

Les modèles de prospective entre Capitoile et Roche  
Tarpéienne: vers la fin du dialogue manqué entre  
économistes et ingénieurs  
Séminaire du CFE du 4 avril 2007

Commentaires par  
Alain Bernard

# Introduction

- Difficile d'intervenir après Jean-Charles
  - Grand talent oratoire et faconde toute béarnaise
  - Comme Obélix, tombé tout petit dans la potion magique de la modélisation énergétique et du changement climatique
  - Ai aussi des lettres de noblesse dans la modélisation, puisque ai fait mes premières armes avec L. Stoléru et J. Mairesse, il y a 40 ans, sur un modèle de croissance optimale multi-sectoriel de l'économie française
- Il nous présente un projet ambitieux, au titre évocateur
  - En nous mettant bien en garde à l'égard des risques de chute
  - En visant à renouer le dialogue entre économistes et ingénieurs (ne peut que me séduire, étant censé appartenir à l'école française dite des « ingénieurs-économistes »)

# Introduction (suite)

- Pris connaissance des documents qui m'ont été envoyés (4 au total) et écouté attentivement son exposé
- Sentiment que pour l'instant IMACLIM-R est un modèle encore en développement, visant à faire le pont entre modèles bottom-up et top-down
- Que donc des remarques ou critiques de collègues sont « encore » les bienvenues
- Ai « tilté », de manière approbative ou interrogative, à des expressions rencontrées au cours de la lecture: recursivité, clay-clay; moteur de croissance, « Endogenous Structural Change induced interactions between demand and supply, and ITC mechanisms » (laissé en anglais car pas bien sûr de savoir traduire), diagramme de Kaya (crois avoir su, mais ne me rappelle pas)
- En fait 4 diapos principales décrivent, symboliquement ou réellement le projet:
  - La 23ème, Pour résumer: position du modèle idéal
  - La 26ème, Un programme basé sur le diagnostic des 4 limites de l'état de l'art actuel
  - La 27ème, Ce que nous voudrions représenter
  - La 28ème, Principaux principes de modélisation

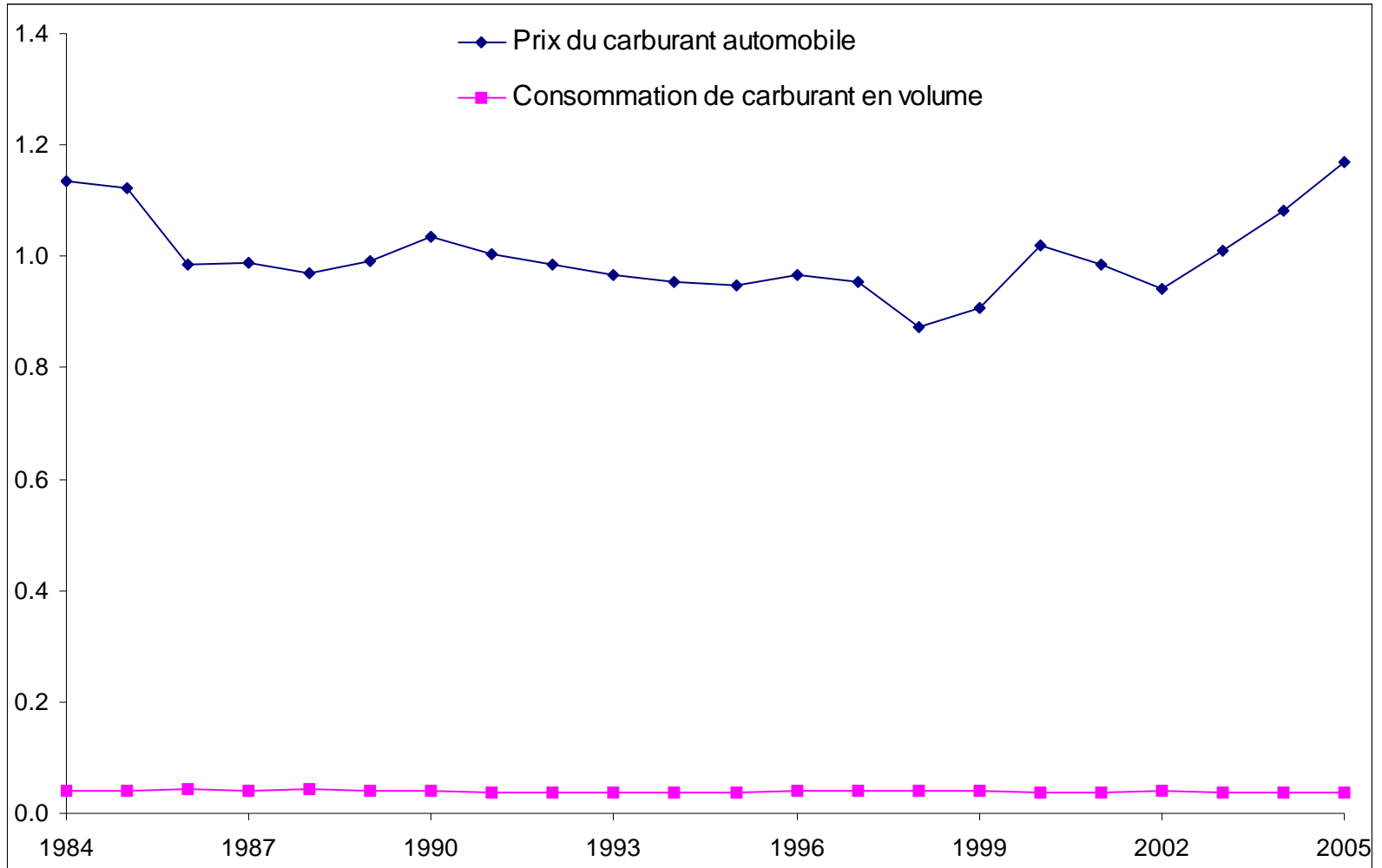
# Introduction (suite)

- Difficile de contester directement ces ambitions et ce programme
- Me placer davantage sur le terrain du réalisme
- Partir des enseignements de l'expérience passée
- Définir ce que l'on peut raisonnablement envisager pour l'avenir, compte tenu en particulier:
  - De ce que l'on veut éclairer par des modèles, en particulier selon l'horizon retenu
  - Des moyens disponibles, notamment dans le domaine de l'information économique et statistique

# Enseignements de l'expérience passée

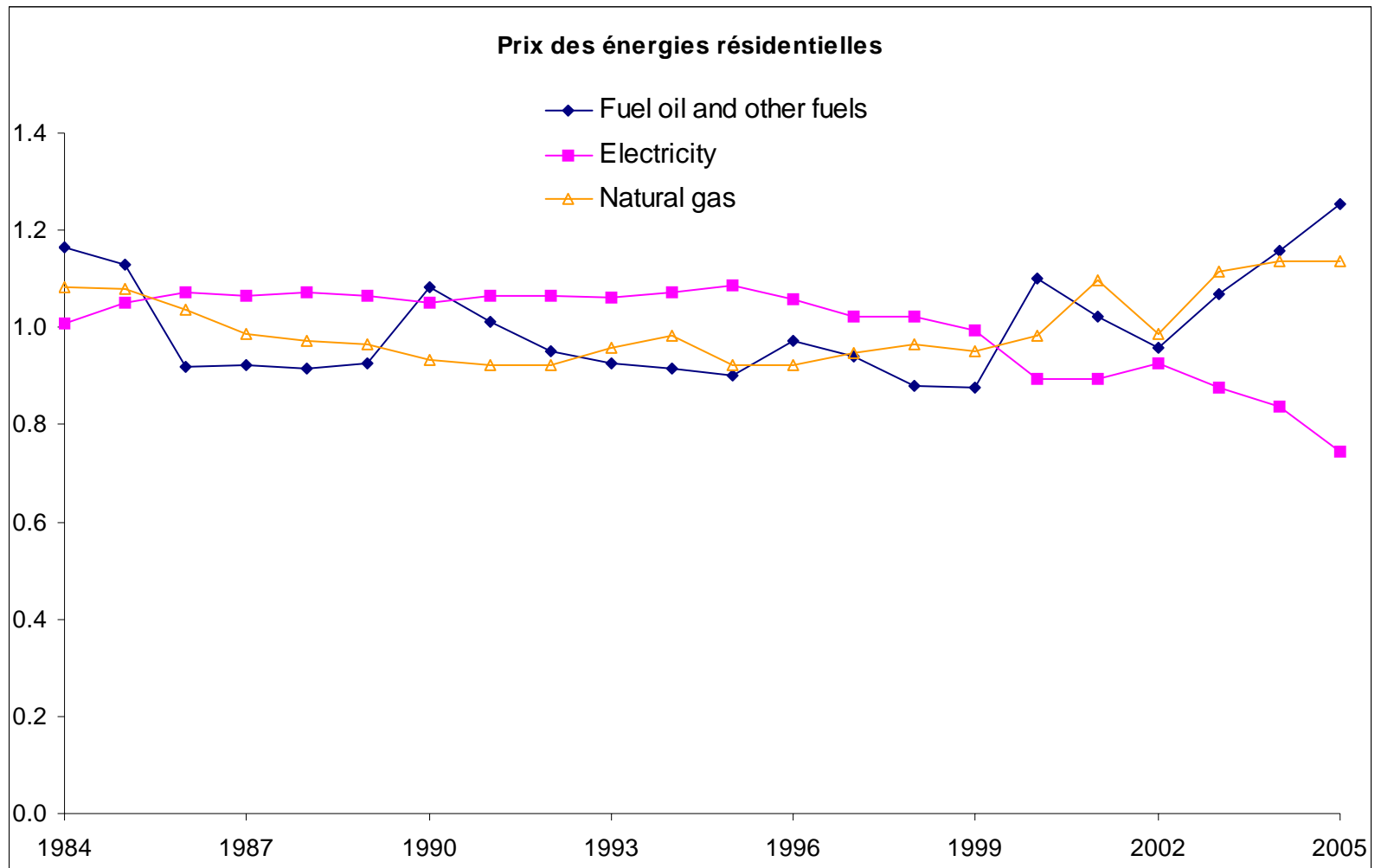
- Dans les applications au problème du changement climatique, deux types d'exercice
  - Exercice standard, pont aux ânes des modèles, qui est la simulation du protocole de Kyoto (horizon 2010, avec d'éventuels prolongements à 2020)
  - Exploration d'horizons plus lointains allant de 2050 à 2100 (EMF21)
- Dans le premier type, variation des prix de l'énergie qui se situe dans l'intervalle des fluctuations passées
- Dans le second type, on est très au-delà de sorte que l'on peut avoir des doutes sur le comportement des agents

# Illustration



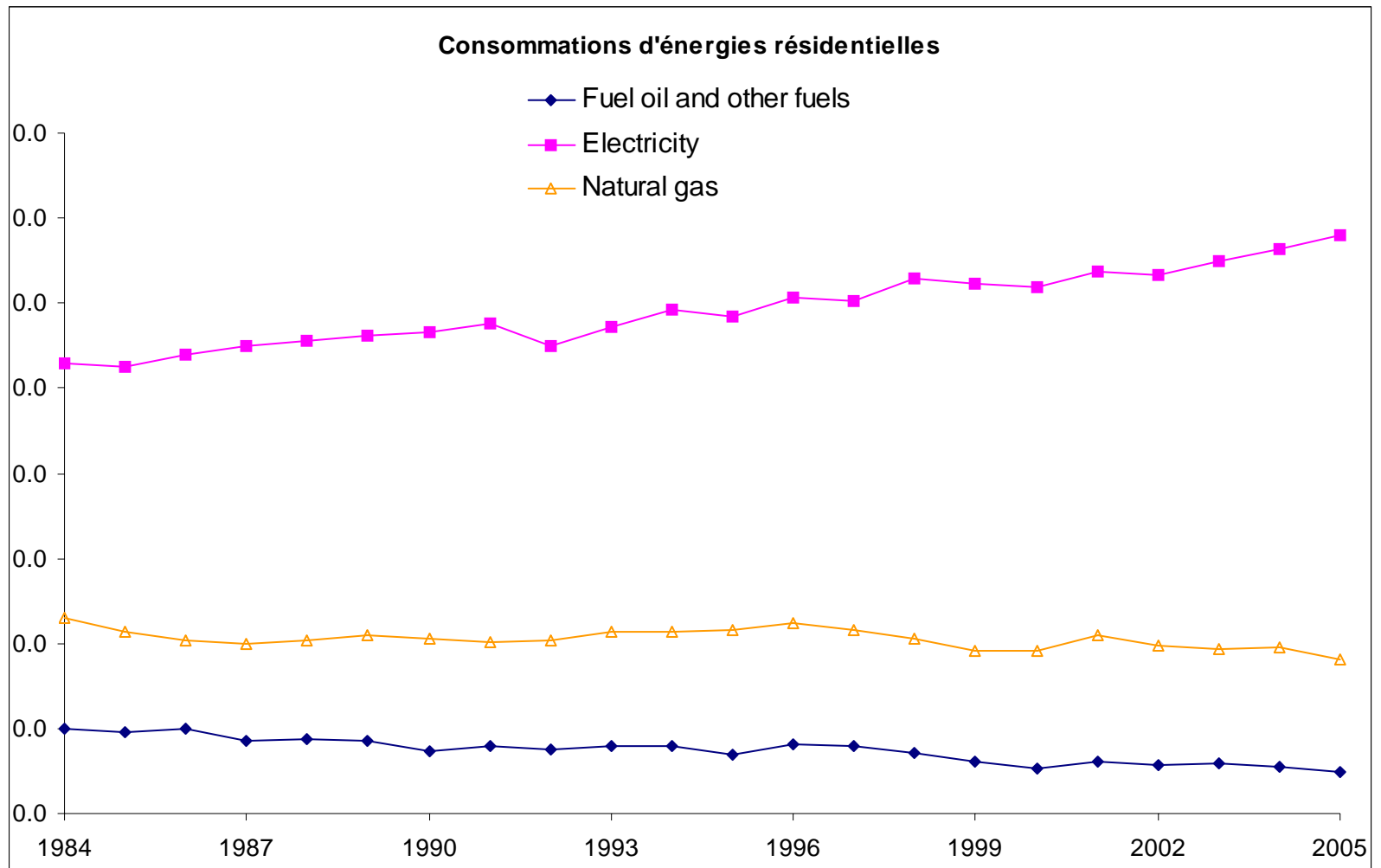
Source: Consumer Expenditure Survey (BLS)

# Illustration (suite)



Source: Consumer Expenditure Survey (BLS)

# Illustration (suite)



Source: Consumer Expenditure Survey (BLS)



# Estimations économétriques (consommation de carburant)

|                                      | Sans progrès<br>technique | Avec progrès<br>technique | MW<br>Middle West | NE<br>North East | S<br>South       | W<br>West        |
|--------------------------------------|---------------------------|---------------------------|-------------------|------------------|------------------|------------------|
| <b>Rank 3</b>                        |                           |                           |                   |                  |                  |                  |
| <i>All households</i>                |                           |                           |                   |                  |                  |                  |
| PT                                   |                           | 0.79%<br>(11.9)           | 1.25%<br>(13.5)   | 0.91%<br>(7.1)   | 1.24%<br>(13.4)  | 0.90%<br>(6.9)   |
| Income elasticity<br>Centre sample   | 0.0384<br>(86.7)          | 0.0385<br>(109.2)         | 0.0424<br>(96.9)  | 0.0389<br>(78.8) | 0.0411<br>(85.9) | 0.0378<br>(71.2) |
| Price elasticity<br>(centre sample)  | -0.178<br>(6.7)           | -0.213<br>(10.0)          | -0.220<br>(6.2)   | -0.189<br>(3.7)  | -0.157<br>(4.3)  | -0.353<br>(6.8)  |
| <i>All households except class 1</i> |                           |                           |                   |                  |                  |                  |
| PT                                   |                           | 0.73%<br>(11.2)           | 1.17%<br>(13.3)   | 0.77%<br>(6.3)   | 1.21%<br>(12.5)  | 0.73%<br>(6.1)   |
| Income elasticity<br>(centre sample) | 0.0365<br>(81.5)          | 0.0365<br>(102.6)         | 0.0411<br>(100.5) | 0.0381<br>(78.1) | 0.0392<br>(77.7) | 0.0358<br>(70.5) |
| Price elasticity<br>(centre sample)  | -0.180<br>(6.8)           | -0.209<br>(9.9)           | -0.243<br>(7.4)   | -0.185<br>(3.7)  | -0.166<br>(4.4)  | -0.308<br>(6.0)  |
| <b>Rank 4</b>                        |                           |                           |                   |                  |                  |                  |
| <i>All households</i>                |                           |                           |                   |                  |                  |                  |
| PT                                   |                           | 0.67%<br>(11.6)           | 1.12%<br>(12.2)   | 0.83%<br>(6.6)   | 1.10%<br>(13.5)  | 0.73%<br>(7.5)   |
| Income elasticity<br>(centre sample) | 0.0381<br>(67.3)          | 0.0378<br>(81.8)          | 0.0438<br>(65.3)  | 0.0407<br>(57.1) | 0.0417<br>(58.8) | 0.0374<br>(48.2) |
| Price elasticity<br>(centre sample)  | -0.088<br>(2.5)           | -0.140<br>(5.1)           | -0.234<br>(4.8)   | -0.183<br>(2.7)  | -0.077<br>(1.6)  | -0.173<br>(2.4)  |
| <i>All households except class 1</i> |                           |                           |                   |                  |                  |                  |
| PT                                   |                           | 0.62%<br>(10.8)           | 1.06%<br>(11.8)   | 0.69%<br>(5.9)   | 1.08%<br>(12.4)  | 0.59%<br>(6.6)   |
| Income elasticity<br>(centre sample) | 0.0359<br>(57.8)          | 0.0356<br>(70.3)          | 0.0422<br>(58.8)  | 0.0396<br>(48.9) | 0.0396<br>(48.0) | 0.0351<br>(40.9) |
| Price elasticity<br>(centre sample)  | -0.097<br>(2.8)           | -0.139<br>(5.1)           | -0.251<br>(5.4)   | -0.167<br>(2.5)  | -0.084<br>(1.6)  | -0.135<br>(1.9)  |

# Estimations économétriques (consommation de carburant)

|                                      | Generation (age of repr. person) |                  |                  |                  |                  |                  | Size of household |                  |                  |                  |                  |
|--------------------------------------|----------------------------------|------------------|------------------|------------------|------------------|------------------|-------------------|------------------|------------------|------------------|------------------|
|                                      | Under25                          | 25<br>to 34      | 35<br>to 44      | 45<br>to 54      | 55<br>to 64      | 65<br>or up      | S1                | S2               | S3               | S4               | S5               |
| <b>Rank 3</b>                        |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| <i>All households</i>                |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| PT                                   | 0.61%<br>(4.1)                   | 0.75%<br>(7.6)   | 0.84%<br>(6.7)   | 1.29%<br>(9.2)   | 1.71%<br>(9.6)   | 1.74%<br>(10.2)  | 1.44%<br>(7.9)    | 0.94%<br>(10.3)  | 0.95%<br>(7.9)   | 0.55%<br>(5.7)   | 1.17%<br>(7.8)   |
| Income elasticity<br>Centre sample   | 0.0416<br>(46.7)                 | 0.0373<br>(62.1) | 0.0396<br>(51.5) | 0.0407<br>(50.6) | 0.0400<br>(51.5) | 0.0328<br>(67.0) | 0.0270<br>(50.4)  | 0.0354<br>(61.5) | 0.0405<br>(53.4) | 0.0386<br>(48.5) | 0.0450<br>(48.6) |
| Price elasticity<br>Centre sample    | -0.080<br>(1.0)                  | -0.175<br>(3.9)  | -0.205<br>(3.8)  | -0.175<br>(3.1)  | -0.278<br>(5.0)  | -0.248<br>(4.4)  | -0.331<br>(5.8)   | -0.186<br>(4.7)  | -0.198<br>(3.9)  | -0.108<br>(2.2)  | -0.264<br>(4.7)  |
| <i>All households except class 1</i> |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| PT                                   | 0.56%<br>(3.5)                   | 0.77%<br>(7.8)   | 0.58%<br>(5.8)   | 1.16%<br>(10.8)  | 1.70%<br>(9.6)   | 1.67%<br>(9.6)   | 1.38%<br>(7.7)    | 0.93%<br>(9.6)   | 0.77%<br>(7.8)   | 0.46%<br>(4.8)   | 1.06%<br>(7.9)   |
| Income elasticity<br>Centre sample   | 0.0406<br>(35.7)                 | 0.0344<br>(62.6) | 0.0377<br>(62.7) | 0.0383<br>(64.5) | 0.0376<br>(52.2) | 0.0314<br>(61.5) | 0.0258<br>(45.8)  | 0.0335<br>(61.4) | 0.0383<br>(63.0) | 0.0355<br>(48.1) | 0.0416<br>(53.4) |
| Price elasticity<br>Centre sample    | -0.064<br>(0.8)                  | -0.197<br>(4.6)  | -0.200<br>(4.5)  | -0.172<br>(3.9)  | -0.303<br>(5.7)  | -0.257<br>(4.5)  | -0.329<br>(5.8)   | -0.217<br>(5.5)  | -0.175<br>(4.0)  | -0.127<br>(2.7)  | -0.280<br>(5.6)  |
| <b>Rank 4</b>                        |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| <i>All households</i>                |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| PT                                   | 0.60%<br>(4.1)                   | 0.65%<br>(8.2)   | 0.76%<br>(5.8)   | 1.19%<br>(8.6)   | 1.52%<br>(9.5)   | 1.50%<br>(10.8)  | 1.18%<br>(8.5)    | 0.84%<br>(10.4)  | 0.86%<br>(7.5)   | 0.54%<br>(5.4)   | 1.05%<br>(7.9)   |
| Income elasticity<br>Centre sample   | 0.0398<br>(33.7)                 | 0.0367<br>(46.0) | 0.0395<br>(40.2) | 0.0411<br>(40.8) | 0.0404<br>(39.5) | 0.0327<br>(46.3) | 0.0259<br>(35.3)  | 0.0365<br>(48.4) | 0.0405<br>(41.5) | 0.0375<br>(38.0) | 0.0443<br>(35.1) |
| Price elasticity<br>Centre sample    | -0.112<br>(1.1)                  | -0.012<br>(0.2)  | -0.211<br>(2.8)  | -0.150<br>(1.9)  | -0.208<br>(2.9)  | -0.152<br>(2.3)  | -0.217<br>(3.2)   | -0.095<br>(1.8)  | -0.159<br>(2.3)  | -0.164<br>(2.4)  | -0.192<br>(2.5)  |
| <i>All households except class 1</i> |                                  |                  |                  |                  |                  |                  |                   |                  |                  |                  |                  |
| PT                                   | 0.53%<br>(3.5)                   | 0.66%<br>(8.9)   | 0.51%<br>(5.0)   | 1.06%<br>(10.3)  | 1.50%<br>(9.4)   | 1.40%<br>(10.4)  | 1.06%<br>(8.5)    | 0.83%<br>(9.6)   | 0.69%<br>(7.7)   | 0.46%<br>(4.7)   | 0.97%<br>(8.5)   |
| Income elasticity<br>Centre sample   | 0.0378<br>(27.7)                 | 0.0335<br>(40.6) | 0.0365<br>(42.0) | 0.0382<br>(44.9) | 0.0375<br>(34.8) | 0.0311<br>(38.6) | 0.0231<br>(30.0)  | 0.0346<br>(41.1) | 0.0373<br>(42.0) | 0.0341<br>(32.2) | 0.0399<br>(32.3) |
| Price elasticity<br>Centre sample    | -0.111<br>(1.0)                  | -0.012<br>(0.2)  | -0.210<br>(3.5)  | -0.134<br>(2.2)  | -0.234<br>(3.4)  | -0.129<br>(1.9)  | -0.197<br>(3.1)   | -0.136<br>(2.5)  | -0.119<br>(2.0)  | -0.177<br>(2.7)  | -0.186<br>(2.7)  |

# Estimations économétriques (transport privé)

| All Households                                 | Rank 3            |                   |                   |                   |                   | Rank 4           |                   |                   |                   |                  |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|------------------|
|  | 0.6               | 0.8               | 1                 | 1.2               | 1.4               | 0.6              | 0.8               | 1                 | 1.2               | 1.4              |
| Relative Income                                |                   |                   |                   |                   |                   |                  |                   |                   |                   |                  |
| <i>Engel coeff.</i>                            |                   |                   |                   |                   |                   |                  |                   |                   |                   |                  |
| Vehicle purchase and insurance                 | 0.1918<br>(40.3)  | 0.1733<br>(49.2)  | 0.1548<br>(67.8)  | 0.1364<br>(39.6)  | 0.1179<br>(25.2)  | 0.1847<br>(16.5) | 0.1715<br>(26.6)  | 0.1567<br>(49.4)  | 0.1402<br>(22.7)  | 0.1221<br>(11.3) |
| Gasoline and motor oil                         | 0.0521<br>(73.6)  | 0.0449<br>(86.0)  | 0.0377<br>(112.1) | 0.0306<br>(59.8)  | 0.0234<br>(33.6)  | 0.0522<br>(31.3) | 0.0447<br>(46.9)  | 0.0373<br>(79.8)  | 0.0300<br>(32.9)  | 0.0228<br>(14.1) |
| Other vehicle charges (maint. ,rent. , licen.) | 0.0428<br>(43.2)  | 0.0424<br>(58.1)  | 0.0421<br>(89.5)  | 0.0417<br>(58.4)  | 0.0413<br>(42.4)  | 0.0405<br>(17.7) | 0.0419<br>(32.0)  | 0.0428<br>(66.6)  | 0.0431<br>(34.4)  | 0.0430<br>(19.4) |
| Current good of the economy                    | 0.7134<br>(147.8) | 0.7394<br>(207.1) | 0.7654<br>(331.0) | 0.7914<br>(226.6) | 0.8174<br>(172.1) | 0.7226<br>(63.6) | 0.7418<br>(113.6) | 0.7632<br>(237.5) | 0.7867<br>(125.7) | 0.8122<br>(74.0) |
| <i>price elasticity</i>                        |                   |                   |                   |                   |                   |                  |                   |                   |                   |                  |
| Vehicle purchase and insurance                 | -1.219<br>(1.8)   | -1.117<br>(2.9)   | -1.099<br>(4.3)   | -1.113<br>(4.6)   | -1.144<br>(4.9)   | -1.223<br>(1.6)  | -1.160<br>(2.8)   | -1.150<br>(4.2)   | -1.162<br>(4.6)   | -1.190<br>(4.5)  |
| Gasoline and motor oil                         | -0.033<br>(0.4)   | -0.128<br>(2.7)   | -0.188<br>(6.5)   | -0.235<br>(7.2)   | -0.278<br>(7.6)   | 0.019<br>(0.2)   | -0.061<br>(1.0)   | -0.102<br>(3.1)   | -0.127<br>(3.1)   | -0.143<br>(2.7)  |
| Other vehicle charges (maint. ,rent. , licen.) | -2.959<br>(1.7)   | -4.206<br>(4.5)   | -4.847<br>(9.4)   | -5.244<br>(9.5)   | -5.519<br>(9.4)   | -4.531<br>(1.9)  | -3.602<br>(3.2)   | -3.584<br>(6.1)   | -3.942<br>(6.1)   | -4.494<br>(5.8)  |
| Current good of the economy                    | -0.198<br>(1.7)   | -0.262<br>(3.3)   | -0.301<br>(5.3)   | -0.325<br>(6.0)   | -0.340<br>(6.5)   | -0.189<br>(1.6)  | -0.225<br>(2.9)   | -0.251<br>(4.5)   | -0.271<br>(5.2)   | -0.288<br>(5.4)  |
| <i>Technical progress</i>                      |                   |                   |                   |                   |                   |                  |                   |                   |                   |                  |
| Vehicle purchase and insurance                 | 0.18%             | (0.1)             |                   |                   |                   | 0.85%            | (0.3)             |                   |                   |                  |
| Gasoline and motor oil                         | 1.37%             | (1.8)             |                   |                   |                   | 1.09%            | (4.3)             |                   |                   |                  |
| Other vehicle charges (maint. ,rent. , licen.) | 0.07%             | (0.2)             |                   |                   |                   | 0.32%            | (0.3)             |                   |                   |                  |
| Current good of the economy                    | -0.11%            | (0.3)             |                   |                   |                   | -0.22%           | (0.4)             |                   |                   |                  |

# Estimations économétriques (énergies résidentielles)

| All Households              | Rank 3            |                    |                    |                    |                   | Rank 4            |                   |                    |                   |                   |
|-----------------------------|-------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|--------------------|-------------------|-------------------|
|                             | 0.6               | 0.8                | 1                  | 1.2                | 1.4               | 0.6               | 0.8               | 1                  | 1.2               | 1.4               |
| Relative Income             |                   |                    |                    |                    |                   |                   |                   |                    |                   |                   |
| <i>Engel coeff.</i>         |                   |                    |                    |                    |                   |                   |                   |                    |                   |                   |
| Fuel oil and other fuels    | 0.0019<br>(9.8)   | 0.0018<br>(12.6)   | 0.0017<br>(18.4)   | 0.0016<br>(11.3)   | 0.0015<br>(7.7)   | 0.0029<br>(5.8)   | 0.0020<br>(7.2)   | 0.0014<br>(10.4)   | 0.0011<br>(4.0)   | 0.0010<br>(2.1)   |
| Electricity                 | 0.0217<br>(29.6)  | 0.0198<br>(36.7)   | 0.0179<br>(51.7)   | 0.0160<br>(30.3)   | 0.0141<br>(19.6)  | 0.0275<br>(17.7)  | 0.0206<br>(23.2)  | 0.0155<br>(35.6)   | 0.0121<br>(14.2)  | 0.0106<br>(7.0)   |
| Natural gas                 | 0.0067<br>(903.3) | 0.0066<br>(1229.8) | 0.0064<br>(1921.0) | 0.0063<br>(1264.1) | 0.0061<br>(926.9) | 0.0081<br>(405.2) | 0.0067<br>(716.3) | 0.0058<br>(1485.0) | 0.0054<br>(752.8) | 0.0054<br>(427.0) |
| Current good of the economy | 0.9696<br>(20.5)  | 0.9718<br>(27.2)   | 0.9739<br>(41.3)   | 0.9761<br>(26.6)   | 0.9783<br>(19.0)  | 0.9616<br>(10.3)  | 0.9707<br>(15.0)  | 0.9773<br>(26.9)   | 0.9815<br>(12.5)  | 0.9831<br>(7.1)   |
| <i>price elasticity</i>     |                   |                    |                    |                    |                   |                   |                   |                    |                   |                   |
| Fuel oil and other fuels    | -0.351<br>(1.4)   | -0.366<br>(2.1)    | -0.381<br>(3.5)    | -0.395<br>(2.8)    | -0.410<br>(2.5)   | -0.268<br>(0.7)   | -0.306<br>(1.3)   | -0.344<br>(2.5)    | -0.382<br>(2.0)   | -0.417<br>(1.6)   |
| Electricity                 | -0.780<br>(3.8)   | -0.714<br>(4.4)    | -0.673<br>(5.2)    | -0.647<br>(5.1)    | -0.633<br>(5.0)   | -0.783<br>(3.3)   | -0.768<br>(4.8)   | -0.733<br>(6.1)    | -0.673<br>(5.2)   | -0.584<br>(3.9)   |
| Natural gas                 | -0.287<br>(2.1)   | -0.272<br>(2.9)    | -0.263<br>(4.0)    | -0.256<br>(3.5)    | -0.251<br>(3.2)   | -0.269<br>(1.5)   | -0.238<br>(2.2)   | -0.223<br>(3.2)    | -0.217<br>(2.5)   | -0.216<br>(2.0)   |
| Current good of the economy | -0.014<br>(1.6)   | -0.012<br>(2.2)    | -0.011<br>(3.2)    | -0.010<br>(2.9)    | -0.010<br>(2.6)   | -0.017<br>(1.3)   | -0.020<br>(2.8)   | -0.018<br>(4.4)    | -0.014<br>(3.0)   | -0.008<br>(1.6)   |
| <i>Technical progress</i>   |                   |                    |                    |                    |                   |                   |                   |                    |                   |                   |
| Fuel oil and other fuels    | 1.28%             | (2.2)              |                    |                    |                   | 2.18%             | (14.3)            |                    |                   |                   |
| Electricity                 | 1.26%             | (0.8)              |                    |                    |                   | 0.61%             | (0.5)             |                    |                   |                   |
| Natural gas                 | -1.19%            | (3.7)              |                    |                    |                   | -0.74%            | (121.5)           |                    |                   |                   |
| Current good of the economy | -0.03%            | (0.7)              |                    |                    |                   | -0.02%            | (0.5)             |                    |                   |                   |

# Quelques enseignements majeurs

## a) Meilleure compréhension des coûts

### Décomposition du coût de mise en œuvre du Protocole de Kyoto sans mécanisme de flexibilité en 2010

#### a. Etats-Unis

|   | EPPA    | GEMINI-E3 | POLES   |
|---|---------|-----------|---------|
| Baisse d'émission (MtC)                                   | 540     | 517       | 476     |
| Baisse d'émission (par rapport à la base 2010)            | - 29,8% | - 28,9%   | - 27,7% |
| Taxe sur le carbone (\$95)                                | 229     | 161       | 145     |
| Coût direct (Mds\$95)                                     | - 45    | - 30,7    | - 29,6  |
| Réduction du PIB (par rapport à la base 2010)             | - 1,0%  | - 0,4%    | —       |
| Effet sur les termes de l'échange(*)                      | + 2,39% | 0,7%      | —       |
| Pertes de surplus (variation équivalente, en pourcentage) | - 0,49% | —         | —       |
| Coût interne y compris distorsions fiscales (Mds\$95)     | —       | - 45,6    | —       |
| Gains des termes de l'échange (Mds\$95)                   | —       | 8,2       | —       |
| Surplus (Mds\$95)   | - 49    | - 37,4    | —       |

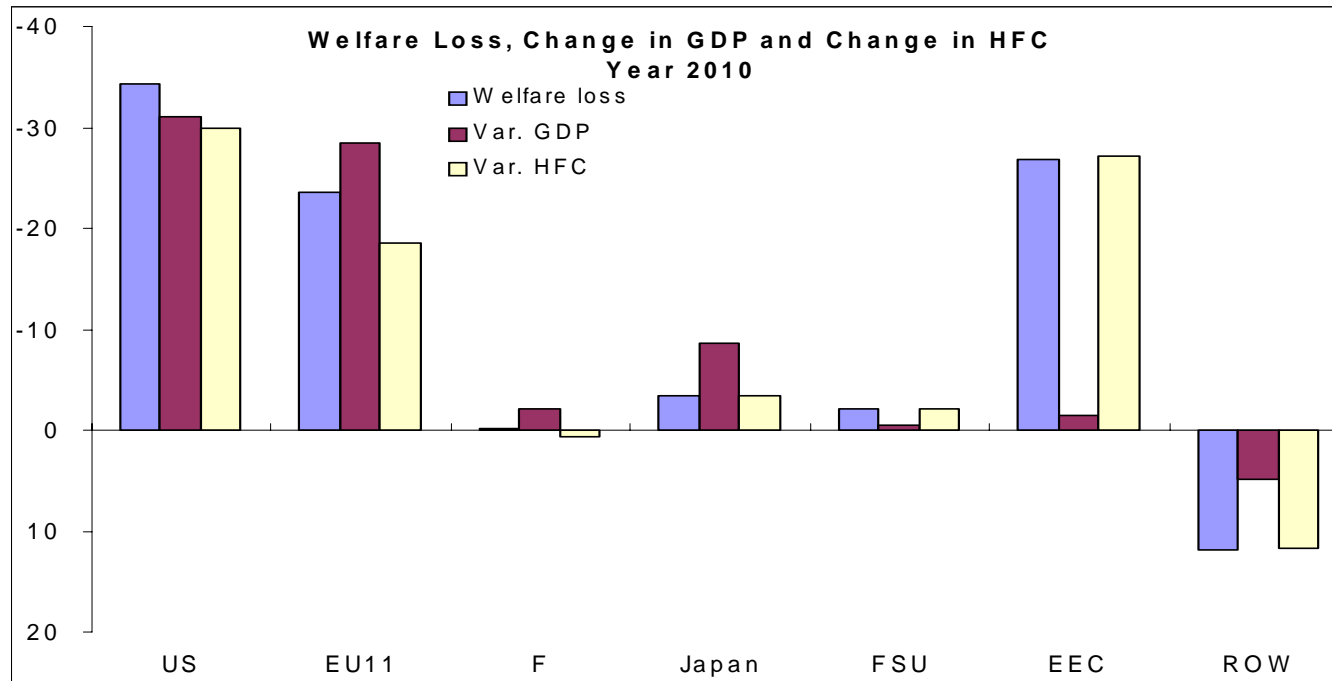
#### b. France

|   | EPPA    | GEMINI-E3 | POLES   |
|---|---------|-----------|---------|
| Baisse d'émission (MtC)                                   | 20,3    | 19,2      | 17,0    |
| Baisse d'émission (par rapport à la base 2010)            | - 17,5% | - 15,8%   | - 14,0% |
| Taxe sur le carbone (\$95)                                | 136     | 237       | 185     |
| Coût direct (Mds\$95)                                     | - 1,23  | - 1,9     | - 1,35  |
| Réduction du PIB (par rapport à la base 2010)             | - 1,1%  | - 0,2%    | —       |
| Effet sur les termes de l'échange(*)                      | +1,1%   | +0,7%     | —       |
| Pertes de surplus (variation équivalente, en pourcentage) | - 0,67% | —         | —       |
| Coût interne y compris distorsions fiscales (Mds\$95)     | —       | - 3,3     | —       |
| Gains des termes de l'échange (Mds\$95)                   | —       | 2,6       | —       |
| Surplus (Mds\$95)   | - 1,2   | - 0,7     | —       |

# Quelques enseignements majeurs

## b) Relations entre agrégats macroéconomiques

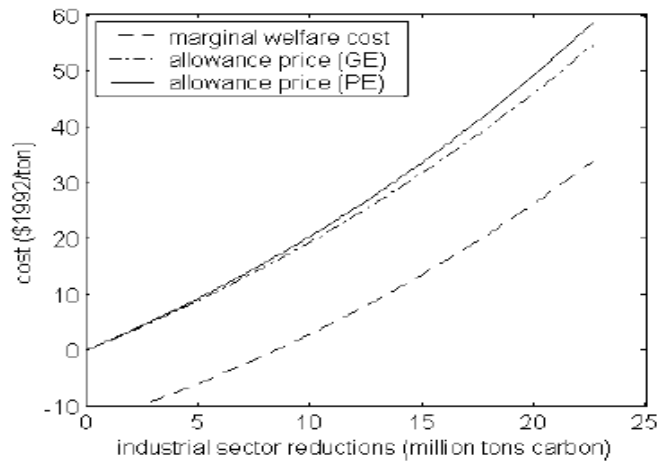
### La mesure du coût de mise en œuvre du protocole de Kyoto



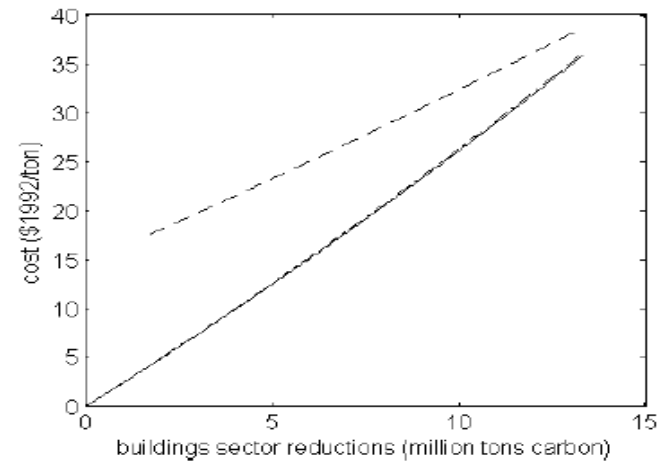
# Quelques enseignements majeurs

## c) Effets des distorsions fiscales (Source Pizer et alii, 2005)

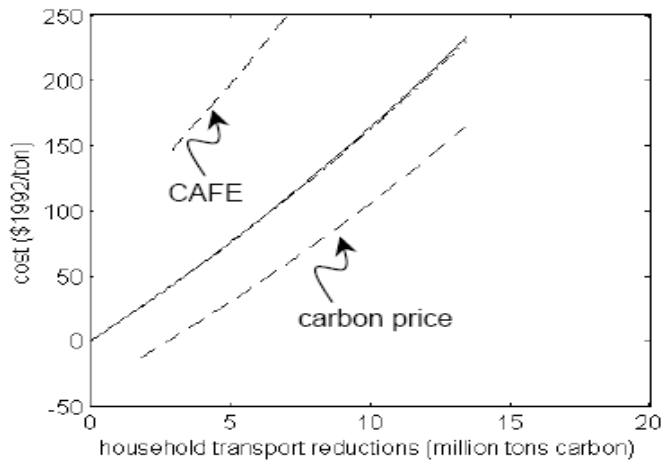
Figure 6: General and Partial Equilibrium Abatement Schedules and Welfare Cost



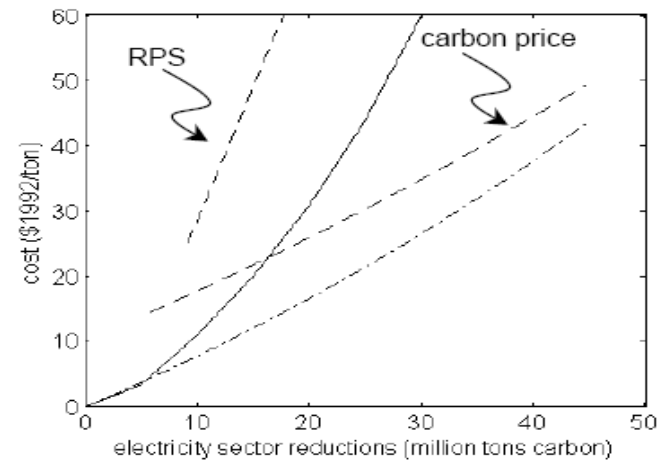
Industrial sector



Commercial buildings



Household transportation



Electricity

# Quelques enseignements majeurs

## d) Impacts des déséquilibres macroéconomiques (chômage classique)

### 1. Scénario Kyoto avec taxes nationales et redistribution par baisse de la TVA

|                    | Scen4<br>kyoto_zone_euro_B_pcons_tva |       |           | Scen5<br>Kyoto_zone_euro_B_ppib_tva |       |           | Scen6<br>kyoto_zone_euro_B_pb_tva |       |           |      |
|--------------------|--------------------------------------|-------|-----------|-------------------------------------|-------|-----------|-----------------------------------|-------|-----------|------|
|                    | 2010                                 | 2010  | 2010      | 2010                                | 2010  | 2010      | 2010                              | 2010  | 2010      | 2010 |
|                    | EU15                                 | FRA   | Allemagne | EU15                                | FRA   | Allemagne | EU15                              | FRA   | Allemagne |      |
| Volume             |                                      |       |           |                                     |       |           |                                   |       |           |      |
| GDP                | 0.0%                                 | -0.1% | 0.1%      | -0.1%                               | -0.2% | 0.1%      | -0.2%                             | -0.3% | 0.1%      |      |
| IMP                | -0.1%                                | 0.0%  | 0.0%      | -0.2%                               | 0.4%  | 0.0%      | -0.3%                             | 0.9%  | -0.1%     |      |
| CONS               | 0.1%                                 | -0.1% | 0.2%      | 0.0%                                | -0.1% | 0.2%      | -0.1%                             | -0.2% | 0.2%      |      |
| GCVTOT             | 0.00%                                | 0.01% | 0.00%     | 0.00%                               | 0.01% | 0.00%     | 0.00%                             | 0.01% | 0.00%     |      |
| INV                | -0.1%                                | -0.1% | -0.5%     | -0.2%                               | 0.5%  | -1.4%     | -0.4%                             | 0.9%  | -2.3%     |      |
| EXP                | -0.3%                                | -0.3% | 0.2%      | -0.3%                               | -0.4% | 0.7%      | -0.4%                             | -0.5% | 1.2%      |      |
| Prix relatif       |                                      |       |           |                                     |       |           |                                   |       |           |      |
| CONS               | -0.1%                                | -0.1% | -0.1%     | -0.1%                               | -0.2% | -0.1%     | -0.1%                             | -0.2% | -0.1%     |      |
| Terms of Trade     | 0.1%                                 | 0.1%  | 0.1%      | 0.1%                                | 0.1%  | 0.1%      | 0.2%                              | 0.2%  | 0.2%      |      |
| W                  | -0.1%                                | -0.1% | -0.1%     | 0.0%                                | 0.0%  | 0.0%      | 0.2%                              | 0.3%  | 0.3%      |      |
| Interest rates     |                                      |       |           |                                     |       |           |                                   |       |           |      |
| Euro zone          | 0.01%                                |       |           | -0.02%                              |       |           | -0.06%                            |       |           |      |
| GBR                | -0.04%                               |       |           | -0.04%                              |       |           | -0.04%                            |       |           |      |
| OEU                | 0.01%                                |       |           | -0.02%                              |       |           | -0.06%                            |       |           |      |
| EMPLOI TOTAL       | 0.1%                                 | -0.1% | 0.2%      | -0.1%                               | -0.2% | 0.1%      | -0.2%                             | -0.5% | 0.0%      |      |
| CAPITAL TOTAL      | 0.0%                                 | -0.1% | 0.1%      | 0.0%                                | -0.2% | 0.1%      | -0.1%                             | -0.2% | 0.2%      |      |
| Soldes commerciaux |                                      |       |           |                                     |       |           |                                   |       |           |      |
| DEU                | 0.10%                                |       |           | 0.24%                               |       |           | 0.39%                             |       |           |      |
| FRA                | -0.04%                               |       |           | -0.15%                              |       |           | -0.28%                            |       |           |      |
| GBR                | 0.00%                                |       |           | 0.00%                               |       |           | 0.00%                             |       |           |      |
| ITA                | -0.09%                               |       |           | -0.13%                              |       |           | -0.11%                            |       |           |      |
| ESP                | 0.21%                                |       |           | 0.34%                               |       |           | 0.58%                             |       |           |      |
| NLD                | -0.61%                               |       |           | -1.79%                              |       |           | -3.07%                            |       |           |      |
| BEL                | -0.20%                               |       |           | -0.38%                              |       |           | -0.35%                            |       |           |      |
| OEU                | 0.12%                                |       |           | 0.39%                               |       |           | 0.55%                             |       |           |      |



# Quelques enseignements majeurs

## d) Impacts des déséquilibres macroéconomiques (chômage classique)

### 2. Scénario Kyoto avec taxes nationales et redistribution par baisse Cot. Soc.

|                    | Scen7<br>kyoto_zone_euro_B_pcons_twx |       |           | Scen8<br>kyoto_zone_euro_B_ppib_twx |       |           | Scen9<br>kyoto_zone_euro_B_pb_twx |       |           |       |
|--------------------|--------------------------------------|-------|-----------|-------------------------------------|-------|-----------|-----------------------------------|-------|-----------|-------|
|                    | 2010                                 | 2010  | 2010      | 2010                                | 2010  | 2010      | 2010                              | 2010  | 2010      | 2010  |
|                    | EU15                                 | FRA   | Allemagne | EU15                                | FRA   | Allemagne | EU15                              | FRA   | Allemagne |       |
| Volume             |                                      |       |           |                                     |       |           |                                   |       |           |       |
| GDP                | 0.1%                                 | 0.1%  | 0.0%      | 0.1%                                | 0.1%  | 0.1%      | 0.1%                              | 0.1%  | 0.1%      | 0.1%  |
| IMP                | -0.1%                                | -0.1% | -0.1%     | -0.1%                               | -0.2% | -0.1%     | -0.1%                             | -0.2% | -0.1%     | -0.1% |
| CONS               | 0.1%                                 | 0.1%  | 0.0%      | 0.1%                                | 0.1%  | 0.1%      | 0.1%                              | 0.1%  | 0.1%      | 0.1%  |
| GCVTOT             | 0.00%                                | 0.00% | 0.00%     | 0.00%                               | 0.00% | 0.00%     | 0.00%                             | 0.00% | 0.00%     | 0.00% |
| INV                | 0.3%                                 | 0.3%  | -0.1%     | 0.3%                                | 0.1%  | -0.1%     | 0.3%                              | 0.1%  | -0.1%     | -0.1% |
| EXP                | -0.2%                                | -0.2% | 0.0%      | -0.2%                               | -0.1% | 0.1%      | -0.2%                             | -0.1% | 0.1%      | 0.1%  |
| Prix relatif       |                                      |       |           |                                     |       |           |                                   |       |           |       |
| CONS               | 0.0%                                 | 0.0%  | 0.0%      | 0.0%                                | 0.0%  | 0.0%      | 0.0%                              | 0.0%  | 0.0%      | 0.0%  |
| Terms of Trac      | 0.1%                                 | 0.1%  | 0.1%      | 0.1%                                | 0.1%  | 0.1%      | 0.1%                              | 0.1%  | 0.1%      | 0.1%  |
| W                  | -0.1%                                | 0.0%  | 0.0%      | -0.2%                               | 0.0%  | 0.0%      | -0.1%                             | 0.0%  | 0.0%      | 0.0%  |
| Interest rates     |                                      |       |           |                                     |       |           |                                   |       |           |       |
| Euro zone          | 0.03%                                |       |           | 0.03%                               |       |           | 0.04%                             |       |           |       |
| GBR                | -0.04%                               |       |           | -0.04%                              |       |           | -0.04%                            |       |           |       |
| OEU                | 0.03%                                |       |           | 0.03%                               |       |           | 0.04%                             |       |           |       |
| EMPLOI TOT         | 0.2%                                 | 0.3%  | 0.2%      | 0.2%                                | 0.3%  | 0.2%      | 0.2%                              | 0.2%  | 0.2%      | 0.2%  |
| CAPITAL TOT        | 0.0%                                 | 0.0%  | 0.0%      | 0.0%                                | 0.1%  | 0.0%      | 0.0%                              | 0.0%  | 0.0%      | 0.0%  |
| Soldes commerciaux |                                      |       |           |                                     |       |           |                                   |       |           |       |
| DEU                | 0.05%                                |       |           | 0.05%                               |       |           | 0.06%                             |       |           |       |
| FRA                | 0.01%                                |       |           | 0.04%                               |       |           | 0.04%                             |       |           |       |
| GBR                | 0.00%                                |       |           | 0.00%                               |       |           | 0.00%                             |       |           |       |
| ITA                | -0.05%                               |       |           | -0.04%                              |       |           | -0.04%                            |       |           |       |
| ESP                | -0.09%                               |       |           | -0.11%                              |       |           | -0.08%                            |       |           |       |
| NLD                | -0.10%                               |       |           | -0.06%                              |       |           | 0.01%                             |       |           |       |
| BEL                | -0.07%                               |       |           | -0.11%                              |       |           | -0.04%                            |       |           |       |
| OEU                | 0.04%                                |       |           | -0.01%                              |       |           | -0.09%                            |       |           |       |

# Quelques enseignements majeurs

## d) Impacts des déséquilibres macroéconomiques (chômage classique)

### 3. Effort accru en France avec taxes nationales et redistribution par baisse TVA

|                    | scen10bis<br>kyoto_zone_euro_B_pcons_tva |       |           | scen11bis<br>kyoto_zone_euro_B_ppib_tva |       |           | scen12bis<br>kyoto_zone_euro_B_pb_tva |        |           |  |
|--------------------|--|-------|-----------|---|-------|-----------|---------------------------------------|--------|-----------|--|
|                    | 2010                                     | 2010  | 2010      | 2010                                    | 2010  | 2010      | 2010                                  | 2010   | 2010      |  |
|                    | EU15                                     | FRA   | Allemagne | EU15                                    | FRA   | Allemagne | EU15                                  | FRA    | Allemagne |  |
| Volume             |  |       |           |   |       |           |                                       |        |           |  |
| GDP                | 0.0%                                     | -0.5% | 0.1%      | -0.1%                                   | -0.7% | 0.1%      | -0.1%                                 | -1.3%  | 0.1%      |  |
| IMP                | -0.1%                                    | -1.5% | 0.1%      | -0.1%                                   | -2.1% | 0.2%      | -0.1%                                 | -3.2%  | 0.2%      |  |
| CONS               | 0.0%                                     | -0.4% | 0.1%      | 0.0%                                    | -0.7% | 0.1%      | -0.1%                                 | -1.4%  | 0.2%      |  |
| GCVTOT             | 0.0%                                     | 0.0%  | 0.0%      | 0.0%                                    | 0.0%  | 0.0%      | 0.0%                                  | 0.0%   | 0.0%      |  |
| INV                | -0.1%                                    | -4.3% | 1.1%      | -0.2%                                   | -6.3% | 1.6%      | -0.3%                                 | -10.7% | 2.7%      |  |
| EXP                | -0.1%                                    | 0.5%  | -0.5%     | -0.1%                                   | 1.1%  | -0.9%     | -0.2%                                 | 2.5%   | -1.5%     |  |
| Prix relatif       |  |       |           |   |       |           |                                       |        |           |  |
| CONS               | -0.1%                                    | -0.2% | 0.0%      | -0.1%                                   | -0.2% | -0.1%     | 0.0%                                  | -0.1%  | -0.1%     |  |
| Terms of Trade     | 0.1%                                     | 0.2%  | 0.0%      | 0.1%                                    | 0.2%  | 0.0%      | 0.0%                                  | 0.2%   | 0.0%      |  |
| W                  | 0.0%                                     | -0.2% | 0.0%      | 0.0%                                    | 0.0%  | 0.0%      | 0.1%                                  | 0.5%   | 0.0%      |  |
| Interest rates     |  |       |           |   |       |           |                                       |        |           |  |
| Euro zone          | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |        |           |  |
| GBR                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |        |           |  |
| OEU                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |        |           |  |
| EMPLOI TOTAL       | 0.0%                                     | -0.4% | 0.1%      | 0.0%                                    | -0.6% | 0.1%      | -0.1%                                 | -1.2%  | 0.1%      |  |
| CAPITAL TOTAL      | 0.0%                                     | -0.3% | 0.0%      | 0.0%                                    | -0.4% | 0.0%      | 0.0%                                  | -0.7%  | 0.1%      |  |
| Soldes commerciaux |  |       |           |   |       |           |                                       |        |           |  |
| DEU                | -0.2%                                    |       |           | -0.3%                                   |       |           | -0.5%                                 |        |           |  |
| FRA                | 0.5%                                     |       |           | 0.8%                                    |       |           | 1.4%                                  |        |           |  |
| GBR                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |        |           |  |
| ITA                | 0.0%                                     |       |           | 0.0%                                    |       |           | -0.1%                                 |        |           |  |
| ESP                | -0.1%                                    |       |           | -0.2%                                   |       |           | -0.3%                                 |        |           |  |
| NLD                | -0.3%                                    |       |           | -0.3%                                   |       |           | -0.6%                                 |        |           |  |
| BEL                | -0.3%                                    |       |           | -0.3%                                   |       |           | -0.4%                                 |        |           |  |
| OEU                | -0.2%                                    |       |           | -0.3%                                   |       |           | -0.5%                                 |        |           |  |

# Quelques enseignements majeurs

## d) Impacts des déséquilibres macroéconomiques (chômage classique)

### 4. Effort accru en France avec taxes nationales et redistribution par baisse Cot. Soc.

|                    | scen13bis<br>kyoto_zone_euro_B_pcons_twx |       |           | scen14bis<br>kyoto_zone_euro_B_ppib_twx |       |           | scen15bis<br>kyoto_zone_euro_B_pb_twx |       |           |  |
|--------------------|--|-------|-----------|---|-------|-----------|---------------------------------------|-------|-----------|--|
|                    | 2010                                     | 2010  | 2010      | 2010                                    | 2010  | 2010      | 2010                                  | 2010  | 2010      |  |
|                    | EU15                                     | FRA   | Allemagne | EU15                                    | FRA   | Allemagne | EU15                                  | FRA   | Allemagne |  |
| Volume             |  |       |           |   |       |           |                                       |       |           |  |
| GDP                | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.2%  | 0.0%      | 0.0%                                  | 0.2%  | 0.0%      |  |
| IMP                | 0.0%                                     | -0.1% | 0.0%      | 0.0%                                    | 0.3%  | 0.0%      | 0.0%                                  | 0.3%  | 0.0%      |  |
| CONS               | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.2%  | 0.0%      | 0.0%                                  | 0.2%  | 0.0%      |  |
| GCVTOT             | 0.0%                                     | 0.0%  | 0.0%      | 0.0%                                    | 0.0%  | 0.0%      | 0.0%                                  | 0.0%  | 0.0%      |  |
| INV                | 0.1%                                     | 0.5%  | 0.0%      | 0.1%                                    | 1.3%  | -0.2%     | 0.1%                                  | 1.2%  | -0.2%     |  |
| EXP                | -0.1%                                    | -0.2% | 0.0%      | -0.1%                                   | -0.3% | 0.1%      | -0.1%                                 | -0.2% | 0.1%      |  |
| Prix relatif       |  |       |           |   |       |           |                                       |       |           |  |
| CONS               | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.1%  | 0.0%      | 0.0%                                  | 0.1%  | 0.0%      |  |
| Terms of trade     | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.1%  | 0.0%      | 0.0%                                  | 0.1%  | 0.0%      |  |
| W                  | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.0%  | 0.0%      | 0.0%                                  | 0.0%  | 0.0%      |  |
| Interest rates     |  |       |           |   |       |           |                                       |       |           |  |
| Euro zone          | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| GBR                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| OEU                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| EMPLOI TOTAL       | 0.1%                                     | 0.5%  | 0.0%      | 0.1%                                    | 0.6%  | 0.0%      | 0.1%                                  | 0.6%  | 0.0%      |  |
| CAPITAL TOTAL      | 0.0%                                     | 0.1%  | 0.0%      | 0.0%                                    | 0.1%  | 0.0%      | 0.0%                                  | 0.1%  | 0.0%      |  |
| Soldes commerciaux |  |       |           |   |       |           |                                       |       |           |  |
| DEU                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| FRA                | 0.0%                                     |       |           | -0.1%                                   |       |           | -0.1%                                 |       |           |  |
| GBR                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| ITA                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| ESP                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| NLD                | -0.1%                                    |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| BEL                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |
| OEU                | 0.0%                                     |       |           | 0.0%                                    |       |           | 0.0%                                  |       |           |  |

# Exploration d'horizons plus lointains (WG EMF 21)

- Objet de l'exercice: prise en compte des autres gaz à effet de serre dans les politiques de mitigation
- Scénario de mitigation calé sur forçage radiatif de 4,5 W/m<sup>2</sup> en 2100 (comparé à état pré-industriel)
- Comparaison de politiques CO<sub>2</sub> seul et multigaz
- Participation de 18 équipes de modélisation (sectorielle, équilibre général)
- Simulations à l'horizon 2050 ou 2100 selon les équipes
- Evaluation de la dispersion des résultats

Table 1

Key characteristics of EMF 21 models

| Model         | Model type (a)   | Representation of NCGG emission reduction options (b) | NCGG contribution method (c) | Solution concept (d) | Time horizon (e) | Group in this paper (f) |
|---------------|------------------|---|------------------------------|----------------------|------------------|-------------------------|
| AMIGA         | MSGE             | RFPF  | GWPs                         | RD                   | 2100             | 1                       |
| GTEM          | MSGE             | RFPF  | GWPs                         | RD                   | 2030             | 1                       |
| GEMINI-E3     | MSGE             | RFPF  | GWPs                         | RD                   | 2050             | 1                       |
| EU-PACE       | MSGE             | RFPF  | GWPs                         | RD                   |                  | 1                       |
| EDGE          | MSGE             | RFPF  | GWPs                         | RD                   | 2030             | 1                       |
| EPPA          | MSGE             | RFPF  | GWPs                         | RD                   | 2100             | 1                       |
| IPAC          | MSGE             | RFPF  | GWPs                         | RD                   | 2100             | 1                       |
| SGM           | MSGE             | RFPF  | GWPs                         | RD                   | 2050             | 1                       |
| WIAGEM        | MSGE             | RFPF  | GWPs                         | RD                   | 2100             | 1                       |
| Combat        | AGE              | RFM   | RF                           | INTOP                | 2100             | 2                       |
| FUND          | AGE              | RFM   | RF                           | INTOP                | 2100             | 2                       |
| MERGE         | AGE              | RFM   | RF                           | INTOP                | 2100             | 2                       |
| GRAPE         | AGE              | SM  | RF                           | INTOP                | 2100             | 2                       |
| IMAGE         | ISM <sup>a</sup> | SM  | GWPs                         | RD                   | 2100             | 3                       |
| MESSAGE       | ISM              | SM-2  | GWPs                         | RD                   | 2100             | 3                       |
| AIM           | ISM              | SM-2  | GWPs                         | RD                   | 2100             | 3                       |
| MiniCAM       | ISM              | SM-2  | GWPs                         | RD                   | 2100             | 3                       |
| POLES/AgriPol | ISM              | SM  | GWPs                         | RD                   | 2030             | 3                       |

# Principaux résultats

a) Scénario de référence (BaU)

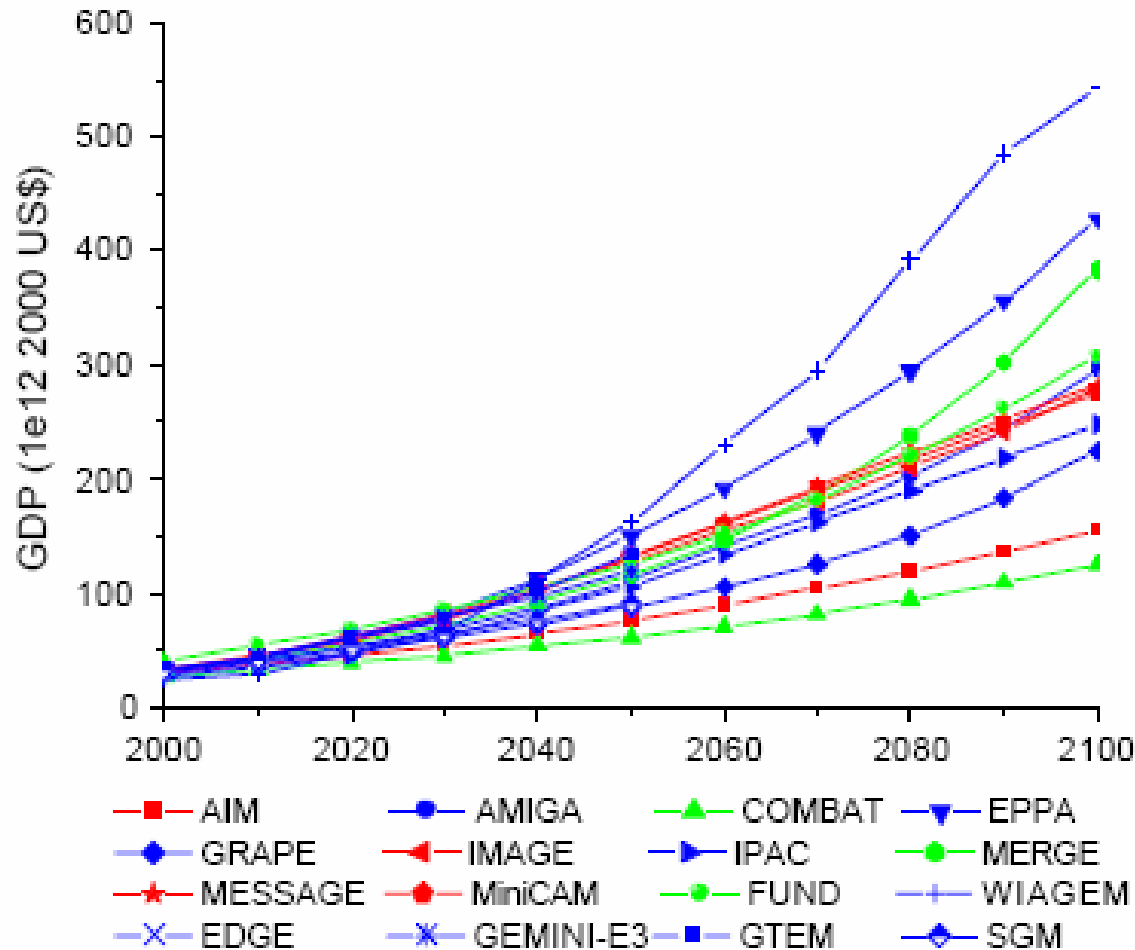
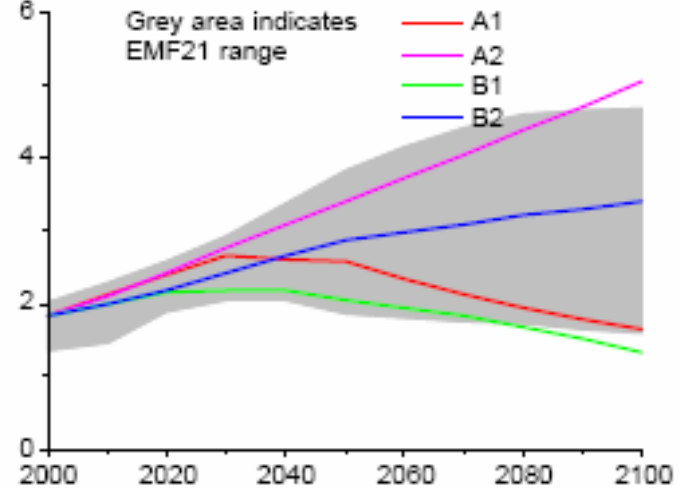
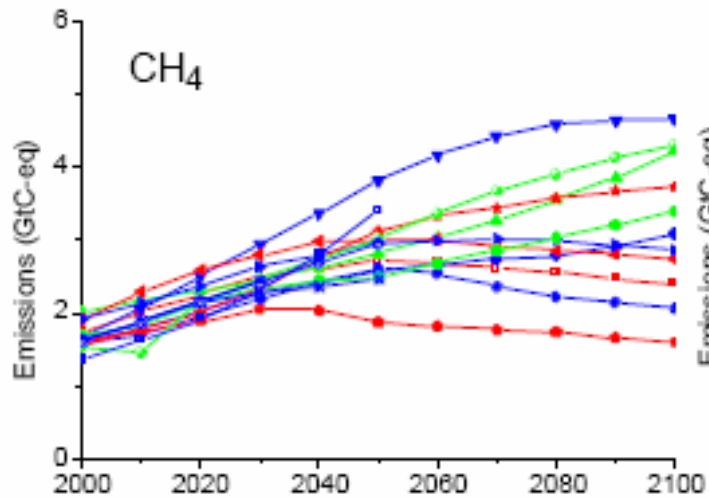
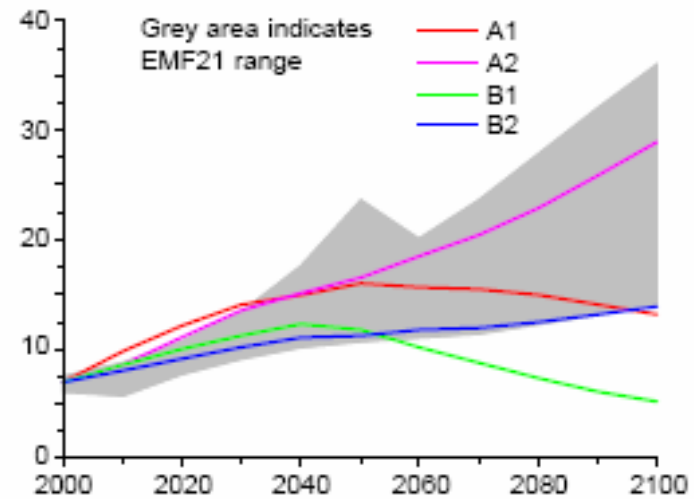
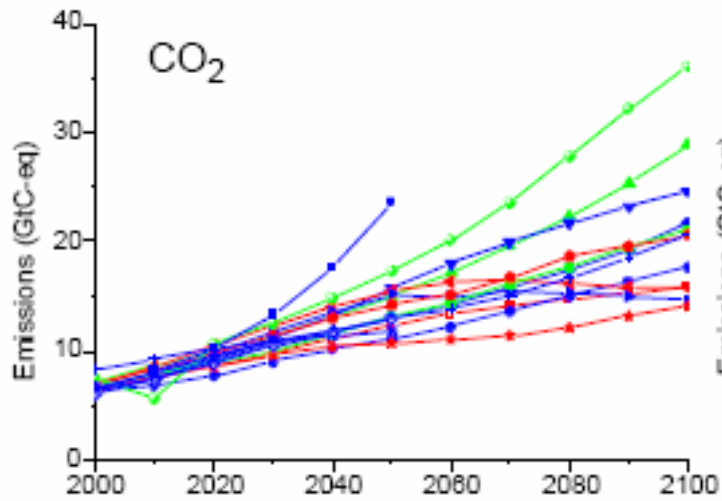


Fig. 1. GDP trajectories in the EMF-21 scenarios.

# Principaux résultats

## b) Emissions



# Principaux résultats

## b) Emissions (suite)

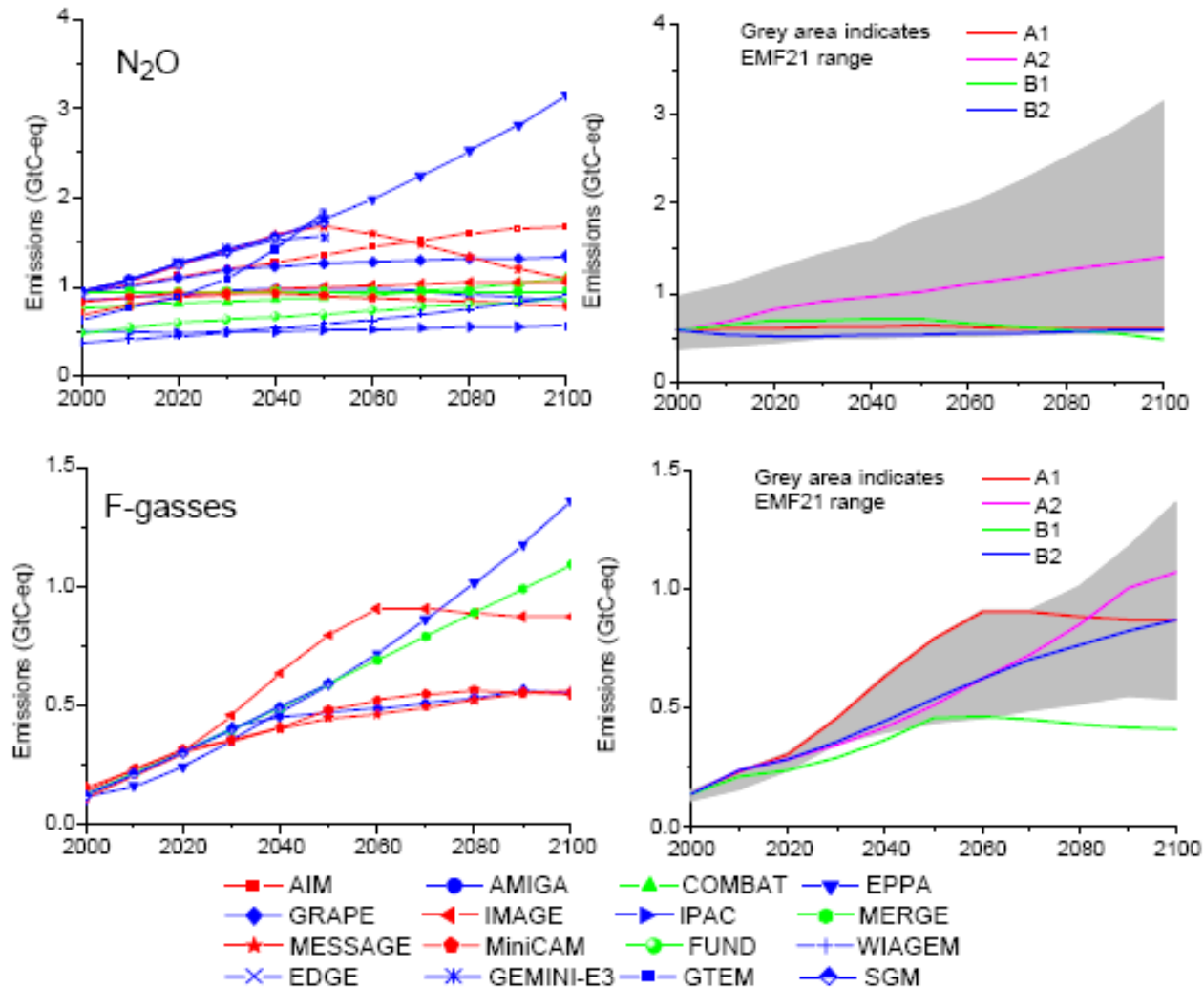


Fig. 2. Baseline emission development in the EMF-21 scenarios (left) and comparison to the SRES scenarios (right).



# Principaux résultats

## c) Taxes et coûts comparatifs des 2 stratégies

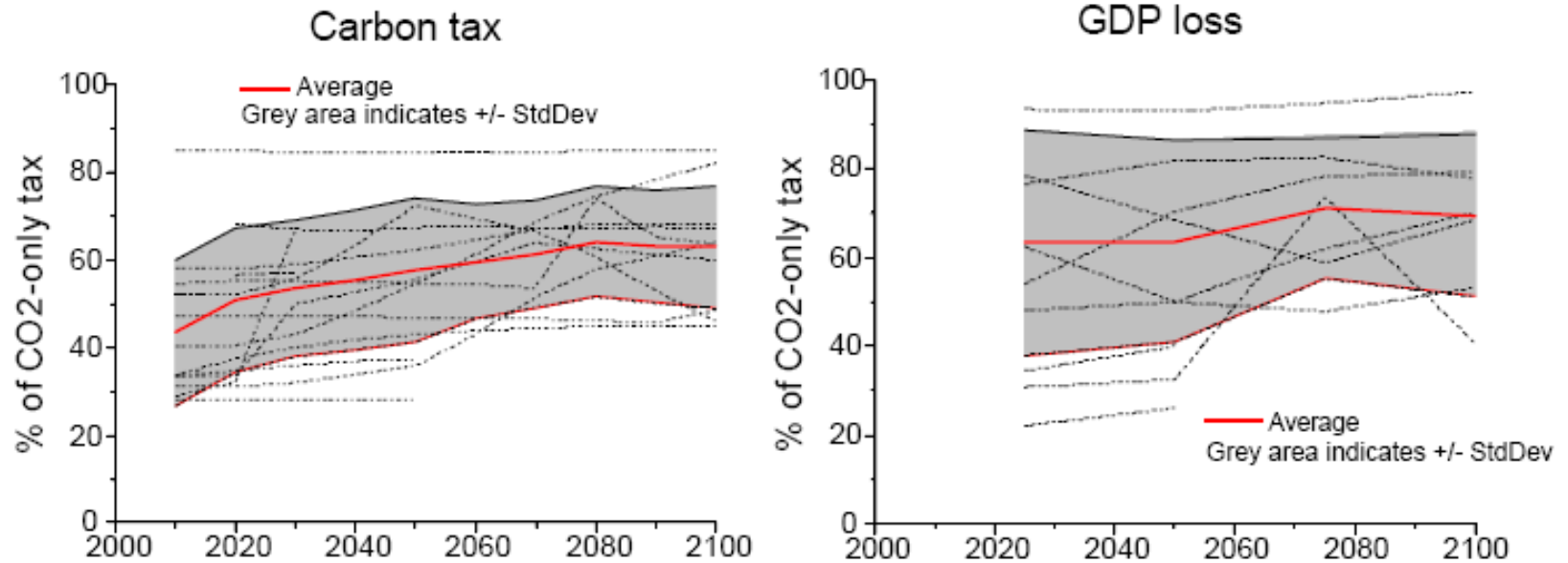


Fig. 6. Costs of stabilising radiative forcing at  $4.5 \text{ W/m}^2$ , ratio of costs in the multi-gas case to the  $\text{CO}_2$ -only case (grey area indicates standard deviation).

# Enseignements tirés de l'expérience passée

- Vertus pédagogiques des exercices réalisés avec les outils de modélisation, en particulier les outils bouclés (équilibre général calculable)
  - Clarification des concepts et des coûts (en particulier mesure et signification)
  - Compréhension des interactions entre politiques sectorielles et contraintes macroéconomiques (rôle des distorsions et des déséquilibres)
  - Mais très grande dispersion des résultats obtenus dès lors qu'on explore des horizons dépassant 15 à 20 ans
- Diagnostic clair des insuffisances de l'information statistique, notamment macroéconomique
  - Base de données quasiment unique (GTAP) qui ne fournit qu'une année (année de référence, actuellement 2001)
  - Qualité médiocre de la base pour les pays en développement
  - Faible détail dans la description de la fiscalité

# Quelques orientations pour l'avenir

- Eclairage d'horizons plus longs que ceux des phases successives d'engagement du Protocole de Kyoto nécessaire (2050 devient incontournable)
- Rôle majeur que devra jouer le progrès technologique (possibilités liées à la substitution, sous toutes ses formes, seront limitées voire épuisées)
- Nécessité de disposer de modèles sectoriels détaillés dans les principaux domaines de consommation énergétique
- Moindre prégnance des objectifs et contraintes de régulation macroéconomique mais nécessité d'assurer la cohérence des évaluations et des politiques sectorielles. A ce titre il faut saluer et soutenir le programme ambitieux que représente IMACLIM-R, même si d'autres approches sont possibles et doivent être aussi encouragées
- Nécessité d'asseoir la modélisation macroéconomique sur un système statistique fiable et développé (séries longues)
- Le recours à des modèles nationaux, éventuellement régionaux (Union Européenne) paraît le mieux adapté aux contraintes de l'information statistique et sans doute conforme à l'évolution que pourrait suivre la négociation internationale sur le climat (« peer competition » plus que fixation d'objectifs quantitatifs)