Photo: flikr. **Brian Hathcock**

White Paper

How flexible emission fees can drive sustainable development

Stiftelsen Hållbart Samhälle
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January 2011

WHITE PAPER

How Flexible Emissions Fees Can Drive Sustainable Development

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Board members

Stiftelsen Hållbart Samhälle

The Swedish Sustainable Economy Foundation (TSSEF)

January 2011

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About the Foundation

Established in 1995, the Foundation's purpose is to offer systemic approaches and solutions to the challenge of developing society in a sustainable way. The Foundation develops and supports the development of these solutions mainly in the areas of ecology, economy and work. The Foundation takes a non-political, holistic approach to promoting these solutions through research and development, education and spread of information.

The Foundation's view: harness market forces to create a prosperous and pollution-free society

Although large inputs of energy are good for the economy, the damage from emissions and use of natural resources, like water, may create costs far outweighing the benefits of this growth

MARKET FORCES

The Foundation recognizes that market forces represent a powerful, dynamic potential to change that could be harnessed to promote sustainable development.

Emissions will ultimately cost

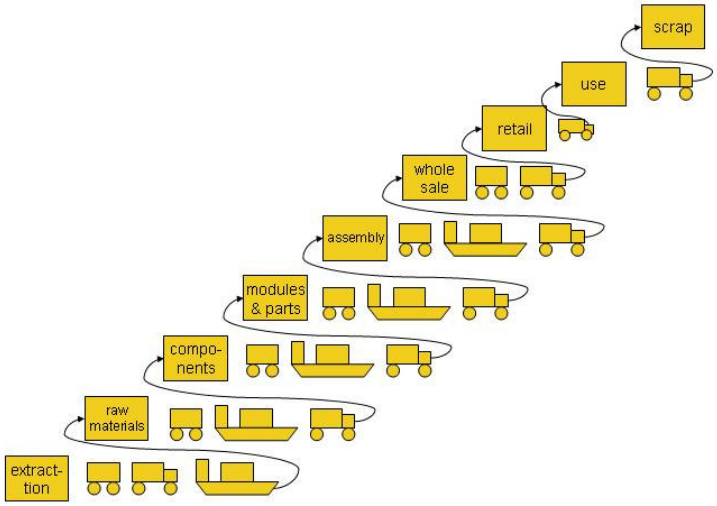
On the other hand, market forces alone do not bring sustainable development and can ultimately present society with huge costs if emissions, for example, are not curbed.

THE PURPOSE OF THIS WHITE PAPER

This paper examines the pricing of emissions and depletion of natural resources. It analyses the interplay between development of supply chains, economic growth and the costs to society of emissions, resource depletion and waste handling. It introduces the subject of emission fees, and the use of market forces to stimulate clean technology (cleantech). Later sections present the Höglund flexible emissions fee mechanism as a way of stimulating development of cleantech, using the principles of dynamic control Höglund developed for diesel engines, among others.

For readers seeking more advanced knowledge the paper provides footnotes, references and sections offering deeper analysis.

GLOBAL SUPPLY CHAINS BRING US ALL KINDS OF GOODS – AND TIE US INTO DEPENDENCY ON FINITE MATERIALS



SUPPLY CHAINS BRING GOODS AND SERVICES TO MODERN CONSUMER

In striving to reach high levels of organizational effectiveness and efficiency, services come to consumers via long supply chains of interlinked, highly specialized firms. The chain starts with raw materials, like sand, which make up components in, for example, electrical devices which eventually end up in the refuse collection system.

Public and private waste streams represent an additional cost for the product over its lifetime, especially if biological and mineral nutrients are emitted to burden and degrade the environment However, waste streams also represent potential sources of raw materials for new products.

THE ACCUMULATION OF BIOLOGICAL AND MINERAL SUBSTANCES IN SOCIETY

The range of products available today to the average consumer comes at a price to societies and the environment in all segments of the chain. Along the supply chain, emissions flow into natural and societal sinks. In many cases, the substances are in a form that makes them in principle unrecoverable. (For example when metals are in special alloys, or materials are fixed together.)

In other cases, these materials represent a biological burden on ecosystems (e.g the Baltic sea is experiencing algal bloom due to excess nutrient emissions)

As an illustration, the table below shows the massive throughput of materials needed to keep London functioning.

Material throughput of London, UK population circa 7,5 million

Input, millions of tonnes	
Water	1,000
Food	2.4
Fuel	20
Timber	1.2
Plastics	2.1
Metals	1.2
Glass	0.36
Cement	2
Building materials	36
Oxygen	40
Paper	2.2

Source: New Scientist

Output, millions of tonnes	
CO^2	60
Household waste	4
Industrial waste	11.4
SO^2	0.4
NOx	0.28
Sewage	7.5

An example of waste streams pouring massive amounts of potentially useful material into the biosphere is that of accumulation of plastic in the oceans. Reporting in the journal Science[1], researcher Richard Thompson, a senior marine ecology lecturer at the University of Plymouth, says "the action of waves and the elements work to break plastic objects down into fragments tiny enough to be ingested by countless other marine organisms."

He argues that the very life of animals in the sea may be threatened. Apart from releasing potentially dangerous chemicals plastic also absorb toxins. These may then be transported to organisms that eat the plastic."

Such toxic chemicals include PCBs (polychlorinated biphenyls) and DDE (dichlorodiphenyldichloroethylene), which are derived from pesticides and other manmade substances. These agents are known endocrine disruptors—chemicals that interfere with the reproductive, developmental, and immune systems of animals.

Some idea of the scale of this accumulation can be gleaned from how researchers from the Algalita Marine Research Foundation in Long Beach, California, found that the mass of plastic fragments in parts of the central Pacific Ocean is six times greater than that of resident plankton.

LEGAL CONTROL AND ENFORCEMENT LAG BEHIND DEVELOPMENT

Commercial development naturally moves faster than the development of legislation and control. This can lead to situations where the economic realities surrounding a business make it cheaper to, for example, use materials mined in a far off country and shipped to its factory, rather than recovering materials from its already sold and discarded products.

Recycling, repairing and reusing all sound like strategies that would use less energy, be simpler to manage and represent a better solution for society as a whole. In practice, however, firms demonstrate de facto that there is more profit in a linear, energy intensive approach to material handling.

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[1] ***Thompson et al.(2005). New Directions in Plastic Debris Science18 November 2005***
http://www.sciencemag.org

Model T ford 1923. Photo: Biscuit in pursuit, FlickR

Take the example of fuel economy: the 1908 Ford Model T went at 25 miles per gallon. As of 2004, the average fuel economy of cars and trucks was 24.6 miles per gallon[2].

WASTE REPRESENTS A MARKET FAILURE AND IS A SIGN OF INEFFICIENCIES

MARKET FAILURE AND EXTERNALIZATION

In today's complex societies and supply chains, then, costs incurred for the provision of products and services with the extraction, production, supply and disposal of materials are not all born by the firms along the supply chain.

Costs for everything from educating workers, to health care, for roads, railways, and for cleaning up pollution and for refuse disposal are not fully born by the firms. This is called externalization of costs[3]. When society incurs harsh costs for externalization, for example when air pollution causes health care burden, the term "market failure" is used[4].

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[2] See http://www.dailyfueleconomytip.com/miscellaneous/100-years-of-improvement/

[3] The question of the environment is viewed, in the traditional economic framework, as being related to the externalization of costs. That is, market economics assumes that a good which is underpriced, is overconsumed. Externalization of cost, in this view, will be corrected by pricing the overconsumed resources which are being used, for example the work of Lester Thurow and also see Pigovian taxes. Not all economics study accepts this paradigm, and, instead, there is a seven decade old tradition of viewing economic relationships as being based on the scarcity of energy, rather than price, as the central feature of economics.

[4] One definition of market failure is: "A condition that arises when unrestrained operation of markets yields socially undesirable results".

Waste in itself actually represents unused resources and are signs that society is not functioning as efficiently as it could. Waste represents business potential given the right conditions.

The Foundation sees these failures as situations where the context within which the firm operates is not effective in ensuring that market forces preserve the environment or health.

> The failure to effectively internalize harmful externalities in the economic system, pervading almost all aspects of human life, has resulted in an unsustainable lifestyle and a potentially lethal conflict of interests both locally and globally.
>
> **Anders Höglund, TSSEF**

Identifying ways to create a context for market forces to operate within where costs are not externalized must be the major tasks of governments. At the least, it befalls government to do everything in their power to introduce monitoring and control mechanisms to curb externalization as they have no mandate to allow degradation of the nation's ecosystem or depletion of resources human, natural, mineral or otherwise.

FOSTERING DEPENDENCE ON FINITE RESOURCES IS AN UNSUSTAINABLE LONG-TERM STRATEGY FOR SOCIETAL DEVELOPMENT

Many long-term visions of business expansion and development of nations take no account of the availability of essential material. For example: according to a study, titled "Metal Stocks and Sustainability,"[5] all of the copper in ore, plus all of the copper currently in use, would be required to bring the world to the level of the developed nations for power transmission, construction and other services and products that depend on copper. The researchers believe scarce metals, such as platinum, risk depletion in this century because there is no suitable substitute for use in devices such as catalytic converters and hydrogen fuel cells. They also found that, for many metals, the average rate of use per person continues to rise. As a result, the report says, even the more plentiful metals may face similar depletion risks in the future.

There are energy constraints to growth too. To quote sustainable development expert Richard Heinberg;[6] "The most cursory examination of our current energy mix yields the alarming realization that about 85 percent of our current energy is derived from three primary sources–oil, natural gas, and coal–that are non-renewable, whose price is likely to trend higher (and perhaps very steeply higher) in the years ahead, whose EROEI[7] (net energy yieldfor energy used for extraction) is declining, and whose environmental impacts are unacceptable."

Several technological changes we have witnessed over the last decades have been rapid: the spread of mobile phones, the Internet, digital music players. All of these examples are, however, light in terms of materials and energy intensity. Technological infrastructure like transport systems, power generation and waste water purification and handling all take decades to transform. A report sponsored by the United States Government[8], concludes: "The depreciated

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[5] Proc. Natl. Acad, Sci. USA. By Robert Gordon and Thomas Graedel of Yale University and Marlen Bertram of the Organisation of European Aluminum Refiners

[6] http://richardheinberg.com/MuseLetter_203_March_2009.html

[7] Energy Return on Energy Invested. For a deper discussion of the relation of EROEI see the article at http://www.chrismartenson.com/forum/implications-eroei-peak-oil/11020

[8] Peaking Of World Oil Production: Impacts, Mitigation, & Risk Management, Robert L. Hirsch, SAIC, February 2005

value of existing U.S. transportation capital stock is nearly $2 trillion and would normally require 25 – 30 years to replace."

Another report, by the Pacific Institute on behalf of Ceres, [9] finds that water stress is rapidly becoming a key strategic risk to commerce. Several business sectors are at risk, including clothing production, food production, metals and mining and electricity production

Material suppliers, like oil companies and metals and mining, have an economic interest in businesses being dependent on their materials. Their mandate is to maximize profits as long as possible until the asset runs out. Conservation, taking depletion into account and minimizing societal dependency risks are not written into the articles of association that govern these organizations. The formation of legal bodies operating under these tenets is accepted practice, the benefits of the creativity and effectiveness these structures unleash is seen as outweighing their downsides.

Given that businesses cannot be expected to act in the interests of the national economy, and that replacement of existing heavy infrastructure would take a long time, and given the scarcity of metals and impending lack of water, governments would be wise to start to:

- steer their country's economy to be less dependent on finite materials
- ensure the ecosystem can provide water, building material, wood for fuel, etc. in sufficient quantities to supply essential services.

IN A DECLINING ECONOMY, LOSS OF FAITH IN MARKET FORCES WILL BRING DEMANDS FOR SANCTIONS REGARDLESS OF THE PROMISE OF MARKET FORCES.

Thanks partly to the development of modern media, consumers are becoming more aware of how global supply chains work, the conditions of the workers along them and the downsides of the emissions created. Increasingly, opinion is going against the negative sides of these practices and, in the light of the current economic downturn, a negative backlash against the highly paid executives who control these chains.

If banks and large corporations are to retain their credibility and license to continue, consumers and voters need to be assured that mechanisms are in place to ensure that externalization is effectively controlled, and development is moving in a positive direction.

THE ARGUMENT FOR RESTRICTION OF EMISSIONS AND MATERIAL DEPLETION

Restricting emissions and depletion:
- ultimately reduces material supply costs to businesses
- encourages recycling and breaks dependance of the economy on finite resources
- preserves the ability of the environment to provide vital services
- ensures the long term stability of the economy

There are four main arguments the Foundation puts forward for governments to start now to develop restriction mechanisms on emissions and material depletion.

Firstly, that the extraction, refining, transport and processing of materials is

[9] http://www.pacinst.org/reports/business_water_climate/full_report.pdf

cheaper than recycling represents a temporary dysfunction, or market failure. This has come about in part, as civil rights groups make us painfully aware, through social inequalities along the supply chain. As materials continue to deplete and living standards rise, businesses relying on cheap raw materials will be badly hit. As larger industries, like the transport industry, have long replacement cycles, these need to start to adapt in a timely fashion to preserve long-term economic stability.

Secondly, emissions and accumulation of materials create costs and represent unused potential. An economy which uses energy and materials effectively is more competitive than one that takes energy invested in mineral extraction and literally dumps it on a waste heap[10].

Thirdly, as consumers and voters are becoming aware, material accumulation can damage ecosystem services which affects productivity and ultimately slows economic growth.

Finally, restricting material depletion reduces the risk of businesses being forced into dependency on cheap and available materials.

THE ARGUMENT AGAINST MAXIMISATION OF GNP AS PROGRESS YARDSTICK

It has been claimed that emissions fees sufficiently high to galvanize a migration to non-polluting technology would reduce economic growth and create more harm than good. The truth is that every fee in the economy is also a revenue. What determines the real economic result is how the money is used.

It is common in model calculations of the effects of emission fees on the growth of GNP to ignore the fact that the GNP figure does not only include produced benign goods and services but also, to a large fraction, products and activities that are both unwanted and/or directly harmful. Therefore it is a mistake to believe that maximum GNP growth is the most important criterion when ranking different development alternatives.

NEED TO CONTROL EMISSIONS WHILE RETAINING ECONOMIC GROWTH

As illustrated above, Governments have no legal mandate to allow degradation of a nation's resources, yet they have the task of stimulating economic growth short term as well as long term.

Clearly, they need to demonstrate that control mechanisms are in place to curb externalization whilst creating the conditions for economic growth.

Increasing taxes is often called for to require polluters to cease. (This approach is called Pigovian taxation.[11]) However, taxes are traditionally difficult to apply effectively and are seen as an unpopular way to exercise government.

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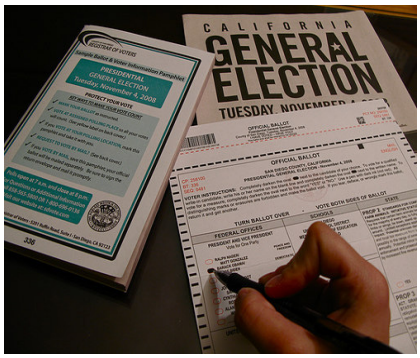
[10] The book "Cradle to Cradle" (see references) argues that extraction and emission need never occur in the future, and econmic growth is dependent on reuse and recycling of resources



Politicians face the question: how can we preserve the environment, reduce waste and be seen to be stimulating economic growth at the same time?

THE PROBLEM WITH REGULATION

Regulation as a strategy can backfire. If it is more profitable to break regulations than to keep them, there will always be a temptation to break the rules. In such a case, regulation will bring with it costs of enforcement and prosecution. If it is profitable to abide by regulations, then the incentive will be to follow the regulations.

Example: CO2 emissions from cars

Reducing the CO2-emissions from new cars, by imposing a maximum allowed level of CO2-emissions measured in grams/km, is not a good idea. In reality it is a textbook example of bad economics due to the fact that the real cost of reducing those CO2-emissions is many times higher than achieving exactly the same emissions reduction by treating all CO2-emissions the same by using one single CO2-fee.

THE PROBLEM WITH EMISSION RIGHTS TRADING

Emission rights trading is the notion that by allowing trade of emission rights, they will become more expensive and thereby encourage less emissions. This system has not demonstrated that it produces a rise in the price of emission permits. In its simplest form, it does not aim at reducing emissions, just the distribution of the rights to emits.[12]

[11] Because the market mechanism fails to factor in the total cost to society, output decisions are flawed, resources are allocated inefficiently, and social welfare is reduced. One method of reducing the effect of this market failure is to impose a tax equal to the amount of the negative externality (or impose a subsidy in the case of a positive externality).

[12] The problem with trading rights can be illustrated with an extreme example. Consider child abuse as the externality to be reduced. Say you allow everybody to strike kids, e.g. 10 times. Since some people do not like hitting kids, or have found other ways to communicate with them, they can sell their 'hitting rights' to other people, more prone to hit kids. This way, the total amount of child abuse would not diminish, but you have created a new market.

THE PROBLEM WITH APPEALING TO PEOPLE'S GOOD NATURE

The conception that the environmental problems facing humanity can be solved by informing and educating people to change their lifestyle and take a personal (economic) responsibility for the global problems, may be based on good intentions but unfortunately this conception is not only ineffective but also counterproductive since it has shifted the focus from, and delayed, the elimination of life-threatening systemic errors.

For example: they may taste better, and give a better conscience when eating them. They may even be better for health, but organically grown vegetables, which are always far more expensive than conventionally grown vegetables, have not succeeded in taking over the market.

THE PROMISE OF CLEANTECH APPLIED TO EXISTING TECHNICAL INFRASTRUCTURE

As argued above, existing technical infrastructure represents a huge investment and takes a long time to replace. For example, diesel engine technology is not only widespread in trucks, boats, electrical generators etc, but is supported by a network of suppliers, manufacturers, service networks and surrounding technology it is integrated into, for example, vehicle electrics and control systems.

A rapid dismantling of such technology, so integrated into the fabric of society would be costly, time consuming and wasteful of the capital, materials and intellectual, invested.

In this context, the existing technological landscape presents a barrier to new advances. Its introduction to be successfully will require massive investments in changes to the existing technological landscape.

On the other hand, existing technology carries a legacy of inefficiency and high emissions.

CLEANTECH TAKES EXISTING TECHNOLOGY AND ADDS LAYERS OF CONTROL AND CLEANING

This Cleantech approach takes outdated, inefficient, polluting technology and with the application of advanced computer control and some addition of cleaning technologies produces services with less emissions more efficiently.

EXAMPLE: DIESEL ENGINE

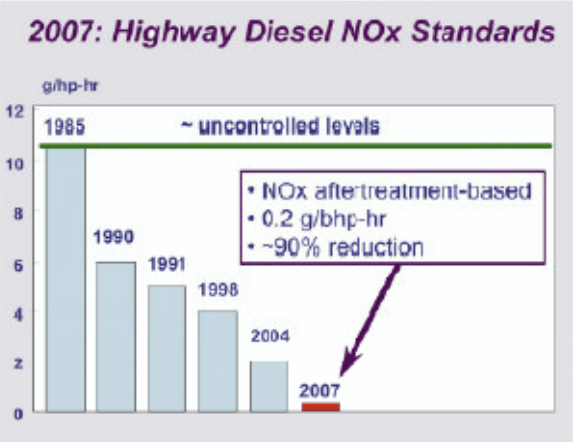
Advanced computer control of the combustion of the diesel engine, combined with advances in particle filtration have transformed this once dirty and environmentally detrimental technology to an efficient, clean transportation solution. This new development is called Control Engineering. Control engineering is the engineering discipline that focuses on the modeling of a diverse range of dynamic systems (e.g. mechanical systems) and the design of controllers that will cause these systems to behave in the desired manner.

ADVANTAGES: REDUCED NEED FOR NEW INFRASTRUCTURE

This is, then one of the promises of cleantech: to take existing technology and build a control and cleaning layer to make it perform to modern standards.

MAINTAIN ECONOMIC STABILITY

This approach has the benefit of being relatively fast compared to scrapping and replacing existing technology. It also creates more economic stability, reducing the need for firms to raise capital for new infrastructure throughout supply chains. Diesel technology has been successful in reducing NOx. Diagram courtesy of the United States Environmental Protection Agency.



For model year 2007, NOx emission standards for heavy-duty engines are reduced over 90% of current standards.

COMPARISON BETWEEN ECONOMY AND DIESEL ENGINE

Most economic instruments and regulatory mechanisms used today, with the exception of electronic trading, originate back to the period before ubiquitous computing, global supply chains and awareness of risks of externalized emissions costs.

The table below illustrates the opportunities afforded by modern technology for applying fees and changing them to adapt to conditions.

Then	Now
• Paper document based trading, with long lead times for accounting • Minimum of statistics • Long and slow methods of communication (e.g. surface post) • Labourious calculations required	• Computerised trading and tax system • Multiple statistics collection points • Fast communication • Calculations can be handled by modern computer technology

Application to political economics means applying control approaches to supply and value chains containing pollutants. More specifically, as combustion is controlled by the millisecond depending on conditions in the piston chamber, emissions can be controlled in real time by a variable fee depending on the behavior of these supply and value chains and the markets, including financial

markets, that influence them. At the same time, the fee is not just to be seen as a cost, but a revenue into the economy. This revenue stream can also be harnessed to drive sustainable development.

This would simultaneously eliminate a major systemic error by creating an incentive structure, in the economic system, which is beneficial for stable, sustainable development.

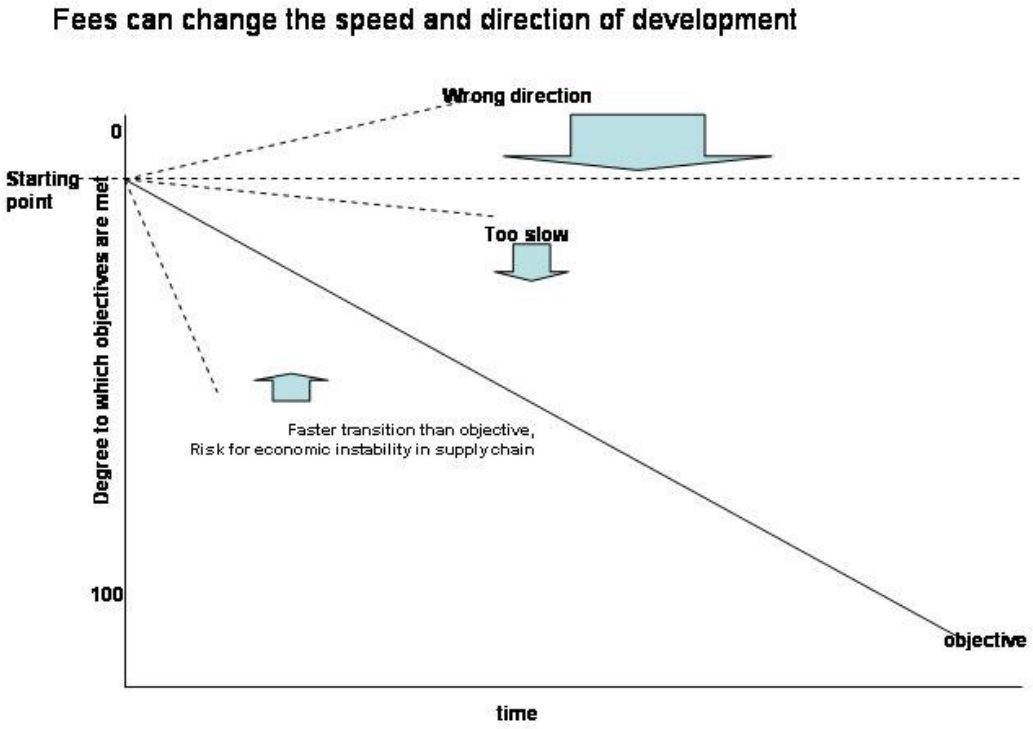
DESCRIPTION OF HÖGLUND'S FEE MECHANISM

BASIC CONCEPT

An emissions fee scheme is set up for substances that government goals call for reduction or elimination of their release into the public waste stream or environment. The size of the fee will be increased if sales and emissions increase, and decreased if the rate of reduction is faster than the objective. If the fee is *sufficiently* high, and if there is market uncertainty as to how large the next fee will be, market forces will work to change the behavior of supply chains[13].

The market will react based on a wide range of factors, including availability of futures markets to hedge the cost of fees, as well as availability of technology and methodology to eliminate emissions.

The fee mechanism allows for the revenue collected to be redirected to firms, for example to introduce cleantech.



[13] A thorough theoretical analysis of Höglund's mechanism has been carried out by IVL, The Swedish Environmtental Research Institute. The report may be downloaded from http://tiny.cc/F6Dxl

THE SIZE OF THE FEE DEPENDS ON THE BEHAVIOR OF THE MARKET. THE LARGER THE GAP BETWEEN OBJECTIVE AND ACTUAL, THE LARGER THE FEE (BLUE ARROW)

MAIN ACTORS

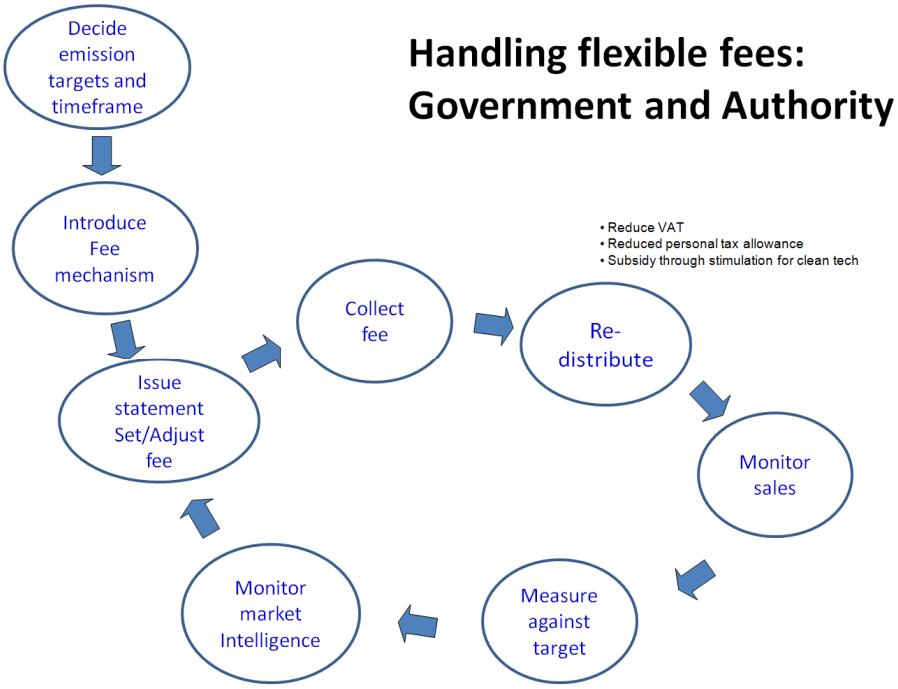
- The government agency that is responsible for monitoring emission levels and setting and collecting feed.
- An importer or producer of an emission causing substance.
- The end users of the substance.
- Suppliers of clean tech.
- Market makers in financial markets (options market and options brokers).

MAIN COMPONENTS

The Höglund approach consists of six main components:

- Identification of a traded substance that gives rise to harmful emissions from its use in supply chains.
- A reasonable objective for rate of emissions reduction, set by government.
- A pollution fee levy mechanism as far back in the supply chain as practicable
- A price setting authority that can monitor fees closely in time and change the fee level regularly.
- A mechanism for returning fees back to stimulate commerce, for example, a monthly payment into citizen's tax accounts, effectively giving them more in their pocket to spend after taxes.
- Opportunity for a futures market to arise spontaneously.

HOW IT WORKS



Identify traded substance

The first step is to agree on priorities for which substance to target, criteria may include the harmful effects on the environment and the economy, ease of introducing fee levy mechanisms, political expediency etc.

Introduce fee mechanism

Exactly how the fee could be levied needs to be worked out – many factors can play in including the effects on cross border trade. Redistribution needs to be considered at this stage – what will the monies be used for and how will they stimulate the desired behaviour of the system?

Announcement of fee

The government announces it will introduce a flexible fee system and give actors time to prepare.

This announcement will create an uncertainty in the market. They will be presented with some major choices including:

- Continue using the substance and introduce a margin in their business plans to pay the fee (i.e. increase prices to pass on costs to end users).
- Plan to invest in cleantech to reduce or remove emissions.

- Plan to invest in non fee-incurring alternatives.

Choices will depend on the willingness of their customers to absorb the costs involved, the price and availability of clearer alternatives and the time frame within which the alternatives can be introduced.

The size of the fee will affect the decision. If it is cheaper to pay the fee, the firm may decide to continue as usual.

Introduction of fee, collection and monitoring

At regular intervals the government monitors the amount of fee collected as well as levels of emissions.

Redistribution of fee

Redistribution, or feedback, is the other cycle of control engineering applied to the behavior of the economy. Redistribution can stimulate consumption, investment in new technology or attractiveness of a certain product or service**.**

Monitor and measure, set fee according to market behavior

If levels of emissions do not fall despite fee introduction, the fee is not affecting the market. After the monitoring point that indicates no change, the fee is adjusted upwards. This continues until emissions fall.

If the fee is so high it creates economic instability and disruption in supply chains, an adjustment downwards is made. If emissions are falling according to objectives, fees remain at previous levels.

A market for futures[14] may arise in order to create some kind of insurance for the supply chain actors. In this case, the futures market will also present the government with a measure of the rate of change the market can handle. Another benefit of a futures market arising is that it focuses the attention of the market onto salient aspects of emissions handling like introduction of new technology, its efficacy, investment needs and the performance of the industry compared to government goals. For a more detailed explanation of the mechanism, see the appendix..

As the fees create a revenue stream, governments can or stimulate and reward reduction of emissions and adoption of new technology with grants and subsidies. New technology will come into the market faster in this way.

[14] In finance, a futures contract is a standardized contract, traded on a futures exchange, to buy or sell a specified commodity of standardized quality (which, in many cases, may be such non-traditional "commodities" as foreign currencies, commercial or government paper [e.g., bonds], or "baskets" of corporate equity ["stock indices"] or other financial instruments) at a certain date in the future, at a price (the futures price) determined by the instantaneous equilibrium between the forces of supply and demand among competing buy and sell orders on the exchange at the time of the purchase or sale of the contract. Source: Wikipedia.org

Issue statement and adjust fee

Depending on market behavior, the government authority can issue statements and adjust the fee.

Constructing the fee mechanism

The fee mechanism should fit existing business, regulatory and fiscal practices as far as possible to reduce implementation costs. System barriers should represent already established regulatory points. Examples of these include:

- Import duties
- Export duties
- Value added tax
- Property taxes

Agencies should also work to place fees as early in the supply chain as possible, again to reduce costs for implementation. This is because *extraction or production* of substances that give rise to pollution often have fewer producers than end users. Another advantage of early fee application is that it brings the substance under control before it enters the myriad of streams in the supply chain.

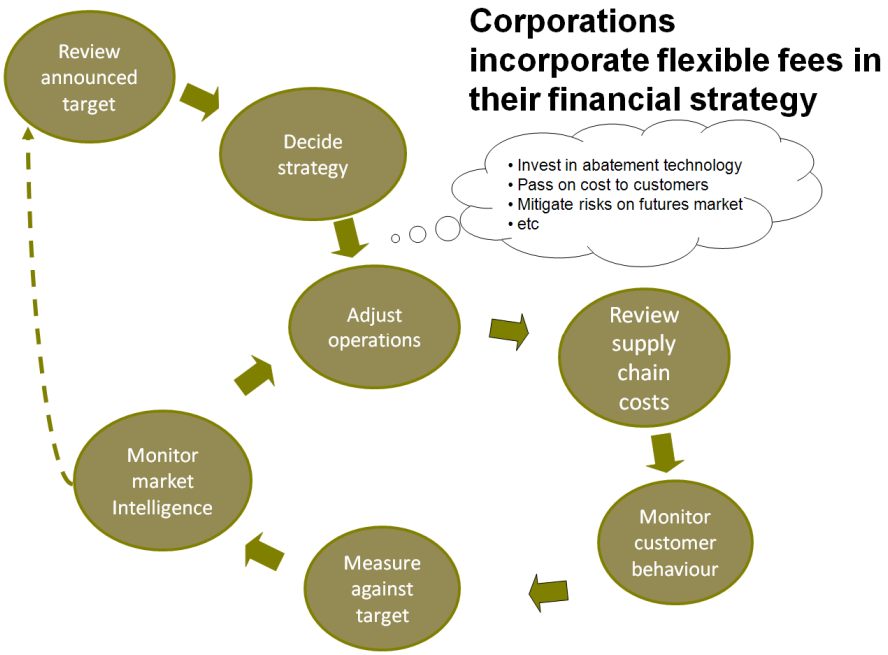
Constructing the redistribution mechanism

It is important to bear in mind that seen from a national level a fee on a substance that is detrimental to emit does not affect GDP or cause inflation. What does negatively affect GDP is the loss of jobs from a reduction in consumer spending.

Not all consumer spending needs to be seen as driving environmental degradation. When consumers share their wealth by supporting cultural events, sporting events, and social gatherings for example, the emissions can be relatively low and the employment opportunities generated high.

In its simplest form the Höglund mechanism calls for a general redistribution of collected fees as fast as possible into the economy through consumers.

How flexible fees affect corporations in the supply chain



The diagram above explains how corporations might respond to the introduction of emissions targets coupled to a flexible emissions fee scheme. Firms will need to review the announcement and decide strategy. It may be that they can respond easily if alternatives are available – or it may require major changes in strategy and technology – with massive investments. They will need to monitor customer behavior and glean market intelligence to inform their strategy.

Defining system boundaries

What should be the focus of a flexible fee mechanism? To answer this question we turn to the following illustration from the paper published in Nature called "a Safe Operating Space for Humanity.[15] Responsible management of releases to the environment needs to encompass these nine areas.

[15] *Nature* **461**, 472-475 (24 September 2009) | doi:10.1038/461472a; Published online 23 September 2009

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof	To be determined		

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

The challenge is to identify national or international supply chain entry and exit points into the systems above. Flexible fees can then be introduced to control them.

As an example, the Earth-system boundary is crossed by carbon dioxide when burning fossil fuels. Entry points into the supply chain are at extraction or import. Here import duties or extraction duties could be applied.

For plastics, fees could be levied on sales of raw plastic pellets, and discounted when pellets are produced from recycled plastic.

WORKED EXAMPLES

PHOSPHOROUS

Phosphorous is finite and like oil it will peak sooner or later. In his frightening book *Eating Fossil Fuels* [16] Dale Allen Pfeiffer shows that conventional agriculture is as oil-addicted as the rest of society. A decline in oil production raises questions about how we will feed ourselves.

In the same way, agriculture is addicted to mined phosphates [17]and would be threatened by a peak in phosphate production. As the U.S. Geological Survey (USGS) wrote in summary on phosphates (PDF) [18]:

There are no substitutes for phosphorus in agriculture.

Fortunately, phosphorus - unlike oil - can be recycled. Responses to a phosphorus peak include re-creating a cycle of nutrients, for example, returning animal (including human) manure to cultivated soil as Asian people have done in the not-so-distant past[19].

As can be seen in the diagram below, phosphorous enters the supply chain in most countries through import as it is mined in just three main places. Phosphorous is an essential component of fertilizer and is applied in agriculture. Some leaks into the surface water and into rivers and eventually into the sea. Once in the sea it is difficult to recover and return to agriculture. It remains in the supply chain in food until it is excreted as urine and taken care of by sewage treatment plants. Inevitably, phosphorus leaks into the sea stimulating among other things algal blooming. This problem is especially prevalent in the Baltic Sea area, creating problems for the fishing industry and damaging the tourist industry by closing beaches.

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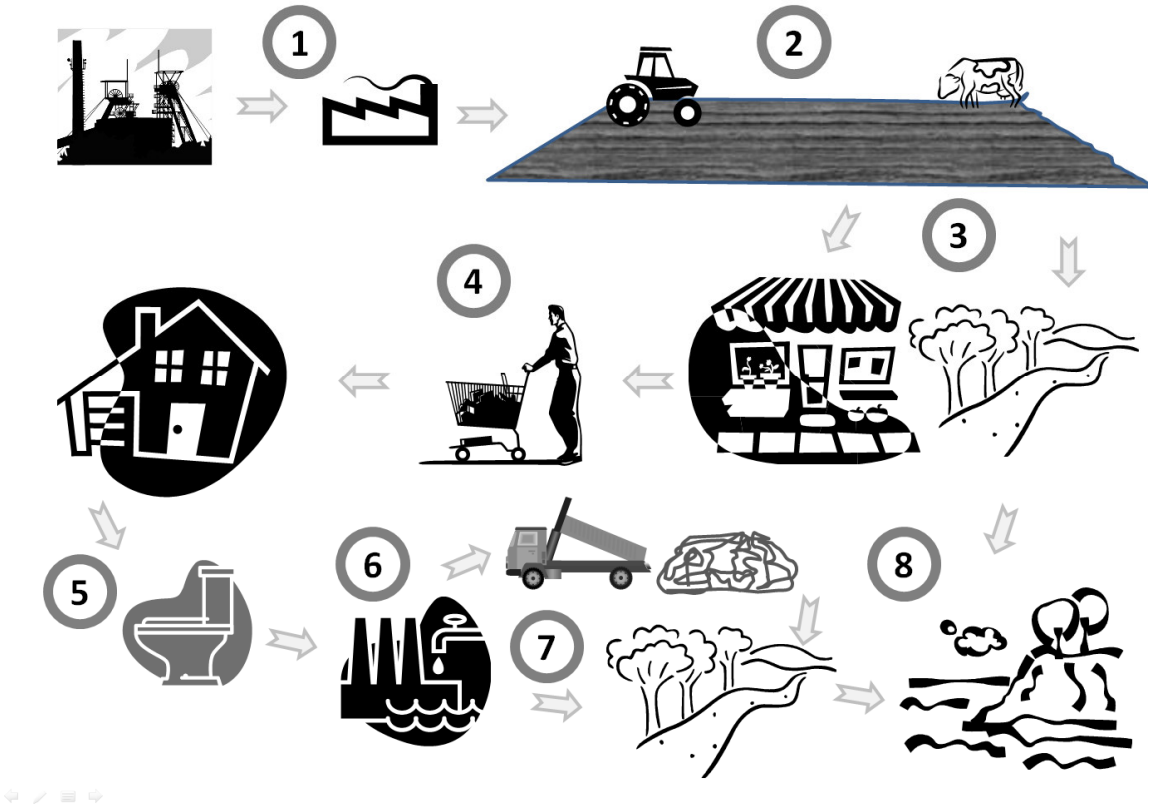
[16] http://www.amazon.com/Eating-Fossil-Fuels-Coming-Agriculture/dp/0865715653

[17] Abelson, Philip H. "A Potential Phosphate Crisis." *Science.* 26 March 1999: Vol. 283. no. 5410, p. 2015.

[18] http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/phospmcs07.pdf

[19] F.H. King. *Farmers of Forty Centuries: Organic Farming in China, Korea and Japan* , Dover Publications, NY, 1911 (ed. 2004)



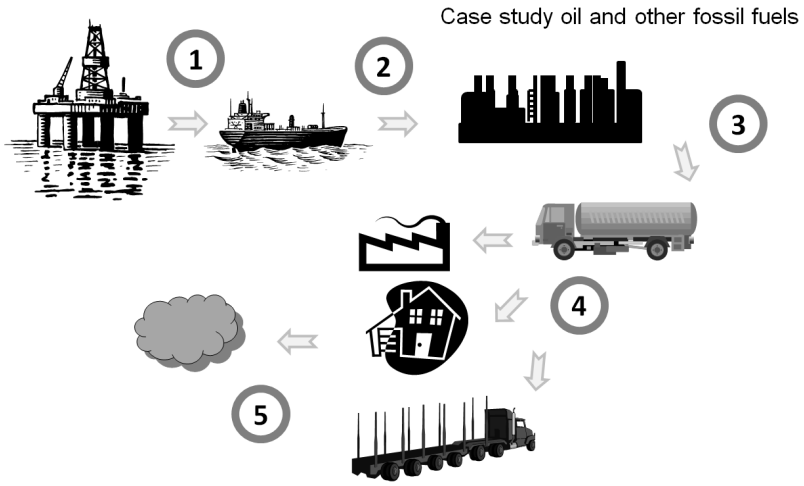
1. Phosphorous is mined and processed into fertilizer along with other nutrients like potassium and nitrogen.
2. Applied to the fields, it is incorporated into vegetables and sold direct or into animal feed.
3. Phosphorus leaks from agriculture into waterways and is exported to shops as food.
4. Consumers purchase food for consumption.
5. Phosphorus leaves the body mainly as urine.
6. Sewage is processed at water purification plants.
7. Some phosphorus is dumped as waste from purification, some ends up in waterways.
8. Eventually phosphorous travels to the sea where it is in principle unrecoverable.

As phosphorous supplies are finite, it would be beneficial to the national economy to encourage recycling - lack of supply will cause food price hikes. It would also reduce damages to waterways and sea ecology.

The Höglund approach could look like this applied to the phosphor case:

Identify system boundaries:	Entry: import of phosphorous in fertilizer and as minerals as well as in food. Exit: release from water treatment plants, leakage from agriculture, release from homes not connected to sewer system.
Plan reasonable phase-out of emissions over time:	Some of the issues that might inform the decision: small amounts of leakage may be tolerable from a waterway ecology viewpoint. On the other hand, dependency should be cut to protect long term viability of the food industry. The technology for recycling phosphorous is widely available. Based on this a zero emissions target could be achieved in say 30 years, with the aim to reduce emission by half within ten.
Set up fee mechanism:	Initially, a fee charged bimonthly on imports of phosphorous-containing compounds for agricultural use. Factors to consider include imported food contains phosphorous − and so does exported food, factors to consider
Set up redistribution:	Issues for consideration: As food price stability is central to the transformation, redistributing the money via general alleviation of personal taxes could be brought about. More disposable income gives more money to spend on food. The current sewage infrastructure stems from designs of the 1800s. Massive investments are needed to enable phosphorous recycling. Some fee income could be used to stimulate development in this area.
Monitor market behavior:	Things to look for: that the fee is sufficiently high to encourage firms with low abatement costs to change operations. Areas where abatement costs appear prohibitive. Monitoring import of food and other ways for phosphorous to enter the country and affect the competitiveness of home grown food. Making sure food prices do not affect inflation.

CARBON DIOXIDE



1. Oil is extracted on land or at sea, and
2. transported to refineries.
3. From the refinery oil products such as heating oil, and diesel and petrol are distributed into supply chains.
4. Most oil is combusted although some percentage of carbon remains trapped in plastics, paints, adhesives, etc.
5. Carbon from the extracted oil ends up as carbon dioxide as a result of combustion.

The Höglund approach could look like this applied to the carbon dioxide case

Identify system boundaries:	**Entry:** import of fossil fuels or extraction in country. **Exit:** as carbon dioxide as result of combustion.
Plan reasonable phase-out of emissions over time:	**Some of the issues that might be considered:** fossil fuels are needed to grow the economy given the present system. No replacement for liquid fuels is close. Climate scientists call for return to 350 ppm CO2 in atmosphere, this would require a fast phase out.
Set up fee mechanism:	Initially, perhaps a fee charged bimonthly on imports/extraction of fossil fuel.
Set up redistribution:	**Issues for consideration**: promoting low carbon economy, renewable energy sources and energy efficiency would be helpful. Food, water and housing security would lay foundations for prosperity.
Monitor market behavior:	**Things to look for:** economic activity remains acceptable, imports reduce at target rate, no import of carbon via other nation's emissions.

BENEFITS OF THE HÖGLUND MECHANISM

COMPETITIVELY NEUTRAL

The fee-setting mechanism is based on what the market can handle. The advantage of this is that the fee does not offer competitive advantages to one actor or another, but rather encourages the free market to dominate within accepted rates of reduction of externalization.

CAN REACT TO PRICE CHANGES

Should prices rise suddenly, as a result of production shortfalls, for example, sales and emissions targets could well be met as a result. In this case, as targets are being met, the fee could be reduced. This will ease the burden of the price shock on companies in the supply chain.

USES TRIED AND TESTED COMPONENTS

The Höglund approach uses components that are already I place. For example, variable fees and taxes are used for differential VAT. Congestion charges are levied depending on time of day. Sweden and a few other countries already levy carbon dioxide fees on fuel.

Using already existing mechanisms means the costs for the introduction of flexible emission fees can be kept low.

UNCERTAINTY STIMULATES MARKET ACTOR'S ATTENTION

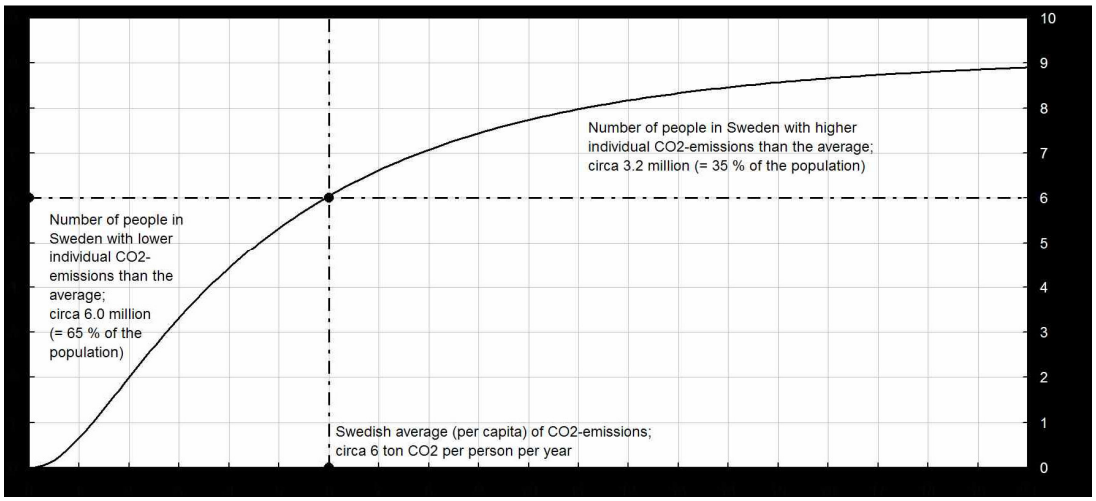
Because the uncertainty generated by the fee system will cause futures market to arise, there will be greater attention on the economic consequences of emission. This is good because the greater information spread will create more awareness of the issues involves and greater willingness to invest in these areas.

POLITICALLY EXPEDIENT

Because the fee is set in effect by market forces, the level of political involvement is restricted to creating agreed emission targets and introducing the mechanism. This relieves politicians from having to get involved in the dichotomy between preserving ecological services, health, and natural resources versus the demand for citizens for economic growth. It makes it possible therefore for politicians to work towards sustainable development.

AFFECTS THOSE WHO CAN AFFORD TO PAY

Analysis reveals that a major percentage of emissions are actually caused by a minority of the population; those with the best incomes. Because the fee is passed on to the end consumer, it will be the best paid members of society - those who can best afford it - who will be affected by higher costs. This means the mechanism can be seen as being fair in its approach. (See diagram below.)



The top 35% of the wealthy in Sweden are also the largest polluters Source; Höglund

STIMULATES THE ECONOMY TO GROW IN A POSITIVE DIRECTION

As pointed out earlier, economic growth in itself is not purely a measure of human progress. As all spending is reflected in the figure, costs negative to society are reflected too, like spending associated with natural disasters, crimes, and polluting industries.

By taking money out of the economy from polluters, and giving it to consumers to spend, a virtuous cycle is created where more and more " appropriate" services are demanded and become relatively cheaper. If, for example, fuel prices soar due to fee increases, and consumers get more in their pockets to spend, we would likely see an increase in demand for rail travel on lines electrified by hydro power.

To summarize; global economic growth and development can be made benign and sustainable by proper use of economic feedback control. The economic feedback control proposed here can be designed to benefit the majority of the population in addition to being efficient, objective and fair in treating all emissions and emitters the same.

REMOVES THE GUILT FROM SPENDING

Many consumers feel guilty because it is clear to them that their life style results in emissions that will affect future generations. At the same time they are torn between the feeling of guilt and the responsibility they feel towards their families and the perceived lack of choice.

The introduction of flexible fees means that consumers who, for example, choose to fly long distance, will in effect be paying for society to address the problem. They can see their flight as an investment in less polluting alternatives.

In the same way, consumers are worried about spending, because unemployment is high and the outlook appears bleak. Flexible fee mechanisms put money in consumers' pockets, creating demand for services and thereby employment. Knowing these mechanisms are in place will encourage consumers to redirect their money into the economy.

Q&A

Surely emissions fees have been tried before- what is different about the Höglund mechanism?

Emission fees have been applied it is true. Sweden has a Carbon Dioxide tax on petrol. What is different (and not been tried) is that Höglund's fee is flexible and carries with it uncertainty. If emissions do not go down, despite fees, fees are raised for example. If they go down too quickly, there is possibly detrimental effects on the economy, so they can be adjusted downwards. Although flexible fees have been introduced in airline seats for example, they have not been tried for emissions.

Will it not be difficult to impose a flexible fee?

Flexible payment mechanisms are actually widespread. For example, congestion charges vary depending on time of day. The Stockholm congestion charge is paid to both leave and enter the city, and charged using a number plate recognition system and a separate account that is direct debited. Most Stockholmers with cars hardly notice the economic activity incurred from travelling in and out of the city**.**

Petrol filling stations nowadays have digital price boards to cope with constant price changes.

Will redistribution be difficult?

Redistribution mechanisms exist that can be used. The *Alaska resident* payment system – the permanent fund dividend redistributes money from oil extraction.[20]

Many tax systems include a base amount of income that is untaxed. Raising this level is effectively redistribution.

Subsidies are well-know redistribution mechanisms.

Surely, tough restrictions at home will destroy companies' competitiveness with foreign firms at home and abroad

It is true that applying an emissions tax in one country could favor importers. For example, manufacturing of a car can take as much oil (and create carbon dioxide emissions) as the car uses as fuel in its lifetime. A car manufactured in another country and imported will be comparatively cheaper then, as its manufacturing costs are lower.

This illustrates some important points:

i) A sustainable approach to economy works best on a regional or global level

[20] See http://www.pfd.state.ak.us/historical/index.aspx

ii) A country introducing flexible emissions fees would do best to concentrate on areas where imports from countries with fewer restrictions created a problem for national producers

iii) The fees collected should be used wisely. For example, subsidies on green vehicles could favor home manufacturers even against importers.

iv) Emissions fees are applied to substances entering the country, and are thereby neutral to competition. Exporters will not be affected if they do not emit pollutants in their home country.

CALL TO ACTION: PILOTS AND DEMONSTRATIONS

The Foundation strongly advises nations to consider the introduction of flexible pollution fees. Experience shows that more information about the fees, the mechanism, about how markets affect the supply chain and futures markets are needed by decision makers before they are able to commit to the introduction of such mechanisms.

The foundation has developed several simulations which can be run as a business game, to expand understanding of the subject area.

The Foundation recommends also the setting up demonstration, or pilot schemes, to allow decision makers to study the implications and mechanisms of this approach. The Foundation is willing to provide their expert assistance for this.

APPENDIX

MORE ON MECHANISMS OF PRICING EMISSIONS FEES

The figure below shows the intersection of a Marginal Abatement Cost (MAC) curve and a Marginal External Cost (MEC). It illustrates the effect of a static pollution fee on levels of pollution, assuming perfect competition. By imposing an optimal fee of t*, the level of pollution is reduced from some level Q (which would be where the MAC curve crosses the horizontal axis) to an optimal level Q*. Similarly, a quantity constraint would fix the cost of pollution such that Q* is reached. Approaching the pollution issue from this perspective, the challenge for policy makers becomes formulating policy which arrives at a fee level that approaches t*, or a quantity constraint that approaches Q*.

It is, in many cases, difficult to identify a reliable MEC curve, particularly with longer-term environmental issues such as climate change. In the case of the climate debate for example, substantial resources have been devoted towards developing a better understanding of the MEC. The International Panel on Climate Change and their assessment reports are an example of the steps that are being taken.

MAC curves on the other hand have been derived either using a "top down" or a "bottom up" methodology. Top-down curves are derived from economic models. These are generally produced from Computable General Equilibrium (CGE or GEM) models. Such curves cannot distinguish accurately which sectors or technologies produce abatement and are dependent on the extrapolation of past trends when deriving their curves. On the other hand, bottom up curves are derived from engineering studies and technology assessments. Such curves exhibit good detail but often have gaps in one or more sectors due to a lack of data and do not include feedback effects on other economic variables of investing in certain options.[21] Deriving the MAC curve is difficult for a variety of reasons, commercial confidentiality being another important example. Indeed, many economist consider that the government is in a poor

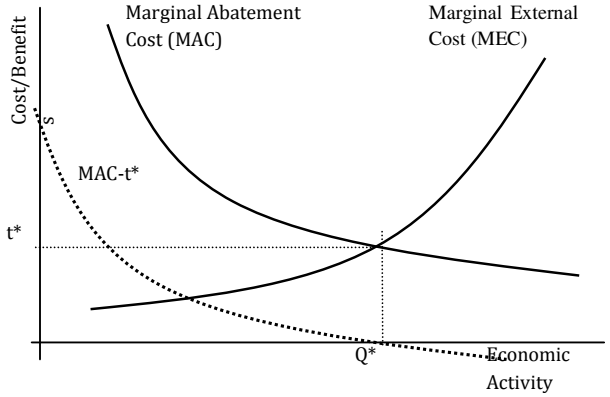


Figure 0-1 – Optimal pollution level Q*

[21] Ellermann et al. (1998)

position to extract this information and some even go so far as to argue that the existence of this information asymmetry is enough to preclude government intervention.[22]

In this regard, environmental policy faces a considerable challenge. On the one hand, the MEC curve must be known to some degree. The less that is known about the result of pollution damages, obviously, the more difficult it is to formulate an effective policy. On the other hand, the MAC curve must also be known to some degree. The less that is known about the MAC curve, the harder it is to formulate an effective policy. Without the certainty of reliable MAC and MEC curves, there is the risk that the policy will overshoot or undershoot what is economically or environmentally optimal.

The flexible pollution fee would allow firms to act on an open market based on the information they have about their own abatement costs. By hedging their abatement investments (or even hedging their decision not to invest), a level of the pollution fee is established. The fee level would, in the long run, be a function of an aggregate MAC of those firms that participate on the market and the life of their abatement investments.

From the NUTEK report "A flexible pollution tax"

[22] Pearce and Turner (1990)

About Anders Höglund

Anders Höglund is an engine researcher and part owner of Swedish-based Cargine Engineering. Anders worked for VOLVO for 26 years as a combustion engine developer. He started to develop his ideas on flexible emission fees in 1988 when he realized that modern control technology approaches, among other things used to make diesel engines clean, can be applied to modern economies. He has been a member of the Board since its foundation in 1995.

About the Author

Stephen Hinton, BSc, Cert Ed started teaching science after completing his studies at the University of London, Institute of Education. Moving into management consulting and then a career in Telecoms during the 90s, he continued to explore sustainable development and the power of innovation. In researching for his book, "Inventing for the Sustainable Planet" he realized that new, sustainable, paradigms were urgently needed. He headed the sustainable drinking water company, Purity, 2006-2008. Currently, he is working to establish new forms of sustainable settlements, called Eco-units and is managing the Humanitarian Water and Food Award, based in Copenhagen. Recognizing his wide range of experience in industry, and his knowledge of sustainable development, Stephen was invited to join the Board of the Foundation in 2007.

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