TRANSPORT, ENVIRONMENT AND INSTITUTIONS: WHY GOOD SCIENCE, ENGINEERING AND ECONOMICS FAIL

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ABSTRACT: Transport is a derived demand: that is, the use of transport is determined by economic and social forces external to transport. Demand for transport is related to costs, including labor, investment and energy, and to service quality (frequency, speed, reliability). Energy use in transport (the prime determinant of Greenhouse Gas (GHG) emissions) is often only a minor percentage of total costs, so market forces alone often do not act to minimize GHG emissions. In addition, transport has social impacts, including air pollution, energy security, noise, human safety and traffic congestion, *inter alia*, few of which are effectively controlled by market forces. Finally, major suppliers and consumers of transport services are often publicly owned, which can act to insulate them from the normal incentives for either efficient or socially responsible behavior. Governments have responded to the need for better linkage between transport networks and their social impacts with a mixture of changes of institutional structure, ownership, and regulation.

This paper discusses examples in which institutional shortcomings in developing (and sometimes developed) countries have acted to weaken or even defeat the implementation of scientific or engineering advances and outlines some cases in which changes have worked, with emphasis on the need to reach the right balance of science, technology, economics and public policy. The paper concludes that global warming is neither understood nor accepted by a significant portion of the world's population and that implementation of GHG control programs will be difficult and at best severely hindered because of institutional weaknesses. The paper urges an intensive effort by scientists to explain GHG issues in terms that ordinary citizens can accept and support.

KEYWORDS: Corruption Indices, Implementation, Megaprojects

1. INTRODUCTION

In evaluating the effect of changes in transport operations and technology on the GHG emissions from transport carriers, it is critical to emphasize that transport is a "derived demand." That is, neither people nor goods typically consume transport merely to sit on a train or truck; instead, transport is primarily a means for moving people and goods from one point to another. Thus, transport actually exists to serve more fundamental needs that are driven by decisions related to broader economic or social activity.[1] Choices about transport are generally made on the basis of economic benefit to the user; to the extent that non-economic benefits or costs influence modal choice, they must be introduced through forces outside transport markets, *per se*.

2. ECONOMIC BENEFITS

In meeting underlying economic requirements, each mode of transport has a specific set of characteristics that are usually summarized by: trip or shipment time from origin to destination; perceived total cost of the trip or movement, including fares or tariffs and insurance and allowing for public subsidy; the frequency and convenience of departures; on-time reliability and safety of the trip or movement; and, access and egress times for the trip or movement. To these general characteristics might be added a number of more detailed influences such as perceived

[1] Some travelers do enjoy the "view out the window," and certain kinds of Dutch Gin (Oude Genever) are put on ships for purposes of ageing, but these exceptions serve to prove the rule.

comfort, minimum shipment size, personal security, etc, depending on the person or commodity involved.

All forms of transport are subject to market-based tradeoffs among these characteristics. Railway freight transport is always cheap, but is usually slow and requires large minimum shipment size. Rail freight is also relatively unreliable and often infrequent. Airlines are usually the fastest way to travel long distances but are increasingly subject to slow airport access, unpredictable security delays and unreliable takeoff and departure times. Discount airlines offer very basic transport, but often do not serve convenient airports, and frequently impose high charges for all but the most basic services. The airline "majors" may offer higher frequency from large airports, but charge more and are increasingly adding annoying "extras" that jack up the total cost. Urban passengers often use slightly different modes (bus and rail transit), but the fundamental choice determinants are the same.

These modal choice tradeoffs never involve CO_2 (or other GHGs) directly: that is, neither shippers nor travelers consider CO_2 or other emissions explicitly in making modal choices. There is never an entry on the ticket or shipping document that includes kilos of CO_2 emitted[2], nor is there a direct way that emissions can be traded against other qualities such as cost and frequency.

The most direct way in which CO_2 emissions enter the transport market calculation is through the cost of the energy consumed.[3] In practice, though, energy costs may not be a significant factor in total cost and thus changes in energy cost may not have much of an effect on tariffs or fares. Table 1 shows that energy (fuel) costs as a percent of total operating costs range between 7 and 30 percent. Other costs, especially labor and depreciation, loom much larger. In one sense, this table shows that carriers might well decide to increase energy costs (and GHG emissions) in order to reduce other operating costs: vehicle operating speed might be a good example. In another sense, the table underlines the fact that measures aimed at reducing CO_2 emissions though (for example) taxes on fuel might not have the full effect expected: taxes might have to be quite high before causing any significant change in fuel use. In summary, market forces acting through transport fuel costs (even as affected by taxes or emissions permit costs) alone might not have a significant impact on transport demand or modal choice.

3. NON-MARKET ASPECTS OF TRANSPORT

Transport has many non-market attributes that we recognize, but find hard to quantify. Consumption of fossil fuel or other hydrocarbon energy, aside from its direct costs, emits CO_2. Transport operations also generate air "pollutants," including Carbon Monoxide (CO), Oxides of Sulfur (SO_x), Oxides of Nitrogen (NO_x), unburned hydrocarbons (HC) and particulate matter (PM). Many parts of transport networks are congested during peak usage times, imposing trip time costs on all users. Transport systems emit noise and are often unsightly. Transport can improve access to jobs, with particular import for the poor who would otherwise have fewer employment options. Urban form and density (and productivity) are governed by the transport options available: some countries may lose as much as three percent of national GDP as a result of congestion in major cities. Highway accidents are one of the major national public health problems in many countries. The difficulty is that, when market forces are not available to influence behavior, then they must be incorporated through the political and policy processes – and that has proven difficult, especially in the case of GHGs.

There are a number of reasons why the political process finds the complex, non-market benefits difficult to manage. The result is that, experts often have a very different and more detailed understanding of complex issues – and understanding that is usually not shared by politicians or the public at large.

To some extent this is caused by the sheer problem of availability and complexity of the information involved. Even interested laypersons find it difficult to get access to the large databases

[2] It is an interesting speculation whether a requirement that each transport ticket or document contain an estimate of the GHGs emitted by the trip or shipment – similar to statements of nutritional content (or absence thereof) in restaurants – would have any impact.

[3] As discussed later, this assumes that the transport provider actually faces the market cost of energy – an assumption that is generally invalid. See Figure 1.

on which much of the modern understanding of global warming is based. In addition, many databases are either not open to the public or are only usable by professionals with specialized expertise in the hardware and software involved. It is encouraging that the web is rapidly expanding information availability and access, but large gaps will always remain between what experts know and the public does not.

This is compounded by the fact that science becomes ever more specialized. It is in fact unlikely if any one scientific discipline qualifies a professional to understand all of the sources of information or analysis involved in analyzing the GHG problem. The public and politicians are inevitably left far behind.

In fact, the real problem may be deeper than a gap in expertise or information; instead, it deals with the way in which problems and facts are understood. "The public perception of scientific ideas depends largely on two factors: people's ability to grasp factual information and the **cultural lens through which that information is filtered**."[4] [emphasis added].

The seriousness of this issue can be seen by one example – the degree to which the public rejects the Theory of Evolution, one of the most thoroughly researched and "proven" sets of knowledge that science has to offer. Table 2 shows the percentage of people in different countries that share the belief that humans evolved (over any time frame) from an earlier life form. For example, Table 2 shows that 45 percent of the US population believes that evolution did NOT occur – that is, they believe in creationism, which is the religious dogma that the earth and all its inhabitants were created in a relatively recent time frame (thousands of years). Though the US appears to be extreme in this regard (only Turkey has a higher percentage of creationists on the chart), the 20 to 25 percent creationist range typical of many EU countries points to a significant percentage of the population that must, by this measure, be unreachable by scientific reasoning and evidence. Polling on this topic has not been done in other countries, but it seems likely that similarly (or higher) results would emerge since the sample in Table 2 contains many of the wealthier and better educated people in the world. In democracies where a committed minority can slow or even halt legislation on a contested measure, 20 to 35 percent can be a major roadblock.

One could validly question whether the Theory of Evolution is an atypical flash point on the boundary between faith and reason. Perhaps global warming, not having historical associations with the religious aversion to Charles Darwin, would be different. Table 3 shows that it is not distinct. About 30 percent of US White Evangelical Protestants reject the idea that global warming is happening **at all** (for whatever reason, anthropogenic or otherwise), in stark contrast to the beliefs of those with no religious affiliation. Perhaps more significant, less than half of religiously affiliated people in the US believe that **anthropogenic** warming is happening. The effect of the "cultural lens" of religion (US Christianity, at least) could hardly be clearer, and it is not promoting a response to global warming.

This is not, of course, to suggest that religion is the only lens that is filtering perceptions. There are significant gaps in perception as a function of degree of education and income level, with concern for global warming growing with increasing income and education, although the correlation clearly suffers from multicolinearity among education, religion and economic status.

A good example is the fact that agreement with the statement that "[t]here is solid evidence that the earth is warming" actually **fell** in the US between April of 2008 and October of 2009. While the scientific evidence actually grew stronger during this period, the economic crisis and the Presidential election focused the attention of the electorate on economic and partisan political issues. Sadly, the issue of global warming has become a partisan political issue in the US, with Republicans generally arguing either that warming is not happening or that doing anything about it would be too costly. The recent, overblown scandal of stolen email correspondence at The Climatic Research Unit at the University of East Anglia[5] gives further evidence of cultural (and political) lenses at work.

Another example of an issue where the cultural lens is critical is the gap in attitudes between

[4] *Nature*, pg 1173, 29 October 2009.

[5] Nature, pg 545, 3 December 2009

developing and developed countries. However productive (or not) it might be to frame the issue in "fault" terms and to argue that the only "fair" solution is to aim for equal emissions per capita, it is also clear that the largest single emitter is now a developing country (China) and India may not be far behind in absolute terms. In this case, even if global warming is accepted, cultural perceptions as to the cause and "fair" solutions will hinder a resolution.

Whatever the perceptual lenses, there are three critical points that scientists, engineers and economists need to focus on: 1) the consensus that is needed to bring about effective policies in the major democracies to deal with GHGs simply does not yet exist, especially in the largest economy and second largest emitter (the US), but probably elsewhere as well; 2) reaching consensus in a wide variety of developing and developed countries will probably take place on grounds that are only partially scientific or engineering or economic; and, 3) the challenge for the academic community is more effective communication of quantitative information and conclusions that will inform politics, notably when a large (usually a majority) of the audience is neither qualified nor necessarily inclined to accept a merely fact-based argument.

4. THE CHALLENGE OF IMPLEMENTATION

Effective management of the threat of global warming will clearly involve reasonably proficient implementation of the largest, most sophisticated and most expensive set of coordinated policies and investment projects ever undertaken on a worldwide scale. Given the policy "noise" that currently exists, and the incentives for poor execution that actually exist, is it reasonable to plan for success; or, in the alternative, is there a way to frame our programs to minimize the predictable problems?

4.1. Policy Noise

Economists often argue (on impeccable theoretical grounds) that price signals are the answer to efficient implementation of carbon emission management programs. The problem, at least in the transport arena, is that nations have such widely varying tax regimes for transport fuels that any reasonable price signal will lost in the fiscal noise. Figure 1 shows the range of policies in force for setting domestic prices (US cents/litre) of gasoline and diesel fuels. This figure plots the November 2008 diesel price (vertical axis) against the gasoline price (horizontal axis) in 152 countries for which the German Technical Cooperation Agency (GTZ) collects fuel prices.[6] Each point thus reflects a paired set of diesel and gasoline prices in a particular country as of November 2008.

The price for crude oil on the world markets at the time of the data collection was roughly the equivalent of 30 US cents per liter for diesel and for gasoline. Any gasoline price to the left of the vertical dashed line, or below the horizontal dashed line is below the related world price and is therefore defined as "highly subsidized" by GTZ. There are seven countries, mostly oil producers (including Iran and Venezuela) in which the price of **both** diesel and gasoline is below the world price. Any gasoline prices to the right of the solid vertical line or diesel prices above the horizontal solid line are considered by GTZ to be "highly taxed." There are 39 countries in which **both** gasoline and diesel fuel are highly taxed (most of the EU countries fall in this category).

Fuel prices in the US (56 cents/liter for gasoline and 78 cents/liter for diesel – the point is circled in Figure 1) are considered by GTZ to be "the international minimum benchmark for a non-subsidized road transport policy." That is, in broad terms, US prices reflect the world price plus a normal industry margin and taxes adequate to pay for the road system in total. By this GTZ definition (which can of course be debated) transport fuel prices begin to be subsidized when the price falls below that in the US, and they begin to be more and more highly taxed (above transport system costs) when they rise above the US levels.

As Figure 1 shows, gasoline prices range from 7 US cents/liter to 195 US cents/liter, and diesel prices range from 1 US cent/liter to over 170 US cents/liter. The ratio of the price of gasoline to the price of diesel (in the same country) ranges from 50 percent to 700 percent. If we accept that the absolute price of gasoline should be in the range of 56 cents/liter and diesel should be 78 cents/liter, then the impact of national tax policies

[6] GTZ 2008

having nothing to do with transport costs or social impacts becomes rather stark. In addition, if we accept that the ratio of the price of gasoline to the price of diesel should be in rough proportion to their energy content (about 90 percent), then the impact of different tax policies for gasoline as compared with diesel (i.e. assigning the burden on autos as compared with trucks or vice versa) also becomes clear.

Most important, a US$10.00 tax per tonne of carbon content would yield a tax per liter of fuel of slightly less than 10 US cents/liter. Even a carbon tax of US$40.00/tonne (~40 US cents/liter of fuel), which has been discussed as a place to start with carbon taxes, would be lost in the noise caused by national revenue policies having little to do with GHGs or even transport costs. In other words, many countries have effectively already imposed a carbon tax that is well above the level needed to create appropriate GHG incentives. Put another way, a carbon tax in the range of US$40/tonne so far proposed will not have as significant an impact on transport as it will have in other sectors, such as coal-fired electric power generation.

4.2. Management Capacity and Incentives

As suggested above, implementation of all of the required carbon reduction measures will involve a coordinated effort that, in many ways, will be larger and more difficult than the world has seen before. The term “mega-project" has been used to define an effort which, because of a combination of sheer size, location and identity of its management, and impact on social objectives, assumes a character far broader than the normal engineering project.[7] Given the character of the GHG control effort, perhaps we even need to invent a new term, “giga-project,” to describe what lies ahead.

The question this poses is whether we have any right to expect (or hope) that the investment, management and policy coordination challenges involved will be met at anything like the cost and timing that is currently planned. Will “everything go right,” or might there be bumps along the road?

There is, unfortunately, little reason to be optimistic. Large public sector initiatives seem inherently to be subject to over-optimism on cost, schedule and performance. Whether this is due to normal political exuberance or something a little darker, the typical unfavorable experience with large public transport projects is shown in Table 4.[8] It deserves emphasis also that, by comparison with transport, planned GHG projects are often based on less proven technology and on more limited operating experience. In addition, most of the transport projects in Table 4 were in a single country where multi-jurisdictional coordination was, in principle, not as serious as a multi-country context.[9] While many of the individual investments in GHG control will be in a single country, international policy development, coordination and implementation will almost always include a large number of countries, which will inevitably complicate the task. The projects in Table 4 were also conducted in developed countries where human and financial resources were adequate to the task: this is not often going to be the case with GHG control programs in developing countries (where much of the work will eventually be done).

4.3. Corruption

Developers of large, multinational programs and drafters of treaties often make the comforting assumption that the governments of the countries involved have two characteristics: 1) they are actually motivated to act in the interest of their citizens; and 2) they are capable of implementing the measures they are committed to by agreement or treaty. Pervasively corrupt governments will not meet either test very well.

Is this a serious concern? Corruption is a very uncomfortable subject that international institutions have long found difficult to discuss. Unfortunately, it will be difficult to ignore the issue in looking ahead to the implementation of a many-year program, especially if there is a transfer of wealth from developed to developing countries or if, as is planned, carbon offsets paid by developed countries are to be implemented and

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[7] See, e.g., Thompson 1982, and Flyvbjerg 2003.

[8] Flyvbjerg, 2003 contains a detailed analysis of the performance of transport mega-projects and the reasons why expectations are not usually met.

[9] The policy and financial coordination problems on the Channel Tunnel project illustrate how multiple jurisdictional disputes can further complicate a mega-project.

enforced in developing countries, especially when implemented by government agencies or state-owned enterprises..

Transparency International compiles annually a corruption perception index based on interviews and responses from individuals and companies doing business in 177 countries.[10] The corruption index could range from 1.0 (utterly corrupt – government officials essentially use their office wholly for private gain) to 10.0 (totally honest – officials carry out their duties entirely in accord with rules and laws and do not attempt to benefit personally from the exercise of public authority). Table 5 shows the corruption indices for a sample of countries.

Table 5 confirms some expectations. The Scandinavian countries enjoy exceptionally honest and effective governments, as do Canada, Austria, Australia, The Netherlands, Switzerland and New Zealand: we would have confidence that these countries would act in the interest of their citizens and that they would be able to implement their obligations. Iraq and Afghanistan suffer from the most corrupt regimes, and we would realistically have to discount expectations as to their willingness and ability to live up to obligations where any significant economic sacrifice or program complexity is involved.

Obviously the measurement of the corruption index has a significant qualitative component and the reported value of each index is subject to a range of error. Moreover, the shadings are gradual. It would be difficult to say exactly when the obvious confidence that a 9.3 rating inspires must be replaced with the pessimism that a rating of 1.3 or 1.5 would require. For example, by experience one would expect countries with the 6.9 to 7.3 indices of France, Belgium, Japan and the US to be within the range of acceptable performance. Similarly, experience might suggest as well that ratings below 5.0 would justify caution, and ratings below 4.0 could indicate a real question about the motivation and/or capabilities of governments, their officials and public enterprise managers in the countries involved.

[10] The entire data set is available at Transparency International 2009.

Figure 2 looks at the issue from a more global point of view. Figure 2 shows the cumulative percentage of four variables (Gross National Income (GNI) at official exchange rates, GNI adjusted for Purchasing Power Parity, tonnes of CO_2 emitted, and population that are found at or below various corruption indices. For example, around 80 percent of the world's population lives in countries with corruption indices of 4.0 or below. More significant, about half of the world's CO_2 is emitted by countries (notably Russia, India and China) where the corruption index is 4.0 or below.

Yes, the question is serious and is likely to pose serious challenges as soon as GHG programs move beyond treaty signing and into actual implementation.

4.4. How to respond?

To some extent, this paper is an unavoidable counsel of despair. Many years of personal experience with governments and public enterprises in developed and developing countries leads me to the conclusion that "optimism in objectives, pessimism in plans" would be a good idea. It seems clear that the easier (but still difficult and not yet achieved) part of GHG control will be the development of appropriate policies and technology and getting reasonable international agreement on them. The really hard part will be implementation. With this said, there do seem to be a number of points that scientists, engineers and economists should be considering:

- Shape the message to the real audience and repeat it consistently. The scientific community simply can no longer talk down to those who, by different faith or culture, look at life differently. The scientific message must be shaped to transcend the critical cultural and educational barriers to understanding. A 2009 study by the Center for Research on Environmental Decisions contains an excellent discussion of the psychology of understanding and communication a better understanding of climate change issues.
- Align science and engineering with economics or, at least, ensure that economic incentives do not undermine science and engineering objectives. This will be particularly true with regulations that, for

whatever reasons, are in conflict with clear price signals (for example, regulations requiring better fuel economy in combination with politically imposed cheap fuels – see Figure 1).

- Keep solutions, programs and investments simple, especially in corrupt environments. Complexity is the enemy, and that which is not transparent usually evaporates. This would, for example, argue strongly for carbon taxes and against trading regimes or carbon offsets where the additionality or implementation of the offset is questionable, or where enforcement is critical.

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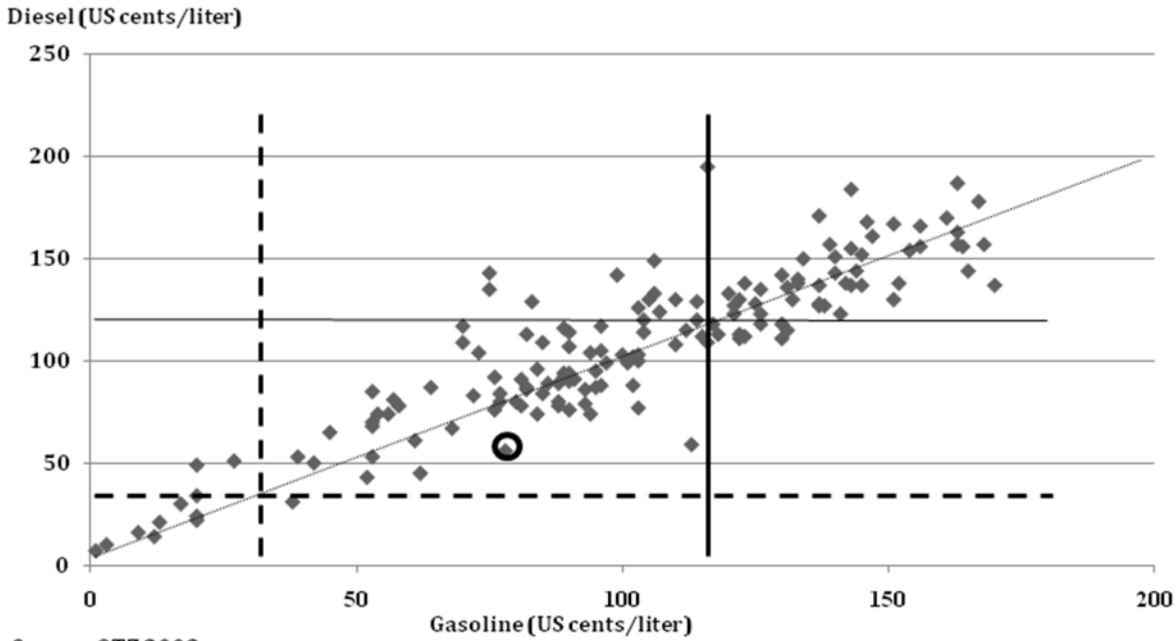
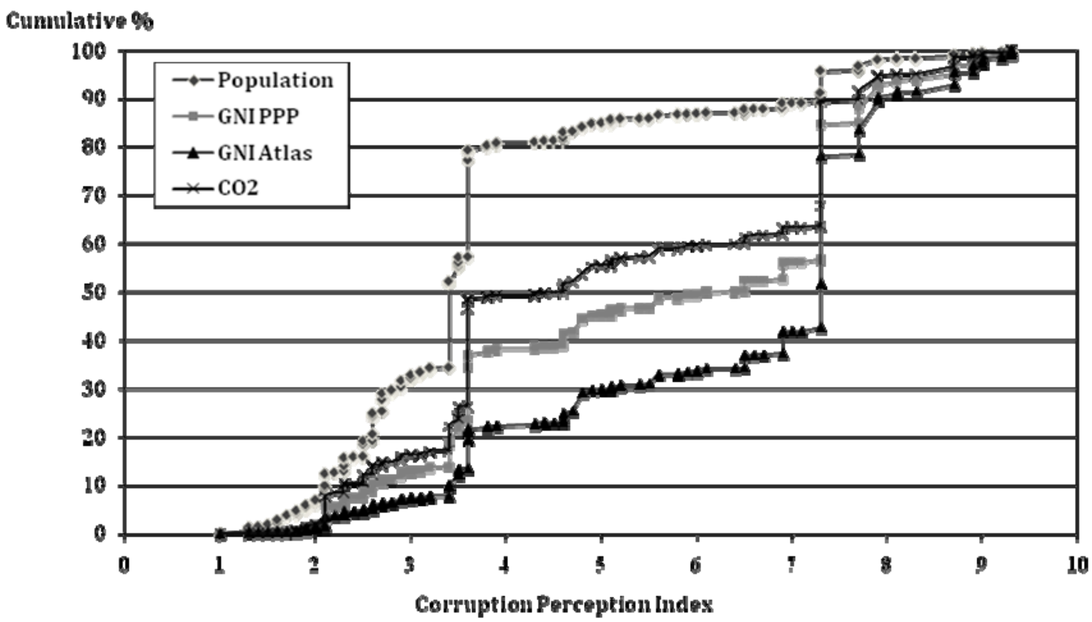
Figure 1
Fuel Price Variations: The Impact of Tax Policy (November 2008)



Source: GTZ 2008

Figure 2
Cumulative Percent of Population, PPP GNI, Atlas Method GNI and CO2 Emissions versus Corruption Perception Index



Note: 1 is totally corrupt, 10 would be completely non-corrupt

Corruption Index from Transparency International 2008, economic data from World Bank World Development Indicators

Discontinuities in order of increasing Corruption Perception Index: Russia, India, China, US

Table 1
The Percent of Total Cost
That Energy Use Represents

Freight

Truck (YRC Worldwide)	13
Rail	20

Passenger

Auto*	11-20
Rail (Amtrak)	19
Bus	9
Commuter Rail	9
Heavy rail	7
Air (SWA)	30

*Ownership costs only

Source: Author's calculations, based on APTA 2009, STB various years, 2008 Annual Reports of YRC Worldwide and Southwest Airlines.

Table 2
Belief that humans evolved from earlier species
(over any time frame)

	Yes	No	No Opinion
US Scientists	95	5	0
Iceland	85	7	8
Australia	72	11	17
France	80	12	8
Denmark	83	13	4
Sweden	82	13	5
Britain	79	13	8
Spain	73	16	11
Norway*	74	18	8
Estonia	64	19	17
Italy	69	20	11
Belgium	74	21	5
Ireland	67	21	12
Hungary	67	21	12
Portugal	64	21	15
Bulgaria	50	21	29
Canada	58	22	20
Germany	69	23	8
Luxembourg	68	23	9
Netherlands	68	23	9
Slovenia	67	25	8
Malta	63	25	12
Romania	55	25	20
Finland	66	27	7
Czech Republic	66	27	7
Poland	59	27	14
Latvia	49	27	24
Switzerland	62	28	10
Croatia	58	28	14
Austria	57	28	15
Slovakia	60	29	11
Lithuania	49	30	21
Greece	55	32	13
Cyprus	46	36	18
US ALL	41	45	14
Turkey	27	51	22

*Separate website source

Source: Gallup 1997, Eurobarometer 2005

Table 3
Linkage Between Religious Belief and Perception of Global Warming in the US 2009

	Anthro-pogenic Warm-ing Exists	No opinion, or warming exists but not anthro-pogenic	There Is No Warm-ing At All
Religiously Unaffiliated	58	24	18
White Mainline Protestant	48	33	19
White non-Hispanic Catholics	44	35	21
Black Protestants	39	47	14
White Evangelical Protestants	33	37	30
US Total	47	33	20

Source: Pew Research, April 16, 2009

Table 4
Cost and Performance Experience for Mega-Projects

Project	Construction Cost Overrun	Initial Traffic as % of Forecast
Humber Bridge, UK	175	25
Channel Tunnel, UK/FR	80	18
Baltimore Metro, US	60	40
Tyne & Wear Metro, UK	55	50
Portland Metro, US	55	45
Buffalo Metro, US	50	30
Miami Metro, US	35	15
Paris Nord TGV, FR	25	25

Source: Flyvbjerg 2003

Table 5
Sample Corruption Indices

Country	**Index**
Iraq	1.3
Afghanistan	1.5
Russian Federation	2.1
Iran, Islamic Rep.	2.3
Pakistan	2.5
Ukraine	2.5
Egypt	2.9
India	3.4
China	3.6
Bulgaria	3.6
Romania	3.8
Poland	4.6
Turkey	4.6
Greece	4.7
Italy	4.8
South Africa	4.9
Hungary	5.1
Czech Republic	5.2
Korea, Rep.	5.6
Israel	6.0
Spain	6.5
Estonia	6.6
France	6.9
Belgium	7.3
Japan	7.3
United States	7.3
United Kingdom	7.7
Germany	7.9
Norway	7.9
Austria	8.1
Australia	8.7
Canada	8.7
Netherlands	8.9
Switzerland	9.0
Denmark	9.3
New Zealand	9.3
Sweden	9.3

Source: Transparency International 2008