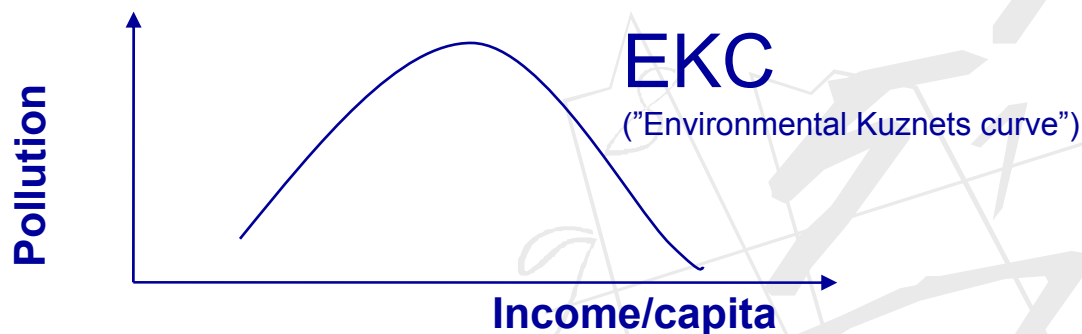


Economic growth and emission leakages

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Hypotheses:

- (A) *technological progress*: abatement, more efficient production
- (B) *composition effects*: less polluting consumption, cleaner production
- (C) *increased demand for environmental goods*: -> environmental policy

Problem:

Do (B) and (C) imply “export” of pollution?



Implications of leakages

- The EKC: a redistribution of bads?
- Effect reducing: the (domestic) effect of environmental policy will be reduced for global environmental problems, c.f. the carbon leakage and pollution haven literature
- May even increase total global emissions, depending upon foreign technology relative to domestic
- Not possible for poorer countries to export emissions when their income levels increase

Earlier literature:

- *Relocation of emissions through trade*: Suri and Chapman (1998), Cole (2000, 2004), Friedl and Getzner (2003), Muridian et al. (2002)
- *Through environmental policy in rich countries*: Lucas et al. (1992), Birdsall and Wheeler (1993)
- *Carbon leakages*: Jacoby et al. (1997), Barker (1999)

This study:

- **The impact on economic growth on emissions abroad, and the effect of policy changes**
- Adds to the econometric studies above by analyzing future changes in leakages within a CGE model
- Studies the sensitivity with respect to policy changes

The case: Norway towards 2030

A rich, open economy:

- transboundary effects are relevant
- likely to expect a tighter climate policy

The study based on a disaggregated CGE model

60 commodities, 40 industries

Based on LTP forecasts:

population growth 0.4 percent

older population: labor force growth 0.3 percent

TFP growth 1.0 percent

fall in oil and gas extraction (from 14 to 4 percent of GDP)

exogenous world market prices and interest rates

Integrates an emission module for domestic emissions

A side model for our trade partners' emissions

Captures changes in country- and sector specific emissions due to domestic trade effects

Domestic emissions

Climate gases: CO₂, N₂O, methane

Regional / local damaging effects: SO₂, NO_x, CO, NMVOC, NH₃

Mainly linked to

- gross production - the use of fuel and transport oils
- household consumption - other material input

Emission shares in 2000

	CO ₂	CH ₄	N ₂ O	SO ₂	NO _x	CO	VOC	NH ₃
From production								
Agriculture	2	30	46	1	3	1	0	92
Fishing etc.	3	0	0	1	13	1	0	0
Manufacture of chemical and mineral products	6	1	0	8	4	0	3	0
Manufacture of industrial chemicals	8	0	41	22	3	9	1	2
Manufacture of metals	16	0	0	39	4	2	1	0
Production and pipeline of oil and gas	28	9	0	1	25	1	66	0
Road transport etc.	6	0	0	3	10	3	2	0
Coastal and inland water transport	3	0	0	4	14	0	0	0
From consumption								
Fuels	3	2	1	3	1	27	3	0
Petrol and car maintenance	9	0	5	1	7	43	9	5
Landfills	0	56	0	0	0	0	0	0
Other	17	0	6	18	17	13	15	2
TOTAL	100	100	100	100	100	100	100	100

Foreign emissions

Import related emissions:
$$IRL^P = \sum_{c=1}^C \sum_{i=1}^n IM_i \frac{im_{ic}}{Y_{ic}} \frac{E^P_{ic}}{1 + \tau}$$

Export related emissions:
$$ERL^P = \sum_{c=1}^C \sum_{i=1}^n EX_i \frac{ex_{ic}}{Y_{ic}} \frac{E^P_{ic}}{1 + \tau}$$

IM_i , EX_i : import/export of good i

im_{ic} , ex_{ic} : import/export of good i from/to country c relative to total import/export of the good

E_{ic}/Y_{ic} : emission intensity of emission E in sector

T : technological progress

Simplifying assumptions:

- Foreign demand unaffected by the changes in trade
-> changes in Norwegian trade will be absorbed in *production* changes abroad
- Cross deliveries abroad unaffected
- Foreign emission elasticities unaffected
- Average, not marginal, emission elasticities
- Trade effects in the importing country only

Leakages in 2000 and 2030 in percent of domestic emissions

	CO ₂	Other climate gases	SO ₂	NO _x	CO	VOC	Ammonia
<i>Year 2000</i>							
- Import related leakages	21,7	11,6	85,6	10,6	18,5	7,3	26,4
- Export related leakages	-42,0	-17,2	-201,3	-27,2	-29,6	-15,8	-6,7
Net leakages	-20,3	-5,6	-115,7	-16,7	-11,1	-8,5	19,7

- Actually **negative** leakages in *Year 2000*,
- Due to energy intensive industries, such as CO₂ intensive metal production, and the oil sector

The forecasts

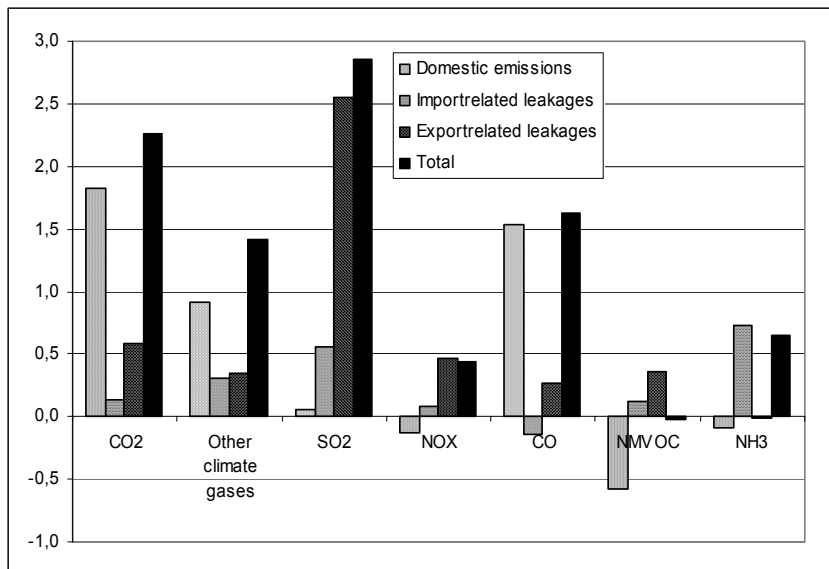
- Most exogenous estimates drawn from the Long Term Programme for Norway, 2001
- Public consumption increase by on average 1.0 percent
- Low growth in total employment, in line with forecasts for other European countries – 0.2 percent annually
- Total factor productivity 1.0 percent in the private sector – 0.5 in public
- Oil and gas exploitation down from 14 to 4 percent of GDP over the period 1000-2030
- Constant CO₂ taxes as in the current regime, varying from 0 to 48 euro per tonne, on average 20 euro per tonne. Highest for gasoline and in the oil sector

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Net leakages	-20,3	-5,6	-115,7	-16,7	-11,1	-8,5	19,7
<i>Year 2030</i>							
- Import related leakages	15,0	16,2	101,8	13,7	9,1	13,0	52,0
- Export related leakages	-13,3	-4,7	-86,5	-12,8	-13,4	-5,2	-7,0
Net leakages	1,6	11,6	15,4	0,9	-4,2	7,8	45,0

- Leakages turn to positive towards 2030
= emissions abroad related to our import > avoided emissions abroad related to Norwegian export
- Due to structural changes
 - mainly reduced Norwegian production of oil and gas, chemical products and farmed fish
 - increased imports of agricultural products (other climate gases, VOC and NH₃)
 - increased imports of electricity, crude oil and chemical products (SO₂)

Emission changes 2000-2030, average yearly growth rate in percent



- Growth in the Norwegian economy:
 - global emissions increase more than the domestic
 - > leakages can contribute to decoupling of economic growth and emissions in Norway
 - GDP grows by 235 percent towards 2030
 - The forecasts show a continued decoupling
 - Mainly due to composition effects
 - Increase in emissions abroad amount to 10-60 percent of the domestic reductions due to structural changes
- > Future decoupling may be at the cost of the environment at our trade partners

Decomposition of changes in domestic emissions 2000-2030, percent of 2000 level

	CO ₂	Other climate gases	SO ₂	NO _x	CO	VOC	NH ₃
Total domestic change	72	53	2	-4	58	-16	-3
- Scale effects	90	91	76	84	184	94	78
- Technique effects	15	-8	-67	-52	-115	-29	-32
- Composition effects	-32	-30	-8	-36	-11	-81	-48
Net leakages	23	18	134	18	6	10	27

The policy scenarios

Weight on CO₂ policy

- *high on the international agenda, Norway wants to be a pioneering country*
- *measures against CO₂ emissions will affect all fossil fuel related pollutants = a general environmental policy*
- *other local environmental problems have for long been subject to strict regulations*

- **Scenario I: Constant policy (the scenario already presented)**

- a differentiated CO₂ tax, on average 20 euro /tonne CO₂ for all emission sources

- **Scenario II: Unilateral strengthening of the CO₂ policy**

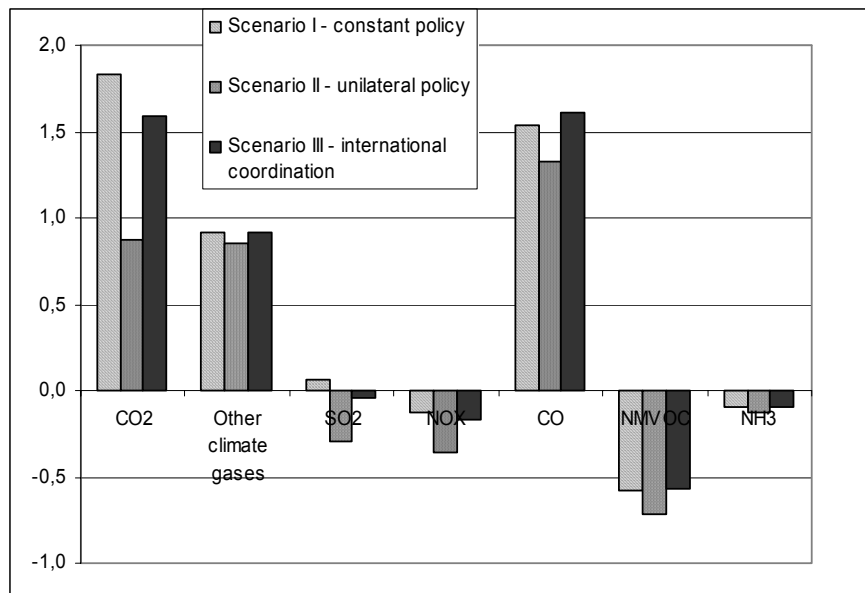
- assumes that economic growth increases WTP for environmental goods = CO₂ taxes
- the tax is uniform (in Scenario I the tax was highly differentiated)
- the tax increases from 13 euro in 2000 to 58 euro in 2030

- **Scenario III: A multinational coordinated policy**

- more realistic?: a continuation of the Kyoto protocol
- assumes a quota price of 16 euro/tonne CO₂ from 2008 and onwards

Domestic emissions

Yearly percentage growth 2000-2030



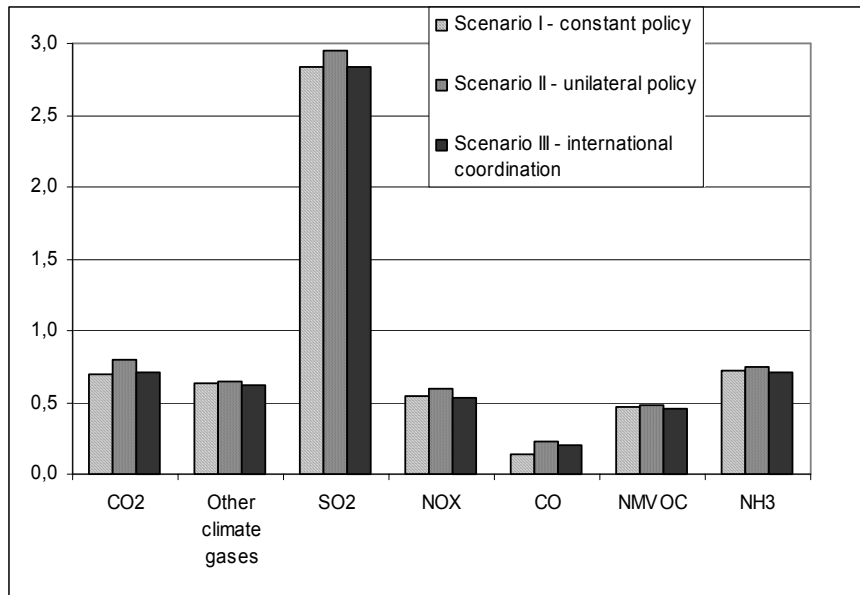
Scenario II

- Long run CO₂ emissions bisected
- Due to heavy losses of competitiveness in polluting sectors that were favored in the current regime
- Fall in wages due to equilibrium effects increase competitiveness of services and labor intensive firms
- Smaller effects for consumers than firms, as gasoline taxes are reduced

Scenario III

- Only a minor strengthening of average CO₂ costs compared to Scenario I, but a heavier burden on power intensive industries
- **90 percent of the long run reductions are met by buying quotas in the international market**
- Gas power production most affected – down 23 percent in 2030
- Rather small long run effects on domestic emissions

Do environmental policy enhance net leakages?



Import related leakages are reduced

- Contrary to preassumption
- Due to the contracting effects and reduced demand

Export related leakages increase

- Due to lower export of gas – coal based electricity production increase in the other Nordic countries

Total:

- Somewhat higher leakages in a unilateral tightening of the CO₂ policy (foreign emission changes due to trade of quotas not included in Scenario III)
- This reduces the policy effects

Yearly percentage growth 2000-2030

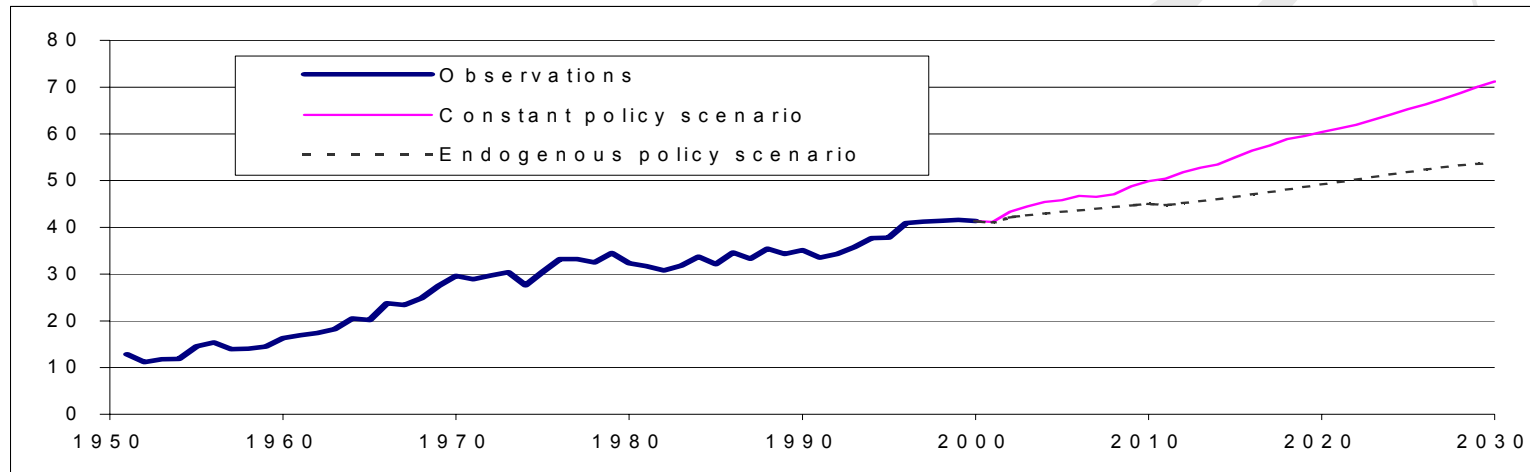
	CO ₂	Other climate gases	SO ₂	NO _x	CO	VOC	NH ₃
Import related leakages							
Scenario I	0,58	2,04	0,64	0,75	-0,83	1,34	2,19
Scenario II (unilat. policy)	0,52	2,15	0,57	0,71	-1,00	1,37	2,35
Scenario III (coordin. policy)	0,42	1,96	0,51	0,66	-0,99	1,23	2,18
Export related leakages							
Scenario I	1,99	3,39	2,72	2,60	1,12	4,21	-0,07
Scenario II (unilat. policy)	2,66	3,42	3,10	3,20	1,70	4,27	-0,74
Scenario III (coordin. policy)	2,22	3,36	2,87	2,66	1,55	4,18	-0,09

Summary

- **Continued decoupling between economic growth and emissions in the future**
 - in line with EKC: low-polluting consumption and production increase at the expense of material/energy-intensive activities
 - holds also for a constant climate policy
- **Emission leakages will increase**
 - mainly due to the draining of the oil sector
 - > national emission accounts underestimate the total, global impacts of economic growth and national policy measures
 - the main effect comes through changes in export, rather than import
- **Leakages reduce the effect of environmental policy to some degree**
 - but our study does not confirm the pollution haven hypothesis

The policy change

From an average 20€ to 58€ per ton CO₂ in 2030



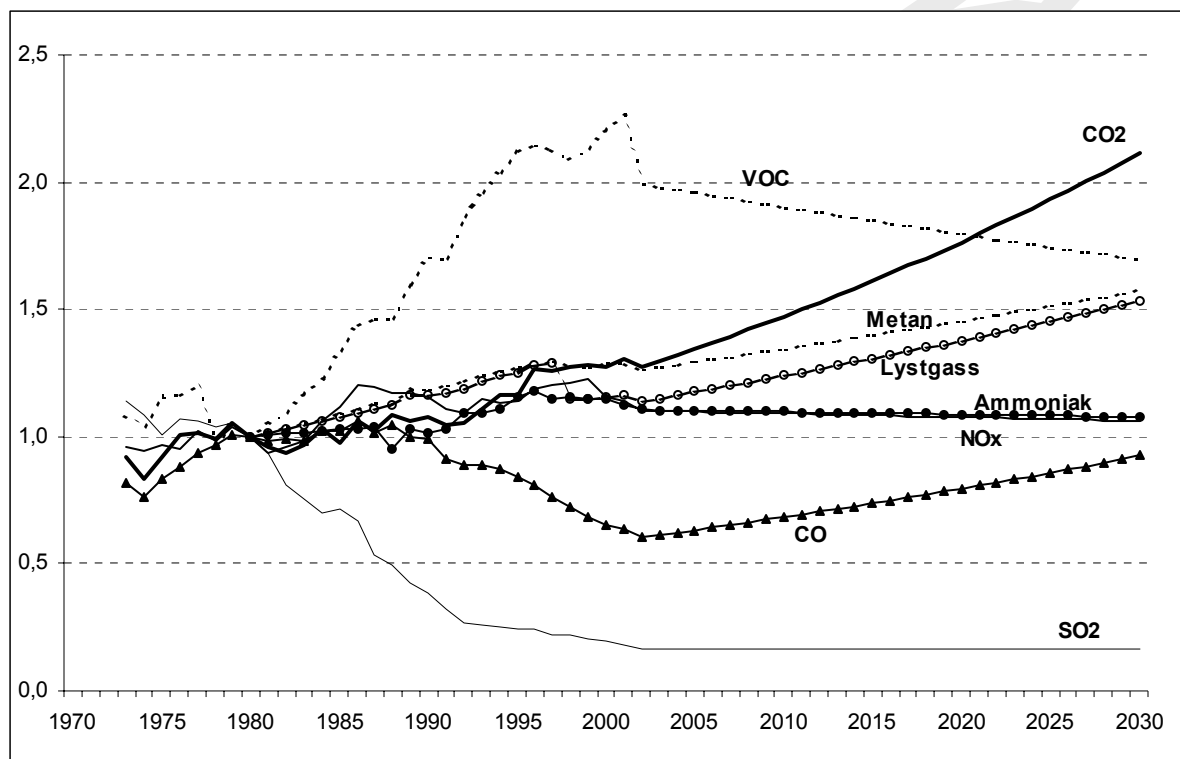
- Decreased taxes for households (gasoline) the first years
- Increased taxes for heavily polluting process industries
- CO₂ intensive industries face the highest rise in costs:

Industry	Unit CO ₂ emissions
Fishery	0.15
Manufacture of Industrial Chemicals	0.13
Manufacture of Metals	0.13
Oil refining	0.10
Extraction and Transport of Crude Oil and Gas	0.07
Manufacture of Chemical and Mineral Products	0.05

Leakages in the past and in the future

	-----1980-----				1996	
	Domestic	Import-related	Export-related	Net, trade-related	Net trade-related- in percent of domestic emissions	Net trade-related- in percent of domestic emissions
CO ₂	31700	5050	6563	-1513	-4,8	-19,1
CH ₄ *	5435	616	496	120	2,2	-17,1
N ₂ O*	4495	639	328	312	6,9	7,1
SO ₂	136	16	23	-7	-4,9	-118,7
NO _x	191	12	16	-4	-2,1	-13,9
CO	878	49	68	-19	-2,2	-6,9
VOC	173	19	19	0	0,0	-9,5
NH ₄	20	5	1	4	19,3	24,3
	-----2000-----				2030	
	Domestic	Import-related	Export-related	Net, trade-related	Net trade-related- in percent of domestic emissions	Net trade-related- in percent of domestic emissions
CO ₂	41338	8959	17353	-8395	-20,3	1,6
CH ₄ *	7678	614	1623	-1009	-13,1	9,5
N ₂ O*	6203	1000	768	232	3,7	13,9
SO ₂	34	29	68	-39	-115,7	15,4
NO _x	201	21	55	-34	-16,7	0,9
CO	547	101	162	-61	-11,1	-4,2
VOC	378	28	60	-32	-8,5	7,8
NH ₄	26	7	2	5	19,7	45,0

Emissions historically, and in the forecasts, 1980=1.00



Domestic markets

Long-term macroeconomic effects

Percentage changes from reference scenario

<i>Prices:</i>	
Transport fuel oils	24,3
Other fuel oils	8,8
Wages	-4,0
Other inputs	-1,0 to -2,5
Consumption	-0,5
Home markets	-0,8
GDP	-0,5
Export	-2,7
Import	-1,7

- General reductions in all markets
- Potential effects both domestically and abroad

Changes in markets

Percentage

Products	Domestic market	Competitiveness	Domestic share	Import share	Import	Export
Chem and Mineral Products	-0.5	-7.3	-15.5	3.7	3.2	-24.3
Wood and Wood Products	-0.5	-3.2	-4.1	5.4	4.9	-15.4
Petrol	-3.2	-2.9	-3.6	5.9	2.4	-18.0
Other Fuels	-2.0	-2.9	-6.5	2.0	2.4	-17.9
Metals	-12.7	-2.3	-4.9	1.5	-11.5	-16.8
Industrial Chemicals	-5.3	-0.7	-0.9	1.1	-4.3	-4.5
Agricultural commodities ¹⁾	0.8	0.0	-0.8	1.4	2.2	2.2
Commodities from Forestry ¹⁾	0.6	0.0	12.9	-7.4	-6.8	6.8
Commodities from Fishery ¹⁾	-0.1	0.0	0.0	0.0	0.0	-20.2
Crude Oil ¹⁾	-9.0	0.0	-0.2	11.8	1.8	1.8
Natural Gas ¹⁾	-59.7	0.0	-3.5	163.0	5.9	5.9
Electricity ¹⁾	0.2	0.0	-1.7	0	0	-100.0
Air Transport	-0.3	0.6	0.4	-1.4	-1.7	0.1
Inland Water Transp.	-0.7	1.1	0.5	-3.4	-4.0	0.2
Fish Products	3.2	1.2	1.0	-3.2	-0.1	8.3
Meat and Dairy Products	0.5	1.8	0.1	-4.8	-4.3	9.1
Pulp and Paper	0.3	1.8	4.2	-2.4	-2.1	10.3
Land Transport	-0.4	1.8	0.0	-4.8	-5.2	7.9
Other Processed Food	0.2	1.9	1.5	-4.3	-4.1	10.5
Beverages and Tobacco	-0.3	1.9	2.0	-3.7	-4.1	9.9
Fish Farming Prod.	7.5	2.0	0.0	-5.1	2.0	14.4
Textiles and Clothes	-0.5	2.1	5.8	-0.4	-0.9	12.4
Ships	-0.1	2.1	4.5	-2.2	-2.4	12.0
Rail Tram Transport	1.2	2.3	0.6	-5.7	-4.6	1.0
Hardware and Machinery	-1.9	2.4	6.5	-1.0	-2.9	4.9
Repair	-1.1	2.4	1.6	-5.1	-6.2	-11.2
Construction services	-1.1	2.4	0.0	-7.1	-8.2	-5.7
Post and Telecom. Services	0.0	2.6	0.5	-6.8	-6.8	0.4
Prints and Publications	-0.7	2.7	2.3	-5.9	-6.5	14.1
Wholesale and Retail Trade	-0.9	3.0	0.2	-8.2	-9.0	-23.9
Other Private Services	-0.2	3.0	0.6	-7.7	-7.9	11.0
Oil Platforms	0.1	3.1	0.7	-8.4	-8.4	15.1
Finance and Insurance	-1.1	3.2	3.4	-5.7	-6.7	16.6
Total	-0.8		0.3	-0.9	-1.7	-2.7