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Policy Paper no 30

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February 2016

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 290647.

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THEME SSH.2011.1.2-1

Socio-economic Sciences and Humanities Europe moving towards a new path of economic growth and social development - Collaborative project

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Making ambitious green goals compatible with economic dynamics by a strategic approach

Karl Aiginger[1]

One of the overarching goals of the project WWWforEurope is to develop a strategy which makes very ambitious green goals compatible with a dynamic, open society. An ambitious sustainability strategy is necessitated since we are approaching the absolute boundaries of the planet quickly. A dynamic, open society is warranted since it enables individuals and countries to follow different life styles and preferences, to learn and to enjoy new technologies and services, so that capabilities[2] and choices are increasing, social progress is enhanced and, differences in skills, income and wealth are narrowing[3].

Today a trade-off exists between ambitious green goals and output maximization (and output growth)[4]. This trade-off is less evident if we use the perspective of welfare and utility (which are enhanced by sustainability). The trade off is mitigated ever more evident if we broaden the macro- and microeconomic goals (from GDP as overarching measure of performance to life expectancy, happiness, human development or "Beyond GDP" in general[5]), or if we leave the economic paradigm and understand welfare as the sum of "functionalities" or needs (nutrition, mobility, housing, health) which we can achieved by a large variety of organisational and social setups. The trade-off furthermore tends to dissolve for a longer time horizon[6].

It is a defining result of this project that it is possible – but a very demanding task- to mitigate the trade-off between green goals and dynamics or even transform it into a synergy. It has to be done by a strategy developing synergies with the policy to solve social goals. We should be

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[1] Thanks to Miklos Antal, Kurt Bayer, Klaus Friesenbichler, Jürgen Janger, Claudia Kettner, Angela Köppl, Marina Fischer- Kowalski, Tomasz Kozluk,, Stefan Schleicher, Margit Schratzenstaller, Gunther Tichy, Teresa Weiss, Ina Meyer for reading and valuable suggestions.

[2] The term capabilities was introduced by *Sen* (1985, 1993, 2001), people should be provided the capability to solve their problems and ambitions (see *Kettner et al.*, 2014). The capability approach views living as a combination of various things and beings. Quality of life should be assessed as capabilities to achieve valuable functionings (*Sen*, 1993) where functionings are achievements of a person i.e. actual doings and beings …like being well nourished, healthy socially integrated and respected. A personal capability is denoted as freedom to live the type of life she has reason to value....depending on personal characteristics and the social and political environment. Sen provides no list of capabilities, but Nussbaum 2008 lists ten central capabilities life, bodily health, bodily integrity, senses, imagination and thought, emotions, practical reason, affiliation, other species, play, control over one´s environment.

[3] Cohesion and poverty reduction demand today that incomes are rising at least for persons and regions far away from the top (given that the rich ones do not accept large absolute decreases in income and wealth).

[4] The trade-off can be shown be the following numbers. If there is zero growth (of GDP) then energy intensity must be reduces by 67% (3% per year) if global warming should be limited to 2 degrees (IPPC 450 ppm goal). If economic growth is 1.5%, this requirement rises to 82% (4.5% per annum), Van den Berg et al 2015

[5] For an overview on new indicator set on economic performance and reasons why they are not commonly used e.g. in macroeconomic models, see *Kettner et al.* (2014).

[6] It is mitigated for lower “time discounts”, i.e. the more individuals and society care for the long and very long run (in which income decreases will reduce the marginal utility of income and resource constraints will become ever more important).

aware of reform resistance and the fact that significant changes always produce winners and losers. Several elements and measures of such a strategy are not yet developed and most of them are neither high on the agenda of policymakers or voters, nor supported by the current price system, an existing regulation, institutions and societal norms.

Starting point: a strong trade-off …

The conventional view of mainstream economics is that a conflict (trade-off) exists between ambitious green goals on the one side[7] and output maximization and economic growth on the other side. It works via increasing costs leading to lower output in the conventional economic model.

Costs of at least one input increases by (i) private abatement and compliance costs (at least for add-on technologies), (ii) subsidies and government expenditures for repairing given damages, and (iii) regulation limiting individual choices. Firms have to produce at a less efficient/profitable point[8] on the production function, this reduces production and GDP[9].

… weakened by welfare considerations

This trade-off is very present in current policy documents and statements by politicians and media. But even within the current economic paradigm the trade-off can be questioned.

First the conflict is smaller or may not even exist if welfare is used as the benchmark of economic dynamics (not GDP). If ecological goals are part of the welfare function, green policy may reduce incomes but not welfare.[10]

Secondly, green policy measures limited to "internalizing" external costs (e.g. taxing firms which had emitted before without the cost being incurred) are increasing welfare anyway (even if output decreases). A trade-off between production and greening arises only, if the policy goals are much more ambitious than internalizing external costs (which has to be the case in a strategy calling for a socio economic transition.

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7 Green goals include reduction of emissions and waste, limiting climate change and loss of diversity, preventing depletion of resources.

8 This of course rests on an understanding of abatement as add on technologies and thus additional costs.

9 There is more than one trade of if we look at the consumer and producer decisions in detail. Firms may not be allowed to use some technology at all (specific resources like mercury or genetic food), consumers may be forbidden some consumption goods (smoking specific stuffs or at specific places).

10 We acknowledge that the choice of welfare as benchmark, does not solve all goals, since within welfare income and ecological sustainability can be given different weights. For several alternatives to GDP as measuring welfare, their merits and shortcomings see *van den Bergh - Antal* (2014).

Shifting the weights within the economic paradigm

Ecological economics - still by and large within the economic paradigm - stresses factors which make an ambitious policy (well beyond internalizing external costs) rational at least because of three facts:

- Sunk cost: existing technologies have sunk costs, which gives them a cost advantage, preventing the switch to cleaner technologies or non-exhaustible inputs at the optimal point of time (from the view of the society).
- Uncertainty and precaution: since there is a lot of uncertainty (about resources but also the impact of emissions), a rational policy should incorporate the precautionary motive. Fewer resources should be used since overuse is more costly than underuse.
- Irreversibility: some changes will from a given point of time become irreversible (extinction of species, exhaustion of resources, climate change).

While ecological economics deals with a situation in which the use of a multitude of resources is possible and many substitution possibilities are available, in this project – driven by the overwhelming evidence of climate change - we need a strategy which respects the absolute boundaries of the planet (global warming, water strategy, bio diversity), acknowledging that a general overuse of resources and not only overuse of a specific resource has to be prevented, and overuse might not be evaluated by antropogen criteria only.

We start from the knowledge that the current state of the affairs is that mankind is on an unsustainable path, and fundamental changes have to be implemented quickly (*IPPC*, 2014), if climate change, the exhaustion of some non-substitutable resources (like water) or biodiversity losses should be prevented. Interventions far above the level of internalizing external costs are necessary. We propose a shift in the perspective which extends the economic paradigm (even beyond ecological economics), and delineate a strategy shifting the trade off into a synergy.

Towards a paradigmatic shift

A new paradigm does not exist yet, even if there are definitely signs of a paradigm shift (see *Geels*, 2013 *and Fischer-Kowalski - Wiedenhofer*, 2014 (for transitions to new systems). But the following elements might be crucial for the transition of a new paradigm fostering social ecological transition:

- Indicator of performance: from GDP and economic growth to beyond GDP
- From optimization under nearly indefinite variety of resources (and prices reflecting relative scarcity) to absolute boundaries of the planet and non-substitutable resources
- From utility dependent on relative income and consumption (status goods and perspective) to utility depending on own income, aspirations, preferences (developed independently of other's preferences)

- From welfare as a function of goals (income, employment, health) to wellbeing as a sum of functionings[11] like nutrition, housing, mobility, knowledge, culture
- From an economic paradigm based on flows to a bimodal approach focusing on stocks and flows (which together provide the means to serve the "services" desired)
- From the importance of owning goods to the ability to use them

The hope for a white knight

Whenever there is a shift to a new paradigm, we do not know its speed and scope. And there are elements we cannot adequately assess. For example there is also the possibility that specific disruptive new technologies might be around the corner[12] which could lead to a significant reduction of material inputs, waste and emissions, like additive manufacturing (3D printing), new materials (advanced polymers) and processes (bio refineries). These technologies will radically impact on the size of firms and (re)regionalization and use of material, it might lower transport costs, consumption of material and energy. If this perspective is correct the main policy strategy for sustainability is to support the (i) development and diffusion of technologies and (ii) to abolish the current outdated infrastructure (in housing, traffic, plants, cities, business models).[13]

In general it is important to use all instruments (prices, emission trading, regulation, public programs) and to foster specifically research in resource and energy saving technologies (directed technology policy; see *Veugelers*, 2014, *Vogel – Kratena - Hranyai* forthcoming). Currently labour productivity increases stronger than energy productivity and only a share of one fifth of innovation projects is directed at reducing material use despite of the fact that the share of materials in costs is as high as the share of labour (*Fischer-Kowalski - Wiedenhofer*, 2014).

New disruptive technologies which reduce the use of fossil fuels dramatically and which have much higher energy and resource efficiency will be implemented faster in dynamic open economies. The strong involvement of government in research and motivation should support the dissemination beyond national borders that some new technologies might not support sustainability if the price system does not give guidance. In general technical progress can be

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[11] Functionings are achievements of a person i.e actual doings and beings …like being well nourished, healthy socially integrated and respected (*Sen*, 1993), see *Köppl et al.* (2014).

[12] *Rifkin* (2014), *Köppl – Schleicher* (2014A, 2014B), *Köppl et al.* (2014). *See however that disruptive new technologies might go in different directions (and can be used for different purposes conflicting with green goals (like enabling the exploration of fossil resources – oil, coal etc; chemical weapons, drones, genetically modified food). It is a difficult question to which extent governments have to allow new technologies to develop as to allow their biggest potential and to direct the process in the direction needed for sustainability.*

Europe in general is not leader in disruptive technologies but usually a follower. Maybe the discussion of the direction in which a disruptive technology should be used is easier I this phase of the strategy and the direction could be made a competitive advantage of Europe

[13] For a more sceptic view on directed change see *Friesenbichler* (2013).

part of the solution, if it fosters energy and resource productivity, and if new technologies use less material and energy, but changes in goals and behaviour and policy will be important too.

Back to today's facts

But currently emissions are increasing worldwide, accompanied by growth of the world economy at a historically high speed (while Europe is stagnating at the pre crisis output level).

Empirical evidence for a trade-off between dynamics and green goals are the numerous[14]:

- Rare (absolute) decoupling evidence from growth for energy; strong rebound effects due to efficiency gains, low prices of energy and increasing incomes (*van den Berg,* 2011).
- Absolute decoupling of material use of industrialized countries since 1970 (but no strong decrease if imported material is included)[15]
- Several econometric models[16] predict reduced growth due to environmental measures

On the political level reform resistance and coordination problems exist:

- Massive interventions of firms and trade organizations against ambitious goals
- Unpopularity of green strategies with voters (opposition to increasing gasoline prices)
- Opposition to "green growth" (calling it a chimera) by environmental minded groups
- Unsolved coordination problems between countries, and specifically between industrialized and emerging countries; conflicts who should curb emissions to which extent and when

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[14] Dynamics as well as green goals are defined in the wwwforeurope vision (*Aiginger et al.*, 2014) and specified in a tentative list of goals. Europe wants to become "a role model for a dynamic, open economic area with internal and ecological sustainability and positive spillovers to neighbours and the world at large".

Dynamics include that a broad set of economic and social values is reached for more and more people and that economic choices are widening. Average incomes are growing slowly, faster in countries and regions with lower per capita income and for individuals with lower incomes. Those wanting to be employed are in general in work, specifically with incentives to be mobile, flexible and open for retraining.

Green goals or sustainability implies that the limits of the planet are respected; absolute emissions are significantly reduced, stronger than needed from an individual European perspective as to allow other countries to have more scope and lower costs. Europe has a legacy of having emitted a higher cumulative level of emissions in the past.

[15] See *Fischer-Kowalski – Wiedenhofer* (2014) and *Weizsäcker – Ayres* (2013).

[16] *Kratena – Sommer* (2014) show that in a dynamic Keynesian general equilibrium model (with equilibria in the long run but not in the short run) a "classical green tax reform" which taxes production emissions and returns receipts by lowering social contribution, GDP decreases in the short run and long run however by a very small amount, while employment increases at least in the short run. The emission reductions resulting from taxing CO2 in Europe are large (absolute decoupling), but leakages to countries with lower standards and costs occur. In a model in which consumption is taxed and receipts returned by lowering social contributions (called green devaluation by the authors), employment is increasing strongly and continuously and GDP increases. Leakage is prevented since production costs do not raise, but the reduction of emissions is lower.

In general in econometric models the impact of ambitious green policies on growth and even more on welfare depend on the specific definition of the "green instrument" (taxes, emission prices) and the use of its revenues. Some models show trade-offs between green instruments and growth and employment, other win-win strategies, again other different results for the short and long run.

Of course this evidence is provided with the background of low resource prices, inefficient or lacking emission taxing and in an environment with low priority and lacking public discussion on long run goals (in schools and media). Regulation and laws are currently far from using their potential to foster sustainability and to direct change in technology. And econometric model exist in which investment in sustainability foster growth and employment.

Elements of a strategy (and measures) to mitigate the trade-off

A strategy has to be consistent (in development and application), tough on goals but open for methods, flexible for surprises and readjustment along the given course. It has to mobilize public transport and to be aware of back lashes, leakage and rebounds.

Consistency

1. Go for strong, consistence and predictable policy signals. Set long-run targets, consistent, well-argued and scientifically founded, discussed with broad majority of political spectrum and NGO's aiming at a consensus
2. Look for an internationally commitment for a given course with different speeds according to economic situation and starting position; prevent cycles in policy (and prices)
3. Make sustainability a cross cutting issue, targeted in all sub policies (incl. industrial policy, regional policy, agricultural policy, education) not only the task of specialists, a minister or general director for environment
4. Go for systemic solutions, not punctual interventions (from batteries, to car size and use, grids, last mile, reversed charging)
5. Redirect technological progress from the current priority of labour saving to priority of resource efficiency[17].

Tough on goals but open for methods

6. Raise standards and regulation early and ambitiously (efficiency standards for housing and offices, efficient spatial planning, carbon free heating); forbid use of fossils for heating in flats and offices (like in Denmark),
7. Set broad quantitative long-run targets not measures how to achieve goals, use taxes and regulation to monitor them, on national and international level
8. Use a combination of instruments: innovation, regulation, taxes; commit to the use command and control, if targets are not reached.

[17] See *Fischer-Kowalski* (2011) for the finding that material costs are equal to labour costs, but promotion on efficiency gains focus primarily on the latter (see *Vogel et al.,* 2015 for "biasing" technology progress).

Overcome reform resistance of business community, consumers, voters

9. Compensate (or overcompensate) environmental taxes by reduction of other taxes (by reducing red tape if necessary)
10. Compensate additional regulation needed for green policy by reducing administrative burdens in other sectors and red tape, by public sector reforms
11. (Over) compensate green policy related costs for manufacturing by making innovation and training cheaper and more efficient; specifically close deficit of Europe vs. US in R&D, top universities, entrepreneurship
12. Reduce distorting subsidies and interventions: eliminate all subsidies for fossil energy, also unconditional subsidies (per square meter, not connected to regional or ecological goals) in the agricultural sector ; cut subsidies specifically in period of low oil prices as to prevent the investment into new plant, building, cars, heating using the outdated technology (making latter change much more expensive)
13. Discuss strategy with business in order to get information, to learn how to foster technological change which disruptive technologies are around the corner, but aware that the firms have to increase profits (Rodrik, 2009).

Initiate decentralized efforts and public support

14. Make sustainability a priority in research and education, a life principle, a community value, in investments of pension funds
15. Combine green ambitions with social inclusiveness (lower income spread, better and more equal early education, eliminate inheritance of education and life chances; thus increasing growth and competitiveness according to WWWforEurope definition[18]
16. Be aware that with lower growth in industrialized countries and wider income dispersion the relation of inherited wealth to life time income increases
17. Develop a strategy for sharing/renting instead of buying; make overproduction, overuse, idle capacities a "no go",
18. Support and encourage local initiatives looking for new models, with emphasis on reuse, repair, recycling and organisations to foster sustainability[19]

Prevent carbon leakage and rebound effects

19. Shift incentives (subsidies and taxes) as well as regulation from production to consumption[20]; specifically make use of green devaluation (taxing carbon emissions in

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[18] *Aiginger - Bärenthaler-Sieber - Vogel* (2013).

[19] See *Kaphengst – Velten* (2014) for the role of rural cooperatives.

consumption instead of production and using the tax receipts for lowering taxes on labour); but be careful that this does not lead to trade wars

20. Make clear that resource prices will rise definitely stronger than other prices[21], if not by market forces than by increasing taxes consistently; prevent rebound effects by regulation

[20] See the model of green devaluation (*Kratena – Sommer*, 2014) for the merit of taxing consumption and its shortcoming.

[21] See *Fischer-Kowalski – Wiedenhofer* (2014) that prices of materials should be increased always by productivity gain of last year.

Summary

Putting the trade-off into a new perspective

It is naïve to deny a potential trade-off between an ambitious green policy and economic dynamics under a static economic perspective (maximizing profits and GDP growth). Any market intervention (specifically those beyond internalizing external costs) switches input prices, narrows down choices and shifts production away from "optimum". The trade-off is somewhat lower if we (i) switch from output maximization to the perspective of welfare (as combination of goals), if we define welfare as a set of functionalities (needs like nutrition, housing, mobility), or if (ii) innovation is "directed" to reducing resource use (instead of increasing labour productivity) ex ante or if we switch to a dynamic perspective with changing preferences, behaviour, regulation, innovation and new technologies.

But a trade-off exists, and can be demonstrated by policy documents or lobbying efforts, in voter's opposition to taxes on emissions and new standards. Interventions to promote ecological sustainability needs more regulation, changes in prices and taxes, redirecting technological chance. These interventions have to be well communicated and systemic, additional burdens and regulation should to be compensated by changes which mobilize entrepreneurship, commitment and personal choices, by reducing red tape and other restrictions.

A strategy has to be developed

It is one of the defining characteristic of this project to mitigate the trade-off between dynamics and ecological sustainability or even to transform it into a synergy by a strategy, in specific a strategy which takes into account also social goals, conflicting interests and reform resistance**.**

A global, consistent, systemic strategy will prove difficult, but it is necessary and feasible, given the importance of the sustainability goals, path dependency, irreversibility phenomena and the absolute limits of the planet. The uncertainty about the effects of climate change and loss of biodiversity advises to adhere to the precautionary principle of moving rather fast. The large differences in incomes and preferences call for some flexibility in operation, but compatible with a shared long run commitment.

Pillars of such a strategy are (i) consistency (based on long run targets and directed technological change), (iii) toughness on goals but openness for methods and differences in preferences, (iv) communication with stakeholders and lowering the burden of change. The strategy should be coordinated with the strategy to attain social objectives be aware of leakage, rebound and lobbying efforts. Since it is not only necessary to define a strategy but also to make it operational and to stick to it, it is essential to look for support by the public, consumers, institutions and business with a strong role of experts, technology and education.

Difference in methods and speed

Climate change(and other environmental issues) as well as economic dynamics are global problems. Given the starting position the regional strategies, preferences and opportunities will be different but some consensus on a common path is needed. Given the technological opportunities, it is necessary that high income and frontier technology countries take the lead in developing new sustainable technologies, independent of the fact how small or large their current contribution to emissions is or which share they contribute to the growth of emissions. The dissemination of clean technologies has to be fostered and leakages to locations with lower standards should be prevented by international agreements and programs. However, the start of new technologies and its first learning phase will be in industrialized countries (in parallel to higher wages, prohibition of child labour and social norms in the past which all developed in countries even if poverty or child labour was already lower here.

It is important to realize that such a strategy for turning the trade off into a synergy has to be developed under a great uncertainty about technology, policy measures and their effectiveness. Feasibility and speed of changes in the behaviour of consumers and firms are uncertain, and government failures are as likely as market failures.

Parallels to the "social question"

The optimism that a synergy can be developed out of a trade-off, draws support from the fact that in the past it was possible to dissolve the trade-off between social ambitions on the one hand and productivity (and growth) by "welfare regimes". The costs of social inclusion in the European Welfare State did not prevent dynamics of countries and well defined competitiveness in the past; an activating social policy and good institutions are seen as growth enhancing and promoting "high road competitiveness" today (see *Hemerijck,* 2014; *Giddens*, 2006; *Aiginger - Bärenthaler-Sieber - Vogel*, 2014). A complicating problem in the case of sustainability is that in this case absolute boundaries exist which have to be taken into consideration.

Postscripts on urgency and on the long run

Some conclusions seem to be less controversial than others. Firstly, eliminating subsidies for fossil energy and preventing the overuse of commons and resources (water) should be implemented without delay (specifically in a period of extremely low oil prices); this reduction of subsidies has multiple dividends, reducing path dependency and lock in position, lowering starting cost for new technologies, reducing public deficits and debt; however we know that each subsidy will be adamantly defended by its clientele and some might have to be compensated for low income earners by tax credits or reductions.

Secondly, the infrastructure (housing, transport, electricity grids) Europe will build in the next decade will decide about the long chances to limit climate change. Thirdly the relation of the issue addressed here (making sustainability compatible with dynamics) should not be considered as isolated from other issues specifically to make the societies more inclusive, reducing poverty and striving for an open society.

And finally, a strategy that makes dynamics compatible with ecological sustainability is important as well for societies catching up and striving for growing incomes, as well as for regions and groups with decreasing marginal utility of incomes. All countries but specifically those with high per-capita income and low income growth should go for welfare goals rather directly using broader indicator systems and paying lower attention to GDP growth[22].

And it is crucial to distinguish between the medium run (10 to 20 years) and the long run (2050 and beyond) strategies. In the medium run growth is necessary to reduce unemployment, to finance the welfare and pension systems, to reduce poverty, to provide capabilities and choices, and even to enable investment in new technologies and renewable resources). In the long run the dependence of employment, capabilities and welfare on growth should be decreased.

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Appendix 1: A strategy of limiting carbon leakage

If ambitious green standards are set in one country, leading to higher production costs, this may involve the relocation of production into a country with lower standards. In the worst case this leads to lower production in the ambitious country and higher emission worldwide, a phenomenon called "carbon leakage" though it can refer to the variety of emissions.

Carbon leakage can be prevented (reduced) by the following measures:

- Raising international standards simultaneously or at least step by step (with difference across countries regarding starting situation (GDP per head, past emissions). Standards could be different according to development (GDP/capacity) but with dynamic predetermined steps of narrowing differences
- Shifting regulation from production to consumption
- Making it obligatory for multinational firms to provide comparable statistics about emissions in different plants (in all annual reports)
- Making it obligatory to use best technology used in one plant of a firm in all plants (maybe after some period); make carbon leakage a subject in international investment agreements (TIIP), green investment strategies
- Going for technological change in which innovation reduce the use of energy and material, but also improves capital and labour productivity and higher quality products

In general most empirical studies[23] show that carbon leakage is empirically limited to energy intensive industries. These are specifically difficult to relocate in the short run, and in the long run investment decision are dependent not on production costs in the narrow sense, but on the availability of natural resources, the dynamics of long run demand (long term growth of "the market") and transport facilities (ports, railroads).

From the global welfare point of view higher standards in rich countries are needed to boost the speed of innovation at all production sites. As a parallel to the labour input, rich countries have absolutely higher wages, but these are compensated by higher labour productivity. Countries with higher energy prices empirically have higher energy productivity (see Europe and spec Switzerland relative to US)[24].

[23] *Cooper and Dröge* (2011).

[24] *Zachmann* (2012).

Appendix 2: The Porter Hypothesis on Environmental Regulation & Innovation

Claudia Kettner

A traditional argument against environmental regulation is the associated costs and the resulting loss of international competitiveness. In 1991, Porter challenged the assumption of this inherent trade-off between economic growth and environmental concerns stating that "Strict environmental regulations do not inevitably hinder competitive advantage against foreign rivals; indeed, they often enhance it" (*Porter*, 1991, p. 168). Strict, well-designed regulation incentivises innovation and thus contributes to improving the competitiveness of firms. This synergetic perspective of environmental regulation and economic performance has become known as the "Porter hypothesis".

Based on anecdotic evidence, *Porter and van der Linde* (1995a) stipulate that environmental regulation can be beneficial for economic performance as it

1. serves as a signal for technological improvements,
2. increases corporate awareness that might deliver benefits (if focused on gathering information),
3. creates investment security for environmental investments, and
4. incentivises innovation.

According to *Porter and van der Linde* (1995a, 1995b) environmental regulation does not only induce innovation that reduces the cost of compliance with environmental standards, but it can also deliver "innovation offsets", environmental benefits AND improvements of the product and/or the production process, that offset the cost of the regulation. In some cases the innovation offsets might even overcompensate the costs. Innovation can, however, not "always completely offset the cost of compliance, especially in the short term before learning can reduce the cost of innovation based solutions" (*Porter and van der Linde*, 1995a, p. 100).

In the literature, three different types of the Porter hypothesis are differentiated[25]:

- the "narrow" version of the Porter hypothesis, stating that *certain forms* of environmental regulation incentivise innovation;
- the "weak" version of the Porter hypothesis, stating that environmental regulation incentivises only environmental innovation but needs not improve firms' competitiveness; and
- the "strong" version of the Porter hypothesis, stating that environmental regulation incentivises innovation in a way so that the benefits ultimately outweigh the costs.

[25] This distinction dates back to *Jaffe and Palmer* (1997).

Ambec et al. (2013) provide an overview of empirical evidence on the Porter hypothesis. With respect to the "weak" version of the Porter hypothesis, the literature generally points towards a positive effect of environmental regulation on environmental innovation, albeit the magnitude of the effect varies. Studies that assess the relationship between environmental performance and economic performance deliver mixed evidence.

Appendix 3: The Rebound Effect, its component and estimates about the size

Claudia Kettner

The *rebound effect* refers to offsets in resource efficiency improvements, most notably in the area of energy use. Depending the magnitude of the rebound effect, two different outcomes can occur: 1. Efficiency gains are diminished due to the rebound effect. This outcome is also referred to as 'take-back'-effect. 2. All efficiency gains are set-off due to the rebound effect and eventually more resources are used; this outcome is also referred to as 'back-fire' or 'Jevons Paradox'[26].

The total rebound effect can be decomposed into four different effects *(e.g. Gillingham et al.*, 2013):

- Direct rebound effect: Technological change directed at energy efficiency reduces the costs of a given energy service, which in turn increases the demand for this service. An improvement of the efficiency of cars, for instance, would ceteris paribus imply lower costs of driving a car and therefore the number of kilometres driven would rise.
- Indirect rebound effect: The money saved due to resource saving technological change is spent on other products (income effect).
- Macro-economic growth effect: Economic growth might be fostered due to higher resource efficiency in turn leading to higher resource use.
- Macro-economic price effects: Reduced demand for a particular resource in one country might reduce world market prices and hence lead to increased consumption in other parts of the world.

The size of the rebound effect and its relevance in the real world are a subject of scientific debate (e.g. *Gillingham et al.*, 2013; *Sorrell*, 2007). Recent reviews of the empirical literature on the rebound effect include *Gillingham et al.* (2014), Greening et al. (2000) and *Sorrell et al*. (2009). In the studies reviewed by Greening et al. (2000), the estimated size of the rebound effect ranges e.g. between 5% and 12% for residential lighting and between 10% and 30% for the transport sector; Gillingham et al. (2014) report similar effects. The review by *Sorrell et al.* (2009) identifies broader ranges (5% - 87%) for personal automotive transport: In the studies reviewed by Greening et al. (2000), the estimated size of the rebound effect ranges e.g. between 5% and 12% for residential lighting and between 10% and 30% for the transport sector; Gillingham et al. (2014) report similar effects. The review by *Sorrell et al.* (2009) identifies broader ranges (5% - 87%) for personal automotive transport.

[26] William Stanley *Jevons* (1865) was the first to note that improvements in energy efficiency may increase the energy consumption of an economy, using increased coal consumption due to cost reductions resulting from the introduction of the steam engine as example.

Appendix 4: The Stern Review on the Economics of Climate Change

Teresa Bauer

The Stern Review on the economics of climate change was released by Nicholas Stern for the British Government in 2006. The issue of the report is to discuss the impact of climate change on world´s economy. Stern describes climate change as one of the greatest market failures with a global range and a long-term impact. The conclusion of the report is that strong, early and global action is needed so that its benefits can outweigh the costs of not acting.

Since the industrial revolution earth has warmed by half degree and moderate predictions forecast a rise of the average temperature by another 2 - 3°C within the next fifty years due to emissions driven by economic growth. Hence the transition to a low carbon-society is crucial and it brings a lot of challenges but also offers new opportunities for growth due to the establishment of new technologies or sectors and efficiency gains. Gaining a comparative advantage and taking a leading position in low-carbon technologies / markets will ensure the future growth of a region and will inspire other regions to invest in green markets as well.

Stern´s economic model predicts without a change of current policies an average reduction in global per capita consumption of 5% now and forever due to the risks and costs of climate change[27]; in contrast, investments to avoid the worst results of climate change are calculated with around 1% of annual global GDP[28] by 2015. Therefore the trade-off between low-carbon policies and economic growth seems to diminish if all consequences of climate change are considered like extreme weather, rising sea levels, declining crop yields, rising migration flows.

Stern pleads for a strong mitigation policy which can reduce most of the risks. But until mitigation policy shows success adaptations to climate change are necessary. Furthermore Stern´s essential policy elements to reduce emissions are:

- **Carbon pricing**: putting an appropriate price on carbon through taxes, trading or regulation to internalize its externality effect and avoid free-riding
- **Technology policy**: although the private sector plays the major role in R&D and technology diffusion, the government should promote and support new technologies
- **Removal of barriers to behavioral change** (lack of reliable information, transaction costs): through regulatory measures like minimum standards, information policies, education

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[27] The calculation of the impact of climate change and its mitigation/prevention costs are subject to uncertainties (technology inventions in future, human behavior) and assumptions (discount rate, degree of climate change, evaluation of social instabilities, extreme weather events, economic categories considered etc.). Hence results differ between studies. For example, models which assume a global warming of 5-6°C estimate a 5-10% loss of global GDP (see *Nordhaus and Boyer*, 2000) and models assuming a warming of 2-3°C estimate a loss of 2-3% of global GDP (see *Tol*, 2002). The costs for developing countries are in all cases higher than for developed ones.

[28] Investments to stabilizing emissions around 550ppm CO_2 (equivalent) range from -1% net gains to +3,5% of GDP.

The Stern review is one of the best known economic reports about climate change. Like every important study the review divided economists' positions. On the one hand economists totally agree with the paper (see Helm, 2008, or Howarth, 2008), on the other hand others disagree because the impact of climate change was overestimated (see Nordhaus, 2007), underestimated (see Ackerman *et al*, 2009) or wrong calculated (see Weitzman, 2007).

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Project Information

Welfare, Wealth and Work for Europe

A European research consortium is working on the analytical foundations for a socio-ecological transition

Abstract

Europe needs change. The financial crisis has exposed long-neglected deficiencies in the present growth path, most visibly in the areas of unemployment and public debt. At the same time, Europe has to cope with new challenges, ranging from globalisation and demographic shifts to new technologies and ecological challenges. Under the title of Welfare, Wealth and Work for Europe – WWWforEurope – a European research consortium is laying the analytical foundation for a new development strategy that will enable a socio-ecological transition to high levels of employment, social inclusion, gender equity and environmental sustainability. The four-year research project within the 7th Framework Programme funded by the European Commission was launched in April 2012. The consortium brings together researchers from 34 scientific institutions in 12 European countries and is coordinated by the Austrian Institute of Economic Research (WIFO). The project coordinator is Karl Aiginger, director of WIFO.

For details on WWWforEurope see: www.foreurope.eu

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