Climate change – challenges for trade, innovation and governance

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1 Introduction

The *problematique* in focus for this paper is the following: what are the consequences of climate change – and climate change mitigation/adaption policies – for globalization? And to what extent is the globalized economy part of the problem or part of the solution?

The paper is structured as follows. Section 2 recapitulates the emergence of the global economy and its relation to modernity followed by section 3 which provides a descriptive statistical analysis of the role of carbon in the globalized world that has emerged since around 1820. Section 4 is focused on the mechanisms of climate change and the planetary boundaries within which the world economy has to develop if there will be a fair chance to stay within the oftenly declared international 2°C target. In section 5 there is first an analysis of the cornerstones of trade theory and their relation to climate change, and secondly an analysis of the positions among ”concerned” economists and trade theorists on that topic. Section 6 contains reflections on the policy challenges in a world that has to put more emphasis on climate change mitigation. Section 7, finally, concludes.[1]

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2 The globalized world and the roots of modernity

Mankind has always been global. Early man expanded from Africa more than 1 miljon years ago to all other continents (Diamond, 1991). In ”modern” time, i.e. the recent five thousand years Fenicians, Greeks, Romans, Mongolians, Russians and Chinese (among others) created various forms of pre modern and primarily regional ”world economies” (Braudel, 1979/86, chapt 1). From around the 15th century, we can recognize an integrated world economy although dominated by three poles: an Islamic, an Indian and a Chinese. In the end of that century a fourth pole of gravitation enters the scene – Europe (Braudel (1979/86, p. 427 ff. Maddison, 2007, chpt 3). Over the centuries there is a shift of dominance between regions but global trade (and migration) increases over time and penetrates world development.

Although Maddison (2007, chpt 2) argues that the late 18th and early 19th centuries were more globalized than was the case 100 years later we in this paper follow the arguments of O`Rourke and Williamson (2002) that the existence of global trade relations does not in itself mean that daily life in societies all over the world is globalized. In their rethorical question of whether globalization (by them defined as world trade) is 2000 (or more), 200 or 20 years old they argue for the middle way.

Their main argument is that the take off in globalization primarily is related to productivity increases in global transportation leading to falling transport costs, mainly in shipping. And although there are, following them, a few instances of productivity increases in the transport sector during the 18th century (due to more efficient logistics) they identify the take off for the global economy to the period after 1820 or even some decades later.[2] This is basically also the conclusion by Woodruff in his analysis of the emeregence of the world economy (Woodruff, 1973/77). In line with that, although in a different manner, the World Development Report some years ago identified two waves of globalization connected to two phases of cost reductions in international transport (World Bank, 2009, chpt 6; Corbett & Winebreak, 2012). Not the least was the later wave connected to a rapid increase in world oil consumption (Wodruff, 1973/77 & van der Wee, 1983/87).

The later half of the 19th century are the decades when transport costs collapses – visible in the declining shipping costs for coal as shown in the paper by O´Rourke and Williamson (2002). This is also – although O´Rourke and Williamson do not discuss such things – the period when the steam engine is industrialized in large scale in production (von Tunzelman, 1978) as well as in shipping (Woodruff, 1973/77). The success of the steam engine in global economic development is revealed in the growing global use of coal from around 1820 (see below).

Globalization, in its modern sense, thus, has received its momentum and energy from carbon for around 200 years. And, as will be argued in this paper, the global system is more dependent on fossil carbon today than ever. Now knowing much more about

[2] This analysis deviates, however, from that of e.g. Maddison (2007, chpt 2) who argues that there is a large increase in ship size and transport capacity of the western European merchant fleet between 1470 and 1820. Also this contradiction falls outside the scope of this paper to solve.

climate change than we did in mid 19th century, and intensively discussing the international policies for climate change mitigation, we have to ask ourselves on the consequences for the global economy, for global trade and for trade policy if we reduce over all global CO_2 emissions with 90% in the decades ahead of us. And, roughly, that large reduction must be the target for policy if we take the threat from climate change seriously.

3 The globalized economy – addict to carbon

The growth of the global economy was, literally, fueled by innovations in energy and transport sectors improving the conditions for global trade during more than a century. After WW2 the technology shift to oil and gas in combination with innovations within communication in a broad sense (not the least based on the development of ICT) as well as within management and how to organize global production processes, laid the ground for the deep globalisation we face today (cf. Castells, 1996/2000; Friedman, 2005). Upscaling of ships and containerization also contributed to this process (World Bank, 2009).

Although today´s globalized world is a real ”digital world” connected by ICT systems, significant parts of this global web serves as a lubricant, facilitating physical transports of people as well as goods, primarily fueled by fossil carbon, nowadays normally by oil. The ambition with the following descriptive statistics is to identify the physical character of the global economy, sometimes forgotten due to the relative decline in industrial production in the old industrialized world.

The transport sector is (2013) responsible for approx. 23% or 7385 Mt CO_2 of total world emissions from fuel combustion (32190 Mt).[3] Since 1990 transport related emissions have increased with approx. 64% while total energy related emissions have increased with approx. 56% (IEA, 2015a). Although also road transport is an important part of the globalized economy – within continents and from inland economic zones to coastal hubs – it may be argued that maritime transport, the most efficient means of transport, and aviation are the core tools for the global physical transport system. International maritime and aviation bunkers make up for 1099 Mt CO_2 emissions which corresponds to 15% of total transport emissions or 3,5% or world total energy related emissions.[4] This is an increase of 64% for maritime bunkers (609 Mt) and 90% for aviation bunkers (490 Mt) compared to 1990. In short*: global physical transport increases its CO_2emissions – not only in tons but also in its share of global total emissions*. This, of course, mirrors a growing consumption of fossil fuels of basically the same magnitude within the maritime and aviation sectors (IEA, 2015a).

[3] The energy sector is by far the largest source of global anthropogenic greenhouse gas emissions (GHG): approx. 69% of total emissions. 90% of the energy related emissions are CO_2 (IEA, 2015a).

[4] Following international agreements international aviation and maritime bunkers benefit from national tax excemptions. It is thus highly probable that the consumption of tax free bunker fuels is a good mirror of total fuel consumption for global transport.

Assuming that there is a small growth of energy productivity in these sectors related to larger ships and more advanced aeroplanes it may be assumed that the growth of physical transport in tons also in recent decades is somewhat larger than the growth of CO_2 emisssions.[5] The analysis of physical data in world trade and transport is however difficult to perform without a work load far beyond the scope of this paper. In world trade statistics the ”volume” indices are just theoretical constructs calculated backwards from price movements on traded goods. This statistics says nothing about the physical weight of most of the commodities traded.[6] Another path to follow to get a proxy of ”real” transport volume is to calculate the total weight of the 10 or 20 most important raw materials mined and harvested in the world and from that calculate the magnitude of transport growth. The very detailed production statistics on raw materials – minerals as well as agricultural and forest products - reveals that the weight of the world economy has roughly doubled from 1990 to the present (USGS, 2014). The global economy of today is definitely not ”post material” or ”post industrial” – it has never been so ”heavy” (see also Smil, 2013 & Wiedmann et al., 2015). And, for the purposes of this paper, we may assume that there is, approximately, a linear relation (at least in the short term) between material mining and harvesting (”production”) and CO_2 emissions. What is mined/harvested in the early phases of the value chains moves the whole way from ”craddle to grave”.

In addition it may on the one hand be assumed that global material transport increases at a faster rate than the material economy as a whole following the development of globalized ”roundabout” production systems/networks. In short: the material in the product ”finally consumed” has nowadays often travelled a lot over the world before providing computing services somewhere in Europe. And so also the parts of the equipment used in the production processes (Laestadius, 1980; Ernst, 2002; Coe & Yeung, 2015). On the other hand it may be assumed that the bulk materials in the global metabolism – the heavy investment goods - do not travel as much as high-tech products with high value/weight ratios.

The situation is similar – although the rate of increase is much faster - for aviation. World aviation statistics reveals that the annual growth of passenger transport as well as freight has increased in the magnitude of 4.5 – 5% annually since 1990. The rate of increase – in spite of the economic crisis 2008 and its aftermath – is in fact higher in the most recent part of that period: the early part of this millennium has hitherto seen an increase of aviation passenger transport with more than 5% annually (Trafikanalys, 2014).

4 Anthropogenic climate change and planetary boundaries

[5] Due to the complexity of the maritime transport system and its cyclical variations it is, however, difficult to isolate technical/energy productivity changes from other mechanisms behind variations in freight rates and transport costs. Here we abstain from further analysis of this.

[6] This of course reflects that the statistics primarily has economic purposes rather than ecological ones.

Although the growing extraction of carbon from the ground now and then over history has initiated analyses on whether there will be fossil fuels enough for further growth (cf. Jevons, 1865/1906 & Aleklett, 2012) the related question on whether the Earth can accomodate the rest products from burning coal has for a long time been neglected. The question was studied in the 19th century already but did not become a core research issue until the 1980s (Bolin et al, 2007).

The fundamental mechanisms behind the antropogenic climate change, its consequences and potential for mitigation are nowadays well described, not the least in the recent round of IPCC reports (IPCC, 2013; 2014a & 2014b). The consequences for mankind are also summarized in several recent policy documents from international organizations (see eg. World Bank, 2012).

The fundamental problem in the transformation ahead of us is that the climate impact of GHG:s depends of the accumulated stock of emissions in the atmosphere – not the annual net flows. All historical emissions count (except those small parts that have transformed into other molecules). The planetary boundaries thus set a limit. Climate researchers agree that if the 2°C target will have a fair chance to be met, emissions must be restricted to around 300 GtC, equivalent to approx. 1100 $GtCO_2$ in addition to the hitherto emitted 600 GtC. That is around one third of already known and exploitable reserves. In short: *we have to leave two thirds of wellknown fossil fuels in the ground* (Cf. Rockström et al, 2009 & IEA, 2015a).

The recent trend of higher carbon efficiency in the world economy - i.e. lower CO_2 emissions per unit of GDP produced – is, although welcome, thus not enough. What counts are the absolute level of the emissions.

The International Energy Association (IEA) is a frequent producer of scenarios on probable, possible and necessary energy paths for the world. Its recent special report before the Paris COP21 negotiations late 2015 (IEA 2015b) produced three scenarios: the first – the INDC scenario - based on pledges given by most countries before the negotiations; the second – the Bridge scenario – containing more demanding policies which can be performed by countries to reach further than present policies/pledges; and a third – the 450°C scenario – constructed from our present knowledge of what is required if we stick to the 2°C target.

Of interest here is the over all agreement among climate scientists and climate policy institutions that present emission paths including recent trends and declared policies for mitigation activities indicate that mankind will face a ”tipping point” in the early 2040:s when the – by now estimated - probability to keep global temperature increases below 2°C is less then 50% (IEA, 2015b). There are, however, several analysts that argue that the process of climate change is faster than that and more severe (see eg Hansen et al., 2013)

5 The agenda for globalization

This is not a forum where the advantages of an open world economy have to be argued for. As we are analyzing the challenges for the global economy we may, however, scrap a little on the surface of what theory says on the phenomena and processes we now face. First of all: the political rationale for open economies comes from trade theory with origins in Ricardo and the Heckscher – Ohlin – Storper – Samuelson (HOSS) aproach. It has also benefitted from various product/industry/technology cycle theories as well as theories on factor movements (capital and labour) and the role of transnational companies (see Helpman, 2011 for an overview). Basically this is a family of theories on *economic efficiency*: under a given set of conditions an open economy is more efficient than a closed one. These conditions are e.g. related to market conditions, information, knowledge/learning, externalities, competition, technology etc. Much of research and policy in this area is focused on the consequences of these market imperfections and how to deal with (compensate for) them. Not the least has the fundamental inequality between developed and developing countries been in focus: to what extent has globalization contributed to development and growth in the initially poor regions and not to stagnation or even underdevelopment? Among more recent studies, also explicitly adding the ecological and natural resource dimension in explaining the growth and development impact of world trade, it is worth mentioning Pomeranz (2000) and Pomeranz & Topik (2006).

There is, in fact, a family resemblence among concerned economic scholars that also in a non perfect world an (optimal) globalization path is the way to go to handle problems related to distribution problems like low salaries, child labour, womens rights etc; phenomena which may be exploited in global production processes but far from always are created by globalization itself. Nevertheless this adds an institutional dimension to the analysis.(see. eg. Bhagwati, 2004; Stiglitz, 2002: Stiglitz, 2007; Stiglitz & Charlton, 2005).

A problem, however, when moving from trade related distribution challenges to the environmental ones is that some of the fundamental assumptions behind standard theories for globalization do not necessarily hold anymore.

The first relates to *externalities*, a concept introduced by Marshall (1890) and Pigou (1920) already and well known by economists. Standard theory normally assumes that there are no (or limited) externalities, i.e. there are no, or insignificant, effects outside the economic transactions under study and if there are, they can be included – i.e. compensated for - by another transaction. The problems with climate change are, not only that there are emissions, but also that these emissions take place in a global commons - i.e. there is no identifyable entity to compensate - and thirdly, that you cannot put a reasonable price on the threat of extinction of parts of mankind – which is the ultimate consequence of present emissions.

The second relates to *the time dimension* of costs and benefits of these externalities. It may normally be assumed that the costs and/or benefits of externalities occur unevenly over a time span and that has to be included in the calculation using a discount rate. This rate is normally calculated from experiences of historical growth rates of production and productivity on the one hand and from estimates of people´s time preferences on the other. Estimating a relevant discount rate for the consequences of GHG-emissions is, however, very tricky. Not only are the processes very slow which transform the discount problem to an intergenerational one. In addition it is far from obvious any more that future generations will be richer and/or benefit from the same kind of productivity increase that the present generation (born in the 1940s-1970s) has. Although we also in the future may utilize brain power to improve our technologies we cannot sustainably continue to develop machinery and systems which are based on fossil carbon. And, unfortunately, this is what much of historical productivity increases have been about.

The third relates to *economic growth*. The, probably, main argument in favor of globalization has been its contribution to over all economic growth. In a situation when we – as argued above - are approaching planetary boundaries a future growth similar to what we have experienced hitherto is far from obvious. In short, the focus in orthodox economic theory on the production factors ”capital” and ”labour” did for a long time hide the role of ”technology/knowledge” in explaining and understanding the mechanisms of growth. Originally identified by Abramowitz (1956) and Solow (1957) the ”technology factor” is nowadays an integrated part of economic theory, not the least in the endogenous growth approach (see eg. Aghion & Howitt, 2009). We may label this as *brain power*.

Energy – i.e. *external power* – has however, with a few exceptions, never been identified as a production factor but has remained an input good similar to other inputs. The long term decline of relative energy prices may have contributed to this neglect of energy in the production function. It may however be argued that the long term increase in (labour) productivity which to a large extent explains economic growth is the result of using brain power to substitute energy for labour. On global level this external energy is primarily (82%) based on fossil carbon.

A consequence is that we cannot assume business as usual (BAU) as regards future productivity increases and economic growth. Both of these must be totally based on brain power and non fossil fuels only – a new challenge for mankind.

This seems to be an almost neglected aspect of the transformation to come. Assuming economic growth in the future – also ”green growth” - without seriously including the productivity dilemma in the analysis is – to borrow a metaphor from Joseph Schumpeter – like playing Hamlet without the Prince. In short: the challenge is not to use productivity increases to transform the economy towards sustainability but *to obtain carbon free productivity increases* parallel to – and also contributing to - the over all reduction of fossil fuels in a magnitude of 4% per year.

The three above mentioned phenomena have together caused intensive debates among economists on what is the right price of CO_2 and how to distribute the payment/taxation of it over time (for a short review see Laestadius, 2015). For many years the conventional wisdom among economists was to postpone ”costly” mitigation activities to future generations; based on the assumption that the future generations historically have always been richer than the living ones due to productivity inceases and growth. As discussed above, this historical experience is no longer something we can trust for the future.

Two decades ago already this problem of the dependence of growth on the Earth´s carrying capacity was discussed in a short paper by Arrow et al. (1995). The core issues have been analyzed before as well as after that but have not always received the attention they deserve. The limits were more easy to neglect when the impact of human activities was small in relation to nature´s own processes. This is no longer the case: the globalized economy is now, as discussed above, rapidly approaching the planetary boundaries.

In the following we focus on how the climate mitigation activities, which must be introduced – athough we have no idea on how rapidly they can be effective – may impact on the global system.

6 Globalization and climate change – the interplay

Two approaches seem relevant when we, finally, try to knit the threads together. The first relates to the necessary – although still not observed in a scale large enough - transformation of the global economy towards sustainability, i.e. towards a significantly much less material intensive world economy which also basically becomes independent on fossil fuel based physical transport. Below this is labeled *the long term view* although it in fact has to be a rapid process if we will have a reasonable chance to keep global temperature increases below 2°C. This basically relates to the *economic transformation process.*

The second approach relates to the concrete policy phenomena which may take place underways as countries try to compensate for, avoid, or profit from climate change and its mitigation. We label that *the short term perspective*. This primarily relates to the *institutional processes*.

6.1 The long term transformation process

As regards the long term view it can be formulated on two levels: 1) the *global production system* must be significantly dematerialized to allow for an almost total reduction in fossil based energy input. 2) also *global transportation activities* must be significantly reduced to make it possible to reach the 2°C targets.

The magnitude/speed of these reductions can be formulated in many ways. The world – and on average all its sub systems and sectors – have to decarbonize with approx. 4% annually for the foreseeable future, i.e. during more than 50 years ahead. This is roughly similar to half of present levels before 2030 and another half before 2050 (Laestadius, 2015). The magnitude of this decarbonization path can be compared with data from global transport emissions which have *increased* with approx. 2.2% annually since 1990 (see page 3 above). The reduction processes can be performed primarily in three ways: *avoid*, *shift* and *improve* . This typology is also in line with mitigation analyses from IEA (see eg. IEA, 2014).

Related to our globalization focus this typology may – on the production system level - be interpreted as follows: GHG emitting processes, products and services must be *avoided*; in reality that means dematerialization of the global production system. In addition there must be a shift from high emitting processes, products and systems to low emitting ones and a shift from fossil based energy sources to renewables. Finally, the energy efficiency of remaining activities, products and services must be *improved.*

As regards global transport it may be argued that they first of all have to be *avoided*. This is a heavy blow on the conventional wisdom regarding the efficiency of the world trading system and may have significant impact on the roundabout production systems of our time of which many seem to be price sensitive (World Bank, 2009, chpt 6). Secondly remaining transports have to *shift* to renewable forms of transport modes and of energy. Finally, remaining transport activitites have to improve their energy efficiency.

This typology implicitly recognizes that focusing on one of the three legs will in general not be enough. There is a *time dimension* in this: there is – simply – not time enough to continue with business as usual (BAU) as regards production and transport and focus on pouring new fuels in old canisters without reducing them significantly.[7]

There is also a *scale dimension* on the energy side. Although there is a large potential to transform to photovoltaics and windpower for electricity generation this is – particularly in the transport sector – not that attractive as the introduction of biofuels. The problem is that there is probably not biomass enough to satisfy all demand that may emerge from the transport system of today´s size and structure. It may in fact be assumed that there will be a global ”struggle for biomass” as more sectors search for solutions to their mitigation challenges (Novotny & Laestadius, 2011).

Assuming that all three legs in the mitigation agenda are used there is still a chance to handle the transformation within the internationally agreed 2°C target. Reducing system activity to half, making it twice as efficient and substituting half of fossil fuels used in that system will decarbonize it to 12,5% of present levels. That may be enough (see Laestadius, 2015 for further analysis).

By now, the challenge should be obvious: how will the global production and trading system transform in this process requiring an annual rate of decarbonization in the magnitude of 4%. A dematerialized production system? Reduction of global trade and thus also a reduction of transports? Wat about the rapidly growing global aviation? Much less roundabout production systems? More closed economies? A new global regionalism? Is it reasonable to assume that the global system should face less pressure to decarbonize than other highly emitting ”sectors” of the world economy? Although raising these questions is part of the aim for this paper, answering them must be part of further studies. Here we focus on two aspects of them only:

The first relates to innovations in general and to what may be labeled ”technology fix” solutions in particular. There is a tendency among policy makers to search for solutions in a technology based *deus ex machina*. Although the transformation ahead will be heavily based on innovations it may argued that the low hanging fruit for the coming decades must be based on what we already know; i.e. innovations from yesterday. The technologies of wind power, photovoltaics, electrical vehicles, high speed trains, biofuels, batteries, energy efficiency, etc. are already there although they are not always

[7] For a detailed analysis on how energy transitions take place, see Smil (2010).

price competitive compared to the still subsidized fossil fuels. It is thus an immediate institutional (political) problem to make these low hanging fruit worth picking. In addition governments may promote innovation policies aiming to upheld a mometum in the transformation to come (see eg. Mazzucato & Perez, 2015).

The technology fix argument is basically a classical "engineering" approach. The global scale of the climate problem - in combination with the short time span within which we now have to react - do, however, make this kind of macro engineering solutions less viable. The most "realistic" technology fix solution discussed in international studies is carbon capture and sequestration (CCS).[8] This is a technology that works at pilot scale level and may work at full scale level within a decade, but it is far from being a global solution. In addition it will necessitate very high global taxes on CO_2 to become economically viable thus contributing also to make other sustainability efforts competitive (see Laestadius, 2015).[9]

The second aspect raises the question of whether the globalized economy can be part of the solution rather than part of the problem. This is probably – at least to some extent - the case. Within a framework of global dematerialization and reduced input of fossil fuels there will for a long time be varieties between countries and firms as regards their ecological footprints. Countries may thus develop "comparative footprint advantages" to produce and export certain products and, consequently, to import others. A system with international trade may thus, under certain conditions, produce less CO_2 emisssions than a system with autarky.[10]

There is also a dynamic dimension of this aspect. The rapidly growing global efforts on sustainable technologies has contributed to rapidly declining learning curves leading to better performance as well as cost reductions for eg. wind power, photovoltaics, high speed trains and electric vehicles. This creates challenges as well as opportunities for global actors intensifying ther innovative activities (see eg. Schmitz & Lema, 2015). The dynamic impact of technology transfer may thus, under certain conditions, more than compensate for the climate impact of trade itself (Tamiotti, et.al., 2009).

There may finally be *a new multi-regional outcome* of this process, combining the efficiency of international specialization on the one hand and shorter transports on the other. As mentioned in section two above, this was the case 500 years ago in the eve of the globalization process we are used to. The fact that parts of international trade is very transport price sensitive (see. eg. Corbett & Winebrake, 2008) is an argument that some advantages of the present international specialization are not that huge and that climate related adaption may end up in new and shorter directions of trade. As a consequence Swedes may e.g. import less lamb and wine from New Zealand.

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[8] For the recent status of CCS see also IEA (2015c).

[9] It may be argued that also nuclear power belongs to the "technology fix" solutions. The technology is there and it works. It is however, if not actively opposed, often a plan B also among its supporters. The present generation of nuclear power technology is not what nuclear scientists once dreamed of, nuclear power plants have obvious problems to become profitable and also here mankind faces the problems related to final storage of the waste.

[10] This is basically the message, although differently formulated, in the paper by Kander et al (2015)

The recent UNFCCC round in Paris (COP21) late 2015 - although having signed an agreement on "holding the increase in the global average temperature to well below 2°C above pre-industrial levels" (UNFCCC, 2015a) - has no formlations at all on how to take the steps which may lead towards the global 4-5% annual decarbonization which is necessary to fullfill the agreement.[11] Still there are basically no climate and transformation analysts who believe these steps can be avoided – only delayed thus contributing to a still worse situation. There is no BAU – only a risky trade off between inevitable mitigation costs and inevitable costs of adaption and restoration.

Irrespective of what was agreed upon in Paris it may thus be assumed that countries – and groups of countries - will search for other paths than along global agreements to proceed with decarbonization strategies. As long as the international system only delivers a fraction of what is needed to stay below the 2°C target, countries may introduce policies to transform their economies towards sustainability and also to protect their achievements.[12] And this will have impact on the global trading regime.

6.2 The short term institutional perspective

This takes us to our second, and more immediate *short term perspective*. As mentioned above: this approach is also basically an *institutional* analysis. In the absence of far reaching global agreements on a common global decarbonization strategy it may be assumed that countries start to act on national bases and/or in country clubs intending to impact on the world economy – and on their own economies. We may thus face an explosion of climate motivated activities like subsidies, taxes, fees, regulations related to sustainability in general and climate change in particular. These actions may go far beyond the famous shrimp war in WTO (see eg. Ahn & Messerlin, 2014). The new climate dimension may be illustrated by six principal cases:

1 Many countries subsidize fossil fuels, be it consumption of gasoline or production of high cost coal. These subsidies are not only significant but also highly ranked targets for international actions to mitigate climate change.[13] Countries with advanced decarbonizing programs may thus react with anti-dumping notifications to exports from countries that subsidize fossil fuels. Many of these actions will be based on the fear of leakage effects - on home markets as well as on third party markets - on industries located in countries in the frontier of climate change mitigation.

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[11] The conclusions that COP21 results will not live upp to the ambitious targets of the agreement – unless countries significantly increase their efforts - are based on the official pledges given by participating countries before the Paris round (UNFCCC, 2015b"holding). In fact the well reputated MIT Joint Programme on Climate Change argues that the pledges given may take us towards a temperature incease in the latitude of 3.1 – 5.2° C in the end of this century (MIT 2015). Also IEA argues that the commitments given by countriec to the COP21 round are far from enough (IEA, 2015a).

[12] This is eg discussed in Article 6 i the Annex "Paris Agreement" document (UNFCCC, 2015a).

[13] Global subsidies of fossil fuels are estimated to be in the latitude of 600 BUSD per year (GSI, 2013). In addition it may be argued that there are indirect less visible subsidies on production as well as consumption which are hidden in other subsidizing programs.

2 Several countries – and groups of countries - do have, or plan to introduce, systems for far going taxation ad/or trading schemes for CO_2.[14] The argument behind is that CO_2 is a threat to mankind. Export competing industries in many countries do presently have excemptions from these systems due to competitive reasons. But high taxing countries may argue that not joining ”best practice” international CO_2 taxation levels is similar to dumping and a threat to mankind.

3 A variety of this is the fact that international bunkers are excluded from national taxation. Countries – or clubs of countries – which, like EU recently, try to introduce bunker taxation, may argue that imports on ”non CO_2 taxed keeels or wings” should be punished.

4 The Swedish steel industry is among world leaders as regards low carbon emission levels per ton steel produced or per ”steel function” delivered; it is maybe even the most carbon efficient. In a situation when Sweden, like some other European countries, are planning to create still tougher plans for decarbonization - leading to significantly higher costs - the industry fears that their efficient steel plants may be closed down in favor of other much more polluting ones.[15] This case of leakage effects – just one of many similar ones in carbon intensive activities – opens for a series of technical barriers to trade (TBT) and antidumping actions from directly involved actors as well as from ”third parties” in the WTO, most of these potential actions seem to be beyond the scope of the present WTO-rules.[16]

5 ”Frontier” countries may argue that the transformation away from a world addict to carbon necessitates *non-neutrality* towards industries and technologies: low carbon technologies must always be favored compared to high carbon. This is far from the core thought style behind the WTO rules and will make the WTO work more complex in the future. Neither is this part of present EU regulations: not taxing biobased gasoline is thus not allowed if you tax fossil based gasoline.

6 Countries may join ”clubs” – as foreseen in the EU Barcelona agreement – to internally among themselves implement rules like the ones illustrated above and enforce restrictions to third party (non club) countries. These third party countries may make notifications to WTO.

The complexity in all these cases is the argument (difficult to deny) that CO_2 emissions are a threat to mankind and that carbon inefficient industries and technologies must be phased out. The implication is that countries that want to be in the front of the transformation away from their dependence of fossil carbon should be given an institutional framework for these activities.

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[14] In its latest ”450 ppm scenario” IEA (2015c) assmes CO_2 prices in the level of USD 100 -140/ ton CO_2 which is a magnitude of order higher compared to present ETS prices

[15] The steel industry – like the cement industry – do, in addition to the energy based CO_2 emissions, have process related emissions which make them vulnerable for single country policies in open economies.

[16] The author of this paper is no expert on WTO law and policies. The conclusions here are primarily based on what is available in van der Bossche & Zdouc, (2012).

It may be argued that the present world trade regime - although environmental and sustainability issues nowadays are identified in all dominant treaties - is far from prepared for the institutional challenges now emerging. For the purposes of this paper three core sources have been superficially analyzed as regards their ”readiness” to handle the consequences of climate change. In addition to the WTO documents the recently published texts on TPP (2015) and TTIP (2015) have been studied.

As regards the WTO rules it may be argued that the main text providing – at best - a legal window for climate related restrictions in the WTO 1994 Marrakech Agreement is article XXb (WTO, 1994: see also van der Bossche & Zdouc, 2012). However, sustainability is not even mentioned explictly in that article. In line with Barret-Lydgate (2012) this may be explained by the fact that there is a fundamental conviction ”that the goals of trade liberalization and sustainable development are mutually supportive. The underlying assumption is that trade liberalization leads to greater prosperity, which creates resources for better environmental management and social policies” (Barret-Lydgate, 2012). This seems also to be the intellectual cornerstone of the ministerial declaration in Doha 2001 which states that

> ”it is the potential impact of economic growth and poverty alleviation that makes trade a powerful ally of sustainable development….. The purpose of trade liberalization and the WTO´s key principle of non discrimination is a more efficient allocation of resources, which should be positvie for the environment” (WTO, 2001, also quoted in Barret-Lydgate, 2012).

The problem – as analysed in section five above – is that this may well be a good description of environmental issues well within the planetary boundaries but they are not in general valid for the mitigation of climate change. Growth as usual will contribute to the problem rather than create resources to handle them.

In the absence of far reaching international agreements on climate mitigation, countries and clubs of countries may – as illustrated in the principal cases above - introduce systems of subsidies and technical barriers of trade (cf. chpt 12 &13 in van der Bossche & Zdouc, 2012) which basically fall outside the established WTO framework.

The emerging regulations in international trade seem to have similar limitations. The recently published preliminary texts on the Trans-Pacific Partnership, on the one hand, reveals a step forward as it has a full chapter on the Environment (chpt 20). On the other hand the section on ”emissions” is short and superficial and there is no recognition in chapter 20 that there may be contradictions beteween climate change mitigation and trade liberalization in a world when some countries want to proceed faster than others (TPP, 2015).

The recently published textual proposal on ”Trade and Sustainable Development” in the TTIP between the EU and the US seems to be more open minded as regards the possibilities for parties to introduce climate change mitigation actions within the framework of the proposed agreement. Not the least the proposed article 3 can be interpreted that way (TTIP, 2015). Still, it is not obvious that the negotiators have recognized that there may be problems to upheld the free trade regime, from which we have benefitted hitherto, also in a potentially tougher world of climate change mitigation. This is also the argument from a recent commentary by Porterfield and

Gallagher who idenity four areas where TTIP may ”jeopardize the ability of the European Union and the United States to put in place the proper regulations to meet climate targets” (Porterfield & Gallagher, 2015).

7 Concluding remarks

This paper has – within the chosen condensed format - been superficial and integrative with an ambition to combine our understanding of the global economy with our knowledge of climate change. It has focused on the growing addiction to carbon which has been fuelling and fuelled by the globalization process during the last two centuries.

We do now face a situation when we, during decades ahead, have to decarbonize at a rate roughly comparable to our earlier increase of fossil fuels to run the world economy. Reducing CO_2 emissions with approximately 4% annually will create tensions in the world system, it may reduce global production systems as well as world trade, it may create more of autarky in the global economy. It may also contribute to a more regionalized global economy and new international division of labour based on the comparative footprint advantages of nations. Whether this will be a ”costly” process we do not know because we do not know the real costs of the present development path with which we have to compare.

Under all circumstances the transformation ahead will be substantial and challenging to handle for international policy makers. It will also create challenging and important research tasks for academia. For all involved it may challenge or even threaten fundamental beliefs on what paths to follow to achieve a better world after having realized that the present path is not sustainable.

We still need to learn a lot to avoid moving into a non manageble climate change in the second half of this century. And we still need to learn a lot on how to govern this process globally.

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