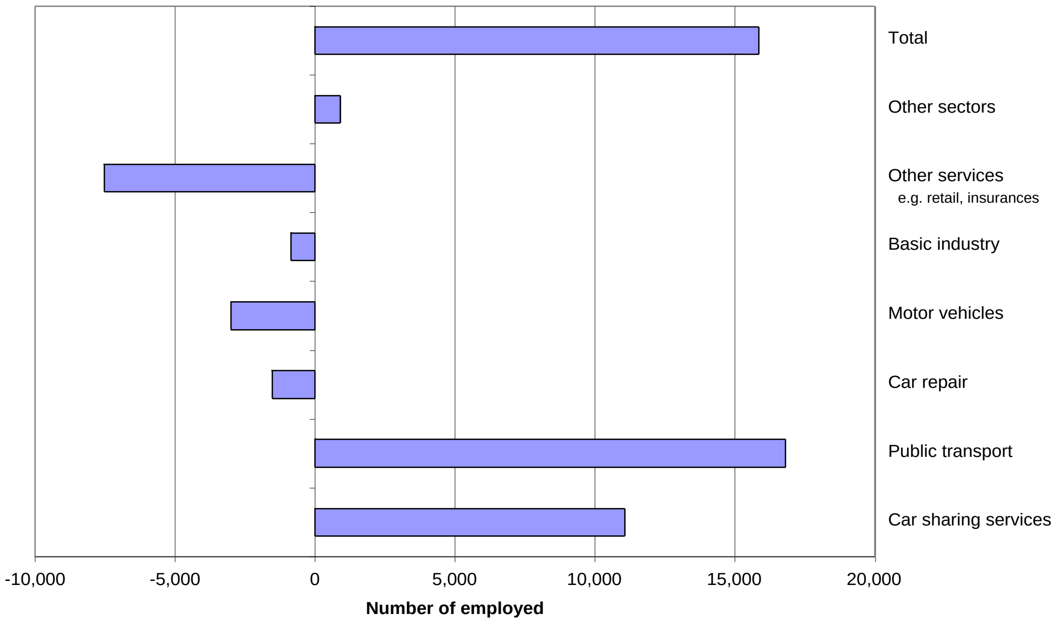


Figure 2. Net employment effects due to increased car sharing (difference between reference and sustainability scenario

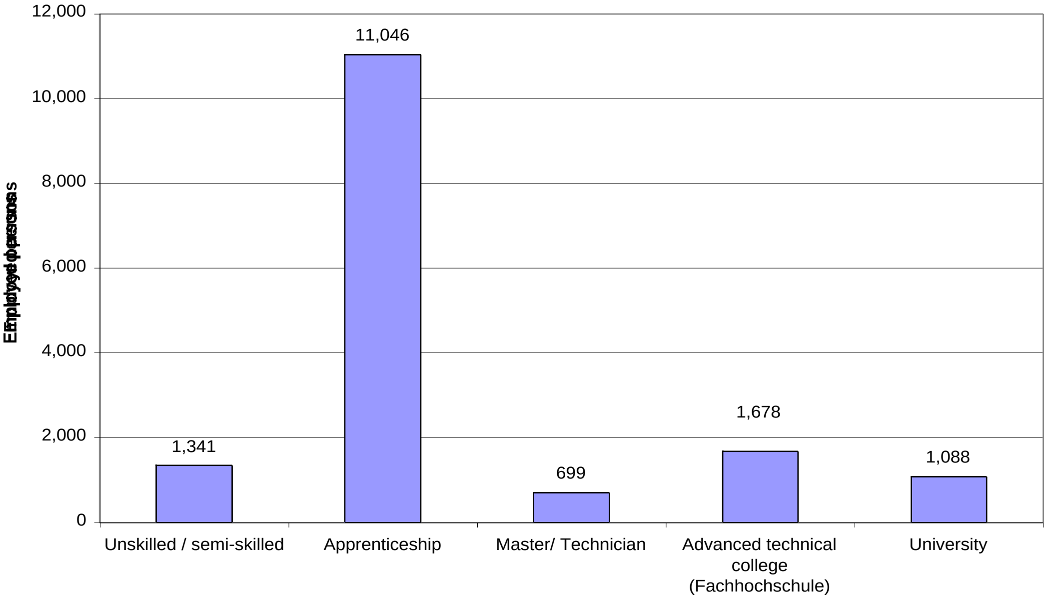


The biggest production losses occur in the production of cars, processing of mineral oil, and in the services sector, i. e. car insurance. But these losses are more than compensated for through increased production in the car-sharing sector, public transportation, and the net of the other sectors. Since the gaining sectors are generally more labour intensive than the losing sectors, *positive employment effects result.*

Qualitative employment effects

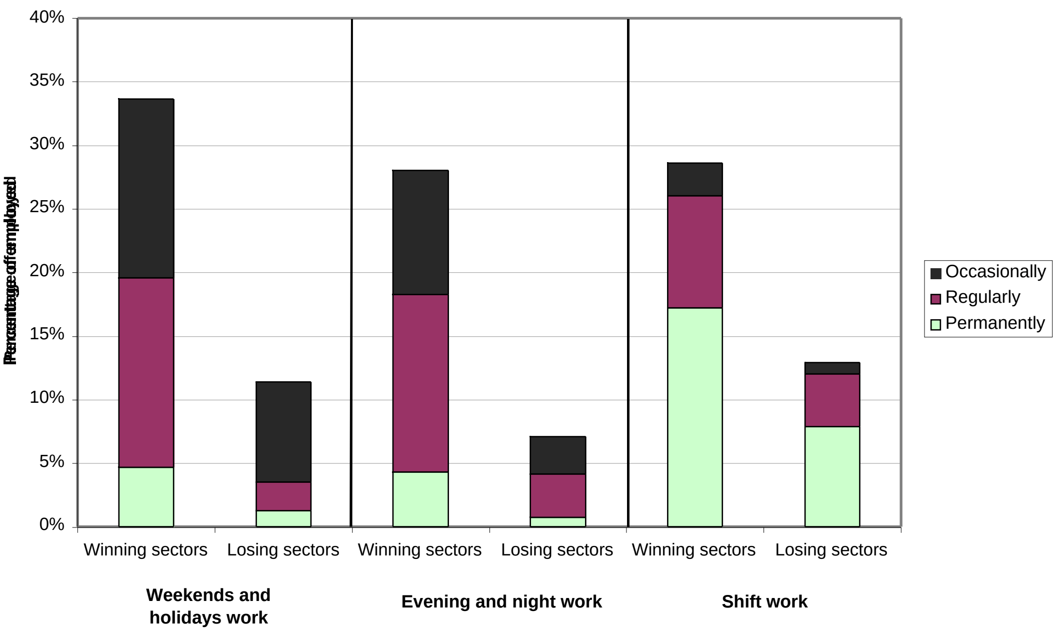
The net impact of car sharing on *job qualification* is displayed in Figure 3. About 78 % of the additional jobs require a rather low level of education (apprenticeship, vocational school, or less), while about 18 % require a higher education degree. Given that the average numbers for Germany are 75 % and 15 %, the increase in car sharing does neither require job qualifications that are significantly below or above average qualification level.

Figure 3. Net effects of an increase in car sharing in 2020 on job qualification levels (difference between reference and sustainability scenario)



The analyses of working conditions show that the additional jobs are primarily permanent full time jobs, and, as can be seen from Figure 4, weekend, night and shift work all increase. More flexible working times result in particular from the increase in employment in the public transport sector and generally correspond to the average flexibility across all sectors.

Figure 4. Net effects of an increase in car sharing in 2020 on the distribution of weekend, night and shift work in the winning and losing sectors (differences between reference scenario and sustainability scenario)



Regional effects

To assess the regional impacts of increased car sharing, it was examined whether the overall effects produced are evenly distributed across the individual regions or whether individual sub-regions can be identified which are particularly - positively or negatively - affected by the sustainability strategies. It was examined what impacts each environmental conservation strategy has on the regional concentration of industrial branches in Germany. Herfindahl-Hirschman indices were calculated as a measure of the regional concentration of the individual industries across the 181 local Labour Office districts and aggregated to an economy-wide indicator. Comparing these aggregate indices for the reference scenario and the sustainability implies, that an *increase in car sharing reduces regional concentration.* That is, that there is a tendency for the jobs created (in car sharing and public transport) to be relatively evenly distributed across the individual local Labour Office districts, whereas job losses (in automobile production and car insurance companies) are more regionally concentrated. Although, the impact on regional concentration is not very significant overall, some individual districts with a high share of employees in automobile production will be severely negatively affected.

Environmental effects

As pointed out earlier, due to the completeness of the model and the consideration of all the intermediate inputs necessary to meet the final demand, the environmental pollution identified complies with the idea of a life-cycle assessment on an aggregated branch level. Simultaneously, this ensures that the same basic assumptions are used for the assessment of environmental effects as for the economic and social analyses above. The changes in environmental pollution resulting in the sustainability scenario compared with the reference scenario for an increase in car sharing appear in Table 2.

Table 2. Environmental impacts of an increase in car sharing (difference between reference and sustainability scenario)

Environmental indicator	Unit	Difference
Energy consumption	PJ	-14.7
CO_2	Kt	- 991
SO_2	Kt	0.1
NO_x	Kt	1.4
NMVOC	Kt	-1.8
Waste water (excl. cooling water)	Mill. m_	-0.5
Disposal of hazardous waste	Kt	-3.7

Thus, the shift in the modal split from cars to public transport reduces energy consumption, and emissions from combustion burning, that is CO_2, NMVOC and CO[5]. But emissions associated with electricity production (for trams, subways), operating trains (SO_2 and dust), or those generated in input sectors, like coal mining (CH_4) increase. But on aggregate, *significant environmental benefits result*, in particular if the high weight attributed to global or irreversible environmental damages caused by the various pollutants and discharges is taken into account (Walz *et al.* 1996).

6. SUMMARY AND CONCLUSIONS

The economic and social ramifications of car sharing are analysed in addition to its environmental consequences in an innovative way. An integrated input-output model is developed and applied to assess the impact of an increase in car sharing to 10 % of the licence holders in Germany until 2020 on pollution, production, sectoral changes, employment, job qualification, working conditions, and regional industrial concentration. The modelling approach complies with the idea of a life-cycle assessment, since indirect effects from intersectional production relations are also taken into account. The scenario results indicate that increased car sharing leads to modest production gains, and, since labour intensity tends to be higher in the winning sectors than in the losing sectors, also to modest employment gains. Although increased car sharing is of little effect at the macroeconomic level, considerable structural changes result at the sectoral level. Production and employment are shifting primarily from automobile production, garages, oil processing or automobile-insurance services to car sharing services and public transportation. Further, increased car sharing tends to require about average job qualifications but more flexible working times. It also results in a regionally more evenly distributed industry structure, but regions with a high share of automobile production face considerable pressure for adjustment. The shift in the modal split in favour of public transportation leads to environmental benefits. Emissions of NO_x, SO_2, dust, and CH_4 increase slightly, but these are more than compensated for by the reductions of CO_2, NMVOC and CO emissions.

The results highlight the need for an integrated policy approach, where measures to foster car sharing are coordinated with industrial, regional and educational policy. Such policies may include increased public financial support for public passenger transportation (net infrastructure and operating business), low-interest credits for start-up car-sharing companies, urban planning authorities could (be forced to) exempt housing developers from requirement to provide sufficient parking spaces if tenants are members of car-sharing organisations, or train stations and municipalities could (be forced to) provide parking space for car-sharing vehicles. Regional policy should aim at alleviating the pressures on regions affected negatively by structural change, and educational policy should account for the required job qualifications. Further, the car sharing sector is likely to benefit from the continuation of the ecological tax reform in Germany, which taxes energy consumption and uses the revenues to lower labour costs, since this sector operates relatively labour intensive. While the modelling results indicate that car sharing will lead to modest employment gains and environmental benefits, the structural change required may trigger political opposition from those sectors, which expect to lose from policies to foster car sharing. The attainability of policy measures may be analysed using insights from political economy theory. Political economy theory suggests that policies are not the outcome of benevolent decision-makers but rather the result of political processes, where self-interested politicians, governments, bureaucrats, organised industry groups, or voters may be involved (Stigler 1971, Becker 1983, Buchanan and Tullock 1975, Peltzman 1976). More recently, ideas from political economy have also been applied to environmental policy making (Rauscher 1997, Fredriksson 1997, Schleich 1999, Schleich and Orden 2000, Walz 2000c). According to the political economy literature, industries organise themselves to lobby governments for political support. The better they manage to solve the free-rider problem of organisation, the more powerful these lobby groups are. Industries are more likely to overcome the transaction costs of organisation and lobbying, if they consist of only a few but highly concentrated and homogeneous firms (Olson 1985). Likewise, lobbies are more likely to gain government support, if the costs of the government interventions are borne by many (taxpayers), while the benefits accrue to only a few. In this case per capita payments are small and per-capita or per-company benefits are large. Also, since politicians strive to get elected, they are more likely to favour those industry sectors with many employees as potential voters. To assess the attainability of measures to foster car sharing in a political economy context, the winning and losing sectors were identified based on the model result given in chapter 5, section "Production and quantitative employment effects". For these sectors, characteristics representing the "political power" were analysed and compared. The results indicate that the losing sectors (automobile producers, oil processing industry, car insurance sector) tend to be politically more powerful than the winning sectors (car sharing organisations, public transport). First, the losing sectors are likely to lobby more efficiently than the winning sectors since they are more highly concentrated (as measured by the market share of the six largest companies in each sector) and tend to consist of fewer firms. Second, the winning sectors may offer more votes in terms of employees. Thus, *political economy theory suggest that measures to foster car sharing may not be easily attainable*.

7. LITERATURE

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8. END NOTES

[1] The paper draws primarily on the results of a recently completed research project for the German Environmental Protection Agency „Umweltbundesamt“ (Walz et al. 2000a, b).

[2] For a detailed description of the model see Walz et al. (2000a)

[3] The model implicitly assumes that underemployment is the rule and that newly created positions can be filled without delay.

[4] Sales taxes are irrelevant for the input-output modelling, but not for calculating final demand compensation.

[5] The high increase in NOx-emissions, which is somewhat surprising, can be explained by the assumed high reduction in NOx-emissions per passenger kilometre by 2020 for cars (82 %) relative to public transport (67 %). The data for cars and public transport are taken from Gohlisch (2000). Assuming higher utilisation rates in the public transport sector could reverse this result.