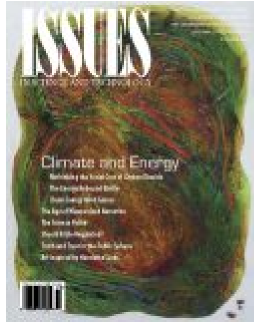

Greenhouse Gas Emissions from International Transport

by **Parth Vaishnav**, **Iddo K. Wernick**

International transport, which includes ocean shipping and aviation, is among the fastest-growing sources of human-generated greenhouse gas emissions. Between 2009 and 2010, carbon dioxide (CO_2) emissions from international transport grew faster— I at 7 and 6.5%, respectively—than those from China, which grew by 6%. Although 2010 was a year of especially rapid growth as global trade and travel bounced back from the 2009 recession, emissions from this activity are expected to grow to between two and three times their current level by 2050. This growth will start from a small but substantial base: If the sector were a country, its current emissions would be roughly the size of those of Japan or Germany.

Rising emissions from international transport could dilute hard-won reductions in other sectors, such as the switch from coal to wind and solar electricity. To see how, consider the case of the United Kingdom. In 2010, it emitted about 500 million tons of CO_2. Domestic and international flights departing from the United Kingdom in that year emitted 33 million tons, or about 7% of the total. The United Kingdom has instituted a legally binding commitment to reduce its annual greenhouse gas emissions in 2050 to one-fifth of their level in 1990. This means that in 2050, the United Kingdom ought to emit a mere 120 million tons of CO_2. The UK.. Department of Energy and Climate Change has forecast that under current policies to control their rise, CO_2 emissions from aviation in the United Kingdom will rise to about 50 million tons, or an untenable 42% of the total.

The unchecked growth of emissions from transport is therefore inconsistent with the drastic reduction in the overall production of greenhouse gases that is required to forestall dangerous climate change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) calls for the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) to put in place mechanisms to limit the contribution of international transport to global warming.

Who is responsible?

Given the nature of global transport, it is difficult to allocate its environmental impacts to any one country. Consider a ship that is registered in Liberia, operated by a Danish shipping line, and making a voyage from Shanghai to Los Angeles carrying products made in China by a European firm for sale in North America. How and to whom should the emissions from this voyage be allocated, and who should be assigned responsibility for reducing them? Questions such as these have proven to be politically intractable.

One reason is that the UNFCCC has traditionally operated on the principle of common but differentiated responsibilities. This principle suggests that developing countries have made a smaller historic contribution to environmental problems than have developed countries, and may not have the wherewithal to tackle them. Therefore, developing countries have argued that they ought to be exempt from taking on legally binding commitments as part of any program to curb global greenhouse gas production.

Conversely, the ICAO and the IMO have operated on the principle of nondiscrimination. This is the notion that regardless of its nationality, an aircraft or ship performing an international voyage ought to be subject to the same rules and standards. Developed countries argue that in the interests of effectiveness and efficiency, this principle is sacrosanct. That is, if developed countries take on legally binding obligations as part of a deal to reduce the environmental footprint of aviation and ocean shipping, then so must developing nations.

THE RESEARCH COMMUNITY SHOULD TAKE THE INITIATIVE TO ENSURE THAT ALL DOCTORAL AND POSTDOCTORAL TRAINEES RECEIVE INSTRUCTION IN THE ETHICAL STANDARDS GOVERNING RESEARCH.

Tools available, but dull

Progress at both the ICAO and the IMO has been sluggish. In 2011, the IMO defined an efficiency standard for new ships. It came into effect in 2013 and will be progressively tightened. For existing ships, the IMO published guidelines for voluntary energy management plans. It forecasts that this combination of measures is likely to reduce emissions from shipping by 180 million ton by 2020, or by 9 to 16% relative to business as usual. By the IMO's own (conservative) estimate, operators would save money by adopting this standard.

The IMO admits that its measures would fall far short of compensating for the increase in emissions due to burgeoning international trade over the next few decades. It has recommended that a market-based mechanism be put in place to augment the measures adopted so far, but has not published details of how this mechanism would work.

For its part, the ICAO in 2011 asked all of its 191 member states to submit plans for greening their aviation sectors. By June 2013, 61 countries, representing about 80% of the world's international air traffic, had done so. The ICAO reported in September 2013 that some of these plans were too sketchy for it to be able to estimate their impact on emissions.

The European Union, facing the same dilemma as the United Kingdom (that is, stringent economy-wide targets undermined by rampant growth in transport emissions), announced that it would include aviation in its Emissions Trading Scheme from 2012 onward. In particular, the European Union said that any flight, domestic or international, that departed from an EU airport would fall under the purview of its scheme.

Although the impact on airfares of the EU proposal would have been modest (in 2012, about $2 per passenger per round trip flight between New York and London) there was international outrage at the European Union's proposal to act unilaterally. Critics pointed out that only the ICAO had the authority to impose an environmental charge on international flights.

The European Union agreed to defer implementation to give the ICAO time to develop an alternative. In September 2013, the ICAO declared that it would propose a market-based mechanism to reduce greenhouse gas emissions from international aviation by 2016 and implement it by 2020. It outlined three plausible variants of such a mechanism. The first variant was to require airlines to buy credits each year if their emissions exceeded a predefined threshold. The second was to require airlines to buy credits and also to generate revenues by applying a fee to each ton of carbon emitted. The third was to set a cap on emissions within the sector, and allocate or auction credits equivalent to this cap. Operators that exceeded such a cap would be required to buy additional credits from others who had come in under it.

The ICAO is also working on developing an efficiency index for aircraft. However, the organization has not yet set mandatory targets for the efficiency levels that current or future aircraft must reach.

Tools may be useful anyway

The measures that the IMO and ICAO have suggested so far could go some way toward addressing the problem. For instance, as a first step in implementing the proposed market-based mechanisms for both industries, accurate data on fuel burn will need to be collected. For shipping, it is not clear that sufficiently detailed data are logged at all. For aviation, these data are not made publically available even if they are logged. The availability of accurate fuel burn data, even in aggregate form, should improve the quality of debate and policymaking even before the schemes themselves have any effect.

In the absence of regulation, even improvements that are economically viable may not be made. For instance, ships are often owned and operated by different entities. The benefits of higher efficiency may accrue to whoever charters the ship. Owners would have to bear the upfront cost of a more efficient ship. The premium that they receive on chartering out these more efficient ships is often not large enough to make up for the extra initial cost. Sometimes owners may not know about the technologies available to them. Or they may not have access to finance to pay for improvements, even if they thought that they could recover their costs over time.

The fuel efficiency of air travel in the United States has improved more than that of any mode of transport in the past 30 years. And yet, recent analysis of the market showed that there was a wide gap in the performance of airlines on this measure. Moreover, the correlation between an airline's efficiency ranking and its profitability was very small. The most profitable airlines were those that served niche markets with little competition, and so did not have a strong incentive to operate as efficiently as possible.

The IMO's standard could provide the impetus for ship owners and operators to ensure that at least those modifications that are likely to produce environmental benefit and pay for themselves over time will be adopted. The same is true of the nascent efficiency standard for aircraft.

As such, efficiency standards can be useful. For shipping, there is scope to make the existing standard more ambitious. For aviation, the ICAO should work on developing and enforcing a standard to augment the proposed market-based mechanism.

Toward an efficient mechanism

The potential of standards is limited by the fact that after a point, reducing emissions from shipping and aviation becomes very expensive. Analysis by the IMO indicates that by 2020, annual CO_2 emissions from shipping could be cut by 250 million tons using methods that would save operators money in the long term. Beyond this level, the cost of reducing each additional ton of emissions would escalate rapidly, and further cuts would become uneconomical, given current technology.

In aviation, there is some enthusiasm for the use of sustainable alternative fuels. Analysis by researchers at the Massachusetts Institute of Technology suggested that even if the feedstock could be grown on land that would otherwise have been left fallow, reducing CO_2 emissions by switching to biofuels produced by currently available technology would cost $50 per ton of emissions avoided. If biofuels from soybean oil were used instead, the cost would be $400 per ton of emissions avoided.

Because the cost of making large cuts in emissions within international transport is probably prohibitive, it is economically efficient for the industry to pay for cuts to be made in other sectors, where they are cheaper to make. Imagine that the international transport sector implemented a global emissions trading scheme in which the right to emit one ton of CO_2 over a certain threshold traded at $30. Analysis published in 2013 and led by Annela Anger, then at the University of Cambridge, suggested that under such conditions, net emissions from international transport would be 40% lower than they would otherwise have been. Only about 2% of this drop would come from reduced emissions in the sector itself. For the rest, airlines and ship operators would buy credits generated by the Clean Development Mechanism, developed under the Kyoto Protocol, which allows a country with an emission-reduction or emission-limitation commitment to purchase certified emission-reduction credits from developing countries. Because these purchases would produce benefits in developing countries, the net impact on global economic output would be slightly positive.

The impact of an emissions fee on airfares is likely to be small. Given that demand for international air travel is relatively insensitive to price, it is unlikely to restrict the movement of people. The cost would primarily be borne by those who are already wealthy enough to fly. This could make it palatable to developing countries, which have argued that taking on costly obligations to reduce the environmental impact of their growth would hurt their poorest citizens.

Analysis by the UN Secretary General's Advisory Group on Climate Finance showed that putting a price of $45 on each ton of CO_2 emissions from marine transport would have a minimal impact on the prices of commodities. For low-value commodities such as jute shipped from Bangladesh to Europe, the price would rise by about 2%. For high-value commodities such as coffee, the rise in price would be about 0.2%.

Even the international airline industry, as represented by the International Air Transport Association and others, has expressed support for a global scheme that allows the industry to offset its emissions by buying credits from other sectors.

Transport as test bed

The governing bodies of the ICAO and the IMO (which represent developing and developed countries) and the international transportation industry have all acknowledged the need for a mandatory global mechanism to curtail or offset the growth of planet-warming emissions from the sector. The ICAO and the IMO have long had a joint working group on harmonizing aeronautical and maritime search and rescue. Their responses to the greenhouse gas challenge have so far been developed independently. They should consider a similar group on greenhouse gas emissions, especially given that they already have converged on a similar basket of measures. They are likely to face similar problems in implementing these measures, and each should learn from the other's experiences. For instance, the ICAO has published details of how different types of market-based mechanisms might work in the aviation sector, and the IMO could use these as a template for its own proposal. The IMO's experience of implementing an efficiency standard for new ships could usefully inform the ICAO's fledgling efforts to devise and roll out a similar benchmark.

Even though the impact on the global economy of attaching a price to the CO2 emitted by international transport is likely to be small, it could still be painful for some small countries, such as those whose economies rely heavily on international tourism. These countries might ask for exemptions from any global scheme, but excluding them would reduce efficiency and effectiveness. Indeed, if airlines or shipping lines routed journeys through countries that were exempt, total emissions could rise.

Auctioning credits or applying a fee to international sales of fuel oil for ships, called bunker fuel, could generate revenues for the Green Climate Fund that was proposed at the Cancun Climate Change Conference. This fund could compensate countries whose economies are disproportionately hurt, thus providing an economically efficient way to reconcile the principle of common but differentiated responsibilities with that of nondiscrimination.

Efforts to get an economy-wide, global deal on reducing greenhouse gas emissions have so far been frustrated. The IMO and ICAO have produced solutions to environmental problems such as acid rain–producing emissions from ships and noise from aircraft. All of their members have agreed to implement these solutions. International transport is an activity that clearly operates in the global commons, and where it is understood that some pooling of national sovereignty is essential.

The sector is small enough that it could buy offsets from existing sources of carbon credits, such as the Clean Development Mechanism, and that the impact on the global economy of taxing pollution from it would be small. And yet, implementation of such a policy would require policymakers to address all of the problems associated with an economy-wide solution: monitoring emissions, ensuring near-universal participation, and compensating countries that are hardest hit, as well as generating and recycling revenues for climate change mitigation and adaptation.

In addressing the specific problem of emissions from international transportation, policymakers have a test bed suitable for pioneering and evaluating innovative strategies and institutions to solve more general problems in the collective control of global climate change. This opportunity should not be squandered.

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The doctrine of materialism, dating back to the ancient Greeks and Chinese and providing background for Descartes and Marx, argues that all phenomena found in nature can be explained by causal material factors. Because materialism is assumed to apply to all observed phenomena, it is also assumed that materialism can be applied to explain the behavior of life and systems of living things. This assumption forms a basis for the study of animal and human biology, as well as the study of ecological and social systems.

Is this so? Are life and living systems amenable to materialist explanations? Are such explanations poorly understood or are they fundamentally elusive? Does life exhibit the regularity that allows for the application of mathematics? Does the reduction of living systems to enable more precise mathematical treatment oversimplify them to the point of rendering them untrue to what they are? At some granular level, might life and living systems rely on the events occurring within an irreducible decision box that remains unpredictable?

Unlike in the physical sciences, description, more than explanation, continues to occupy most life scientists. Better description of ailments constituted much of medical practice until the beginning of the 20th century. A history of disciplined observation of the regularities found in living systems has yielded great insights (such as the germ theory of disease and immunization through vaccination) and delivered enormous health benefits in terms of increased longevity and prevented suffering. The advent of better diagnostics that enable more precise (and even dynamic) description of biological parameters continues to improve the delivery of health services to patients. Long-term statistical studies benefit large populations. Nonetheless, for the individual patient, the ability to associate symptoms with physiological mechanisms and predict health outcomes suffers because of the small sample size.

Because protecting and promoting human life remains fundamental to human society, medicine is always necessary whether or not it derives from a complete understanding of how the human body works. The patient is sick and must be treated. Honest practitioners will say, though, that despite the advanced diagnostics, a partial understanding of very basic mechanisms of how the human body works continues to be the case. Drugs that have the effect of aggravating cardiovascular problems for the same reason they are effective in reducing joint inflammation offer a case in point.

Although some proponents argue that DNA analysis will offer personal “customizeability” in future health care, the knowledge of sequence has yet to lead directly to knowledge of outcomes. The structure of the DNA molecule is known, but the syntax (and thus the meaning) of the genetic code remains mysterious. The structure itself is not deterministic. The weakness in the current knowledge of the mechanisms leading to disease is also evident at the level of organisms and their habitat, as science remains far from achieving a definitive characterization of the pathways and toxicology of the brew of synthetic chemicals that cloak the environment. In practice, the material chain of events leading to the diagnosis, treatment, and outcome of a human patient will remain uncertain. Statistical data and physiology and patient behavior, as well as physician patience and judgment, all contribute to treatment decisions. The ability to generate predictions based on statistical analyses worsens in moving from simple organisms to more complicated systems. Science can describe microbes better than it can describe adolescent girls, and describe girls better than the functioning of a modern city. Applying materialism to human social activity requires identifying parameters to measure and using those measurements to predict. Measuring the data and trusting that it can be used to predict the future responds to very practical needs. The fact that rational frameworks can be applied to describe human societies appeals to bureaucrats, businesspeople, and scientists alike. Mathematical models remove bias. The abstraction provided allows for nonideological decisionmaking.

Models as justifiers

Government bureaucrats, seeking objective explanations to justify expenditures, encourage the use of statistical models to describe the processes at work in societies. Based on model results, scientific rigor is invoked, as is the claim to objectivity, when determining how to direct public resources. Commerce itself of course benefits handsomely from the predictability of a reliable, mechanistic world. When Cornelius Vanderbilt offered regularly scheduled ship and rail service, commerce followed. Both bureaucrats and businesspeople rely on an orderly world where society operates according to rules. Mechanistic models offer an ideal, despite their lack of any consistent ability to predict.

Arguably, the scientific enterprise betrays an innate preference for systems that exhibit regularity most of all. That regularity gives meaning to a scientific description of reality that relies on the existence of fixed relationships between variables. The need for regularity may even undermine objectivity. For example, breeding strains of laboratory mice with rapid reproductive cycles may expedite orderly data generation, but it may also introduce bias into the subject population that becomes embedded in the analysis. Only by assuming regularity can sociologists and ecologists isolate single variables and attempt to describe their effect on a society or ecosystem.

What harm could come from the expectation that all features of life and living systems can be counted and understood? How would society benefit from revisiting the suitability of so strictly applying materialism to predict outcomes for life and living systems? Despite the flaws of the materialist approach, does it not ensure the greatest amount of objectivity? Does it not provide the most benefit to the largest number of people? Why should society question a strictly materialist model of life for social decisionmaking?

Blind adherence to the materialist idea that today's best mathematical models should always provide the basis for social policy poses several problems. New biases are introduced, or perpetuated, by relying too heavily on materialist approaches. As computers become more powerful, society may be limited to considering variables that can be captured or counted (i.e., digitized or "datafied") so that they can be modeled mathematically. The drive to digitize all information can force crude approximations of the factors that influence life and living systems. Modern society winds up restricting its interests to data suited to the binary format of current digital computers.

Many human factors may lie outside that format. For example, the quest for greater efficiency will move health care even more toward an exercise in matching diagnostic codes and treatment codes. These codes already drive the system more than responding to its needs. Code-matching naturally follows as the best response in a world where it is possible to handle essentially unlimited amounts of data. Once the framework is established, data definitions become entrenched. Subsequent policy evolution locks in early decisions about what codes to use, what data fields to populate, and what budget factors to consider in conducting cost/benefit analyses. Legacy data definitions drive the governmental and industrial responses, limiting the future range of possible actions.

Unspoken assumptions

When formulating broader social policy, unspoken assumptions abound regarding what constitutes the "greater good." Here, too, the desired objectives, and the means to reach them, will favor measureable data. The data can be used to advance any number of policy agendas that may objectively reflect the interest of their proponents but remain partial. The drive to quantification favors economic analysis and the necessary valuation of public goods. Conveniently, dollars offer an eminently measurable variable, a common convertible currency that captures the value of livelihoods and lives, playgrounds and prisons, and all things of value to society. Using economic models, the policies of the 1950s and 1960s that presaged civic decline and suburban sprawl offered the most promising solutions to the social engineers and business interests that promoted them at the time.

The materialist approach influences not only how the United States sees itself, but how it sees other societies as well. The notion that aggregate wealth offers the best proxy for measuring social progress is not universal. Other cultures may aspire to a more equitable wealth distribution, greater national prominence, recognized technological prowess, or the exalted glory of God. These social goals remain important to societies around the globe and influence national-level decisionmaking in much of the world. The successes of neoliberalism notwithstanding, seeing the world through a strictly materialist lens may systematically underestimate the importance of the religious and cultural forces that motivate societies.

Perhaps the most troubling consequence of considering the best current modeling efforts as constituting the definitive materialist approach (that is, the rational understanding) is that the tail wags the dog more and more. In a digital age, model results are used to set priorities, and social goals that may hide what is in plain sight. The overwhelming attention to the modeling of climate change serves to diminish the attention paid to other, equal and even greater, environmental concerns such as municipal water systems, childhood disease, and urban air pollution, as well as social concerns such as public safety.

Things easily modeled receive the most attention in the social sphere whether they convey or obscure the relevant scientific parameters. Climate offers a clear case of modeling exercises used to advance political agendas by choosing which data to focus on and how to tweak the (literally) hundreds of parameters in any given model. Whether by design or default, the model tends to vindicate the modeler; for instance, the modeler that selects which natural mechanisms to include and which to neglect when modeling the annual global flux of carbon. Models, and policies to be based on them, ignore the consequences of climate change mitigation strategies, such as costly regressive electricity rates that force even middle-class people to scavenge the forest for fuel, or the benefits of global carbon fertilization. What becomes obscured is the fact that a self-consistent description useful for numerical modeling may not faithfully represent reality, whether physical or social.

Models offer an abstraction, a common basis for dialogue. For example, global initiatives such as the ongoing international activity beginning with the Earth Summit in Rio de Janeiro in 1992 were inspired by and continue to derive their relevance from model results. In trying to describe social and environmental problems, much effort is expended in modeling global inequity or evidence of environmental crisis. The effects of changing consumer attitudes that drive rising living standards and regional political realities such as war and lawlessness typically do not find their way into the analysis. Still, a vast enterprise continues to operate under the assumption that model refinement will always lead to greater accuracy in describing socially dependent natural phenomenon and that such accuracy will lead to better remedies for problems. Such expectations derive from the fact that materialist assumptions go unchallenged.

Adding needed perspective

What can be done? Given the pervasiveness and attractiveness of materialism and its centrality to Western thought, no simple list of policy recommendations can correct for its undue influence. Several steps in how the nation and society treat the results of strictly mathematical descriptions of social phenomena may help put things in better proportion from the public perspective.

One step would be to demand greater transparency in models used as evidence to formulate social policy. Transparency in the assumptions and limits of validity for studies involving large complicated systems would offer government and society a better understanding of the instances where quantitative analysis is and is not appropriate. Such stipulations might be alien not only to those who use models to justify their political agenda, but to scientists trying their best to create self-consistent digital versions of observed phenomena. Such transparency would expose the latent bias and the poor understanding of mechanism manifest in many mathematical descriptions of living (and nonliving) systems. Nature can never be proved wrong, but the errors of those who claim to understand it are legendary.

A further step involves actively incorporating ground-truthing from practitioners, not only from experts, when investigating the effects of proposed changes in public policy. Those with the common sense that is born of experience (such as patient caregivers, field scientists, engineers, and local officials) should be allowed to reclaim a stronger voice in public decisionmaking. Using protocols that treat expert analysis or computer simulations as sacrosanct in all cases should be reexamined.

As in the case for life and living systems, at the thermodynamic ensemble level, the description of physical systems also relies on statistics. The main difference between living and nonliving systems is that in nonliving systems, the units lack volition (i.e., will), a property found in the units that make up living systems. The debate is old, and the contention here is that despite their regularities, humans and human societies make choices. They are choices because they can, and do, defy prediction, even if the choices may seem inevitable, or at least explainable, in hindsight. Should life be modeled to the point of deliberately ridding it of the very drama that makes it dear? Stripping life of its serendipity to fit a model may not only be an assault on the soul; it may simply substitute one type of bias for another.

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