Spatial-economic-ecological model for the assessment of sustainability policies of the Russian Federation

Modeling effects of pollution on public health and social welfare

Energy efficiency and sustainability policies in Russia

Final project conference of the FP7 project on developing the Spatial-economic-ecological model for the assessment of sustainability policies of the Russian Federation

15 December 2011

Moscow

Social block

- Labor market
- Health and labor market effects of pollution
- Income distribution (poverty and inequality)

Health effects of pollution in a CGE model

- Mayeres and Van Regemorter (2003), GEM-E3 (economy-energy-environment).
  - Consider 5 energy-related pollutants (CO_2, nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic compounds (VOC) and particulates (PM)) and translates them into concentration or deposition of pollutants (ambient concentration)
  - To restore health, you need money and time inputs
    - Introduce health into the utility function
    - Health production function (health index). Money is necessary to buy medical services. Public health expenditures: price subsidies to co-finance private expenditures on medical care.
    - Pollution reduces the total available time of HH.
  - Feedback effects:
    - Pollution reduces the total available time of HH, hence, income and labor and leisure decisions (directly and via income).
    - Pollution affects labor productivity (labor in efficient units decreases)
- Yang, Matus, Paltsev and Reilly (2005), EPPA (Emissions Prediction and Policy Analysis) model, MIT
  - Consider six pollutants (tropospheric ozone (O_3), nitrates, SO_2, CO, and particulate matter (PM 10, PM 2.5))
  - Introduce household healthcare production sector to combat adverse effects of pollution
  - The HHP relies on hh labor and medical services bought in the market. Separate production relationships for health effects of each pollutant.

Health effects in GEM-E3

- Representative consumer, two level nested LES utility function (as in the standard GEM-E3) but with a health component. Direct effect of pollution: a separable effect of air pollution on utility

$$U^0 = \alpha_1^0 \ln\left(C - \overline{C}\right) + \alpha_2^0 \ln(l - \bar{l}) + \alpha_3^0 \ln(H - \overline{H}) - \sum_{m=1}^{M} \alpha_{H,m}^0 A_m$$

- Health production function (health index)

$$A_m = A_m(EM_1, \ldots, EM_{PO}) \ \forall m$$

$$H = H^* - \sum_m \beta_{1,m} A_m + \beta_2 MED$$

- Budget constraint

$$p_C C + wl + p_{MED} MED \le Y$$

- Public health expenditures: transfers from the budget to finance private expenditures on health or a subsidy in price
- $p_{MED} = q_{MED} + t_{MED}$ or $MED = MED_{HH} - MED_{PUB}$, and MED_{HH} in HP

- Feedback on LS: pollution reduces the total available time, hence, income and labor and leisure decisions. Reflects time costs of investment into health.

$$Y = w\left(T - \sum_{m=1}^{M} \theta_m A_m\right) + P$$

Health-related effects in production

- In addition, the productivity of labor in the production sectors is affected.

- A way to introduce the effect of deteriorated health on productivity (labor in efficiency units decreases) *and* the institutional setting where the monetary effects of time of illness are shared by households and employers

  – A rise in air pollution reduces labor productivity: more labor is needed to produce one unit of output (via gamma function - % of working days lost)

$$Min \qquad rK_j + w^g L_j$$

$$s.t. \quad X_{Dj} = \left[d_{Kj}^{\frac{1}{\sigma_j}} K_j^{\frac{\sigma_j - 1}{\sigma_j}} + d_{Lj}^{\frac{1}{\sigma_j}} \left(L_j \left(1 - \gamma \left(A_1, \ldots, A_M \right) \right) \right)^{\frac{\sigma_j - 1}{\sigma_j}} \right]^{\frac{\sigma_j}{\sigma_j - 1}}$$

- The increased costs of labor induce a substitution towards the other production factors

ExternE

- Presents estimates for the total damage of air pollution, including the mortality, morbidity and non-health related impacts

Table 1: The total damage of air pollution and the damage related to mortality, morbidity and non-health impacts

Secondary pollutant	Total damage (ECU/person/unit of ambient concentration[a])	Components of total damage		
		Mortality	Morbidity	Non-health impacts
PM_{10}, nitrates	18.92	12.64	4.48	1.80
$PM_{2.5}$, sulphates	31.14	20.97	7.37	2.80
SO_2	0.53	0.52	0.003	0.00
O_3	5.87	0.86	3.05	1.96

Source: ExternE (1996, 1998, 2000)

[a] units of ambient concentration: μg/m³ for $PM_{2.5}$, PM_{10}, nitrates, sulphates, SO_2; 6h ppb for O_3

- For the calibration of the model these values are decomposed further by distinguishing between
  - different economic agents (consumers, producers and government)
  - different components of the MWTP (i.e., time cost, nonseparable health cost and separable cost component).

Valuation of damage

- Pollution costs data are adopted from Mayers and Van Regemorter (2003)

- Assessment of the value (in monetary terms) of the environmental damages caused by the incremental pollution (compared to a reference situation). Damage to public health include acute morbidity and mortality, chronic morbidity.

- For the monetary valuation of the physical damage, a valuation function VAL for the physical damage is used.

  – Mortality is evaluated at either statistical value of life or at lost life year value.
  – The economic valuation of morbidity effects of the damage should be based on the willingness-to-pay or willingness to accept concept.
  – Costs related to hospital costs could be treated as a demand for medical services, lost work time - as a reduction in the labor force (in money equivalents), and damages beyond these market effects as a loss of leisure.

Adjustments to valuation of damage

- In Mayers and Van Regemorter (2003) the costs of pollution are evaluated in ECU 1995.
- We use inflation data for EU from EconStats (http://www.econstats.com) to convert ECU 1995 into EUR 2006.
- GDP per capita in EU is higher than in Russia. So we correct the costs of pollution in the following way:

$$Costs\_Russia = Costs\_EU * \frac{GDP\_per\_capita\_RUS}{GDP\_per\_capita\_EU}$$

- Finally costs were converted in rubles with the annual average exchange rate.

Labor market

- Walrasian framework vs search/matching
- Adjustment via wages rather than quantity
- Unemployment (voluntary?)

Income distribution issues

- CGE model with representative agents (CGE-RH)
  - *Basic idea:* poverty analysis is performed by using the variation of income of RH generated by CGE model. Allows no within-group income distribution study
- Integrated multi-households CGE analysis (CGE-IMH)
  - Large number of representative households, as many households as could be found in income and expenditure household surveys.
- Sequential micro-simulation approach (CGE-SMS)
  - the approach is to use the CGE model to generate a price vector (including wage rates)
  - a household micro-simulation (HHMS) model is used to calculate the household behavior (consumption and labor supply).
  - The aggregate vectors from HHMS (consumption and LS) are then fed into the CGE model in which they are now exogenous variables and the iteration process continues until the results, between two iteration processes for all variables, are equal to zero.

Data for social block

- Two main sources of data for the social block of SUST-RUS: Rosstat and *Russian Longitudinal Monitoring Survey* (RLMS) for 2006 as SAM in SUST-RUS is for 2006.
- Heterogeneity taken into account:
  – Regional – 7 federal okrugs;
  – Skill level in the LM – low, medium, high
  – Household types by income per capita (into three equally sized groups) - low, middle and high income

Data cntd’

- *<u>Population and population growth rate by federal regions</u>.* Data on *population number* are reported by Rosstat. The main source of these data for Rosstat is population censuses. Birth and death data are used as well. *Growth rate* is calculated as a percentage change in population number in current year with respect to the previous year.
- *<u>Skills of labor force</u>.* Skills are defined on the base of one-digit International Standard Classification of Occupations.
  - According to RLMS the biggest group of worker is medium skilled workers. They constitute two thirds of all workers. High skilled and low skilled workers represent 22% and 12% of all workers respectively.

Level of skills	ISCO codes	Occupations
Low	9	Elementary (unskilled) occupations
Medium	3-8	Technicians and associate professionals, clerks, service workers and market workers, skilled agricultural and fishery workers, craft and related trades, plant and machine operators and assemblers
High	1-2	Legislators, senior managers, officials and professionals

Data cntd'

- *Household types.* Three types according to their income per capita. To reach interregional comparability income data are corrected by regional subsistence level.
  - Households in the first (lowest) quantile of income distribution are considered as low income families. Medium income and high income households are those in the second and in the third (richest) quantiles of income distribution.
  - According to RLMS 26% of workers live in low income households, 32% of workers live in medium income families and 41% in high income households.
- *Share of wage income by skill type, household type and okrug.* The figures are calculated on the basis of RLMS. Wage income is monthly labor income at the main job of individual.

Okrug	Income type	Skill type	Share of wage income
Central	Low income	High	14%
Central	Low income	Medium	74%
Central	Low income	Low	12%

Data cntd'

- *Distribution of skills by okrug and household type.* Use RLMS to generate the data. *A*n example

Okrug	Income type	Skill type	Share
Central	Low income	High	16%
Central	Low income	Medium	69%
Central	Low income	Low	15%

- *Level of unemployment by skills.* No direct way to get data on level of unemployment by *skills* for Russian federal regions. Rosstat does not report such data and there is no information on skills for unemployed in RLMS data set. We use the following procedure to calculate requested data:
    - We take data on unemployment level by educational group in Russian regions from Rosstat publications (year 2006);
    - Then we derive educational structure of workers by skills in each region from RLMS, 2006;
    - Combining data from (a) and (b) we get data on unemployment level by skills. Rather strong assumption is used in this computation. We suppose that educational structure by skills is similar for employed and unemployed.

Table 1: Health impact of pollutants from ExternE (in cases/(yr-1000people-µg/m^3)

Pollutant	Effect	Rate
PM10	Acute mortality	0.00399
ug/m3	Respiratory hospital admissions	0.00207
	Congestive heart failure	0.00259
	Cerebrovascular hospital admission	0.00504
	RADs	20.00000
	Bronchodilator usage by children for asthma	0.54250
	Bronchodilator usage by adults for asthma	4.56376
	Cough in asthmatic children	0.93100
	Cough in asthmatic adults	4.69284
	Wheeze in asthmatic children	0.72030
	Wheeze in asthmatic adults	1.69681
	Chronic mortality	0.15700
	Chronic bronchitis in adults	0.03920
	Change in prevalence of children with bronchitis	0.32200
	Change in prevalence of children with chronic cough	0.41400

Table 2 : Valuation of mortality and morbidity impacts from ExternE (ECU 1990)

Mortality	
Statistical life	2600000
Lost life year	81000
Acute Morbidity	
Hospital admission for respiratory or cardiovascular symptoms	6500
Emergency room visit or hospital visit for childhood croup	185
Restricted activity days (RAD)	62
Symptoms of chronic bronchitis or cough	6
Asthma attacks or minor symptoms	31
Chronic Morbidity	
Chronic bronchitis/asthma in adults	87000
Non fatal cancer/malginant neoplasm	372000
Changes in prevalence of cough/bronchitis in children	186

Table 3: Damage from an increase in air pollution (10^6 ECU90 per 1000 persons)

From an increase of one μg/m^3 of PM10 concentration	0.008322
from an increase of one μg/m^3 of PM 2.5 concentration	0.013631
from an increase of one μg/m^3 of SO_2 concentration	0.000596
from increase of one ppb of ozone concentration	0.001510