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cahier économique

Luxgem: modèle d'équilibre général calculable pour le Luxembourg

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Sommaire

Préface

Luxgem, le modèle d'équilibre général calculable du STATEC

Le présent cahier économique présente un nouvel outil qui va enrichir la panoplie des modèles macro-économiques dont dispose le Luxembourg. A côté du modèle macro-économétrique annuel MODUX du STATEC et du modèle DGSE (dynamic general structural equilibrium) baptisé LSM (Luxembourg structural model) de l'Observatoire de la compétitivité, le modèle LuxGem est un modèle d'équilibre général calculable.

Le paysage des modèles économiques était resté assez désert pendant des décennies, ce n'est que vers les années quatre-vingt, que le Luxembourg a commencé à rattraper son retard en se dotant de modèle macro-économiques pour la prévision et la simulation des politiques économiques.

L'usage des outils de modélisation ne fait pas encore partie de la culture économique des décideurs et des médias du Grand-duché du Luxembourg. On peut avancer plusieurs raisons, certes spéculatives, sur le rôle et l'histoire de cette discipline. Il y a tout d'abord, dans l'appareil d'Etat, la prédominance des juristes et des littéraires qui se méfient de toute formalisation et des lois statistiques. Il y a, ensuite, l'argument souvent invoqué de « l'exception » luxembourgeoise, c.-à-d. l'idée qui veut que, par sa petite taille et son ouverture sur l'extérieur, le fonctionnement du pays dérogerait aux lois de la science économique. Ces deux facteurs pénalisent encore le développement de la modélisation économique au Luxembourg.

Le contexte est encore plus défavorable actuellement en raison de la crise financière et économique, qui a ébranlé la confiance des les modèles d'évaluation du risque communément utilisés par les économistes de banque. Loin d'ébranler la confiance dans les outils de l'économie mathématique, la crise va certainement pousser la science économique à se remettre en question et à élaborer de nouvelles approches quantitatives plus sophistiquées, reproduisant mieux l'hétérogénéité des acteurs et les ruptures de trajectoire. Cette crise est également salutaire en ce qu'elle va forcer les conjoncturistes à multiplier les précautions et prendre soin des facteurs de risque et d'incertitude.

Les avantages (et les inconvénients) des modèles d'équilibre général sont bien décrits par les auteurs du présent cahier économique. Les chercheurs de l'ULB sous la direction du Professeur Aly Bayar ont permis du Luxembourg de profiter de l'expérience qu'ils ont accumulée au cours des années.

Le cahier contient plusieurs simulations signées F. Adam et F. B. Aka (STATEC) qui donnent une idée des potentialités du modèle. Le fait d'avoir choisi des problématiques inexplorées jusque-là comme par exemple un choc des prix de l'énergie - laissent entrevoir le potentiel du nouveau modèle : l'articulation entre les branches d'activités, les la consommation des matières premières, sujets jusque là exclus des simulations.

Certes, tous les problèmes n'ont pas encore été résolus. Citons par exemple « les règles de fermeture » appropriées pour une petite économie ; les caractéristiques du secteur financier, branche particulière ou encore l'imperfection du fonctionnement des marchés ; tous ces problèmes appellent des développements supplémentaires, actuellement en cours.

Cet outil, comme les autres évoqués plus haut, devront encore être domestiqués par les conjoncturistes dans un dialogue permanent avec les concepteurs. Dans le cas du modèle Luxgem, le transfert de connaissance doit avoir lieu avec l'équipe ECOMOD de l'Université Libre de Bruxelles. Par ailleurs, il faudra mettre à l'épreuve les modèles concurrents (MODUX, LSM) afin de comprendre leurs singularités, différences et complémentarités. La modélisation a été ancrée comme principale activité de recherche scientifique appliquée dans le projet de loi réformant le STATEC, déposée à la Chambre en décembre 2008.

Par ailleurs, les STATEC publie les équations des modèles qu'il utilise de manière à ce qu'il puisse satisfaire à l'exigence de transparence, reprise mutatis mutandis de la Charte de la statistique européenne. Cette transparence est suffisamment remarquable pour être relevée avec force.

Dr Serge Allegrezza,
Directeur du STATEC

Introduction

Ce cahier économique du STATEC n° 110 aborde la description d'un modèle d'équilibre général calculable (MEGC), appelé Luxgem, représentant l'économie luxembourgeoise et élaboré par le réseau EcoMod de l'ULB (www.ecomod.net). Le cahier 110 comporte deux parties: le rapport technique détaillé, élaboré par EcoMod (à partir de la page 27), ainsi que, en préambule, une description sommaire, rédigée par les experts du STATEC qui propose également des simulations standardisées, ce qui facilite la comparaison de Luxgem avec l'autre modèle du STATEC, Modux.

Le rapport technique détaillé comporte, outre une description littéraire des fondements théoriques, une liste complète avec les variables et les équations, tout comme une représentation fidèle des données économiques sous-jacentes (matrice de comptabilité sociale, des paramètres c.-à-d. élasticités et facteurs d'émission de gaz à effets de serre, etc...).

Le STATEC peut recourir dorénavant à plusieurs modèles économiques qui représentent l'économie luxembourgeoise:

1. un modèle économétrique (Modux) qui sert à la réalisation des prévisions à court et moyen terme;

2. un modèle dynamique stochastique d'équilibre général (DSGE), appelé LSM, visant à évaluer les mesures de politique économique dans le cadre de la stratégie de Lisbonne; commandité par l'OBSCOMP;

3. Luxgem, le modèle d'équilibre général calculable (EGC) dynamique permettant de réaliser des simulations de court, moyen et long terme.

Les modèles étant en principe complémentaires, il importe de cerner de près les propriétés de chacun. Ainsi, à la différence de Modux, qui est un modèle estimé, les deux derniers modèles sont calibrés sur des données relatives à une année de base. Cette variété de modèles utilisés par le STATEC devrait permettre de conforter les prévisions et les anticipations relatives à l'économie luxembourgeoise.

L'objectif de la première partie de ce rapport est d'établir des variantes du modèle d'équilibre général de l'économie luxembourgeoise Luxgem, c.-à-d. de simuler et d'analyser les effets de différents chocs de politique économique. Cette étude des variantes est une première étape très utile pour valider empiriquement le modèle dans une perspective de comparaison avec les simulations réalisées aves les autres modèles.

L'une des difficultés du modèle EGC est sa complexité quant aux multiples équations interdépendantes qu'il comporte. Pour rendre plus aisée la compréhension des mécanismes en œuvre au sein du modèle, les résultats de chaque simulation de politique économique sont illustrés dans la première partie par un encart qui en décrit le schéma théorique sous-jacent. Nous espérons que ces brefs détours seront utiles pour comprendre les cheminements dans le modèle.

1. Description sommaire de Luxgem et résultats des simulations

1.1 Description de Luxgem

Luxgem est un modèle d'équilibre général calculable multisectoriel dynamique, et à ce titre se prête bien à l'étude de l'impact de chocs exogènes sur le reste de l'économie. Le modèle est désagrégé en 16 branches productives, produisant 20 catégories de biens, et 4 agents économiques (les entreprises, les ménages, l'Etat et le reste du monde). Cette structure est décrite dans la matrice de comptabilité sociale (MCS) de l'économie luxembourgeoise sur laquelle repose le modèle (cf. annexe I p. 28 et annexe II p. 33-35).

La Matrice de comptabilité sociale (MCS)

La MCS est la base de données sur laquelle repose le modèle EGC, ou sur laquelle le modèle est calibré. La MCS du Luxembourg, établie pour l'année 2004, est composée de 40 branches d'activité et 51 biens et services (dont 14 vecteurs énergétiques). Mais cette MCS est ensuite agrégée en 20 biens et services dont 7 vecteurs énergétiques (cf. note sur la matrice de comptabilité sociale, annexe I).

La structure de Luxgem

Le modèle Luxgem est un modèle qui incorpore les comportements de 4 types d'agents économiques: les ménages, les entreprises, l'état et le reste du monde.

Les entreprises

Le modèle ne tient pas compte du comportement individualisé des entreprises mais adopte l'hypothèse de firme représentative dans chaque branche. Les entreprises maximisent leur profit et déterminent les niveaux optimaux d'intrants et de produits sur un marché de concurrence parfaite.

Les ménages

Le ménage représentatif perçoit des revenus du travail et du capital plus des transferts du gouvernement moins les contributions de sécurité sociale. Il paie des impôts sur son revenu et épargne une part de son revenu net.

Le gouvernement

Le gouvernement collecte les différents types d'impôts qui représentent son revenu. Les dépenses du gouvernement comprennent les dépenses publiques de consommation, l'investissement public et les différents transferts qu'il réalise au profit des autres agents ou secteurs.

Le reste du monde

La présence du reste du monde indique un modèle en économie ouverte. Le reste du monde retrace les relations commerciales internationales de l'économie luxembourgeoise. Ces relations reposent sur l'hypothèse du petit pays qui signifie que le pays est "*price taker*". Par ailleurs une substitution imparfaite est postulée entre les biens produits localement et les biens importés (hypothèse d'Armington (1969)[1]).

La dynamique du modèle

Luxgem est un modèle d'équilibres séquentiels. Le modèle est résolu à chaque période et les équilibres sont liés entre eux par l'accumulation du capital. C'est donc la détermination endogène de l'évolution de l'investissement qui indique la dynamique du modèle. Ainsi, l'investissement et l'accumulation de capital au temps *t* dépendent du taux de rendement espéré du capital de l'année *t+1*, déterminé par le taux de rendement actuel au temps *t*.

L'équilibre sur les marchés

A l'équilibre, les marchés de produits, du capital et du travail sont en équilibre: les offres sont égales aux demandes.

Néanmoins, il faut noter que dans Luxgem, alors que la main-d'œuvre est mobile entre les activités de production, le stock de capital est spécifique à chaque secteur, de telle sorte que l'égalité entre demande et offre de capital détermine le taux de rémunération du capital spécifique par branche d'activité[2].

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[1] Hypothèse de différenciation des produits selon laquelle un même produit faisant l'objet de commerce international peut être perçu par ses consommateurs potentiels comme étant plus ou moins différent selon le pays d'origine. Armington, P.S. (1969) "A Theory of Demand for Products Distinguished by Place of Production", IMF Staff Paper 16, 159-176.

[2] Il aurait été alternativement possible de considérer un taux de rémunération unique du capital dans l'économie (modèle à **capital mobile**). En effet la mobilité du capital provoquerait alors une égalisation de la productivité marginale du capital dans les différents secteurs de l'économie et aboutirait à un **taux de rendement unique du capital** dans l'ensemble de l'économie.

Mécanisme de perturbation de l'équilibre

Tout choc de politique économique (c'est-à-dire toute modification de l'environnement économique interne ou externe) se répercute sur la demande à travers les prix, la production et la réallocation de ressources dans l'économie jusqu'à ce que les demandes et les offres soient à nouveau égales.

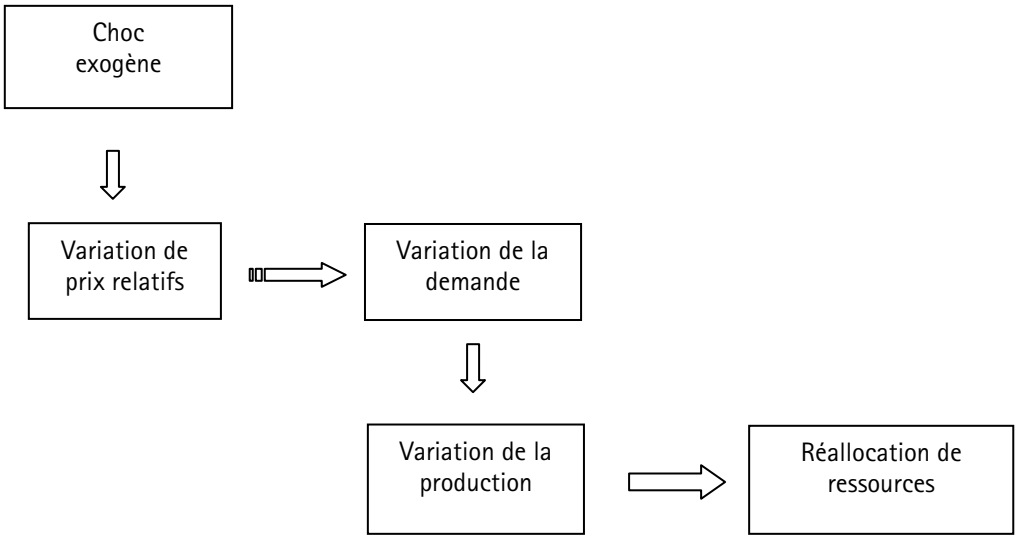
En effet, les entreprises déterminent les intrants nécessaires à la production de biens de consommation finale, compte tenu des prix. A l'équilibre sur le marché, les offres de biens finals et des intrants sont déterminées ainsi que les demandes.

Supposons par exemple que les goûts des consommateurs varient en faveur d'un bien, la demande de ce bien va augmenter, et le prix de ce bien augmentera. Les entreprises voudront donc produire plus de ce bien avec plus d'intrants.

Ainsi, le prix des consommations intermédiaires va augmenter suite à la hausse de la demande du bien final. Ce genre de mécanisme d'équilibre général basé sur la théorie de l'équilibre général est au cœur du modèle d'équilibre général calculable (cf. Schéma 1).

La structure désagrégée en 16 branches d'activité et 20 types de biens de Luxgem permet d'analyser les impacts des simulations de politique économique à un niveau sectoriel détaillé. En effet un des avantages d'un modèle multisectoriel et multi-agents comme Luxgem est de permettre d'analyser toutes les interactions entre les secteurs et aussi entre les agents, suite à la modification du prix relatif d'un bien spécifique ou du niveau de la demande d'un bien.

Schéma 1: Logique de propagation d'un choc exogène dans le modèle EGC



Source: STATEC

La fermeture macroéconomique adoptée dans le modèle Luxgem

Avant toute simulation avec les modèles d'équilibre général calculables (EGC), il est utile d'examiner la fermeture macroéconomique (le bouclage) postulé dans le modèle. En effet, dans les modèles EGC, le choix de la fermeture est lié à la vision du modélisateur du fonctionnement de l'économie en présence, et ce choix conditionne les enchainements qui suivent tout choc sur une variable exogène. La fermeture adoptée dans le modèle aura par conséquent des implications importantes quant aux résultats des simulations.

Le constructeur du modèle a retenu une fermeture de type "équilibre entre épargne et investissement" (dite classique[1]), où l'investissement est laissé à l'initiative privée, et a adopté les hypothèses supplémentaires suivantes:

1. l'investissement est supposé s'ajuster à l'épargne domestique et étrangère disponible;
2. les dépenses publiques sont fixes en termes réels;
3. la formation brute de capital fixe du gouvernement est fixe en termes réels;
4. les revenus de la propriété reçus et payés, les autres transferts courants, les transferts en capital reçus et payés sont fixes en termes réels;
5. les acquisitions moins les cessions de valeurs mobilières non financières et non produites sont fixes en termes réels;
6. la balance courante (épargne étrangère) est endogène (cf. 2.3.12);
7. le taux de change réel est endogène (cf. 2.3.12 et liste des variables).

Il apparait en effet dans le modèle que[2]:

$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g} + S_w$$

Avec:

I:	investissement total
I_p:	investissement privé
I_g:	investissement public (exogène)
S_m:	épargne des ménages (fixe)
S_g:	épargne publique (exogène)

L'épargne domestique $\overline{S}_d = \overline{S}_m + \overline{S_g}$

L'épargne publique (S_g) est exogène, et c'est l'investissement qui s'ajuste à l'épargne disponible dans l'économie. Il s'agit d'une fermeture de type "savings-driven", où l'investissement est déterminé de façon endogène par la disponibilité d'épargne dans l'économie. Cette fermeture dite classique se prête bien à l'étude d'une économie comme celle du Luxembourg où l'investissement est laissé à l'initiative privée.

Par ailleurs, l'investissement public (I_g) est exogène (Hyp. 3). C'est donc l'investissement privé (I_p) qui s'ajuste suite aux chocs sur des variables exogènes du modèle.

On sait par ailleurs que la production *Y* d'un pays se décompose comme suit:

$$Y = C + I + G + X - M$$

Avec:

C:	la consommation privée,
I:	l'investissement,
G:	la consommation publique,
X:	les exportations,
M:	les importations.

L'épargne domestique *S* représente la part non consommée de la production soit:

$$S = Y - C - G$$

C'est-à-dire:

$$S = C + I + G + X - M - C - G$$
$$S = I + X - M$$

On a donc l'égalité comptable entre le solde épargne-investissement et le solde extérieur ($S\text{-}I = X\text{–}M$).

Cette égalité traduit une identité entre le solde financier et le solde des transactions courantes, de sorte qu'un déséquilibre de la balance des transactions courantes s'accompagne d'un déséquilibre entre l'épargne nationale et l'investissement national.

[1] Des fermetures non classiques sont théoriquement possibles (keynésienne, Kaldorienne, à la Johansen). Cf. Decaluwé B, A. Martens et L. Savard "La politique économique du développement et les modèles d'équilibre général calculable" , Presse universitaire de Montréal, 2001.

[2] Une barre au-dessus d'une variable indique qu'elle est fixe ou exogène.

Les implications du bouclage retenu

Supposons une hausse exogène de l'investissement public (I_g), l'investissement total dans l'économie augmente. L'épargne domestique étant fixe, il y aura un surplus de demande d'investissement par rapport à l'épargne disponible, insuffisante par rapport à l'investissement ($I > S$).

Le déséquilibre entre une épargne faible et un besoin d'investissement élevé devra être résorbé par exemple par l'épargne étrangère (S_w), l'épargne domestique étant limitée.

$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g} + S_w$$

Supposons d'autre part que l'épargne domestique (S_d) augmente suite à une hausse exogène de l'épargne publique (S_g), l'épargne totale dans l'économie sera accrue, on aura ($I < S$). L'investissement public (I_g) étant fixe, c'est l'investissement privé (I_p) qui doit alors s'ajuster à la hausse pour absorber l'excès d'offre d'épargne.

Ces mécanismes sont au centre des interactions en jeu au sein du modèle d'équilibre général Luxgem. En effet toute modification qui affecte les variables exogènes centrales conduira à une modification des variables endogènes et à un nouvel équilibre du modèle.

1.2 Les simulations

Les simulations effectuées retenues ici sont les suivantes:

- une baisse de la demande mondiale pour les services financiers adressée à l'économie luxembourgeoise;
- une hausse de la consommation publique;
- une hausse des investissements publics;
- une baisse des impôts directs sur les revenus des ménages;
- une baisse des cotisations sociales pour employeurs.

Les simulations sur les dépenses publiques (consommation et investissement publics) permettent de dériver les multiplicateurs.

A la fin de chaque simulation, un encart de nature plus technique clarifie les cheminements du choc en question sur base des équations du modèle.

1.2.1 Baisse de la demande mondiale de services financiers adressée à l'économie luxembourgeoise

Cette simulation analyse les effets d'une baisse de 10% de la demande mondiale de services financiers à l'économie Luxembourgeoise. L'analyse des effets de la simulation est basée sur la structure (équations) et les hypothèses du modèle Luxgem.

Les simulations réalisées à l'aide du modèle retiennent comme choc une baisse exogène hypothétique de 10% de la demande de services financiers à l'économie luxembourgeoise.

Plus précisément, on applique une baisse de 10% en 2008, 2009 et 2010 sur la demande mondiale de services financiers, reflétant une dégradation de l'environnement financier international. Cette baisse de 10% de la demande mondiale au secteur financier se traduit par la baisse des exportations de ce secteur avec des effets d'équilibre général sur le reste de l'économie.

Les résultats des simulations sont mesurés en pourcentage de déviation par rapport au scénario de référence (BAU[1]). La baisse de 10% de la demande mondiale dans le secteur financier a pour effet de faire baisser le prix des exportations de produits financiers

de 4.8% en 2008, et de 1.2% en 2009 avant de le faire augmenter de 0.3% en 2010. La variation du prix des exportations de produits financiers va engendrer des variations de prix relatifs qui vont provoquer à terme une variation de la production dans les autres branches de l'économie.

Impact sur l'activité réelle (mesurée par la valeur ajoutée) et l'emploi

La baisse de 10% de la demande mondiale de services financiers a pour effet de faire baisser l'activité dans le secteur financier. La baisse de l'activité du secteur financier provoque une baisse de la valeur ajoutée totale, étant donné son importance dans cette dernière (30%). L'activité du secteur des services aux entreprises baisse également, car très liée au secteur financier (cf. tableau 1). Il y a aussi une baisse de l'activité en 2008 et 2009 dans le secteur du commerce de gros et de détail, ainsi que dans celui des hôtels et restaurants. L'activité dans le secteur électricité et énergie baisse en 2008 de 0.3%.

La baisse de l'activité provoque une baisse de l'emploi total dans l'économie, surtout dans le secteur financier, et le secteur des services aux entreprises suite à la hausse des prix à la production domestique combinée à la hausse du coût salarial nominal moyen. De même, l'emploi dans les branches telles que le commerce de gros et de détail, les hôtels et restaurants, l'électricité et l'énergie et les autres services diminue en 2008, 2009 et 2010.

On obtient une hausse de la valeur ajoutée et de la production du secteur manufacturier et du secteur de la construction qui peut s'expliquer par le fait que (due à des effets d'équilibre général, le stock de capital étant spécifique à chaque secteur) la rémunération du capital augmente dans les secteurs manufacturier et de la construction (en 2008) ce qui attire les investissements dans ces secteurs et entraîne une hausse de l'investissement (et une hausse corrélative de l'emploi), tandis que cette rémunération diminue dans le secteur financier (dès 2008) et dans celui des services aux entreprises (à partir de 2009) provoquant une baisse de l'investissement et du stock de capital dans ces secteurs (et une baisse de l'emploi).

En définitive, suite à la baisse de la demande mondiale d'exportation de produits financiers, on constate une baisse d'activité dans le secteur financier du Luxembourg, ce qui provoque une baisse de l'activité totale étant donné le poids du secteur financier dans cette dernière. L'activité baisse dans la plupart des branches de services, de façon plutôt directe (cf. services aux entreprises) ou indirecte (autres services).

Impacts macroéconomiques

A court terme l'investissement augmente de 1.3% en 2008, 1.5% en 2009 et de 2.3% en 2010. Ces hausses peuvent s'expliquer par la baisse des prix relatifs des services financiers. En effet il devient relativement plus intéressant d'investir sur le marché local que d'exporter des services financiers. La consommation privée diminue (de 2.4% en 2008, de 1% en 2009 et de 0.4% en 2010). Les importations et les exportations baissent et l'emploi total diminue également suite à la baisse de la demande de facteurs.

Finalement le PIB diminue à court terme (de 1.5% en 2008, de 1.6% en 2009 et de 1.6% en 2010) et cette baisse du PIB est répartie diversement dans les différentes branches. On a une baisse de l'épargne des ménages et de leur propension à épargner (par rapport au scénario de référence), car leurs revenus réels diminuent, ce qui peut également expliquer la baisse de la consommation privée. Par ailleurs la rémunération moyenne du capital diminue dans l'économie ce qui peut entrainer (en économie ouverte) une fuite de capitaux en direction du reste du monde, vers des marchés de capitaux plus rémunérateurs.

Impacts à long terme

En appliquant un choc permanent de 10% de réduction sur la demande d'exportation de produits financiers au Luxembourg sur toute la période (2008-2020), on peut retracer les trajectoires de long terme des variables (cf. graphiques 1 et 2). On constate ainsi qu'à long terme l'impact sur les valeurs ajoutées des secteurs de la construction et de l'industrie est positif alors que celui sur le secteur financier et la plupart des services est négatif. Par ailleurs, l'impact sur la consommation privée devient positif dans le long terme tandis que celui sur les exportations et les importations reste négatif. La déviation du PIB par rapport au scénario de base reste également négative bien que celui sur les investissements soit positif.

[1] "Business as usual", c'est-à-dire le scénario de référence, en l'absence de choc.

Tableau 1: Impact sur la valeur ajoutée et l'emploi suite à la baisse de la demande étrangère pour services financiers

	Valeur ajoutée			Emploi		
Secteurs	2008	2009	2010	2008	2009	2010
				(% de variation par rapport au BAU)		
Agriculture	-0.0	0.7	1.2	-0.1	0.5	0.9
Extraction de produits énergétiques	0.0	0.0	0.0	0.0	0.0	0.0
nucléaires	0.0	0.0	0.0	0.0	0.0	0.0
Industries manufacturières	0.0	0.4	0.6	0.1	0.2	0.3
Electricité, énergie	-0.3	0.1	0.3	-1.4	-1.0	-0.7
Construction	4.7	3.3	2.1	7.3	1.8	1.1
Commerce de gros et de détail	-0.8	-0.5	0.0	-1.5	-0.8	-0.4
Hôtels et restaurants	-0.7	-0.2	0.1	-1.2	-0.7	-0.4
Transports et communication	-0.0	0.7	1.0	-0.1	0.3	0.6
Services financiers	-7.4	-9.2	-10.0	-14.1	-11.1	-9.9
Services immobiliers	-0.0	0.6	0.9	-0.6	-0.1	0.2
Services aux entreprises	-0.5	-0.6	-0.9	-0.7	-1.1	-1.4
Administration publique	-0.2	-0.2	-0.2	0.0	-0.4	-0.3
Education	-0.5	-0.3	-0.3	-0.4	-0.3	-0.3
Santé et services sociaux	-0.9	-0.5	-0.4	-1.1	-0.6	-0.5
Autres services	-0.4	0.1	0.4	-0.6	-0.2	-0.0
Total	-1.4	-1.6	-1.7	-1.4	-1.4	-1.2

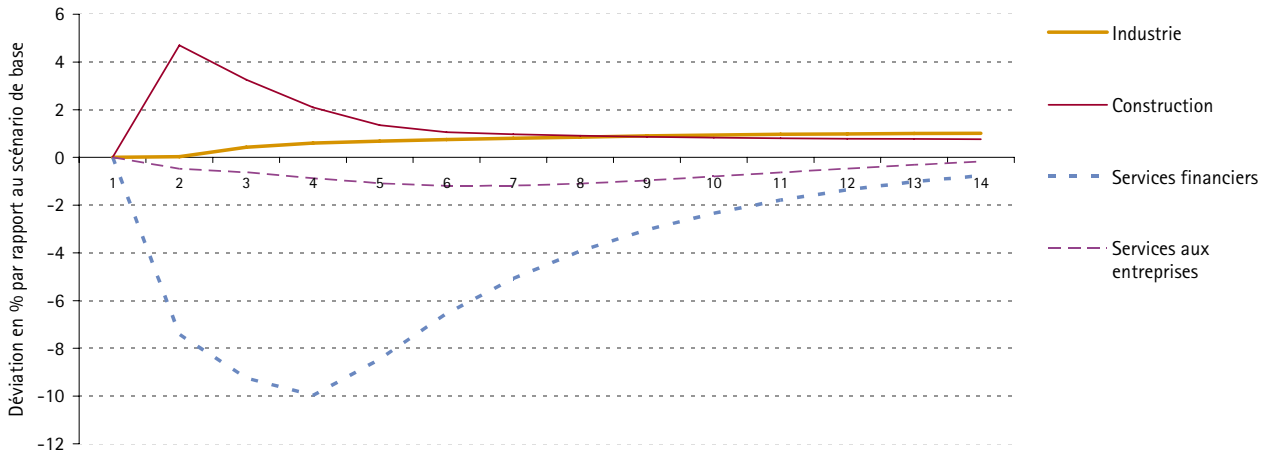
Source: STATEC

Tableau 2: Impact sur les principales variables macroéconomiques suite à la baisse de la demande étrangère pour services financiers

Variables	2008	2009	2010
	(% de variation par rapport au BAU)		
PIB	-1.5	-1.6	-1.6
Consommation privée	-2.4	-1.0	-0.4
Consommation publique	0.0	0.0	0.0
FBCF	1.3	1.5	2.3
Exportations	-4.2	-4.0	-3.7
Importations	-4.4	-3.6	-3.1
Indice des prix à la consommation	2.7	1.0	-0.2
Emploi total	-1.4	-1.4	-1.2
Revenu réel des ménages	-4.4	-2.2	-1.0
Épargne des ménages en terme réel	-8.5	-4.3	-2.2
Propension à épargner	-1.4	-0.8	-0.4
Salaire réel moyen	-1.0	-0.3	0.1
Rémunération moyenne du capital en terme réel	-10.6	-5.5	-3.1

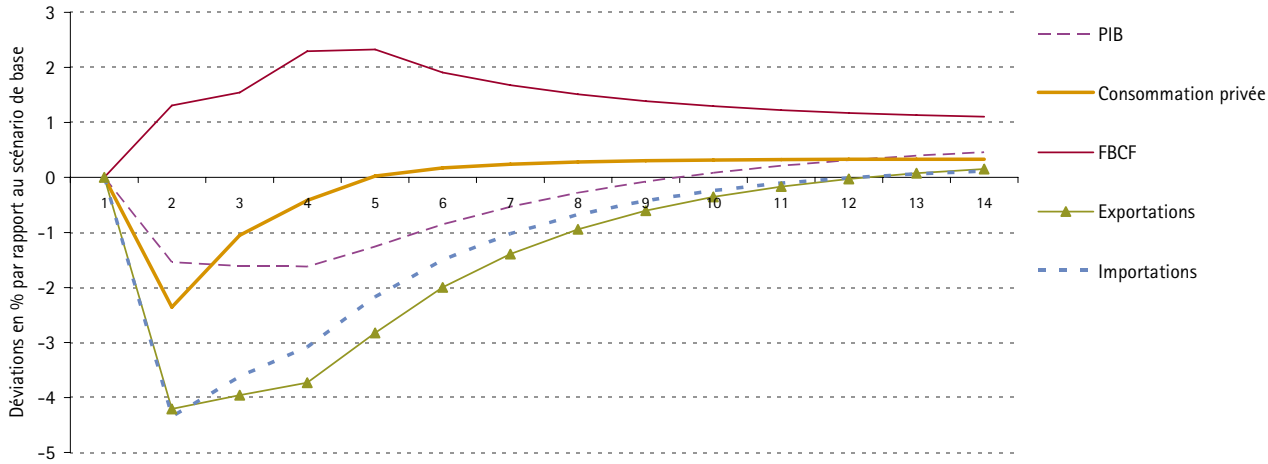
Source: STATEC

Graphique 1: Impact sur les valeurs ajoutées sectorielles à long terme suite à la baisse de la demande étrangère pour services financiers



Source: STATEC

Graphique 2: Impacts à long terme sur les composantes du PIB suite à la baisse de la demande étrangère pour services financiers



Source: STATEC

Cheminement détaillé des conséquences de la baisse de la demande étrangère pour services financiers

Dans le modèle Luxgem, la demande mondiale d'un produit *c* est exprimée théoriquement par l'équation suivante:

$$END_c = \overline{ENDI_c} \cdot (\overline{PWE_c} \cdot ER / PEFOB_c)^{elastE_c} \qquad (1.12.211)$$

La variable sur laquelle porte le choc dans le modèle est E_c (exportations totales): une baisse de la demande mondiale signifie ici une diminution des exportations de produits financiers pour le Luxembourg:

$$E_c = EN_c + \overline{REXP_c}$$

Avec:

EN_c: l'offre d'exportation de biens *c* au reste du monde (RDM).

$\overline{REXPc}$: les réexportations du bien *c* vers le RDM (exogène)[1].
END_c: la demande de biens *c* par le reste du monde (RDM).

$\overline{ENDIc}$: le niveau des exportations de biens *c* vers le RDM (exogène).

$\overline{PWE_c}$: le prix mondial des exportations du bien *c*.
ER: le taux de change réel
$PEFOB_c$: le prix domestique fob (franco à bord)[2] du bien *c*.
$elasE_c$: l'élasticité prix de la demande d'exportation

A l'équilibre, sur le marché du bien *c*, on doit avoir l'égalité entre l'offre et la demande exprimé par:

$$EN_c = END_c \qquad (1.12.241)$$

Cette égalité entre quantité offerte et demandée détermine le prix d'équilibre $PEFOB_c$

Avec:

EN_c: l'offre d'exportation de produits *c* au RDM.

Supposons une baisse exogène de la demande mondiale (*ENDIc*) du bien c. Suite à cette baisse, il y aura un déséquilibre entre l'offre et la demande tel que la demande devient inférieure à l'offre ($EN_c > END_c$).

On sait que EN_c, l'offre de produit *c* est:

$$EN_c = XDDE_c \cdot \left(\frac{PDDE_c}{PE_c} \right)^{\sigma T_c} \cdot \gamma T 2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \qquad (1.12.210)$$

[1] Une barre au dessus d'une variable indique qu'elle est exogène.

[2] Free on board

Avec

$XDDE_c$: la production domestique du bien *c* livrée sur le marché local et étranger.
$PDDE_c$: l'indice du prix de la production domestique du bien *c*.
PE_c: le prix domestique des exportations reçu par les producteurs locaux.

Sachant par ailleurs que la demande END_c de produits *c* est:

$$END_c = \overline{ENDI_c} \cdot \left(\frac{ER \cdot \overline{PWE_c}}{PEFOB_c} \right)^{elastE_c} \qquad (1.12.211)$$

Avec les variables

$\overline{ENDIc}$: le niveau des exportations de biens *c* vers le RDM (exogène).

$\overline{PWE_c}$: le prix mondial des exportations du bien *c*.
ER: le taux de change réel
$PEFOB_c$: le prix domestique fob du bien *c*.
$elasE_c$: l'élasticité prix de la demande d'exportation

L'égalité $EN_c = END_c$ implique:

$$XDDE_c \cdot \left(\frac{PDDE_c}{PE_c} \right)^{\sigma T_c} \cdot \gamma T 2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} = \overline{ENDI_c} \cdot \left(\frac{ER \cdot \overline{PWE_c}}{PEFOB_c} \right)^{elastE_c}$$

La condition de zéro profit indique que la valeur totale de la production du produit *c* est égale à la valeur de la production fournie sur le marché local plus celle livrée sur les marchés étrangers c'est à dire:

$$PDDE_c \cdot XDDE_c = PDD_c \cdot XDD_c + PE_c \cdot EN_c \qquad (1.12.250)$$

Avec XDD_c: les biens domestiques livrés sur le marché local.

Suite à une baisse exogène de la demande mondiale (*ENDIc*) du bien *c*, il y aura un déséquilibre sur le marché entre l'offre et la demande qui devient inférieure à l'offre. Pour que l'équilibre se rétablisse, il faut

- soit un ajustement de l'offre EN_c à la baisse à travers le membre de gauche de l'équation ci-après, par les variables $XDDE_c$ (la production domestique du bien *c* livrée sur le marché local et étranger), $PDDE_c$ (baisse de l'indice du prix de la production domestique biens *c*), et PE_c (hausse du prix domestique des exportations reçu par les producteurs locaux).

$$XDDE_c \cdot \left(\frac{PDDE_c}{PE_c} \right)^{\sigma T_c} \cdot \gamma T 2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} = \overline{ENDI_c} \cdot \left(\frac{ER \cdot \overline{PWE_c}}{PEFOB_c} \right)^{elastE_c}$$

- soit un ajustement du prix d'équilibre à travers le membre de droite de l'équation ci-dessus par les variables *ER* (le taux de change réel devrait augmenter) ou $PEFOB_c$ (le prix domestique fob du bien *c* devrait diminuer).

A court terme, la production domestique du bien *c* livrée sur le marché local et étranger ($XDDE_c$) est moins variable que les prix. Il ne reste donc comme variable d'ajustement que les prix relatifs de l'offre et de la demande du produit *c*, c'est-à-dire:

$$\left(\frac{PDDE_c}{PE_c}\right) \text{ et } \left(\frac{ER \cdot \overline{PWE_c}}{PEFOB_c}\right)$$

Si le prix d'équilibre $PEFOB_c$ baisse, cela induit un changement de PE_c à la hausse dans la mesure où:

$$PE_c = (PEFOB_c - \sum_{ctm} tcetm_{ctm,c} - P_{ctm})(1 - tvae_c) \quad (1.12.109)$$

Par la suite, la variation à la hausse de PE_c va entrainer une modification des prix relatifs et une baisse de l'offre d'exportation EN_c car:

$$EN_c = XDDE_c \cdot \left(\frac{PDDE_c}{PE_c}\right)^{\sigma T_c} \cdot \gamma T 2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad (1.12.210)$$

A travers la condition de zéro profit, si PE_c et EN_c varient, $PDDE_c$ ou $XDDE_c$ devraient varier pour maintenir l'égalité:

$$PDDE_c \cdot XDDE_c = PDD_c \cdot XDD_c + PE_c \cdot EN_c \quad (1.12.250)$$

Il en résulte une variation de l'indice des prix de la production domestique par branche (PD_s) compte tenu de l'équation ci-après:

$$PD_s = \sum_c ioC_{s,c} \cdot PDDE_c \quad (1.12.249)$$

Ainsi donc, une modification des prix relatifs du produit *c* entraine une variation de l'indice des prix par branche d'activité, ce qui peut influencer la production par branche.

Dans le cas d'une variation à la hausse de $PDDE_c$, il en résulte une modification à la hausse de la part de la production (XDD_c) livrée sur le marché domestique (cf. Eq. 1.12.67).

1.2.2 Une hausse de la consommation publique

Cette simulation analyse les effets d'une hausse d'un point de PIB de la consommation publique. Ce choc a un effet positif sur la demande globale par la consommation et l'investissement.

Cette hausse de l'investissement entraine une hausse de l'emploi domestique total et va engendrer à terme une hausse de la valeur ajoutée totale et du PIB. On aura une hausse des revenus distribués et en conséquence une hausse proportionnelle de la consommation. Compte tenu de la structure de consommation, cette hausse de la consommation favorise une augmentation des importations, avec un effet dommageur sur le solde extérieur.

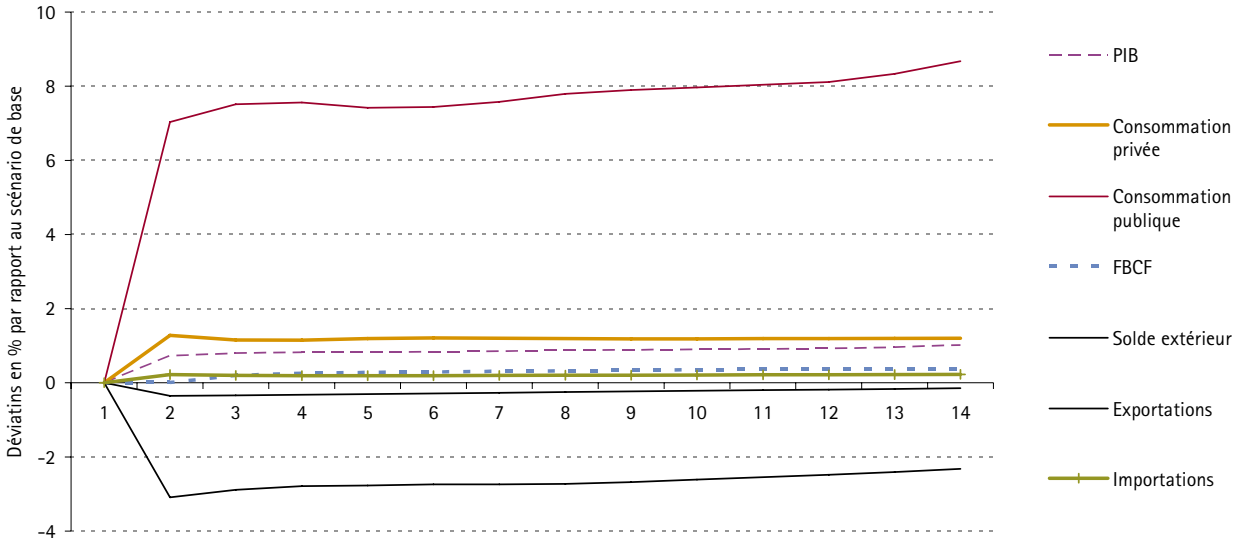
On constate, suite aux simulations, une hausse de l'épargne domestique, à cause de la hausse des revenus distribués, et de l'épargne étrangère. La hausse du niveau d'épargne a un effet favorable à moyen et long terme sur le niveau d'investissement qui augmente dans l'économie et favorise la hausse de l'offre pour rétablir l'équilibre avec la demande.

Tableau 3: Impact macro-économique de la hausse de la hausse de la consommation publique d'un point de PIB

	2008	2009	2010	2011	2012
			(% de variation par rapport au BAU)		
PIB	0.7	0.8	0.8	0.8	0.8
Consommation privée	1.3	1.2	1.2	1.2	1.2
Consommation publique	7.0	7.5	7.6	7.4	7.4
FBCF	0.0	0.2	0.3	0.3	0.3
Solde extérieur	-3.1	-2.9	-2.8	-2.8	-2.7
Exportations	-0.4	-0.3	-0.3	-0.3	-0.3
Importations	0.2	0.2	0.2	0.2	0.2

Source: STATEC

Graphique 3: Impact macroéconomique à long terme d'une hausse de 1 point de PIB de la consommation publique



Source: STATEC

Cheminement détaillé des conséquences de la hausse de la consommation publique

Dans le modèle Luxgem la consommation publique *GEXP* est exprimée par l'équation suivante:

$$GEXP = \overline{CGBUD} \cdot PICG + IGTN + TRST + TRHGPROPN + TRHGSB + TRHGOTHN - DEPPbTN + TRPvGKN + ACQUISN \quad (1.12.165)$$

On remarque dans la formulation de l'équation précédente que les dépenses de consommation finale du gouvernement (*CGBUD*) sont exogènes. La simulation consiste donc à faire un choc sur cette variable afin d'analyser les effets sur les autres variables du modèle. Ainsi, dans le modèle, la variable sur laquelle porte le choc est *rCGBUDGDP*: (la part de la consommation finale du gouvernement dans le PIB)

$$\overline{rCGBUDGDP} = \frac{CGBUD \cdot PICG}{GDP} \cdot 100$$

La variable *CGBUD* est alors endogénéisée et peut varier suite au choc.

Avec:

CGBUD: la dépense de consommation finale du gouvernement en terme réel (exogène)[1];
PICG: l'indice de prix de la dépense de consommation finale du gouvernement;
IGTN: la formation de capital par le gouvernement en terme nominal;
TRHGOTHN: autres transferts courants versés par le gouvernement aux ménages en terme nominal;
TRPvGKN: les transferts en capital payés par le gouvernement en terme réel en terme nominal;
TRHGPROPN: les revenus de la propriété versés aux ménages par le gouvernement en terme nominal;
TRST: les subventions à la production et aux produits;
TRHGSB: les transferts sociaux autres que transferts sociaux en nature;
DEPPbTHN: la consommation de capital fixe des administrations publiques en terme nominal;
ACQUISN: les acquisitions moins les cessions de valeurs mobilières non financières et non produites en terme nominal.

A revenu identique, la modification de la consommation publique du gouvernement aura un impact défavorable sur le solde budgétaire en terme nominal (*SGBALN*) et en terme réel (*SGBAL*).

$$SGBAL \cdot GDPDEF = GREV - GEXP \quad (1.12.166)$$

$$SGBALN = SGBAL \cdot GDPDEF \quad (1.12.167)$$

Le solde budgétaire négatif traduit une baisse de l'épargne du gouvernement. Si l'on se réfère à l'équation suivante:

$$S = SH + SW \cdot ER + \sum_{nsgv} DEPPv_{nsgv} \cdot PI_{nsgv} + TRPvGKN + ACQUISN + SGBALN \quad (1.12.218)$$

Avec

SH: l'épargne des ménages;
SW: épargne du RDM;
ER: le taux de change réel;
$DEPPv_{nsgv}$: la dépréciation liée au stock de capital public;
PI_{nsgv}: indice de prix correspondant aux investissements publics;
TRPvGKN: les transferts en capital payés par le gouvernement en terme réel en terme nominal;
ACQUISN: les acquisitions moins les cessions de valeurs mobilières non financières et non produites en terme nominal;
SGBALN: solde budgétaire en terme nominal.

[1] Une barre au dessus d'une variable indique qu'elle est exogène.

Un solde budgétaire du gouvernement en terme nominal négatif traduit une baisse de l'épargne publique. Étant donnée l'identité entre épargne et investissement, une baisse de l'épargne publique est synonyme d'une épargne totale insuffisante pour financer les investissements.

$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g}$$

$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g} + S_w$$

Compte tenu du bouclage retenu dans le modèle, suite à la baisse de l'épargne publique (S_g), l'épargne totale disponible dans l'économie sera réduite, on aura ($I > S$). L'investissement public (I_g) étant exogène ou fixe, c'est l'investissement privé (I_p) qui doit alors s'ajuster à la baisse pour équilibrer l'épargne.

D'un autre côté, la hausse de la consommation publique a un impact sur la dépense gouvernementale de consommation finale par type de biens (CG_c) et donc sur chaque branche productive selon l'équation suivante:

$$CG_c = ioCG_c \cdot \overline{CGBUD} \qquad (1.12.189)$$

$ioCG_c$: paramètre de Leontief pour l'allocation des dépenses de consommation finale du gouvernement entre différents biens et services.

Finalement, la modification de la dépense gouvernementale de consommation finale par type de biens (CG_c) aura des effets sur la consommation totale du gouvernement (*CGT*) et enfin sur le *PIB*.

1.2.3 Une hausse des investissements publics d'un point de PIB

Suite à la hausse de l'investissement public, on remarque une baisse du solde extérieur (de 3.5 en 2008, 3.9 en 2009 et de 4.0 en 2010). L'emploi augmente ainsi que la consommation privée et l'investissement. Il n'y a pas ici d'effet d'éviction[1] de l'investissement privé. L'épargne des ménages augmente et va entrainer la hausse de l'investissement qui à son tour va engendrer une hausse de la valeur ajoutée totale et du PIB.

Mais à long terme, l'effet favorable sur la croissance s'estompe et décroit. On a un effet multiplicateur plus petit pour l'investissement public que dans le cas de la hausse de la consommation publique, étant donné les parts relatives de ces deux variables dans le PIB. Une relance par la consommation publique s'avère donc plus efficace en termes de relance économique de court terme.

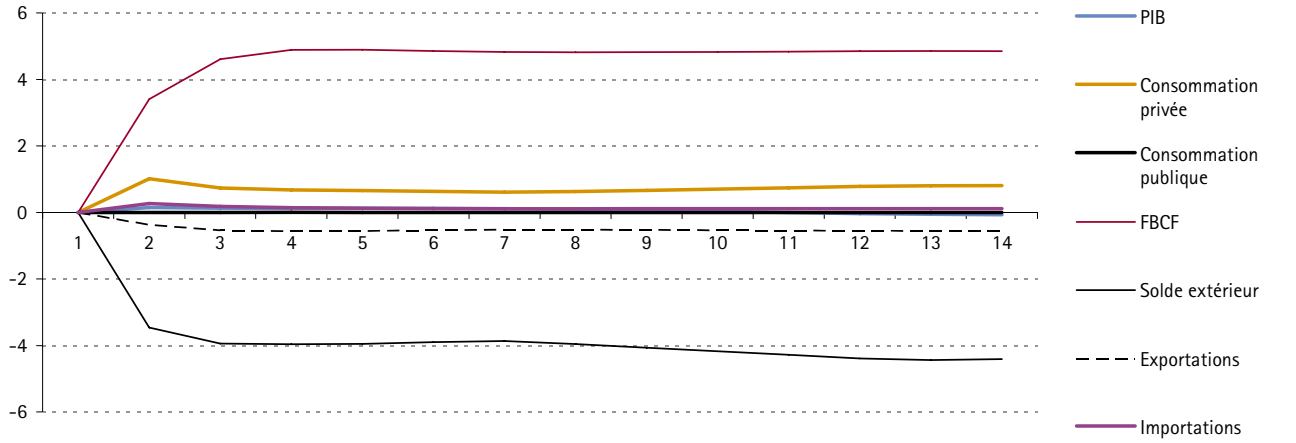
Tableau 4: Effets macroéconomiques suite à la hausse de l'investissement public d'un point du PIB

	2008	2009	2010	2011	2012
	(% de variation par rapport au BAU)				
PIB	0.2	0.1	0.1	0.1	0.1
Consommation privée	1.0	0.7	0.7	0.7	0.6
Consommation publique	0.0	0.0	0.0	0.0	0.0
FBCF	3.4	4.6	4.9	4.9	4.9
Solde extérieur	-3.5	-3.9	-4.0	-4.0	-3.9
Exportations	-0.4	-0.5	-0.6	-0.6	-0.5
Importations	0.3	0.2	0.1	0.1	0.1

Source: STATEC

[1] L'effet d'éviction est la baisse non voulue de l'investissement et de la consommation des agents privés provoquée indirectement par une politique budgétaire expansionniste. La référence à l'effet d'éviction est utilisée par ceux qui critiquent les politiques de relance keynésiennes financées par l'emprunt public. Les emprunts publics provoquent l'éviction des emprunteurs privés. L'État peut investir davantage mais les entreprises privées investiront moins. La stimulation de la croissance par augmentation de la dépense publique est donc amoindrie ou annulée.

Graphique 4: Impacts macroéconomiques à long terme d'une hausse d'un point de PIB de l'investissement public



Source: STATEC

Cheminement détaillé des conséquences de la hausse de l'investissement public d'un point de PIB

L'investissement public ou encore la formation de capital par le gouvernement en terme nominal (*IGTN*) est exprimée dans le modèle par l'équation suivante:

$$IGTN = \overline{IGT} \cdot PIG \qquad (1.12.191)$$

On notera que la dépense d'investissement du gouvernement (*IGT*) est exogène, dès lors la simulation consistera à faire un choc sur variable afin d'analyser les effets transmis sur les autres variables du modèle.

Dans le modèle la variable sur laquelle porte le choc est *rIGT*: (la part de l'investissement public dans le PIB)

$$\overline{rIGT} = \frac{IGT \cdot PIG}{GDP} \cdot 100$$

La variable *IGT* est alors endogénéisée et peut varier suite au choc.

Avec:

$\overline{IGT}$: la dépense de consommation finale du gouvernement en terme réel (exogène)
PIG: l'indice de prix de la dépense de consommation finale du gouvernement

On sait par ailleurs que:

$$GEXP = \overline{CGBUD} \cdot PICG + IGTN + TRST + TRHGPROPN + TRHGSB + TRHGOTHN - DEPPbTN + TRPvGKN + ACQUISN \qquad (1.12.165)$$

On remplace *IGTN* par sa valeur dans l'équation précédente et on obtient:

$$GEXP = \overline{CGBUD} \cdot PICG + \overline{IGT} \cdot PIG + TRST + TRHGPROPN + TRHGSB + TRHGOTHN - DEPPbTN + TRPvGKN + ACQUISN \qquad (1.12.165)$$

Une hausse de l'investissement du gouvernement (*IGT*) aura un impact sur la consommation publique décrite par l'équation précédente.

Si le revenu du gouvernement (*GREV*) ne change pas, la modification de la consommation publique du gouvernement aura un impact défavorable su le solde budgétaire en terme nominal (*SGBALN*) et réel (*SGBAL*).

$$SGBAL \cdot GDPDEF = GREV - GEXP \quad (1.12.166)$$

$$SGBALN = SGBAL \cdot GDPDEF \quad (1.12.167)$$

Néanmoins, la hausse de la dépense de l'investissement public total (*IGT*) aura un impact favorable sur l'investissement public par branche ($INVPb_{sgv}$), puis sur la demande de biens d'investissement par branches ($INVCPb_{sgv,c}$), et enfin sur l'investissement total et le PIB. Ainsi, la production par branche et les taxes sur la production seront accrues et en définitive les revenus des agents et leur épargne augmenteront.

Ainsi, une hausse d'investissement public, par son effet multiplicateur, peut avoir un impact favorable sur la production et les revenus des agents et à terme sur l'épargne qui augmentera dans l'économie pour satisfaire l'égalité entre investissement et épargne.

$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g}$$
$$I \equiv I_p + \overline{I_g} = \overline{S}_m + \overline{S_g} + S_w$$

En fonction du bouclage ci-dessus, une hausse exogène de **l'investissement public** (I_g) signifie que l'investissement total dans l'économie augmente. L'épargne publique étant fixe, il y aura un surplus de demande d'investissement par rapport à l'épargne disponible, insuffisante par rapport à l'investissement ($I > S$).

Le déséquilibre entre une épargne faible et un besoin d'investissement élevé peut aussi être résorbé par l'épargne privée et/ou l'épargne étrangère (S_w) qui peut se traduire par un afflux de capitaux en provenance du RDM.

1.2.4 Baisse d'un point de PIB des impôts directs sur les revenus des ménages

Suite à la baisse des impôts directs sur le revenu des ménages, on constate une hausse de leur revenu réel de 1.2% sur la période 2008-2012, ce qui permet une augmentation de leur consommation et aussi de leur propension à épargner et de leur épargne.

Au niveau macroéconomique, cette baisse d'impôt entraine une hausse de l'investissement privé suite à la hausse de l'épargne. Par ailleurs, les importations augmentent compte tenu de leur part dans la structure de consommation des ménages. Néanmoins les exportations diminuent suite à une hausse des prix et une baisse de la compétitivité. En définitive, cette baisse d'impôt a un effet favorable sur le PIB à court et à long terme.

Tableau 5: Baisse d'un point de PIB des impôts directs sur les revenus des ménages: Effets sur les consommateurs privés

	2008	2009	2010	2011	2012
	(% variation par rapport au BAU)				
Revenu réel des ménages	1.2	1.2	1.2	1.2	1.2
Consommation réelle des méanges	0.9	0.9	0.9	0.9	0.9
Epargne réelle des ménages	1.9	1.8	1.7	1.7	1.7
Propension à épargner (%)	33.0	34.5	33.9	33.0	32.6
Propoension à épargner (% points de différence par rapport au BAU)	0.2	0.2	0.2	0.2	0.2
Salaires reels moyens	**-0.3**	**-0.3**	**-0.3**	**-0.2**	**-0.2**
Rémunération réelle moyenne du capital	0.4	0.3	0.2	0.2	0.1

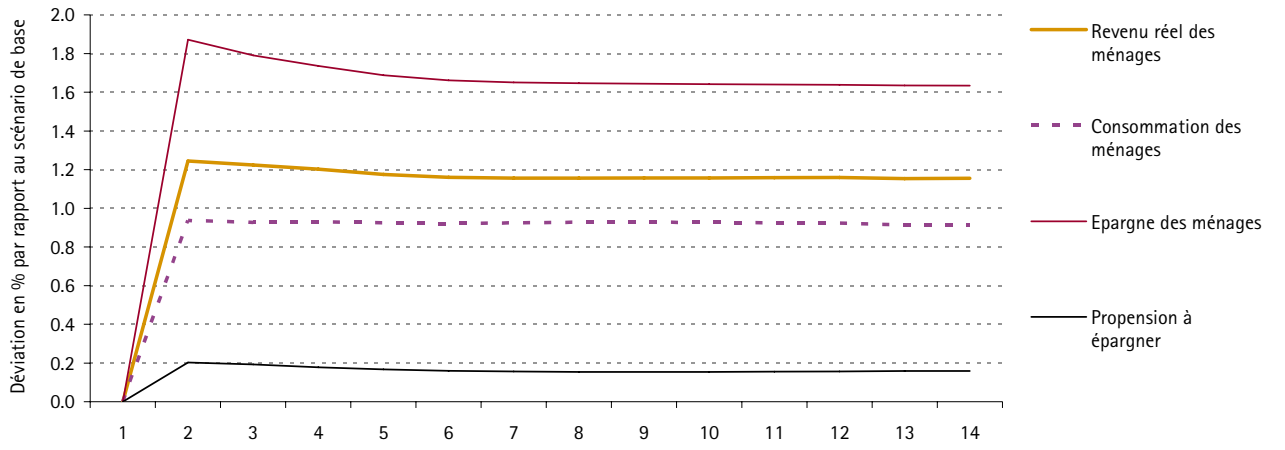
Source: STATEC

Tableau 6: Baisse de 1% des impôts directs sur les revenus des ménages: Effets macroéconomiques en termes réels

	2008	2009	2010	2011	2012
	(% de variation par rapport au BAU)				
PIB	0.2	0.2	0.2	0.1	0.1
Consommation privée	1.0	0.9	0.9	0.9	0.9
Consommation publique	0.0	0.0	0.0	0.0	0.0
FBCF	0.2	0.0	0.0	0.1	0.1
Solde extérieur	-0.7	-0.6	-0.7	-0.7	-0.8
Exportations	-0.1	0.0	0.0	0.0	0.0
Importations	0.1	0.1	0.1	0.1	0.1

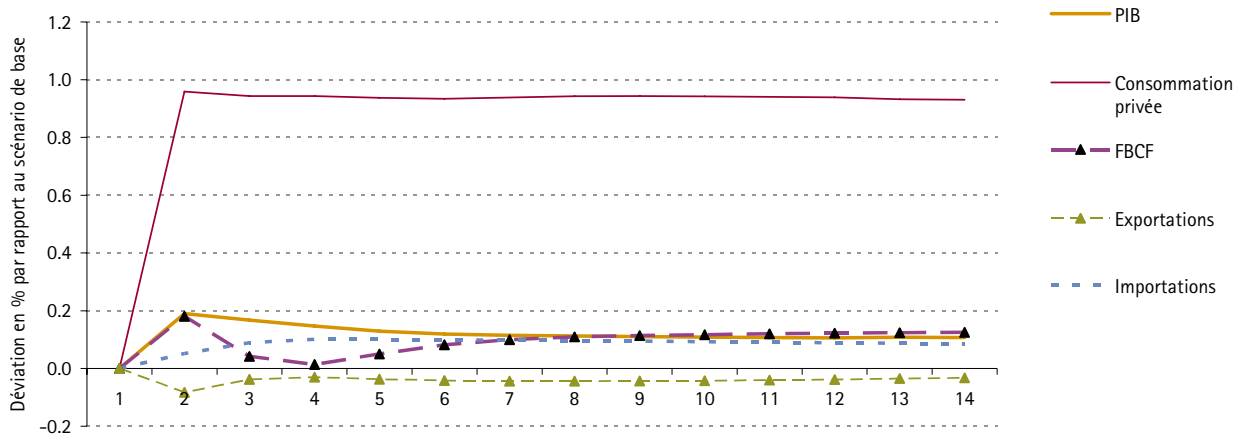
Source: STATEC

Graphique 5: Baisse d'un point de PIB des impôts directs sur les revenus des ménages (impact à long terme)



Source: STATEC

Graphique 6: Baisse d'un point de PIB des impôts directs sur les revenus des ménages (impact à long terme, suite)



Source: STATEC

Cheminement détaillé des effets d'une baisse de l'imposition directe des ménages

Une diminution du taux d'imposition sur le revenu des ménages aura un impact direct sur le revenu disponible (*YDH*) des ménages:

$$YDH = (1 - \overline{ty}) \cdot YH \qquad (1.12.149)$$

Avec:

$\overline{ty}$: le taux de taxe sur le revenu des ménages (exogène);
YH: le revenu des ménages

Par ailleurs, la modification du revenu disponible des ménages aura des effets sur leur épargne (*SH*).

$$SH = MPS \cdot (1 - \overline{ty}) \cdot YH \qquad (1.12.151)$$

Où *MPS* désigne la propension marginale à épargner des ménages.

Finalement, on aura un impact sur le budget disponible pour la consommation (*CBUD*) des ménages:

$$CBUD = (1 - \overline{ty}) \cdot YH - SH \qquad (1.12.150)$$

Du côté du gouvernement, cette baisse des impôts va occasionner une baisse de revenu (*TRPROPH*) proportionnelle au revenu des ménages.

$$TRPROPH = ty \cdot YH \qquad (1.12.179)$$

1.2.5 Baisse d'un point de PIB des cotisations sociales employeurs

Suite à la baisse des cotisations sociales employeurs, on constate une hausse de l'emploi domestique et national et une baisse du taux de chômage (de 0.2 point en 2008 et de 0.1 point en 2009 et en 2010).

Au niveau macroéconomique, on a une hausse de l'épargne et de l'investissement privé. Mais à long terme l'investissement diminue à cause de la substitution du travail au capital. Par ailleurs, la consommation augmente, ce qui entraine une hausse des importations tandis que les exportations augmentent également. En définitive, la baisse des cotisations sociales employeurs favorise l'emploi et le PIB.

Tableau 7: Baisse de 1 point de % des cotisations sociales employeurs: Effets sur le marché du travail

	2008	2009	2010	2011	2012
	(% de variation par rapport au BAU)				
Emploi domestique	0.5	0.6	0.7	0.8	0.8
Nombre de frontaliers	1.0	1.4	1.6	1.7	1.8
Emploi national	0.2	0.1	0.1	0.1	0.1
Nombre de chômeurs	**-3.3**	**-2.0**	**-1.3**	**-0.9**	**-0.7**
Population active	0.1	0.0	0.0	0.0	0.0
Taux de chômage (%)	4.1	4.2	4.5	4.9	5.3
Taux de chômage (% de points de différence par rapport au BAU)	**-0.2**	**-0.1**	**-0.1**	**-0.1**	**0.0**

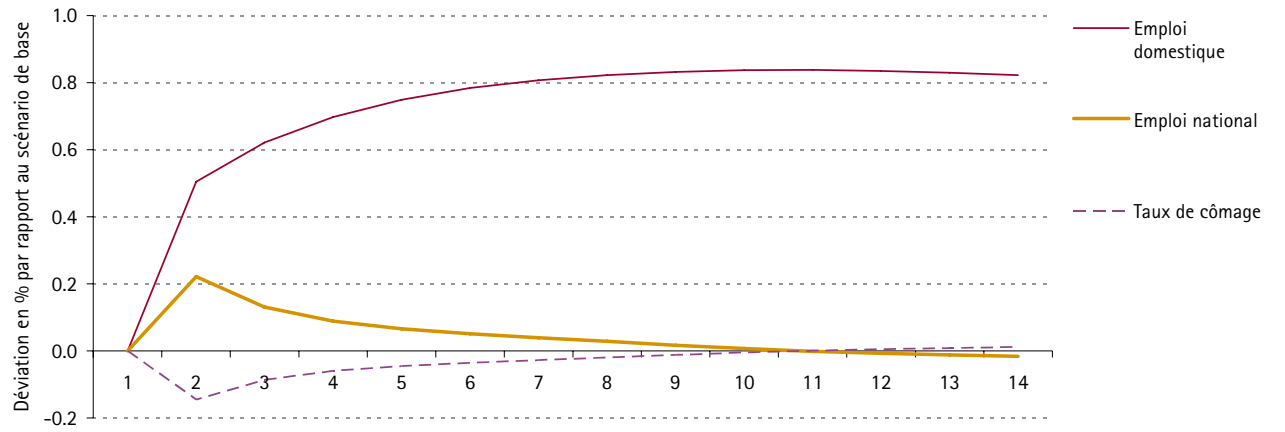
Source: STATEC

Tableau 8: Effets macroéconomiques en termes réels

	2008	2009	2010	2011	2012
	(% de variation par rapport au BAU)				
PIB	0.24	0.30	0.35	0.39	0.42
Consommation privée	0.26	0.21	0.20	0.20	0.19
Consommation publique	0.00	0.00	0.00	0.00	0.00
FBCF	0.11	0.04	0.00	**-0.02**	**-0.04**
Solde extérieur	0.44	0.79	0.99	1.14	1.25
Exportations	0.23	0.33	0.39	0.43	0.45
Importations	0.19	0.24	0.27	0.29	0.29

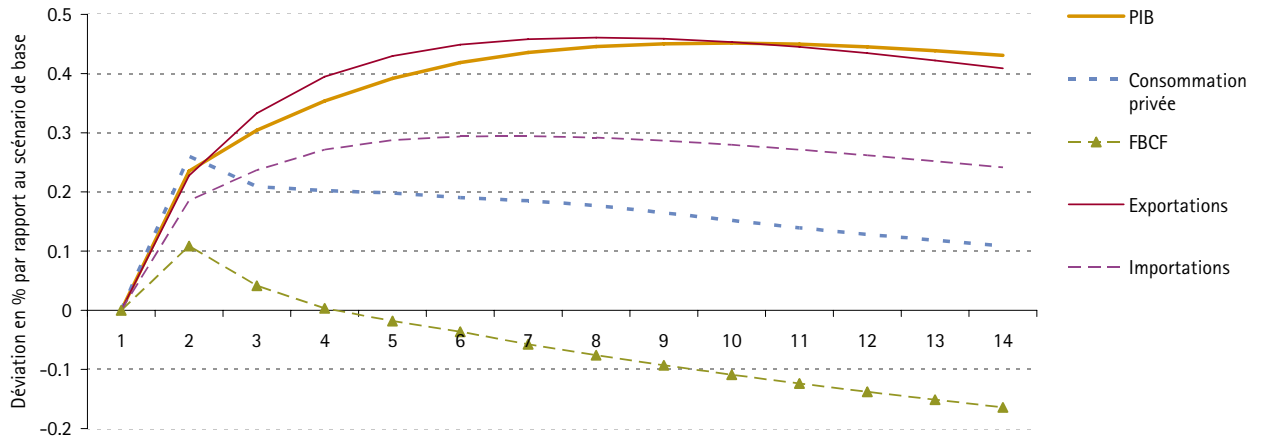
Source: STATEC

Graphique 7: Baisse d'un point de PIB des cotisations sociales employeurs (effets à long terme)
par rapport au scénario de base



Source: STATEC

Graphique 8: Baisse d'un point de PIB des cotisations sociales employeurs (effets à long terme, suite)



Source: STATEC

Cheminement détaillé de l'impact d'une baisse des cotisations sociales employeurs

La diminution du taux de cotisation sociale des employeurs devrait avoir un impact positif sur le nombre d'employés (LSK_s) que les entreprises pourront engager par branche, et par conséquent sur la valeur ajoutée et la production de chaque branche, et à terme sur le PIB.

$$LSK_s = KL_s \cdot \left\{PKL_s / \left[PL \cdot (1 + premLSK_s) \cdot (1 + \overline{tl_s} / (1 - \overline{tl_s}))\right]\right\}^{\sigma F_s} \cdot \gamma FL_s^{\sigma F_s} \cdot aF_s^{(\sigma F_s - 1)} \qquad (1.12.158)$$

KL_s: la valeur ajoutée par branche

$\overline{tl_s}$: le taux de cotisation sociale (exogène)

Mais du côté du gouvernement, cette baisse des impôts va occasionner une baisse de revenu ($TRPSOC_s$) par branche.

$$TRSOCS_s = \left[\left[tl_s / (1 - tl_s)\right] \cdot LSK_s \cdot PL \cdot (1 + premLSK_s)\right] \qquad (1.12.184)$$

A dépenses inchangées ces baisses d'impôts auront un effet favorable sur l'emploi, mais un impact négatif sur le solde budgétaire du gouvernement.

1.3 Conclusions

Ce travail a permis de calculer des variantes du modèle d'équilibre général de l'économie luxembourgeoise Luxgem. L'analyse des effets de différents chocs de politique économique à l'aide de ce modèle montre que Luxgem est un outil pertinent pour examiner les impacts intersectoriels des modifications de l'environnement tant national qu'international. Cette étude de variantes permet ainsi de faire un pas dans la validation du modèle théorique sous jacent à Luxgem.

En effet les moyens de validation des modèles d'EGC sont très faibles et l'on ne dispose pas des informations sur les intervalles de confiance comme dans les tests économétriques. Une première approche consiste à comparer les résultats émanant des modèles EGC à ceux réellement obtenus, mais en général, les modélisateurs en EGC ont recours à des "tests" de sensibilité des résultats des modèles aux variations des valeurs des paramètres (les élasticités) ou aux modifications des règles de bouclage du modèle.

2. Rapport technique élaboré par EcoMod[1]

2.1 General overview

STATEC has a new tool for economic analysis: the model Luxgem.

Luxgem is a state-of-the-art, dynamic, multi-sector general equilibrium model for Luxembourg. It has powerful capabilities for impact and scenario analysis, for sectoral forecasting and projections.

Luxgem incorporates the economic behaviour of four economic agents: firms, household, government and the rest of the world.

Luxgem distinguishes 16 branches of activity, consisting of both public and private enterprises (see Table 1). Each branch of activity produces one or several types of goods and services, as reflected by the make matrix. In total, there are 20 types of commodities, which follow the disaggregation presented in Table 2. Six of the commodities presented in Table 2 represent energy inputs: other products of mining and quarrying of energy; liquid fuels; fuels; other products of coke, refined petroleum, etc.; production and distribution of electricity; other gas, steam and hot water supply.

Table 1: Disaggregation of branches of activity in Luxgem

1	Agriculture, etc
2	Mining and quarrying of energy producing materials
3	Manufacture of coke, refined petroleum products, etc.
4	Manufacturing
5	Electricity, gas, steam, etc
6	Construction
7	Wholesale and retail trade services
8	Hotels and restaurants
9	Transport, storage and communication
10	Financial sector
11	Real estate services
12	Business services
13	Public administration
14	Education
15	Health and social work
16	Other services

Luxgem can be used for detailed impact and scenario analysis at the sectoral level, as well as for forecasting at the sectoral level. It helps its users understand the total macro and sectoral effects of policy decisions. It has the inter-industry detail from input-output, supply and use tables. It allows for behavioural responses to housing and consumer prices, wages, and production costs as in computable general equilibrium models. The model is dynamic, generating forecasts and simulations on an annual basis, and accounting for behavioural responses to wage, price, and other economic factors.

[1] Frédéric Dramais, Cristina Mohora et Masudi Opese (ECOMOD)

Table 2: Disaggregation of commodities in Luxgem

1	Agriculture, etc
2	Natural gas
3	Other products of mining and quarrying of energy
4	Liquid fuels
5	Fuels
6	Other products of coke, refined petroleum, etc.
7	Manufacturing
8	Production and distribution of electricity
9	Other gas, steam and hot water supply
10	Construction
11	Wholesale and retail trade services
12	Hotels and restaurants
13	Transport, storage and communication
14	Financial sector
15	Real estate services
16	Business services
17	Public administration
18	Education
19	Health and social work
20	Other services

2.2 Luxgem's theoretical foundation

Luxgem is based on the general equilibrium theory. It is designed to measure the direct, indirect economic impacts of policy changes on an economy in the short, medium and long run. The input-output core enables the model to trace the extent and the channels of changes in policy and international environment. The resulting price changes affect the demand for the sectoral outputs and alter the resource allocation of factors. The simulations explore the effects of external shocks (such as changes in the international prices, the fluctuations in the real exchange rate, foreign demand, etc) and domestic policy changes. Model simulations provide results regarding the impacts on the:

- GDP
- production by branch of activity
- value added by branch of activity
- trade flows by commodity
- employment
- investment
- macroeconomic variables
- prices
- wages
- income
- public finance outcomes
- greenhouse gas emissions on fuel combustion
- etc.

This type of economic modelling is an important tool for analysing a great number of economic issues. It is extremely useful to decision-makers dealing with issues of trade, public finance, social security, regional integration, impact assessment, and the consequent implications for energy and environmental standards. Applied general equilibrium models are now widely used in economic policy analyses by all the major international institutions such as the World Bank, the OECD, the European Commission, the World Trade Organisation, the UNCTAD, major multinational companies, and hundreds of municipal administrations, etc. This widespread use is explained by the capability of these models to provide an elaborate and realistic representation of the economy including the linkages between all agents, sectors and other economies. This complete coverage allows a unique insight

into the effects of changes in the economic environment throughout the whole economy. These models are very powerful and flexible. They can take into account human capital accumulation, intergenerational issues, environmental issues, and even health issues.

General equilibrium (CGE) models simulate the workings of a market economy and are unique in their ability to analyze the impacts of economic policy decisions, especially when the policy has macro, and sectoral resource allocation repercussions. CGEs are explicitly designed to capture all structural impacts including changes in relative prices, demand composition, and sectoral output and employment.

The main premise of the CGE models is that "structure" matters and they explicitly consider the workings of a multi-sectoral, multi-market, general equilibrium system undergoing structural adjustment, i.e. CGE models simulate the transactions in a market economy. They capture the interaction of various actors in the economy including: households (as consumers, workers and savers); firms (as producers, consumers of intermediate goods, and investors); government (as consumer and transfer agent); and the rest of the world (as consumers of exports, producers of imports and providers or recipients of international capital flows). Consistent with microeconomic theory, all agents are assumed to optimize within budget constraints as well as the constraints imposed by regulatory frameworks. CGE models are unique in their ability to present the trade-offs of a given policy decision, especially when the policy has economy-wide repercussions as in the case of corporate, sales and individual income taxes. Even the sign of an affected variable may change when an analysis is extended from partial to general equilibrium.

One of the most desirable properties of CGE models is their ability to trace economy-wide implications of several policy changes simultaneously, taking into account both the interactions between these policy changes as well as the policy changes and existing distortions.

The use of detailed inter-industry flow information allows the modelling of the interaction between industries that can result from the change in relative prices of specific commodities or the level of demand.

2.3 Luxgem's main technical features

Luxgem incorporates the economic behaviour of four economic agents: firms, household, government and the rest of the world. The behaviour of each agent in the model is described in detail below.

Luxgem is currently calibrated on the Social Accounting Matrix for 2004. The model has been solved by using the general algebraic modeling system GAMS (Rosenthal, 2006).

The following conventions are adopted for the presentation of the model. Variable names are given in capital letters, small letters denote parameters calibrated from the database (SAM) and elasticity parameters. The subscript *s* stands for one of the production activities (16 branches of activity). The subscript *c* stands for one of the commodities (20 types of commodities). The subscript *eng* stands for one of the energy inputs (6 types of energy inputs) while *nen* stands for all other commodities except the energy inputs (14 types of commodities). The subscript *enel* stands for the electricity and *ennel* for the non-electric energy inputs (5 types of energy inputs). The subscript *enco* stands for products of mining and quarrying of energy and refined petroleum products (4 types of energy inputs) and the subscript *ng* for the natural gas. The subscript *enfl* stands for fuels and *nenfl* for all non-electric energy inputs except fuels (4 types of energy inputs). The subscript *sel* stands for the electricity, gas, steam, etc. sector and *nsel* for all other branches except the electricity sector (15 branches of activity).The subscript *trs* stands for the transport, storage and communication sector while *ntrs* for all branches except transport, storage and communication sector (15 branches of activity). The subscript *cre* stands for the real estate services. The subscript *ctm* stands for one of the two trade and transport services in the model (wholesale and retail trade services and transport services) while *nctmn* stands for all the other commodities except the trade and transport services and energy inputs (12 types of commodities). The subscript *sgv* stands for one of the three branches of activity (public administration, education and health and social work), while *nsgv* stands for all the

other branches except the public administration, education and health and social work (13 branches of activity). Finally, the subscript *t* stands for year t.

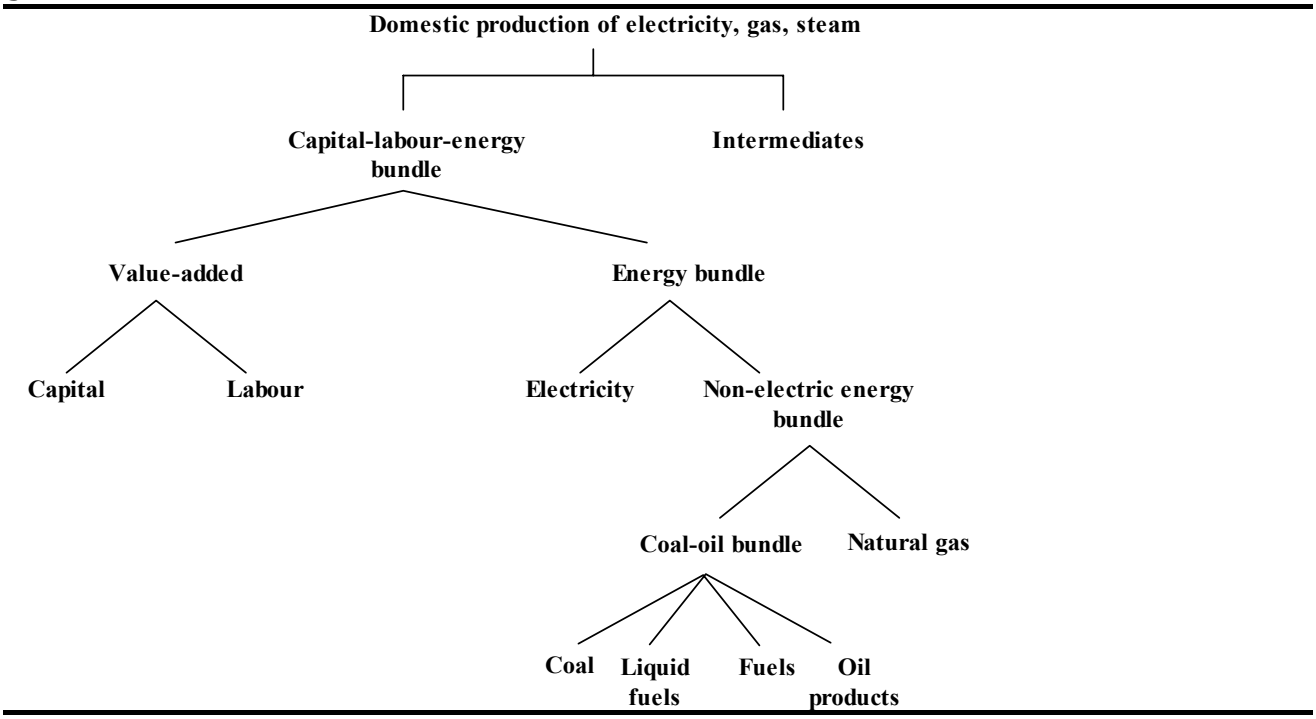
2.3.1 Firms

The CGE model does not take into account the behaviour of individual firms, but of groups of similar ones aggregated into branches. The model distinguishes 16 perfectly competitive branches of activity (summarized in Table 1).

The usual assumption for such a model is that producers operate on perfectly competitive markets and maximize profits (or minimize costs for each level of output) to determine optimal levels of inputs and output. For example, for the firms operating internationally, the world market dictates the output price to a large extent, so, for an optimal outcome they have to produce as efficiently as possible. Some other firms are constrained in the costs level by domestic competitors. Thus, the optimizing producers minimize their production costs at every output level, given their production technology. Furthermore, production prices equal average and marginal costs, a condition that implies profit maximization for a constant returns to scale technology.

The level of production for each branch of activity is determined from a nested production structure. For the electricity, gas and steam sector the producers are assumed to choose in the first stage between intermediate inputs and a capital-labour-energy bundle according to a Leontief production function. In the second stage, the optimal mix between value-added and energy is given by another optimization process, where substitution possibilities between value added and energy are represented by a constant elasticity of substitution (CES) function. In the third stage, value added is given by a CES function of capital and labour while the energy bundle by a CES function of electricity and a non-electric energy bundle. In the fourth stage, the optimal mix between natural gas and the coal-oil bundle is given by another optimization process, where substitution possibilities between natural gas and the coal-oil bundle are represented by another CES function. Finally, in the fifth stage the optimal allocation of the coal-oil bundle between different energy inputs is provided by another CES function (see Figure 1). Firms' costs related to corporate income tax and social security contributions are also taken into account in the optimization process.

Figure 1. The nested Leontief and CES production technology for the domestic production of electricity, gas and steam



Capital-labour-energy bundle (KLE_{sel}) is related to domestic production by branch *sel* (XD_{sel}) through a Leontief production function, which assumes an optimal allocation of inputs:

$$KLE_{sel} = aKLE_{sel} \cdot XD_{sel} \tag{1}$$

where $aKLE_{sel}$ is the fixed coefficient relating capital-labour-energy bundle to domestic production. Similarly, total intermediate inputs used by industry *sel* (IO_{sel}) are derived as:

$$IO_{sel} = \sum_{c} io_{c,sel} \cdot XD_{sel} \tag{2}$$

where $io_{c,sel}$ are the technical coefficients. Thus, domestic production valued at basic prices net of taxes (tp_{sel}) but including direct subsidies (tsp_{sel}) on production, $\left[PD_{sel} \cdot (1 - tp_{sel} + tsp_{sel})\right]$, is given by the sum of capital-labour-energy bundle (KLE_{sel}) for branch *sel* valued at basic prices $(PKLE_{sel})$ and intermediate commodities used by sector *sel* valued at the price of the commodities (P_c), including the trade and transport margins $(\sum_{ctm} tcictm_{ctm,c} \cdot P_{ctm})$, non-deductible VAT $(tvaic_c)$, excise duties $(texcic_c)$ and other taxes (tic_c) on intermediate consumption:

$$\begin{aligned} PD_{sel} \cdot XD_{sel} \cdot (1 - tp_{sel} + tsp_{sel}) = \sum_{nen} \{ io_{nen,sel} \cdot XD_{sel} \cdot [(1 - tsic_{nen}) \cdot P_{nen} + \\ \sum_{ctm} tcictm_{ctm,nen} \cdot P_{ctm}] \cdot (1 + tic_{nen} + texcic_{nen}) \cdot (1 + tvaic_{nen}) \} + PKLE_{sel} \cdot KLE_{sel} \end{aligned} \tag{3}$$

The trade and transport margins are valued at the price (P_{ctm}) of the corresponding service (wholesale and retail trade services or transport services), while $tcictm_{ctm,c}$ represents the trade and transport services *ctm* per unit of intermediate consumption of commodity *c*.

Capital-labour-energy bundle is a CES aggregation of value added (KL_{sel}) and energy $(ENER_{sel})$:

$$KL_{sel} = aKLEN_{sel} \cdot (\gamma KL_{sel} \cdot KL_{sel}^{-\rho KLEN_{sel}} + \gamma ENER_{sel} \cdot ENER_{sel}^{-\rho KLEN_{sel}})^{-1/\rho KLEN_{sel}} \tag{4}$$

Minimizing the costs function:

$$Cost_{sel}(KL_{sel}, ENER_{sel}) = PKL_{sel} \cdot KL_{sel} + PENER_{sel} \cdot ENER_{sel} \tag{5}$$

subject to (4) yields the demand equations for value added and energy bundle:

$$KL_{sel} = KLE_{sel} \cdot (PKLE_{sel} / PKL_{sel})^{\sigma KLEN_{sel}} \cdot \gamma KL_{sel}^{\sigma KLEN_{sel}} \cdot aKLEN_{sel}^{(\sigma KLEN_{sel} - 1)} \tag{6}$$

$$ENER_{sel} = KLE_{sel} \cdot (PKLE_{sel} / PENER_{sel})^{\sigma KLEN_{sel}} \cdot \gamma ENER_{sel}^{\sigma KLEN_{sel}} \cdot aKLEN_{sel}^{(\sigma KLEN_{sel} - 1)} \tag{7}$$

and the associated zero profit condition:

$$PKLE_{sel} \cdot KLE_{sel} = PENER_{sel} \cdot ENER_{sel} + PKL_{sel} \cdot KL_{sel} \tag{8}$$

where $PENER_{sel}$ gives the price index corresponding to the energy bundle and PKL_{sel} stands for the price index corresponding to value added. The elasticity of substitution between value added and energy bundle is given by $\sigma KLEN_{sel}$, where $\sigma KLEN_{sel} = 1/(1 + \rho KLEN_{sel})$, and γKL_{sel} and $\gamma ENER_{sel}$ represent the distribution parameters corresponding to value added and energy bundle, respectively.

Value-added is a CES aggregation of capital (KSK_{sel}) and labour (LSK_{sel}), expressed in number of employees:

$$KL_{sel} = aF_{sel} \cdot (\gamma FK_{sel} \cdot KSK_{sel}^{-\rho F_{sel}} + \gamma FL_{sel} \cdot LSK_{sel}^{-\rho F_{sel}})^{-1/\rho F_{sel}} \quad (9)$$

Minimizing the costs function:

$$Cost_{sel}(KSK_{sel}, LSK_{sel}) = [PK_{sel} \cdot (1+tk_{sel}) + d_{sel} \cdot PI_{sel}] \cdot KSK_{sel} + [PL \cdot (1+premLSK_{sel}) \cdot (1+tl_{sel}/(1-tl_{sel}))] \cdot LSK_{sel} \quad (10)$$

subject to (9) yields the demand equations for capital and labour:

$$KSK_{sel} = KL_{sel} \cdot \{PKL_{sel}/[PK_{sel} \cdot (1+tk_{sel}) + d_{sel} \cdot PI_{sel}]\}^{\sigma F_{sel}} \cdot \gamma FK_{sel}^{\sigma F_{sel}} \cdot aF_{sel}^{(\sigma F_{sel}-1)} \quad (11)$$

$$LSK_{sel} = KL_{sel} \cdot \{PKL_{sel}/[PL \cdot (1+premLSK_{sel}) \cdot (1+tl_{sel}/(1-tl_{sel}))]\}^{\sigma F_{sel}} \cdot \gamma FL_{sel}^{\sigma F_{sel}} \cdot aF_{sel}^{(\sigma F_{sel}-1)} \quad (12)$$

and the associated zero profit condition:

$$PKL_{sel} \cdot KL_{sel} = [PK_{sel} \cdot (1+tk_{sel}) + d_{sel} \cdot PI_{sel}] \cdot KSK_{sel} + PL \cdot (1+premLSK_{sel}) \cdot [1+tl_{sel}/(1-tl_{sel})] \cdot LSK_{sel} \quad (13)$$

where PL is the average wage in the domestic employment and $premLSK_{sel}$ is the wage differential of branch *sel* with respect to the average wage PL, tl_{sel} is the social security contributions rate for industry *sel*, PK_{sel} is the return to capital in branch *sel*, tk_{sel} is the corporate income tax rate for branch *sel*, and d_{sel} is the depreciation rate in industry *sel*. The depreciation related to the private and public capital stock is valued at the price index corresponding to investments by branch of activity *sel* (PI_{sel}). The elasticity of substitution between capital and labour is given by σF_{sel}, where $\sigma F_{sel} = 1/(1+\rho F_{sel})$, and γFK_{sel} and γFL_{sel} represent the distribution parameters corresponding to capital and labour.

At the third nest, the energy bundle is given by another CES function of electricity $(ENINP_{enel,sel})$ and a non-electric energy bundle $(ENERNE_{sel})$

$$ENER_{sel} = aENER_{sel} \cdot (\gamma ENEREL_{enel,sel} \cdot ENINP_{enel,sel}^{-\rho ENER_{sel}} + \gamma ENERNE_{sel} \cdot ENERNE_{sel}^{-\rho ENER_{sel}})^{-1/\rho ENER_{sel}} \quad (14)$$

Minimizing the costs function:

$$Cost_{sel}(ENINP_{enel,sel}, ENERNE_{sel}) = \sum_{enel} \{[(1-tsic_{enel}) \cdot P_{enel} + \sum_{ctm} tcictm_{ctm,enel} \cdot P_{ctm}] \cdot (1+tic_{enel}+texcic_{enel}) \cdot (1+tvaic_{enel}) \cdot ENINP_{enel,sel}\} + PENERNE_{sel} \cdot ENERNE_{sel} \quad (15)$$

subject to (14) yields the demand equations for electricity and the non-electric energy bundle:

$$ENINP_{enel,sel} = ENER_{sel} \cdot \{PENER_{sel}/\{[(1-tsic_{enel}) \cdot P_{enel} + \sum_{ctm} tcictm_{ctm,enel} \cdot P_{ctm}] \cdot (1+tvaic_{enel}) \cdot (1+tic_{enel}+texcic_{enel})\}\}^{\sigma ENER_{sel}} \cdot \gamma ENEREL_{enel,sel}^{\sigma ENER_{sel}} \cdot aENER_{sel}^{(\sigma ENER_{sel}-1)} \quad (16)$$

$$ENERNE_{sel} = ENER_{sel} \cdot (PENER_{sel} / PENERNE_{sel})^{\sigma ENER_{sel}} \cdot \gamma ENERNE_{sel}^{\sigma ENER_{sel}} \cdot aENER_{sel}^{(\sigma ENER_{sel}-1)} \quad (17)$$

and the associated zero profit condition:

$$PENER_{sel} \cdot ENER_{sel} = \sum_{enel} \{[(1-tsic_{enel}) \cdot P_{enel} + \sum_{ctm} tcictm_{ctm,enel} \cdot P_{ctm}] \cdot (1+tic_{enel} + texcic_{enel}) \cdot (1+tvaic_{enel}) \cdot ENINP_{enel,sel}\} + PENERNE_{sel} \cdot ENERNE_{sel} \quad (18)$$

where $PENERNE_{sel}$ gives the price index corresponding to the non-electric energy bundle. The elasticity of substitution between electricity and the non-electric energy bundle is given by $\sigma ENER_{sel}$, where $\sigma ENER_{sel} = 1/(1+\rho ENER_{sel})$, and $\gamma ENEREL_{enel,sel}$ and $\gamma ENERNE_{sel}$ represent the distribution parameters corresponding to electricity and the non-electric energy bundle, respectively.

As already explained, at the forth nest the producers choose between the optimal consumption of natural gas $(ENINP_{ng,sel})$ and a coal-oil bundle $(ENERCO_{sel})$ according to another CES function:

$$ENERNE_{sel} = aENERCO_{sel} \cdot (\gamma ENINPG_{ng,sel} \cdot ENINP_{ng,sel}^{-\rho ENERCO_{sel}} + \gamma ENERCO_{sel} \cdot ENERCO_{sel}^{-\rho ENERCO_{sel}})^{-1/\rho ENERCO_{sel}} \quad (19)$$

Minimizing the costs function:

$$Cost_{sel}(ENINP_{ng,sel}, ENERCO_{sel}) = \sum_{ng} \{[(1-tsic_{ng}) \cdot P_{ng} + \sum_{ctm} tcictm_{ctm,ng} \cdot P_{ctm}] \cdot (1+tic_{ng} + texcic_{ng}) \cdot (1+tvaic_{ng}) \cdot ENINP_{ng,sel}\} + PENERCO_{sel} \cdot ENERCO_{sel} \quad (20)$$

subject to (19) yields the demand equations for natural gas and the coal-oil bundle:

$$ENINP_{ng,sel} = ENERNE_{sel} \cdot \{PENERNE_{sel} / \{[(1-tsic_{ng}) \cdot P_{ng} + \sum_{ctm} tcictm_{ctm,ng} \cdot P_{ctm}] \cdot (1+tvaic_{ng}) \cdot (1+tic_{ng} + texcic_{ng})\}\}^{\sigma ENERCO_{sel}} \cdot \gamma ENINPG_{ng,sel}^{\sigma ENERCO_{sel}} \cdot aENERCO_{sel}^{(\sigma ENERCO_{sel}-1)} \quad (21)$$

$$ENERCO_{sel} = ENERNE_{sel} \cdot (PENERNE_{sel} / PENERCO_{sel})^{\sigma ENERCO_{sel}} \cdot \gamma ENERCO_{sel}^{\sigma ENERCO_{sel}} \cdot aENERCO_{sel}^{(\sigma ENERCO_{sel}-1)} \quad (22)$$

and the associated zero profit condition:

$$PENERNE_{sel} \cdot ENERNE_{sel} = \sum_{ng} \{[(1-tsic_{ng}) \cdot P_{ng} + \sum_{ctm} tcictm_{ctm,ng} \cdot P_{ctm}] \cdot (1+tic_{ng} + texcic_{ng}) \cdot (1+tvaic_{ng}) \cdot ENINP_{ng,sel}\} + PENERCO_{sel} \cdot ENERCO_{sel} \quad (23)$$

where $PENERCO_{sel}$ provides the price index corresponding to the coal-oil bundle, $\sigma ENERCO_{sel}$ is the elasticity of substitution between natural gas and the coal-oil bundle, with $\sigma ENERCO_{sel} = 1/(1+\rho ENERCO_{sel})$. $\gamma ENINPG_{ng,sel}$ and $\gamma ENERCO_{sel}$ represent the distribution parameters corresponding to natural gas and the coal-oil bundle, respectively.

At the fifth nest, the coal-oil bundle is given by another CES function of different energy inputs $(ENINP_{enco,sel})$:

$$ENERCO_{sel} = aENINP_{sel} \cdot (\sum_{enco} \gamma ENINP_{enco,sel} \cdot ENINP_{enco,sel}^{-\rho ENINP_{sel}})^{-1/\rho ENINP_{sel}} \quad (24)$$

Minimizing the costs function:

$$Cost_{sel}(ENINP_{enco,sel}) = \sum_{enco} \{[(1-tsic_{enco}) \cdot P_{enco} + \sum_{ctm} tcictm_{ctm,enco} \cdot P_{ctm}] \cdot (1+tic_{enco}+texcic_{enco}) \cdot (1+tvaic_{enco}) \cdot ENINP_{enco,sel}\} \quad (25)$$

subject to (24) yields the demand equations for mining and quarrying of energy producing materials, products of coke and refined petroleum products:

$$ENINP_{enco,sel} = ENERCO_{sel} \cdot \{PENERCO_{sel} / \{[(1-tsic_{enco}) \cdot P_{enco} + \sum_{ctm} tcictm_{ctm,enco} \cdot P_{ctm}] \cdot (1+tvaic_{enco}) \cdot (1+tic_{enco}+texcic_{enco})\}\}^{\sigma ENINP_{sel}} \cdot \gamma ENINP_{enco,sel}^{\sigma ENINP_{sel}} \cdot aENINP_{sel}^{(\sigma ENINP_{sel}-1)} \quad (26)$$

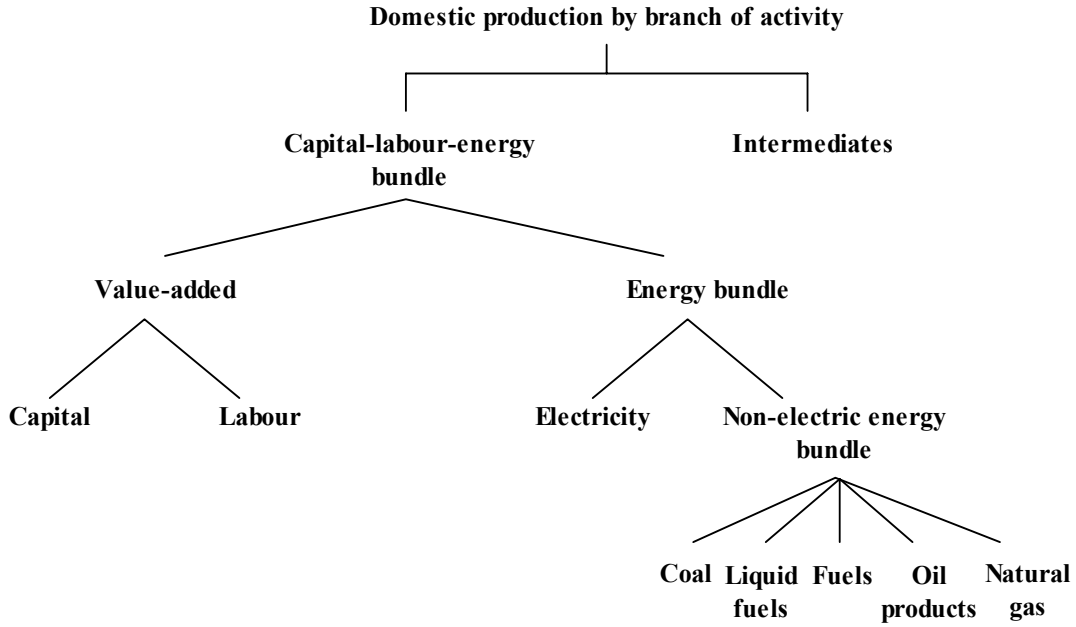
and the associated zero profit condition:

$$PENERCO_{sel} \cdot ENERCO_{sel} = \sum_{enco} \{[(1-tsic_{enco}) \cdot P_{enco} + \sum_{ctm} tcictm_{ctm,enco} \cdot P_{ctm}] \cdot (1+tic_{enco}+texcic_{enco}) \cdot (1+tvaic_{enco}) \cdot ENINP_{enco,sel}\} \quad (27)$$

where $\sigma ENINP_{sel}$ is the elasticity of substitution between mining and quarrying of energy producing materials, products of coke and refined petroleum products, with $\sigma ENINP_{sel} = 1/(1+\rho ENINP_{sel})$. $\gamma ENINP_{enco,sel}$ represent the distribution parameters corresponding to mining and quarrying of energy producing materials, products of coke and refined petroleum products, respectively.

The nested production structure of all other branches of activity is similar to the one of electricity, gas and steam sector. The only difference stands at the fourth nest where the non-electric energy bundle is given by a CES function of mining and quarrying of energy producing materials, products of coke, refined petroleum products and natural gas (see Figure 2). Therefore, only the demand equations for these energy inputs are discussed below.

Figure 2. The nested Leontief and CES production technology for the domestic production of all branches of activity except the electricity, gas and steam



As explained, at the fourth nest, the non-electric energy bundle $(ENERNE_{nsel})$ in branch *nsel* is given by another CES function of different non-electric energy inputs $(ENINP_{ennel,nsel})$:

$$ENERNE_{nsel} = aENINP_{nsel} \cdot (\sum_{ennel} \gamma ENINP_{ennel,nsel} \cdot ENINP_{ennel,nsel}^{-\rho ENINP_{nsel}})^{-1/\rho ENINP_{nsel}} \quad (28)$$

Minimizing the costs function:

$$Cost_{nsel}(ENINP_{ennel,nsel}) = \sum_{ennel} \{[(1-tsic_{ennel}) \cdot P_{ennel} + \sum_{ctm} tcictm_{ctm,ennel} \cdot P_{ctm}] \cdot (1+tic_{ennel}+texcic_{ennel}) \cdot (1+tvaic_{ennel}) \cdot ENINP_{ennel,nsel}\} \quad (29)$$

subject to (28) yields the demand equations for mining and quarrying of energy producing materials, products of coke, refined petroleum products and natural gas:

$$ENINP_{ennel,nsel} = ENERNE_{nsel} \cdot \{PENERNE_{nsel} / \{[(1-tsic_{ennel}) \cdot P_{ennel} + \sum_{ctm} tcictm_{ctm,ennel} \cdot P_{ctm}] \cdot (1+tvaic_{ennel}) \cdot (1+tic_{ennel}+texcic_{ennel})\}\}^{\sigma ENINP_{nsel}} \cdot \gamma ENINP_{ennel,nsel}^{\sigma ENINP_{nsel}} \cdot aENINP_{nsel}^{(\sigma ENINP_{nsel}-1)} \quad (30)$$

and the associated zero profit condition:

$$PENERNE_{nsel} \cdot ENERNE_{nsel} = \sum_{ennel} \{[(1-tsic_{ennel}) \cdot P_{ennel} + \sum_{ctm} tcictm_{ctm,ennel} \cdot P_{ctm}] \cdot (1+tic_{ennel}+texcic_{ennel}) \cdot (1+tvaic_{ennel}) \cdot ENINP_{ennel,nsel}\} \quad (31)$$

where $\sigma ENINP_{nsel}$ is the elasticity of substitution between mining and quarrying of energy producing materials, products of coke, refined petroleum products and natural gas in branch *nsel*, with $\sigma ENINP_{nsel} = 1/(1+\rho ENINP_{nsel})$. $\gamma ENINP_{ennel,nsel}$ represent the distribution parameters corresponding to mining and quarrying of energy producing materials, products of coke, refined petroleum products and natural gas, respectively.

Capital is industry specific, introducing rigidities in the capital market. The inter-sectoral wage differential is a parameter derived as the ratio between the wage by branch and the average wage in thedomestic employment (Dervis, De Melo and Robinson, 1982). Holding the inter-sectoral wage differentials constant in counterfactual policy simulations introduce rigidities in the labour market.

Each branch of activity in Luxgem produces several types of goods and services. The optimal allocation of domestic production between the different types of commodities is given by a Leontief function:

$$XDDE_c = \sum_s ioC_{s,c} \cdot XD_s \quad (32)$$

where $XDDE_c$ represents the domestic production of commodity *c* by different branches, supplied on the home and foreign markets, XD_s is the domestic production of branch *s*, and $ioC_{s,c}$ is a fixed coefficient expressing the volume of production of commodity *c* by the industry *s* per unit of production of industry *s*.

The corresponding zero profit condition is given by:

$$PD_s = \sum_c ioC_{s,c} \cdot PDDE_c \quad (33)$$

where $PDDE_c$ is the domestic price of commodity *c* supplied on the home and foreign markets and PD_s is the price index corresponding to domestic production by branch *s*.

2.3.2 Household

The representative household receives all the capital and labour income plus transfers from the government less the imputed social contributions. Government transfers comprise the social benefits other than social transfers in kind, property income and other current transfers. The household pays income taxes and saves a share of the net income. Household net income (YHD) is derived as:

$$YHD = (1 - ty) \cdot YH \tag{34}$$

while household savings (SH) are given by:

$$SH = MPS \cdot (1 - ty) \cdot YH \tag{35}$$

where YH is the household income, ty is the personal income tax rate and MPS gives the household propensity to save. Household propensity to save reacts to changes in the after-tax average return to capital, according to:

$$MPS = MPSI \cdot \{[(1-ty) \cdot PKavr]/[(1-tyz) \cdot PKavrZ]\}^{elasS} \tag{36}$$

where $MPSI$ is the benchmark level of the propensity to save, $PKavr$ is the real average return to capital received by the household, $PKavrZ$ is the benchmark level of the real average return to capital received by the household, tyz is the benchmark level of the personal income tax rate and $elasS$ is the elasticity of the propensity to save to the return to capital. Subsequently, household budget disposable for consumption $(CBUD)$ is derived as:

$$CBUD = (1-ty) \cdot YH - SH \tag{37}$$

The disposable budget for consumption is allocated between different goods and services according to a Stone-Geary utility function. Maximizing the utility function:

$$U(C_c) = \prod_c (C_c - \mu H_c)^{\alpha H_c} \tag{38}$$

subject to the budget constraint:

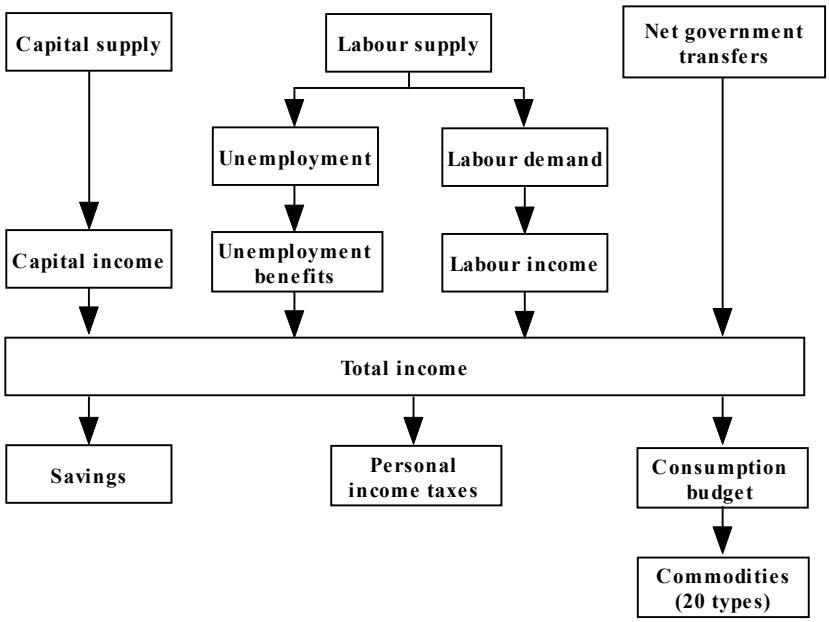
$$CBUD = \sum_c \{[(1-tsc_c) \cdot P_c + \sum_{ctm} (tchtm_{ctm,c} \cdot P_{ctm})] \cdot (1+tc_c+texc_c) \cdot (1+tvac_c) \cdot C_c\} \tag{39}$$

with: $\sum_c \alpha H_c = 1$, yields the demand equations for commodities. Consumption of commodity *c* (C_c) is valued at purchaser's prices, which include trade and transport margins $(\sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm})$, value-added taxes $(tvac_c)$, excise duties $(texc_c)$ and other taxes on consumption (tc_c) less subsidies (tsc_c), where P_c is the price of commodity *c* net of taxes but including subsidies. The trade and transport margins on private consumption are valued at the prices corresponding to the trade and transport services (P_{ctm}), where $tchtm_{ctm,c}$ represents the quantity of trade and transport services *ctm* per unit of commodity *c*.

In the allocation process, the consumer first decides on the minimum (subsistence) level of consumption of commodity *c* (μH_c). Then, the marginal income is allocated between different types of commodities according to the marginal budget shares (αH_c).

A schematic representation of household' decisions is given in figure 3.

Figure 3. Decision structure of the household



Household welfare gains/losses are values using the equivalent variation in income (EV), which is based on the concept of a money metric indirect utility function (Varian, 1992).

$$EV = \prod_c \{\{[(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot(1+tvacz_c)\}/ \alpha H_c\}^{\alpha H_c}\cdot(VU-VUI) \quad (40)$$

The indirect utility function (VU) corresponding to the Linear Expenditures System (LES) in the counter-factual (policy scenario) equilibrium is defined as:

$$VU = \{CBUD - \sum_c \{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\cdot \mu H_c\}\}\cdot \prod_c \{\alpha H_c/\{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\}\}^{\alpha H_c} \quad (41)$$

and the indirect utility function (VUI) in the benchmark equilibrium is given by:

$$VUI = \{CBUDZ - \sum_c \{[(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot (1+tvacz_c)\cdot \mu H_c\}\}\cdot \prod_c \{\alpha H_c/\{[(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot (1+tvacz_c)\}\}^{\alpha H_c} \quad (42)$$

where $CBUDZ$ is the benchmark level of the disposable budget for consumption, PZ_c is the benchmark level of the price of commodity c net of taxes but including subsidies, $tchtmz_{ctm,c}$ is the benchmark level of the trade and transport margin rate, and $tscz_c$, $tvacz_c$, $texcz_c$ and tcz_c are the benchmark rates corresponding to subsidies, VAT, excise duties and other taxes on consumption, respectively.

Equivalent variation measures the income needed to make the household as well off as she is in the new counterfactual equilibrium (policy scenario) evaluated at benchmark prices. Thus, the equivalent variation is positive for welfare gains from the policy scenario and negative for losses (Harrison and Kriström, 1997).

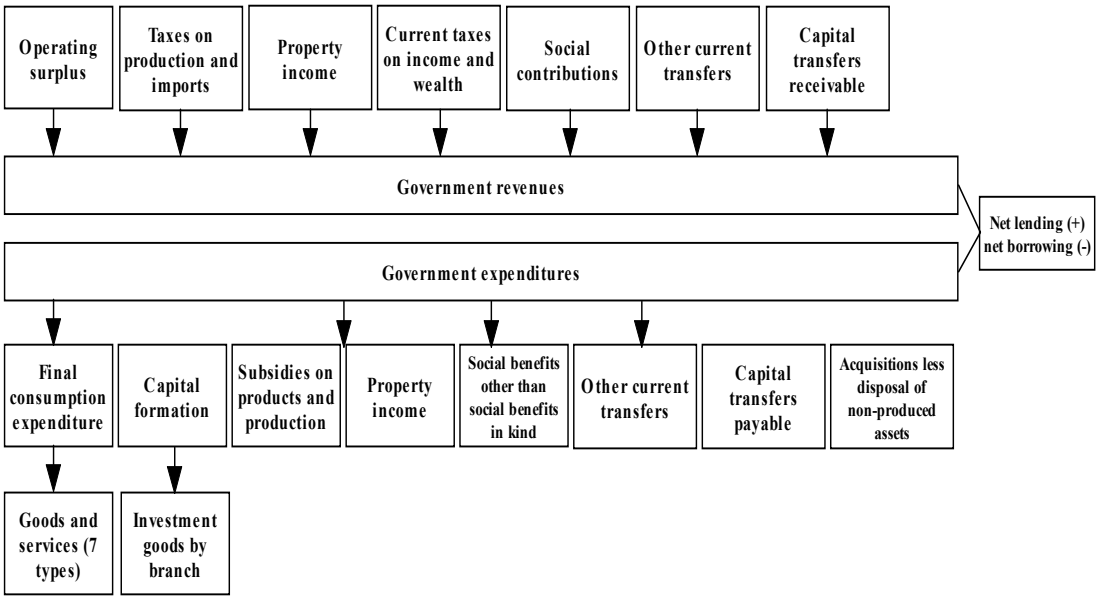
2.3.3 Government

Government collects all the taxes, such as: current taxes on income wealth etc., VAT, excise duties, other taxes on products, tariffs, social security contributions and other taxes on production (see Figure 4). Value-added taxes, excise duties and other taxes on products are differentiated in the model according to the category of consumption on which they apply: intermediate consumption, private consumption, gross capital formation or exports. In the derivation of each category of tax revenue the tax rate is applied to the corresponding tax base.

Total government revenues are given by the operating surplus (B.2) corresponding to the government $(TROPERS)$, taxes on production and imports (D.2) $(TRPROD)$, property income (D.4) from the rest of the world $(TRGWPROPN)$, current taxes on income wealth etc. (D.5) $(TRPROP)$, social contributions (D.61) $(TRSOCT)$, other current transfers (D.7) from the rest of the world $(TRGWOTHN)$ and capital transfers receivable (D.9) $(TRGPvKN)$:

$$GREV = TROPERS + TRPROD + TRGWPROPN + TRPROP + TRSOCT + TRGWOTHN + TRGPvKN \quad (43)$$

Figure 4. Structure of the government budget



Operating surplus (B.2) corresponding to the government is derived as a share $(shYKG)$ of the total net operating surplus:

$$TROPERS = shYKG \cdot \sum_{s} PK_s \cdot KSK_s \tag{44}$$

where PK_s represents the return to capital in branch *s* and KSK_s is the total capital stock of branch *s*.

Taxes on production and imports (D.2) are calculated as the sum of taxes on products (D.21) $(TRPRODC)$ and other taxes on production (D.29) $(TRPRODPP)$:

$$TRPROD = TRPRODC + TRPRODPP \tag{45}$$

where taxes on products (D.21) are further given by:

$$TRPRODC = TRPRODVAT + TRPRODTM + TRPRODOTH \tag{46}$$

The value added type taxes (D.211) $(TRPRODVAT)$ are provided by value added type taxes on final consumption $(TRPRODVATFC)$ and the value added type taxes on intermediate consumption $(TRPRODVATIC)$:

$$TRPRODVAT = TRPRODVATFC + TRPRODVATIC \tag{47}$$

The value added type taxes on final consumption include value added taxes on household final consumption expenditure, value added taxes on private investment goods, value added taxes on net exports (net of re-exports) and value added taxes on re-exports (for fuels):

$$\begin{aligned} TRPRODVATFC = & \sum_{c} \{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot tvac_c\cdot C_c\} + \\ & \sum_{c} \{[(1-tsi_c)\cdot P_c + \sum_{ctm} tcitm_{ctm,c}\cdot P_{ctm}]\cdot(1+ti_c)\cdot tvai_c\cdot \sum_{s} INVCPv_{s,c}\} + \\ & \sum_{c} [EN_c\cdot(PEFOB_c - \sum_{ctm} tcetm_{ctm,c}\cdot P_{ctm})\cdot tvae_c] + \sum_{c} [REXP_c\cdot(PWM_c\cdot ER + \\ & \sum_{ctm} tcrextm_{ctm,c}\cdot P_{ctm})\cdot(1+texce_c)\cdot tvarexp_c] \end{aligned} \tag{48}$$

where $INVCPv_{s,c}$ gives the private investment demand for commodity *c* by the industry *s*, $tcitm_{ctm,c}$ represents the trade and transport margin rate on investment good *c*, $tvai_c$ is the VAT rate on investment goods, ti_c gives the tax rate corresponding to other taxes on investment goods and tsi_c the subsidy rate on investment good *c*. EN_c are the exports of commodity *c* (net of re-exports), $PEFOB_c$ is the domestic price of exports free on board (f.o.b.), $tcetm_{ctm,c}$ gives the trade and transport margin rate on net exports, and $tvae_c$ represents the VAT rate on net exports (net of re-exports). Value added taxes on re-exports $(REXP_c)$ are calculated on the import prices (PWM_c) expressed in domestic currency using the exchange rate (ER) plus trade and transport margins and excise duties $(texce_c)$ on re-exports. The trade and transport margins on re-exports are valued at the prices corresponding to the trade and transport services (P_{ctm}), where $tcrextm_{ctm,c}$ represents the quantity of trade and transport services *ctm* per unit of commodity *c*.

The value added type taxes on intermediate consumption are derived as the sum of value added taxes on energy inputs plus value added taxes on other goods and services:

$$TRPRODVATIC = \sum_{nen,s}\{[(1-tsic_{nen})\cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen}\cdot P_{ctm}]\cdot(1+tic_{nen} + texcic_{nen})\cdot tvaic_{nen}\cdot io_{nen,s}\cdot XD_s\} + \sum_{eng,s}\{[(1-tsic_{eng})\cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng}\cdot P_{ctm}]\cdot (1+tic_{eng}+texcic_{eng})\cdot tvaic_{eng}\cdot ENINP_{eng,s}\} \quad (49)$$

Value added taxes are applied on prices including excise duties and other taxes on consumption.

The taxes and duties on imports excluding VAT (D.212) $(TRPRODTM)$ include tariff revenues and excise duties on household consumption, excise duties on energy inputs and on non-energy intermediate consumption and excise duties on re-exports:

$$TRPRODTM = \sum_{c}(tm_c\cdot MN_c\cdot PWM_c\cdot ER) + \sum_{c}\{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot texc_c\cdot C_c\} + \sum_{nen,s}\{[(1-tsic_{nen})\cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen}\cdot P_{ctm}]\cdot texcic_{nen}\cdot io_{nen,s}\cdot XD_s\} + \sum_{eng,s}\{[(1-tsic_{eng})\cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng}\cdot P_{ctm}]\cdot texcic_{eng}\cdot ENINP_{eng,s}\} + \sum_{c}[(PWM_c\cdot ER + \sum_{ctm} tcrextm_{ctm,c}\cdot P_{ctm})\cdot texce_c\cdot REXP_c] \quad (50)$$

where tm_c is the tariff rate on commodity c, MN_c give the imports of commodity c (net of re-exports), PWM_c represents the world import price of commodity c and ER is the real exchange rate.

The taxes on products except VAT and import taxes (D.214) $(TRPRODOTH)$ comprise other taxes on household consumption, other taxes on investment goods and other taxes on energy inputs and on non-energy intermediate consumption:

$$TRPRODOTH = \sum_{c}\{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot tc_c\cdot C_c\} + \sum_{c}\{[(1-tsi_c)\cdot P_c + \sum_{ctm} tcitm_{ctm,c}\cdot P_{ctm}]\cdot ti_c\cdot \sum_{s} INVCPv_{s,c}\} + \sum_{nen,s}\{[(1-tsic_{nen})\cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen}\cdot P_{ctm}]\cdot tic_{nen}\cdot io_{nen,s}\cdot XD_s\} + \sum_{eng,s}\{[(1-tsic_{eng})\cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng}\cdot P_{ctm}]\cdot tic_{eng}\cdot ENINP_{eng,s}\} \quad (51)$$

The other taxes on production (D.29) $(TRPRODPP)$ are calculated by applying the tax rate (tp_s) to the domestic production of branch s (XD_s):

$$TRPRODPP = \sum_{s} tp_s\cdot XD_s\cdot PD_s \quad (52)$$

where PD_s stands for the price index corresponding to domestic production of branch s.

The property income (D.4) received by the government from the rest of the world, in foreign currency, is exogenous. The property income (D.4) is expressed in domestic currency $(TRGWPROPN)$ using the exchange rate:

$$TRGWPROPN = TRGWPROP\cdot ER \quad (53)$$

Current taxes on income wealth etc. (D.5) $(TRPROP)$ are provided by the sum of taxes on the income or profits of corporations and other current taxes (D.51B+D.59) $(TRPROPF)$ and taxes on individual or household income (D.51A) $(TRPROPH)$:

$$TRPROP = TRPROPH + TRPROPF \tag{54}$$

where taxes on the income or profits of corporations and other current taxes are calculated by applying the corporate income tax rate (tk_s) to the net operating surplus:

$$TRPROPF = \sum_s tk_s \cdot KSK_s \cdot PK_s \tag{55}$$

and taxes on individual or household income are derived by applying the personal income tax rate (ty) to the household income:

$$TRPROPH = ty \cdot YH \tag{56}$$

Total social contributions (D.61) consist of actual social contributions (D.611) $(TRSOC)$ and imputed social contributions (D.612) $(TRSOCIN)$:

$$TRSOCT = TRSOC + TRSOCIN \tag{57}$$

where actual social contributions are derived as:

$$TRSOC = \sum_s \{[tl_s/(1-tl_s)] \cdot LSK_s \cdot PL \cdot (1+premLSK_s)\} \tag{58}$$

LSK_s represents the number of employees in branch *s*, PL is the average wage in the domestic employment and $premLSK_s$ is the wage differential of branch *s* with respect to the average wage PL and tl_s is the social security contributions rate for industry *s*.

Imputed social contributions in real terms $(TRSOCI)$ are fixed and further expressed in nominal terms using the consumer price index $(PCINDEX)$:

$$TRSOCIN = TRSOCI \cdot PCINDEX \tag{59}$$

Other current transfers (D.7) received by the government from the rest of the world, in foreign currency, are fixed $(TRGWOTH)$ while the current transfers in domestic currency $(TRGWOTHN)$ are given by:

$$TRGWOTHN = TRGWOTH \cdot ER \tag{60}$$

Government capital transfers receivable (D.9) in real terms $(TRGPvK)$ are exogenous and are further expressed in nominal terms using the GDP deflator $(GDPDEF)$:

$$TRGPvKN = TRGPvK \cdot GDPDEF \tag{61}$$

Total government expenditures $(GEXP)$ comprise government final consumption expenditure (P.3) $(CGBUD)$, capital formation by the government (P.5) (IGT), subsidies by the government on products and production (D.3) $(TRST)$, property income payable (D.4) $(TRHGPROPN)$, social benefits other than social transfers in kind (D.62) $(TRHGSB)$, other current transfers (D.7) by the government to the household $(TRHGOTHN)$, government capital transfers payable (D.9) $(TRPvGKN)$, acquisitions less disposals of non-produced non-financial assets expressed in nominal terms (K.2) $(ACQUISN)$ less the depreciation related to the public capital stock $(\sum_{sgv} DEPPb_{sgv} \cdot PI_{sgv})$:

$$GEXP = CGBUD \cdot PICG + IGTN + TRST + TRHGPROPN + TRHGSB + TRHGOTHN - DEPPbTN + TRPvGKN + ACQUISN \quad (62)$$

where $PICG$ is the price index corresponding to government final consumption expenditure.

Government final consumption expenditure (P.3) by commodity (CG_c) is related to total final consumption expenditure through a Leontief function:

$$CG_c = ioCG_c \cdot CGBUD \quad (63)$$

where $ioCG_c$ is the share of consumption of commodity c in the total final consumption expenditure by the government.

The price index corresponding to government final consumption expenditure $(PICG)$ is defined as the weighted average of the price corresponding to goods and services consumed by the government::

$$PICG = \sum_c ioCG_c \cdot P_c \quad (64)$$

and it is used to express total government final consumption expenditure in nominal terms $(CGBUDN)$:

$$CGBUDN = CGBUD \cdot PICG \quad (65)$$

The allocation of public gross capital formation in real terms (IGT) between different branches of activity is given by a Leontief function:

$$INVPb_{sgv} = ioIG_{sgv} \cdot IGT \quad (66)$$

where $ioIG_{sgv}$ gives the share of public investments by branch $(INVPb_{sgv})$ in the total public investments (IGT). The price index corresponding to public gross capital formation (PIG) is derived as the weighted average of the price corresponding to investments by branch of activity (PI_{sgv}) :

$$PIG = \sum_{sgv} ioIG_{sgv} \cdot PI_{sgv} \quad (67)$$

and is used to express the gross capital formation by the government in nominal terms $(IGTN)$:

$$IGTN = IGT \cdot PIG \quad (68)$$

Both total final consumption expenditure by the government and public gross capital formation are fixed in real terms.

Total subsidies on products and production (D.3) by the government are given by the subsidies on private consumption, on investments goods, on energy inputs and on non-energy intermediate consumption and by subsidies on production:

$$TRST = \sum_c P_c \cdot tsc_c \cdot C_c + \sum_{s,c} P_c \cdot tsi_c \cdot INVCPv_{s,c} + \sum_{s,nen} P_{nen} \cdot tsic_{nen} \cdot io_{nen,s} \cdot XD_s + \sum_{s,eng} P_{eng} \cdot tsic_{eng} \cdot ENINP_{eng,s} + \sum_s PD_s \cdot tsp_s \cdot XD_s \quad (69)$$

where tsc_c represents the subsidy rate on private consumption, tsi_c is the subsidy rate on investment good c, $tsic_c$ gives the subsidy rate on intermediate consumption and tsp_s provides the subsidy rate on production of branch s.

Property income (D.4) received by the household from the government is expressed in nominal terms using the consumer price index $(PCINDEX)$:

$$TRHGPROPN = TRHGPROP \cdot PCINDEX \quad (70)$$

where property income in real terms $(TRHGPROP)$ is exogenous.

Social benefits other than social transfers in kind (D.62) consist of unemployment benefits, determined by the combination of the replacement rate $(trep)$, the national average wage $(PLAVR)$, the number of unemployed $(UNEMP)$ and the share of unemployed subject to unemployment benefits $(shUNEMPIND)$, and other transfers $(TRHGSBOTH)$ such as pensions, translated into nominal terms by using the Laspeyres consumer price index $(PCINDEX)$.

$$TRHGSB = trep \cdot PLAVR \cdot shUNEMPIND \cdot UNEMP + TRHGSBOTH \cdot PCINDEX \quad (71)$$

The share of social benefits other than social transfers in kind (D.62) excluding unemployment benefits in total government expenditures $(shTRHGSBOTH)$ is fixed while the level of social benefits is endogenous:

$$shTRHGSBOTH = (TRHGSBOTH \cdot PCINDEX) / GEXP \cdot 100 \quad (72)$$

The other current transfers (D.7) received by the household from the government in real terms $(TRHGOTH)$ are fixed and are expressed in nominal terms using the consumer price index $(PCINDEX)$:

$$TRHGOTHN = TRHGOTH \cdot PCINDEX$$

The total consumption of fixed capital (K.1) corresponding to the public capital stock $(DEPPbTN)$ is calculated as the sum of consumption of fixed capital corresponding to the public administration sector, education and health (branches *sgv*) and valued using the price index (unit cost) of the public investments carried out in branch *sgv* (PI_{sgv}) :

$$DEPPbTN = \sum_{sgv} DEPPb_{sgv} \cdot PI_{sgv} \quad (73)$$

Government capital transfers payable (D.9) $(TRPvGK)$ and acquisitions less disposals of non-produced non-financial assets (K.2) $(ACQUIS)$ are also fixed in real terms and are expressed in nominal terms using the GDP deflator:

$$TRPvGKN = TRPvGK \cdot GDPDEF \quad (74)$$

$$ACQUISN = ACQUIS \cdot GDPDEF \quad (75)$$

The difference between government revenues and government expenditures gives the government net lending (+)/net borrowing (-) (B.9) in real terms $(SGBAL)$, expressed in nominal terms $(SGBALN)$ using the GDP deflator:

$$SGBAL \cdot GDPDEF = GREV - GEXP \quad (76)$$

$$SGBALN = SGBAL \cdot GDPDEF \quad (77)$$

2.3.4 Foreign trade

The specification of the foreign trade is based on the small-country assumption, which means that the country is a price taker in both its import and its export markets. A distinction has been made in Luxgem between imports for domestic use, exports by domestic producers and re-exports.

On the import side, imperfect substitution is assumed between domestically produced and imported (net of re-exports) goods, according to the Armington function (see Figure 5). Thus, domestic consumers use composite goods (X_c) of imported and domestically produced goods, according to a CES function:

$$X_c = aA_c \cdot (\gamma A1_c \cdot XDD_c^{-\rho A_c} + \gamma A2_c \cdot MN_c^{-\rho A_c})^{-1/\rho A_c} \quad (78)$$

Minimizing the cost function:

$$Cost_c(XDD_c, MN_c) = PDD_c \cdot XDD_c + PM_c \cdot MN_c \quad (79)$$

subject to (78) provides the demand for imports for domestic use (MN_c) and demand for domestically produced goods (XDD_c):

$$MN_c = X_c \cdot (P_c/PM_c)^{\sigma A_c} \cdot \gamma A2_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad (80)$$

$$XDD_c = X_c \cdot (P_c/PDD_c)^{\sigma A_c} \cdot \gamma A1_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad (81)$$

and the corresponding zero profit condition:

$$P_c \cdot X_c = PM_c \cdot MN_c + PDD_c \cdot XDD_c \quad (82)$$

where P_c is the price index of the composite good c incorporating the imported and domestically produced goods supplied on the domestic market, PM_c represents the domestic price of imports (including tariffs) and PDD_c is the price of good c. aA_c represents the efficiency parameter while $\gamma A1_c$ and $\gamma A2_c$ are the distribution parameters corresponding to domestic demand for the domestically produced goods and the demand for imports, respectively. The elasticity of substitution between imports and domestically produced goods (σA_c) is given by $1/(1+\rho A_c)$.

Total imports (M_c) are provided by:

$$M_c = MN_c + REXP_c \quad (83)$$

where re-exports $(REXP_c)$ are treated exogenously in the current version of Luxgem.

In a similar fashion, the differentiation between the exported goods by the domestic producers (EN_c) and the domestic goods supplied on the domestic market (XDD_c) is captured through a constant elasticity of transformation (CET) function:

$$XDDE_c = aT_c \cdot (\gamma T1_c \cdot XDD_c^{-\rho T_c} + \gamma T2_c \cdot EN_c^{-\rho T_c})^{-1/\rho T_c} \quad (84)$$

where $XDDE_c$ is the domestic production of commodity c by different branches, supplied on the home and foreign markets, aT_c is the efficiency parameter, $\gamma T1_c$ and $\gamma T2_c$ are the distribution parameters corresponding to XDD_c and

EN_c, respectively, and the elasticity of transformation (σT_c) between domestically produced goods supplied on the domestic market and the exports by the domestic producers is given by $1/(1+\rho T_c)$.

By maximizing the revenue:

$$Revenue_c(XDD_c, EN_c) = PDD_c \cdot XDD_c + PE_c \cdot EN_c \tag{85}$$

subject to (84) we derive the supply of exports by the domestic producers and the supply by the domestic producers to the domestic market:

$$EN_c = XDDE_c \cdot (PDDE_c/PE_c)^{\sigma T_c} \cdot \gamma T2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \tag{86}$$

$$XDD_c = XDDE_c \cdot (PDDE_c/PDD_c)^{\sigma T_c} \cdot \gamma T1_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \tag{87}$$

and the corresponding zero profit condition:

$$PDDE_c \cdot XDDE_c = PDD_c \cdot XDD_c + PE_c \cdot EN_c \tag{88}$$

where $PDDE_c$ is the price index corresponding to $XDDE_c$, and PE_c represents the domestic price of exports received by the domestic producers.

Total exports are derived as:

$$E_c = EN_c + REXP_c \tag{89}$$

In addition, an export demand function is introduced in the model (see Figure 5):

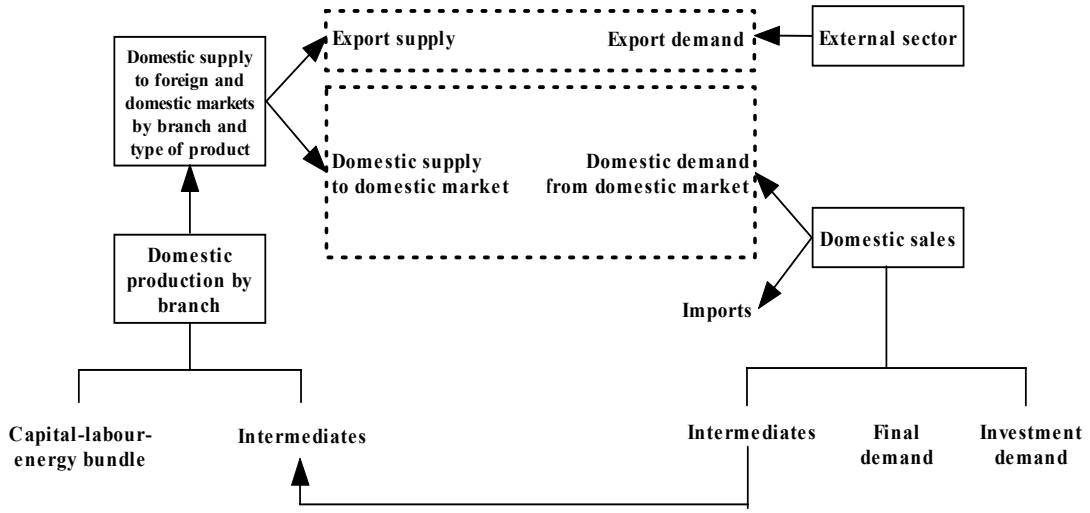
$$END_c = ENDI_c \cdot (PWE_c \cdot ER/PEFOB_c)^{elasE_c} \tag{90}$$

such that the export demand for domestically produced goods by the foreign sector (END_c), depends on the benchmark level of the export demand by the foreign sector $(ENDI_c)$, the relative price change and the price elasticity of export demand $(elasE_c)$. PWE_c represents the world price of exports of commodity c, ER is the real exchange rate, and $PEFOB_c$ gives the domestic price of exports of commodity c free on board (f.o.b.). The market clearing equation for exports:

$$EN_c = END_c \tag{91}$$

determines the domestic price of exports f.o.b.

Figure 5. Foreign trade specification



The balance of payments takes into account all the trade and capital flows:

$$\sum_c (MN_c \cdot PWM_c + REXP_c \cdot PWM_c) + LSW \cdot PL \cdot (1+premLSKF)/ER = \sum_c (EN_c \cdot PEFOB_c/ER) + \sum_c (REXP_c \cdot PREXP_c / ER) + TRGWPROP + TRGWOTH + SW \quad (92)$$

where PWM_c is the world price of imports of commodity c, $PREXP_c$ gives the domestic price of re-exports free on board, $TRGWPROP$ represents the property income (D.4) received by the government from the foreign sector in foreign currency, $TRGWOTH$ provides other current transfers (D.7) received by the government from the rest of the world in foreign currency, $[LSW \cdot PL \cdot (1+premLSKF)/ER]$ give the net factor (labour) payments to the foreign sector (payments for non-resident workers in Luxembourg), and SW reflects the surplus/deficit of the current account. The net payments for the non-resident workers in Luxembourg are derived by taking into account: the number of commuters (LSW), the average wage PL corresponding to the domestic employment (net of social security contributions) and the wage differential of non-resident workers with respect to the average wage $(premLSKF)$.

2.3.5 Investment demand

Total savings (S) used to buy investment goods are given by:

$$S = SH + SW \cdot ER + \sum_{nsgv} DEPPv_{nsgv} \cdot PI_{nsgv} + TRPvGKN + ACQUISN + SGBALN \quad (93)$$

where SH represents the household savings, $SGBALN$ is the government net lending (+)/ net borrowing (-) (B.9) in nominal terms, SW is the current account balance expressed in the domestic currency using the exchange rate (ER), $TRPvGKN$ gives the government capital transfers payable (D.9) in nominal terms, $ACQUISN$ provides the acquisitions less disposals of non-produced non-financial assets (K.2) in nominal terms, and $\sum_{nsgv} DEPPv_{nsgv} \cdot PI_{nsgv}$ is the depreciation related to the private capital stock.

The depreciation related to the private capital stock is valued at the price of private investments carried out in the industry *nsgv* (PI_{nsgv}) and is derived as:

$$DEPPv_{nsgv} = d_{nsgv} \cdot KSK_{nsgv} \tag{94}$$

where d_{nsgv} is the depreciation rate and KSK_{nsgv} gives the capital stock of industry *nsgv*.

The optimal allocation of private investments by branch ($INVPv_{nsgv}$) between different types of investment commodities ($INVCPv_{nsgv,c}$) is given by the Leontief function:

$$INVCPv_{nsgv,c} = ioI_{c,nsgv} \cdot INVPv_{nsgv} \tag{95}$$

where $ioI_{c,nsgv}$ is a parameter that provides the composition of industry's investments in terms of investment goods.

The composite price (unit cost) of the private investments carried out in branch *nsgv* (PI_{nsgv}) is defined as the weighted average of the price of investment goods bought by industry *nsgv*:

$$PI_{nsgv} = \sum_{c} (1+tvai_c) \cdot (1+ti_c) \cdot [(1-tsi_c) \cdot P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot ioI_{c,nsgv} \tag{96}$$

where P_c stands for the price of (investment) commodity *c*, $tvai_c$ is the VAT rate on investment good *c*, ti_c is the tax rate corresponding to other taxes on investment goods, tsi_c is the subsidy rate on investment good *c* and $tcitm_{ctm,c}$ is the trade and transport margin rate on investment good *c*.

The allocation of public gross capital formation between different branches of activity has been explained in section 1.3. The optimal allocation of public investments by branch ($INVPb_{sgv}$) between different types of investment commodities ($INVCPb_{sgv,c}$) is given by another Leontief function:

$$INVCPb_{sgv,c} = ioI_{c,sgv} \cdot INVPb_{sgv} \tag{97}$$

where $ioI_{c,sgv}$ is a parameter that provides the composition of industry's investments in terms of investment goods.

Similarly to the private investments, the price index (unit cost) of the public investments carried out in branch *sgv* (PI_{sgv}) is defined as the weighted average of the price of investment goods bought by the industry *sgv*:

$$PI_{sgv} = \sum_{c} P_c \cdot ioI_{c,sgv} \tag{98}$$

The depreciation related to the public capital stock ($DEPPb_{sgv}$) is further derived as:

$$DEPPb_{sgv} = d_{sgv} \cdot KSK_{sgv} \tag{99}$$

2.3.6 Price equations

A common assumption for CGE models, which has also been adopted here, is that the economy is initially in equilibrium with the quantities normalized in such a way that prices of commodities equal unity. Due to the homogeneity of degree zero in prices, the model only determines relative prices. Therefore, a particular price is selected to provide the numeraire price level against which all relative prices in the model will be measured. In this case, the GDP deflator $(GDPDEF)$ is chosen as the numeraire. GDP deflator is defined as the ratio of GDP at current market prices to GDP at constant prices.

Different prices are defined for all the branches, exports and imports. The domestic price of net exports (net of re-exports) (PE_c) reflects the price received by the domestic producers for selling their production on the foreign market. The relationship between the domestic price of net exports received by the domestic producers and the domestic price of net exports free on board is provided by:

$$PE_c = (PEFOB_c - \sum_{ctm} tcetm_{ctm,c} \cdot P_{ctm}) \cdot (1 - tvae_c) \tag{100}$$

where $tvae_c$ stands for the VAT rate on net exports. The cost of trade and transport services reduces the domestic price received by the producers, where $tcetm_{ctm,c}$ is the quantity of trade and transport services *ctm* per unit of commodity *c* exported (net exports), and P_{ctm} represents the price of the trade and transport services *ctm*. Two types of trade and transport margins are distinguished in the model corresponding to: wholesale and retail trade services and transport services.

The domestic price of re-exports free on board $(PREXP_c)$ is derived according to:

$$PREXP_c = (PWM_c \cdot ER + \sum_{ctm} tcrextm_{ctm,c} \cdot P_{ctm}) \cdot (1 + texce_c) \cdot (1 + tvarexp_c) \tag{101}$$

where $tcrextm_{ctm,c}$ is the quantity of trade and transport services *ctm* per unit of commodity *c* re-exported, $texce_c$ gives the excise duties rate on re-exports and $tvarexp_c$ provides the VAT rate on re-exports.

As already explained, trade and transport margins are paid on all categories of demand in Luxgem except the government consumption (on intermediate consumption, on private consumption and on investment goods) and on exports.

The domestic price of imports (PM_c) is determined by the world price of imports, the exchange rate and the tariff rate (tm_c), according to:

$$PM_c = (1 + tm_c) \cdot PWM_c \cdot ER \tag{102}$$

The consumer price index $(PCINDEX)$ used in the model is of the Laspeyres type and is defined as:

$$\begin{aligned} PCINDEX = &\sum_c \{ [(1 - tsc_c) \cdot P_c + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot (1 + tc_c + texc_c) \cdot (1 + tvac_c) \cdot CZ_c \} / \\ &\sum_c \{ [(1 - tscz_c) \cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c} \cdot PZ_{ctm}] \cdot (1 + tcz_c + texcz_c) \cdot (1 + tvacz_c) \cdot CZ_c \} \end{aligned} \tag{103}$$

where tsc_c is the subsidy rate on commodity *c* and $tscz_c$ its benchmark level, P_c is the price index of commodity *c* net of taxes but including subsidies and PZ_c gives its benchmark level, $tchtm_{ctm,c}$ represents the trade and transport margin rate on private consumption and $tchtmz_{ctm,c}$ is its benchmark level. $tvac_c$, $texc_c$ and tc_c give the VAT rate on private consumption, the excise duty rate on private consumption and the tax rate corresponding to other taxes on products, respectively, while $tvacz_c$, $texcz_c$ and tcz_c are their benchmark levels. Finally, CZ_c accounts for the benchmark level of private consumption of commodity *c*.

Consumer prices (PCT_c) are further defined as:

$$PCT_c = [(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c) \quad (104)$$

2.3.7 Labour market

The following identity defines the relation between the labour supply, the labour demand, and unemployment:

$$\sum_s LSK_s = LSR + LSW - UNEMP \quad (105)$$

where LSK_s is the number of employees in industry *s*, $UNEMP$ represents the number of unemployed, LSW is the number of commuters and LSR reflects the active population.

The responsiveness of real wage to the labour market conditions is surprised by a wage curve:

$$log(PLAVR/PCINDEX) = elasU\cdot log(UNRATE) + err \quad (106)$$

where $PLAVR$ is the nominal wage corresponding to national employment (net of social security contributions), $PCINDEX$ is the consumer price index, $UNRATE$ provides the unemployment rate, err is the error term and the unemployment elasticity $(elasU)$ has been set to -0.1 (Sanz-de-Galdeano and Turunen, 2006).

The labour supply is provided by the equation:

$$LSR = LSRI\cdot[(PLAVR\cdot(1\text{-}ty)\cdot PCINDEXZ)/(PLAVRZ\cdot(1\text{-}tyz)\cdot PCINDEX)]^{elasLS} \quad (107)$$

where $LSRI$ is the benchmark level corresponding to the active population, ty is the personal income tax rate, and $PLAVRZ$, $PCINDEXZ$, tyz are the benchmark levels corresponding to the nominal wage, CPI and personal income tax rate, respectively. The real wage elasticity of the labour supply $(elasLS)$ has been set to 0.2.

The change in the share of commuters in the domestic employment depends on the relative changes in net wages between Luxembourg and Grande Région, the relative changes in real estate prices between Luxembourg and Grande Région and the differences between the unemployment rates in Grande Région and in Luxembourg:

$$log\left(\frac{LSW_t - LSW_{t-1}}{EMPI_t}\right) = \beta_1\cdot log\left(\frac{PLAVR_t\cdot(1-ty)}{PLAVRGR_t\cdot ER_t}\right) + \beta_2\cdot log\left(\frac{\sum_{cre} P_{cre,t}}{PIMMOGR_t\cdot ER_t}\right) + \beta_3\cdot log\left(\frac{UNRATE}{UNRATEGR}\right) + \beta_4 \quad (108)$$

where $EMPI$ represents the domestic employment, $PLAVRGR$ is the net wage in Grande Région expressed in domestic currency using the exchange rate, $PIMMOGR$ gives the price of real estate in the Grande Région expressed in domestic currency using the exchange rate, P_{cre} is the price of real estate services in Luxembourg, $UNRATEGR$ is the unemployment rate in the Grande Région and β_1 to β_4 are estimators of the parameters coming from Modux.

The domestic employment is given by:

$$EMPI = LSR - UNEMP + LSW \tag{109}$$

while the national employment is defined as:

$$EMPN = LSR - UNEMP \tag{110}$$

2.3.8 Market clearing equations

The equilibrium in the product, capital and labour markets requires that demand equals supply at prevailing prices (taking into account unemployment for the labour market). Labour market clearing equation has already been presented above. Capital stock is sector specific, such that the equality between capital demand and supply determines the return to capital by branch of activity.

Separate market clearing equations are distinguished in the model for each commodity *c*. For the trade and transport services *ctm*, the sum of demand for intermediate consumption of commodity *ctm* $(\sum_s io_{ctm,s} \cdot XD_s)$, the private demand for commodity *ctm* (C_{ctm}), the public demand for commodity *ctm* (CG_{ctm}), the change in inventories (SV_{ctm}) and the demand for trade and transport services $(MARGTM_{ctm})$ which are invoiced separately (trade and transport margins) should be equal with the total supply of commodity *ctm* (X_{ctm}) from imports and domestic production:

$$X_{ctm} = \sum_s io_{ctm,s} \cdot XD_s + C_{ctm} + CG_{ctm} + SV_{ctm} + MARGTM_{ctm} \tag{111}$$

The demand for trade and transport services *ctm* $(MARGTM_{ctm})$ invoiced separately (Löfgren, Harris and Robinson, 2002), is further derived as the sum of demand for trade and transport services on private consumption $(\sum_c tchtm_{ctm,c} \cdot C_c)$, of demand for trade and transport services on private investment goods $[\sum_c tcitm_{ctm,c} \cdot \sum_s INVCPv_{s,c}]$, of demand for trade and transport services on net exports (net of re-exports) $(\sum_c tcetm_{ctm,c} \cdot EN_c)$, of demand for trade and transport services on re-exports $(\sum_c tcrextm_{ctm,c} \cdot REXP_c)$, of demand for trade and transport services on non-energy intermediate consumption $(\sum_{s,nen} tcictm_{ctm,nen} \cdot io_{nen,s} \cdot XD_s)$ and of demand for trade and transport services on energy inputs $(\sum_{s,eng} tcictm_{ctm,eng} \cdot ENINP_{eng,s})$:

$$\begin{aligned} MARGTM_{ctm} = \sum_c [&tchtm_{ctm,c} \cdot C_c + tcitm_{ctm,c} \cdot \sum_s INVCPv_{s,c} + tcetm_{ctm,c} \cdot EN_c + \\ &tcrextm_{ctm,c} \cdot REXP_c] + \sum_{s,nen} tcictm_{ctm,nen} \cdot io_{nen,s} \cdot XD_s + \sum_{s,eng} tcictm_{ctm,eng} \cdot ENINP_{eng,s} \end{aligned} \tag{112}$$

For the energy inputs the sum of demand for energy input *eng* $(\sum_s ENINP_{eng,s})$, the private demand for energy input *eng* (C_{eng}), the public demand for energy input *eng* (CG_{eng}) and the change in inventories (SV_{eng}) should be equal with the total supply of commodity *eng* (X_{eng}) from imports and domestic production:

$$X_{eng} = \sum_{s} ENINP_{eng,s} + C_{eng} + CG_{eng} + SV_{eng} \tag{113}$$

The market clearing equations corresponding to all commodities *nctmn*, except the trade and transport services and energy inputs are given by:

$$X_{nctmn} = \sum_{s} io_{nctmn,s} \cdot XD_{s} + C_{nctmn} + CG_{nctmn} + \sum_{nsgv} INVCPv_{nsgv,nctmn} + \sum_{sgv} INVCPb_{sgv,nctmn} + SV_{nctmn} \tag{114}$$

where $\sum_{sgv} INVCPb_{sgv,nctmn}$ stands for the public demand for investment goods.

The demand for inventories for each commodity c is defined as a fixed share of domestic sales:

$$SV_{c} = svr_{c} \cdot X_{c} \tag{115}$$

2.3.9 Other macroeconomic indicators

Gross domestic product is provided at both constant prices (GDP) and at current market prices $(GDPC)$:

$$\begin{aligned} GDP = & \sum_{c} \{C_{c} \cdot [(1 - tscz_{c}) \cdot PZ_{c} + \sum_{ctm} tchtmz_{ctm,c} \cdot PZ_{ctm}] \cdot (1 + tcz_{c} + texcz_{c}) \cdot (1 + tvacz_{c}) + \\ & CG_{c} \cdot PZ_{c}\} + \sum_{nsgv,c} \{INVCPv_{nsgv,c} \cdot [(1 - tsiz_{c}) \cdot PZ_{c} + \sum_{ctm} tcitmz_{ctm,c} \cdot PZ_{ctm}] \cdot (1 + tiz_{c}) \cdot \\ & (1 + tvaiz_{c})\} + \sum_{sgv,c} INVCPb_{sgv,c} \cdot PZ_{c} + \sum_{c} SV_{c} \cdot PZ_{c} - \sum_{c} (MN_{c} \cdot PWMZ_{c} \cdot ERZ + REXP_{c} \cdot \\ & PWMZ_{c} \cdot ERZ) + \sum_{c} (EN_{c} \cdot PEFOBZ_{c} + REXP_{c} \cdot PREXPZ_{c}) \end{aligned} \tag{116}$$

$$\begin{aligned} GDPC = & \sum_{c} \{C_{c} \cdot [(1 - tsc_{c}) \cdot P_{c} + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot (1 + tc_{c} + texc_{c}) \cdot (1 + tvac_{c}) + \\ & CG_{c} \cdot P_{c}\} + \sum_{nsgv,c} \{INVCPv_{nsgv,c} \cdot [(1 - tsi_{c}) \cdot P_{c} + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot (1 + ti_{c}) \cdot (1 + tvai_{c})\} + \\ & \sum_{sgv,c} INVCPb_{sgv,c} \cdot P_{c} + \sum_{c} SV_{c} \cdot P_{c} - \sum_{c} (MN_{c} \cdot PWM_{c} \cdot ER + REXP_{c} \cdot PWM_{c} \cdot ER) + \\ & \sum_{c} (EN_{c} \cdot PEFOB_{c} + REXP_{c} \cdot PREXP_{c}) \end{aligned} \tag{117}$$

where $PREXP_{c}$ stands for the domestic price of re-exports free on board, $PREXPZ_{c}$ gives the benchmark level of the domestic price of re-exports free on board and $PWMZ_{c}$, $PEFOBZ_{c}$ and ERZ represent the benchmark levels corresponding to the world price of imports, domestic price of exports f.o.b. and the real exchange rate, respectively.

Derivation of some other macroeconomic indicators like the components of GDP at constant prices is provided in section 1.13.

2.3.10 Incorporation of dynamics

Luxgem has a recursive dynamic structure composed of a sequence of several temporary equilibria. The first equilibrium in the sequence is given by the benchmark year. In each time period, the model is solved for an equilibrium given the exogenous conditions assumed for that particular period. The equilibria are connected to each other through capital accumulation. Thus, the endogenous determination of investment behaviour is essential for the dynamic part of the model. Investment and capital accumulation in year *t* depend on expected rates of return for year *t+1*, which are determined by actual returns on capital in year *t*.

The normal rate of return to capital in all industries *nsgv* (ROR_{nsgv}), except the public administration, education and health and social work, is specified as an inverse logistic function (see Figure 6) of the proportionate growth in sector's *nsgv* capital stock (Dixon and Rimmer, 2002):

$$ROR_{nsgv,t} = RORH_{nsgv} + (1/B_{nsgv}) \cdot [ln(KSKg_{nsgv,t} - KSKg\,min_{nsgv}) - ln(KSKg\,max_{nsgv} - KSKg_{nsgv,t}) - ln(KSKtrend_{nsgv} - KSKg\,min_{nsgv}) + ln(KSKg\,max_{nsgv} - KSKtrend_{nsgv})] \quad (118)$$

where $RORH_{nsgv}$ is the historically normal rate of return in branch *nsgv*, $KSKg_{nsgv,t}$ is the capital growth rate in industry *nsgv* in year *t*, $KSKg\,min_{nsgv}$ and $KSKg\,max_{nsgv}$ are the minimum and the maximum possible growth rates of capital stock in branch *nsgv*, $KSKtrend_{nsgv}$ is the industry's historically normal growth rate and B_{nsgv} is a positive parameter. The minimum possible growth rate is set at the negative of the rate of depreciation in branch *nsgv*. This condition implies that investments in each branch of activity have positive values, such that once installed, capital cannot be shifted from one sector to another except for the gradual process of depreciation. The maximum possible growth rate of capital stock in industry *nsgv* is set at $KSKtrend_{nsgv}$ plus $lim\,INV_{nsgv}$ in order to avoid unrealistically large simulated growth rates (Dixon and Rimmer, 2002). In the current version $lim\,INV_{nsgv}$ is taken equal to 6 per cent for all the branches. For example, if the historically normal growth rate in an industry is 4 per cent, the upper limit in any year *t* would not exceed 10 per cent.

Parameter (B_{nsgv}) reflects the sensitivity of capital growth in branch *nsgv* to variations in its expected rate of return. It is derived by differentiating equation (118) with respect to $KSKg_{nsgv,t}$:

$$B_{nsgv} = SEA \cdot \left[\frac{KSKg\,max_{nsgv} - KSKg\,min_{nsgv}}{(KSKg\,max_{nsgv} - KSKtrend_{nsgv}) \cdot (KSKtrend_{nsgv} - KSKg\,min_{nsgv})} \right] \quad (119)$$

where:

$$SEA = \left(\frac{\partial ROR_{nsgv,t}}{\partial KSKg_{nsgv,t}} \right)^{-1} \quad (120)$$

Evaluating (120) in the neighbourhood of $KSKg_{nsgv,t} = KSKtrend_{nsgv}$ provides:

$$SEA = \left(\frac{\partial ROR_{nsgv,t}}{\partial KSKg_{nsgv,t}} \Bigg| KSKg_{nsgv,t} = KSKtrend_{nsgv} \right)^{-1} \quad (121)$$

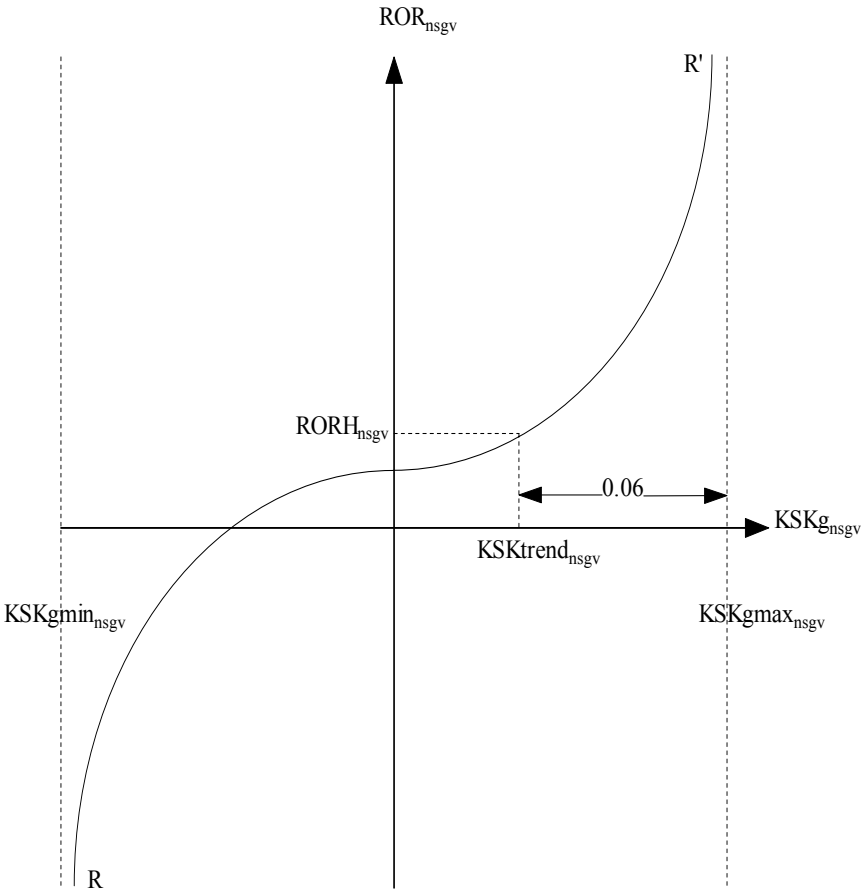
where SEA is the reciprocal of the slope of the RR' in figure 6, which is considered to be the same for all industries due to the lack of detailed estimates by branch.

The present value $(PVK_{nsgv,t})$ of investing a unit of capital in industry *nsgv* in year *t* is defined as:

$$PVK_{nsgv,t} = -PI_{nsgv,t} + [\,PK_{nsgv,t+1} + PI_{nsgv,t+1} \cdot d_{nsgv} + PI_{nsgv,t+1} \cdot (1 - d_{nsgv})] / [1 + NINT_t] \qquad (122)$$

where $PI_{nsgv,t}$ is the cost of buying a unit of capital (the price of composite investment good) in year *t*, $PK_{nsgv,t} + PI_{nsgv,t+1} \cdot d_{nsgv}$ is the rental rate on industry's *nsgv* capital stock, d_{nsgv} is the depreciation rate in branch *nsgv* and $NINT_t$ is the nominal interest rate in year *t* (Dixon and Rimmer, 2002). The purchase of one unit of capital in year *t* by industry *nsgv* involves an immediate expenditure $(PI_{nsgv,t})$, followed by two benefits in year *t+1* which are discounted by $(1 + NINT_t)$: the rental value of an extra unit of capital in year *t+1* $(PK_{nsgv,t+1} + PI_{nsgv,t+1} \cdot d_{nsgv})$, including the depreciation, and the value at which the depreciated unit of capital can be sold in year *t+1* $[PI_{nsgv,t+1} \cdot (1 - d_{nsgv})]$.

Figure 6. The expected rate of return for industry nsgv



The expected rate of return on investment in industry *nsgv* in year *t* is given by dividing both sides of (122) by $PI_{nsgv,t}$:

$$ROR_{nsgv,t} = -1 + [\,PK_{nsgv,t+1} / PI_{nsgv,t} + PI_{nsgv,t+1} / PI_{nsgv,t}\,] / [1 + NINT_t] \qquad (123)$$

Under static expectations, investors are assumed to anticipate that the asset prices (the cost of buying a unit of capital) and the net rental rates will increase by the current rate of inflation $(RINF_t)$. Thus, the expected rate of return $(ROR_{nsgv,t})$ under static expectations is given by:

$$ROR_{nsgv,t} = -1 + [\,PK_{nsgv,t} \cdot (1 + RINF_t) / PI_{nsgv,t} + PI_{nsgv,t} \cdot (1 + RINF_t) / PI_{nsgv,t}\,] / [\,1 + NINT_t\,] \quad (124)$$

Simplifying further, we get:

$$ROR_{nsgv,t} = -1 + [\,PK_{nsgv,t} / PI_{nsgv,t} + 1\,] / (1 + RINT_t) \quad (125)$$

where the real interest rate $(RINT_t)$ is defined as:

$$1 + RINT_t = (1 + NINT_t) / (1 + RINF_t) \quad (126)$$

The weighted average real return to capital has been taken as a proxy for the real interest rate in Luxgem. The return to capital is expressed in real terms using the production price index:

$$RINT_t = \{\sum_{nsgv} [(PK_{nsgv,t} / PD_{nsgv,t}) \cdot KSK_{nsgv,t}\,] / \sum_{nsgv} KSK_{nsgv,t} + 1\} / (1 + RINF_t) - 1 \quad (127)$$

The capital stock in industry *nsgv* in the next period (year *t+1*) is given by:

$$KSK_{nsgv,t+1} = (1\text{-}d_{nsgv}) \cdot KSK_{nsgv,t} + INVPv_{nsgv,t} \quad (128)$$

where $KSK_{nsgv,t}$ is the current capital stock (in year *t*) and $INVPv_{nsgv,t}$ give the private investments by branch in year *t*.

The capital growth rate in terms of capital stock in year *t+1* and the capital stock in year *t* is given by:

$$KSKg_{nsgv,t} = KSK_{nsgv,t+1} / KSK_{nsgv,t} - 1 \quad (129)$$

whereas the actual growth rate of capital in industry *nsgv* can be derived from equation. (118) as:

$$KSKg_{nsgv,t} = \left[\alpha ROR_{nsgv,t} \cdot KSKg\,max_{nsgv} \cdot (KSKtrend_{nsgv} - KSKg\,min_{nsgv}) + KSKg\,min_{nsgv} \cdot (KSKg\,max_{nsgv} - KSKtrend_{nsgv})\right] / \left[\alpha ROR_{nsgv,t} \cdot (KSKtrend_{nsgv} - KSKg\,min_{nsgv}) + (KSKg\,max_{nsgv} - KSKtrend_{nsgv})\right] \quad (130)$$

The parameter $\alpha ROR_{nsgv,t}$ is given by:

$$\alpha ROR_{nsgv,t} = e^{[(ROR_{nsgv,t} - RORH_{nsgv}) \cdot (KSKgmax_{nsgv} - KSKgmin_{nsgv})] / [(KSKgmax_{nsgv} - KSKtrend_{nsgv}) \cdot (KSKtrend_{nsgv} - KSKgmin_{nsgv})]} \quad (131)$$

The investments in branch *nsgv* in year *t* $(INVPv_{nsgv,t})$ are derived from equations (128)-(130) as:

$$INVPv_{nsgv,t} = KSK_{nsgv,t} \cdot [\,\alpha ROR_{nsgv,t} \cdot KSKgmax_{nsgv} \cdot (KSKtrend_{nsgv} - KSKgmin_{nsgv}) + KSKgmin_{nsgv} \cdot (KSKgmax_{nsgv} - KSKtrend_{nsgv})] / [\,\alpha ROR_{nsgv,t} \cdot (KSKtrend_{nsgv} - KSKgmin_{nsgv}) + (KSKgmax_{nsgv} - KSKtrend_{nsgv})] + d_{nsgv} \cdot KSK_{nsgv,t} \quad (132)$$

while the level of savings necessary to satisfy the demand for investments are provided by:

$$S_t - \sum_c SV_{c,t} \cdot P_{c,t} - TRGPvKN_t = \sum_s INVPv_{s,t} \cdot PI_{s,t} \quad (133)$$

which also insures the consistency between total private investments and private savings.

The accumulation of the public capital stock is modelled in a simple way. As already explained in section 1.3, public gross capital formation is fixed in real terms, while its allocation between different branches of activity is provided by a Leontief function. Then, the accumulation of capital in the public administration, education and health and social work branches (*sgv*) is given by:

$$KSK_{sgv,t+1} = (1 - d_{sgv}) \cdot KSK_{sgv,t} + INVPb_{sgv,t} \quad (134)$$

where $INVPb_{sgv,t}$ represents the public investment in branch *sgv* in year *t*.

The model is solved dynamically with annual steps. The simulation horizon of the model has been set at 5 years but it can easily be extended.

2.3.11 HG Emissions

The Social Accounting Matrix for Luxembourg provides the consumption of energy in value terms (mil. euro). Implicit price levels for the energy vector (expressed in mil euro/TJ) have been calculated by branch of activity using the SAM and the energy balance for 2004. An important difference between the methodologies used in developing the SAM and the energy balance refers to the transport sector. In the SAM the consumption of fuels for transport purposes is allocated between different branches of activity and the residential sector (the household), while in the energy balance it is all allocated to the transport sector. Therefore, the energy balance has been first adjusted to harmonize it with the SAM, by re-allocating the consumption of fuels for transport purposes between different branches of activity and the residential sector. The implicit prices have been calculated using the harmonized SAM and energy balance.

The implicit price level by energy input and branch of activity is assumed to grow at the same rate as the price of domestic sales of energy inputs (P_{eng}) expressed in real terms using the GDP deflator $(GDPDEF)$:

$$PENINP_{eng,s} = PENINPZ_{eng,s} \cdot ((P_{eng} / GDPDEF) / (PZ_{eng} / GDPDEFZ)) \quad (135)$$

where $PENINP_{eng,s}$ is the implicit price level by type of energy input and branch of activity and $PENINPZ_{eng,s}$ its benchmark level. PZ_{eng} and $GDPDEFZ$ represent the benchmark levels of the price of domestic sales of energy inputs and the GDP deflator, respectively.

Similarly, the implicit price levels for the energy vector (expressed in mil euro/TJ) consumed by the residential sector have been derived using the SAM and the energy balance. Its evolution is linked to the price of domestic sales of energy inputs in real terms:

$$PENINPH_{eng} = PENINPHZ_{eng} \cdot [(P_{eng} / GDPDEF) / (PZ_{eng} / GDPDEFZ)] \quad (136)$$

where $PENINPH_{eng}$ is the implicit price level by type of energy input and $PENINPHZ_{eng}$ its benchmark level.

Luxgem explicitly takes into account the evolution of the GHG emissions (CO2, N2O and CH4) on fuel combustion, by linking them to the consumption of energy.

CO2 emissions on fuel combustion by fuel and branch of activity, expressed in Kt, are derived as:

$$CO2EMISEN_{ennel,s} = (ENINP_{ennel,s} / PENINP_{ennel,s}) \cdot CO2GJ_{ennel,s} \quad (137)$$

where the ratio between the consumption of non-electric energy inputs in mil euro $(ENINP_{ennel,s})$ and the implicit price level provides the consumption of non-electric energy inputs in TJ and $CO2GJ_{ennel,s}$ represent the emission factors expressed in Kt/TJ.

CO2 emissions on fuel combustion by the residential sector by type of fuel, expressed in Kt, are derived as:

$$CO2EMISENH_{ennel} = (C_{ennel} / PENINPH_{ennel}) \cdot CO2HGJ_{ennel} \quad (138)$$

where the ratio between the consumption of non-electric energy inputs in mil euro (C_{ennel}) and the implicit price level provides the consumption of non-electric energy inputs in TJ and $CO2HGJ_{ennel}$ represent the emission factors expressed in Kt/TJ.

In order to be as consistent as possible with the CRF reporting format the CO2 emissions for the transport activity have been calculated as the sum of CO2 emissions for transport purposes by all branches of activity $(\sum_{enfl} CO2EMISEN_{enfl,s})$ plus the CO2 emissions for transport purposes by the residential sector $(\sum_{enfl} CO2EMISENH_{enfl})$ plus the CO2 emissions for heating purposes $(\sum_{nenfl} CO2EMISEN_{nenfl,trs})$ by the transport sector itself:

$$CO2EMIS_{trs} = \sum_{nenfl} CO2EMISEN_{nenfl,trs} + \sum_{enfl} CO2EMISEN_{enfl,s} + \sum_{enfl} CO2EMISENH_{enfl} \quad (139)$$

The slight difference between the two approaches is imposed by the SAM. The CRF reporting format does not include the CO2 emissions for heating purposes $(\sum_{nenfl} CO2EMISEN_{nenfl,trs})$ by the transport sector in the calculation of the total CO2 emissions corresponding to the transport activity. Therefore, in order to be able to compare the results corresponding to the two approaches, the CO2 emissions for transport activity $(CO2EMISTRF)$ and for heating purposes by the transport sector $(CO2EMISTRHE)$ have been reported separately:

$$CO2EMISTRF = \sum_{enfl,s} CO2EMISEN_{enfl,s} + \sum_{enfl} CO2EMISENH_{enfl} \quad (140)$$

$$CO2EMISTRHE = \sum_{nenfl,ntrs} CO2EMISEN_{nenfl,ntrs} \quad (141)$$

The CO2 emissions corresponding to all branches of activity except the transport sector $(CO2EMIS_{ntrs})$ are given only by CO2 emissions on fuel combustion for heating purposes:

$$CO2EMIS_{ntrs} = \sum_{nenfl} CO2EMISEN_{nenfl,ntrs} \quad (142)$$

The total CO2 emissions by the residential sector $(CO2EMISH)$ only include the emissions on fuel combustion for heating purposes:

$$CO2EMISH = \sum_{nenfl} CO2EMISENH_{nenfl} \quad (143)$$

Subsequently, total CO2 emissions on fuel combustion for transport and heating purposes by all branches of activity are defined as:

$$CO2EMISS = \sum_{s} CO2EMIS_{s} \quad (144)$$

while the total CO2 emissions on fuel combustion $(CO2EMISTOT)$ are given by the CO2 emissions produced by all branches of activities plus the emissions steaming from the residential sector:

$$CO2EMISTOT = CO2EMISS + CO2EMISH \quad (145)$$

The N2O and CH4 emissions are generated in a similar fashion. Consequently, GHG emissions are defined as the sum of CO2, N2O and CH4 emissions. All equations corresponding to N2O and CH4 and GHG emissions are provided in section 1.13.

2.3.12 Closure rules

The closure rules refer to the manner in which demand and supply of commodities, the macroeconomic identities and the factor markets are equilibrated ex-post. Due to the complexity of the model, a combination of closure rules is needed. The particular set of closure rules should also be consistent, to the largest extent possible, with the institutional structure of the economy and with the purpose of the model.

In mathematical terms, the model should consist of an equal number of independent equations and endogenous variables. The closure rules reflect the choice of the model builder of which variables are exogenous and which variables are endogenous, so as to achieve ex-post equality.

Three macro balances are usually identified in CGE models that can be a potential source of ex-ante disequilibria and must be reconciled ex-post (Adelman and Robinson, 1989):

- The savings-investment balance;
- The government balance;
- The external balance.

The most widely accepted macro closure rule for CGE models implies the assumption that investment and savings balance. In the model, the investment is assumed to adjust to the available domestic and foreign savings. This reflects an economy in which savings form a binding constraint. The interest rate is assumed to effectively balance the supply and demand for investments, even if the specific mechanism is not incorporated in the model.

Additional assumptions are needed with regard to government behaviour in Luxgem. First, the total government final expenditures are fixed in real terms while the allocation of total expenditures between the consumption of different goods and services is provided by a Leontief function. Second, the gross capital formation by the government is fixed in real terms while the allocation between different branches of activity (public administration, education and health) is provided by another Leontief function. Third, property income receivable and payable, other current transfers, capital transfers receivable and payable and acquisitions less disposals of non-produced non-financial assets are fixed in real terms. Thus, the government net lending (+)/ net borrowing (-) is endogenously determined in the current version of Luxgem. Alternative assumptions are possible, where total government expenditures can be fixed in real terms or as a share of GDP, while the total final expenditures or the public gross fixed capital formation adjust.

An appealing closure rule for the government behaviour in case of an equal yield tax reform could be: to fix the government net lending (+)/ net borrowing (-) in real terms or as a share of GDP, or to fix the government revenues in real terms or as a share of GDP. For example, if we want to decrease the social security contributions rate and to compensate the decrease in revenues by an increase in the VAT, we could fix the government revenues in real terms or as a share of GDP while the VAT rate adjusts. Alternatively, we could keep the government surplus/deficit unchanged while the VAT rate adjusts. As a result, we can derive the VAT rate required to keep the government revenues or the government net lending (+)/ net borrowing (-) to its initial level.

With respect to the external balance, both current account balance and the real exchange rate are endogenous in the present version of Luxgem.

The setup of the closure rules is important in determining the mechanisms governing the model. Therefore, the closure rules should be established also taking into account the policy scenario in question.

According to Walras' law if *(n-1)* markets are cleared the *n*th one is cleared as well. Therefore, in order to avoid over-determination of the model, the equation for labour market clearing has been dropped (see equation (105), section 1.7). However, the system of equations guarantees, through Walras' law, that domestic employment is equal to the active population plus the number of commuters less the number of unemployed.

2.3.13 Model equations

2.3.13.1 Household

$$[(1-tsc_c)\cdot P_c+\sum_{ctm}(tchtm_{ctm,c}\cdot P_{ctm})]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\cdot C_c = [(1-tsc_c)\cdot P_c+\sum_{ctm}(tchtm_{ctm,c}\cdot P_{ctm})]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\cdot\mu H_c+\alpha H_c\cdot \{CBUD-[(1-tsc_{cc})\cdot P_{cc}+\sum_{ctm}(tchtm_{ctm,cc}\cdot P_{ctm})]\cdot(1+tc_{cc}+texc_{cc})\cdot(1+tvac_{cc})\cdot\mu H_{cc}\} \quad (1.12.146)$$

$$YH = shYKH\cdot\sum_s(PK_s\cdot KSK_s)+PLAVR\cdot[\sum_s LSK_s-LSW]+TRHG-TRSOCIN \quad (1.12.147)$$

$$TRHG = TRHGSB+TRHGPROPN+TRHGOTHN \quad (1.12.148)$$

$$YHD = (1-ty)\cdot YH \quad (1.12.149)$$

$$CBUD = (1-ty)\cdot YH - SH \quad (1.12.150)$$

$$SH = MPS\cdot(1-ty)\cdot YH \quad (1.12.151)$$

$$MPS = MPSI\cdot\{[(1-ty)\cdot PKavr]/[(1-tyz)\cdot PKavrZ]\}^{elasS} \quad (1.12.152)$$

2.3.13.2 Firms

$$KLE_s = aKLE_s\cdot XD_s \quad (1.12.153)$$

$$KL_s = KLE_s\cdot(PKLE_s/PKL_s)^{\sigma KLEN_s}\cdot\gamma KL_s^{\sigma KLEN_s}\cdot aKLEN_s^{(\sigma KLEN_s-1)} \quad (1.12.154)$$

$$ENER_s = KLE_s\cdot(PKLE_s/PENER_s)^{\sigma KLEN_s}\cdot\gamma ENER_s^{\sigma KLEN_s}\cdot aKLEN_s^{(\sigma KLEN_s-1)} \quad (1.12.155)$$

$$ENERNE_s = ENER_s\cdot(PENER_s/PENERNE_s)^{\sigma ENER_s}\cdot\gamma ENERNE_s^{\sigma ENER_s}\cdot aENER_s^{(\sigma ENER_s-1)} \quad (1.12.156)$$

$$KSK_s = KL_s\cdot\{PKL_s/[PK_s\cdot(1+tk_s)+d_s\cdot PI_s]\}^{\sigma F_s}\cdot\gamma FK_s^{\sigma F_s}\cdot aF_s^{(\sigma F_s-1)} \quad (1.12.157)$$

$$LSK_s = KL_s\cdot\{PKL_s/[PL\cdot(1+premLSK_s)\cdot(1+tl_s/(1-tl_s))]\}^{\sigma F_s}\cdot\gamma FL_s^{\sigma F_s}\cdot aF_s^{(\sigma F_s-1)} \quad (1.12.158)$$

$$ENERCO_{sel} = ENERNE_{sel}\cdot(PENERNE_{sel}/PENERCO_{sel})^{\sigma ENERCO_{sel}}\cdot\gamma ENERCO_{sel}^{\sigma ENERCO_{sel}}\cdot aENERCO_{sel}^{(\sigma ENERCO_{sel}-1)} \quad (1.12.159)$$

$$ENINP_{enel,s} = ENER_s\cdot\{PENER_s/\{[(1-tsic_{enel})\cdot P_{enel}+\sum_{ctm}tcictm_{ctm,enel}\cdot P_{ctm}]\cdot(1+tvaic_{enel})\cdot(1+tic_{enel}+texcic_{enel})\}\}^{\sigma ENER_s}\cdot\gamma EREL_{enel,s}^{\sigma ENER_s}\cdot aENER_s^{(\sigma ENER_s-1)} \quad (1.12.160)$$

$$ENINP_{ennel,nsel} = ENERNE_{nsel} \cdot \{ PENERNE_{nsel} / \{[(1-tsic_{ennel}) \cdot P_{ennel} + \sum_{ctm} tcictm_{ctm,ennel} \cdot P_{ctm}] \cdot (1+tvaic_{ennel}) \cdot (1+tic_{ennel} + texcic_{ennel}) \}\}^{\sigma ENINP_{nsel}} \cdot \gamma ENINP_{ennel,nsel}^{\sigma ENINP_{nsel}} \cdot aENINP_{nsel}^{(\sigma ENINP_{nsel}-1)} \quad (1.12.161)$$

$$ENINP_{ng,sel} = ENERNE_{sel} \cdot \{ PENERNE_{sel} / \{[(1-tsic_{ng}) \cdot P_{ng} + \sum_{ctm} tcictm_{ctm,ng} \cdot P_{ctm}] \cdot (1+tvaic_{ng}) \cdot (1+tic_{ng} + texcic_{ng}) \}\}^{\sigma ENERCO_{sel}} \cdot \gamma ENINPG_{ng,sel}^{\sigma ENERCO_{sel}} \cdot aENERCO_{sel}^{(\sigma ENERCO_{sel}-1)} \quad (1.12.162)$$

$$ENINP_{enco,sel} = ENERCO_{sel} \cdot \{ PENERCO_{sel} / \{[(1-tsic_{enco}) \cdot P_{enco} + \sum_{ctm} tcictm_{ctm,enco} \cdot P_{ctm}] \cdot (1+tvaic_{enco}) \cdot (1+tic_{enco} + texcic_{enco}) \}\}^{\sigma ENINP_{sel}} \cdot \gamma ENINP_{enco,sel}^{\sigma ENINP_{sel}} \cdot aENINP_{sel}^{(\sigma ENINP_{sel}-1)} \quad (1.12.163)$$

2.3.13.3 Government

$$GREV = TROPERS + TRPROD + TRGWPROPN + TRPROP + TRSOCT + TRGWOTHN + TRGPvKN \quad (1.12.164)$$

$$GEXP = CGBUD \cdot PICG + IGTN + TRST + TRHGPROPN + TRHGSB + TRHGOTHN - DEPPbTN + TRPvGKN + ACQUISN \quad (1.12.165)$$

$$SGBAL \cdot GDPDEF = GREV - GEXP \quad (1.12.166)$$

$$SGBALN = SGBAL \cdot GDPDEF \quad (1.12.167)$$

$$TROPERS = shYKG \cdot \sum_{s} PK_s \cdot KSK_s \quad (1.12.168)$$

$$TRPROD = TRPRODC + TRPRODPP \quad (1.12.169)$$

$$TRPRODC = TRPRODVAT + TRPRODTM + TRPRODOTH \quad (1.12.170)$$

$$TRPRODVAT = TRPRODVATFC + TRPRODVATIC \quad (1.12.171)$$

$$TRPRODVATFC = \sum_{c} \{[(1-tsc_c) \cdot P_c + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot (1+tc_c + texc_c) \cdot tvac_c \cdot C_c\} + \sum_{c} \{[(1-tsi_c) \cdot P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot (1+ti_c) \cdot tvai_c \cdot \sum_{s} INVCPv_{s,c}\} + \sum_{c} [EN_c \cdot (PEFOB_c - \sum_{ctm} tcetm_{ctm,c} \cdot P_{ctm}) \cdot tvae_c] + \sum_{c} [REXP_c \cdot (PWM_c \cdot ER + \sum_{ctm} tcrextm_{ctm,c} \cdot P_{ctm}) \cdot (1+texce_c) \cdot tvarexp_c] \quad (1.12.172)$$

$$TRPRODVATIC = \sum_{nen,s} \{[(1-tsic_{nen}) \cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen} \cdot P_{ctm}] \cdot (1+tic_{nen} + texcic_{nen}) \cdot tvaic_{nen} \cdot io_{nen,s} \cdot XD_s\} + \sum_{eng,s} \{[(1-tsic_{eng}) \cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng} \cdot P_{ctm}] \cdot (1+tic_{eng} + texcic_{eng}) \cdot tvaic_{eng} \cdot ENINP_{eng,s}\} \quad (1.12.173)$$

$$TRPRODTM = \sum_{c}(tm_{c} \cdot MN_{c} \cdot PWM_{c} \cdot ER) + \sum_{c}\{[(1-tsc_{c}) \cdot P_{c} + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot texc_{c} \cdot C_{c}\} + \sum_{nen,s}\{[(1-tsic_{nen}) \cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen} \cdot P_{ctm}] \cdot texcic_{nen} \cdot io_{nen,s} \cdot XD_{s}\} + \sum_{eng,s}\{[(1-tsic_{eng}) \cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng} \cdot P_{ctm}] \cdot texcic_{eng} \cdot ENINP_{eng,s}\} + \sum_{c}[(PWM_{c} \cdot ER + \sum_{ctm} tcrextm_{ctm,c} \cdot P_{ctm}) \cdot texce_{c} \cdot REXP_{c}]$$ (1.12.174)

$$TRPRODOTH = \sum_{c}\{[(1-tsc_{c}) \cdot P_{c} + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot tc_{c} \cdot C_{c}\} + \sum_{c}\{[(1-tsi_{c}) \cdot P_{c} + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot ti_{c} \cdot \sum_{s} INVCPv_{s,c}\} + \sum_{nen,s}\{[(1-tsic_{nen}) \cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen} \cdot P_{ctm}] \cdot tic_{nen} \cdot io_{nen,s} \cdot XD_{s}\} + \sum_{eng,s}\{[(1-tsic_{eng}) \cdot P_{eng} + \sum_{ctm} tcictm_{ctm,eng} \cdot P_{ctm}] \cdot tic_{eng} \cdot ENINP_{eng,s}\}$$ (1.12.175)

$$TRPRODPP = \sum_{s} tp_{s} \cdot XD_{s} \cdot PD_{s}$$ (1.12.176)

$$TRGWPROPN = TRGWPROP \cdot ER$$ (1.12.177)

$$TRPROP = TRPROPH + TRPROPF$$ (1.12.178)

$$TRPROPH = ty \cdot YH$$ (1.12.179)

$$TRPROPF = \sum_{s} tk_{s} \cdot KSK_{s} \cdot PK_{s}$$ (1.12.180)

$$TRPROPFS_{s} = tk_{s} \cdot KSK_{s} \cdot PK_{s}$$ (1.12.181)

$$TRSOCT = TRSOC + TRSOCIN$$ (1.12.182)

$$TRSOC = \sum_{s} TRSOCS_{s}$$ (1.12.183)

$$TRSOCS_{s} = [tl_{s}/(1-tl_{s})] \cdot LSK_{s} \cdot PL \cdot (1+premLSK_{s})$$ (1.12.184)

$$TRSOCIN = TRSOCI \cdot PCINDEX$$ (1.12.185)

$$TRGWOTHN = TRGWOTH \cdot ER$$ (1.12.186)

$$TRGPvKN = TRGPvK \cdot GDPDEF$$ (1.12.187)

$$CGBUDN = CGBUD \cdot PICG$$ (1.12.188)

$$CG_{c} = ioCG_{c} \cdot CGBUD$$ (1.12.189)

$$PICG = \sum_{c} ioCG_{c} \cdot P_{c}$$ (1.12.190)

$$IGTN = IGT \cdot PIG$$ (1.12.191)

$$INVPb_{sgv} = ioIG_{sgv} \cdot IGT \tag{1.12.192}$$

$$PIG = \sum_{sgv} ioIG_{sgv} \cdot PI_{sgv} \tag{1.12.193}$$

$$TRST = \sum_{c} P_c \cdot tsc_c \cdot C_c + \sum_{s,c} P_c \cdot tsi_c \cdot INVCPv_{s,c} + \sum_{s,nen} P_{nen} \cdot tsic_{nen} \cdot io_{nen,s} \cdot XD_s + \sum_{s,eng} P_{eng} \cdot tsic_{eng} \cdot ENINP_{eng,s} + \sum_{s} PD_s \cdot tsp_s \cdot XD_s \tag{1.12.194}$$

$$TRHGPROPN = TRHGPROP \cdot PCINDEX \tag{1.12.195}$$

$$TRHGSB = trep \cdot PLAVR \cdot shUNEMPIND \cdot UNEMP + TRHGSBOTH \cdot PCINDEX \tag{1.12.196}$$

$$TRHGOTHN = TRHGOTH \cdot PCINDEX \tag{1.12.197}$$

$$DEPPbTN = \sum_{sgv} DEPPb_{sgv} \cdot PI_{sgv} \tag{1.12.198}$$

$$TRPvGKN = TRPvGK \cdot GDPDEF \tag{1.12.199}$$

$$ACQUISN = ACQUIS \cdot GDPDEF \tag{1.12.200}$$

$$shTRHGSBOTH = (TRHGSBOTH \cdot PCINDEX) / GEXP \cdot 100 \tag{1.12.201}$$

$$rTRYHGDP = (ty \cdot YH) / GDPC \cdot 100 \tag{1.12.202}$$

$$rTRVATCGDP = \sum_{c} \{[(1 - tsc_c) \cdot P_c + \sum_{ctm} tchtm_{ctm,c} \cdot P_{ctm}] \cdot (1 + tc_c + texc_c) \cdot tvac_c \cdot C_c\} / GDPC \cdot 100 \tag{1.12.203}$$

$$rTRLGDP = TRSOC / GDPC \cdot 100 \tag{1.12.204}$$

$$rCGBUDGDP = (CGBUD \cdot PICG) / GDPC \cdot 100 \tag{1.12.205}$$

$$rIGTGDP = IGTN / GDPC \cdot 100 \tag{1.12.206}$$

$$rSGBALGDP = SGBALN / GDPC \cdot 100 \tag{1.12.207}$$

2.3.13.4 Domestic supply to domestic and foreign markets

$$XDDE_c = \sum_{s} ioC_{s,c} \cdot XD_s \tag{1.12.208}$$

2.3.13.5 Foreign trade

$$E_c = EN_c + REXP_c \tag{1.12.209}$$

$$EN_c = XDDE_c \cdot (PDDE_c / PE_c)^{\sigma T_c} \cdot \gamma T2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \tag{1.12.210}$$

$$END_c = ENDI_c \cdot (PWE_c \cdot ER / PEFOB_c)^{elasE_c} \tag{1.12.211}$$

$$XDD_c = XDDE_c \cdot (PDDE_c/PDD_c)^{\sigma T_c} \cdot \gamma T1_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad (1.12.212)$$

$$M_c = MN_c + REXP_c \quad (1.12.213)$$

$$MN_c = X_c \cdot (P_c/PM_c)^{\sigma A_c} \cdot \gamma A2_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad (1.12.214)$$

$$XDD_c = X_c \cdot (P_c/PDD_c)^{\sigma A_c} \cdot \gamma A1_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad (1.12.215)$$

$$\sum_c (MN_c \cdot PWM_c + REXP_c \cdot PWM_c) + LSW \cdot PL \cdot (1+premLSKF)/ER = \sum_c (EN_c \cdot PEFOB_c/ER) + \sum_c (REXP_c \cdot PREXP_c / ER) + TRGWPROP + TRGWOTH + SW \quad (1.12.216)$$

$$rSWGDP = (SW \cdot ER/GDPC) \cdot 100 \quad (1.12.217)$$

2.3.13.6 Savings and investment

$$S = SH + SW \cdot ER + \sum_{nsgv} DEPPv_{nsgv} \cdot PI_{nsgv} + TRPvGKN + ACQUISN + SGBALN \quad (1.12.218)$$

$$INVCPb_{sgv,c} = ioI_{c,sgv} \cdot INVPb_{sgv} \quad (1.12.219)$$

$$INVCPv_{nsgv,c} = ioI_{c,nsgv} \cdot INVPv_{nsgv} \quad (1.12.220)$$

$$PI_{nsgv} = \sum_c (1+tvai_c) \cdot (1+ti_c) \cdot [(1-tsi_c) \cdot P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot ioI_{c,nsgv} \quad (1.12.221)$$

$$PI_{sgv} = \sum_c P_c \cdot ioI_{c,sgv} \quad (1.12.222)$$

$$SV_c = svr_c \cdot X_c \quad (1.12.223)$$

$$DEPPv_{nsgv} = d_{nsgv} \cdot KSK_{nsgv} \quad (1.12.224)$$

$$DEPPb_{sgv} = d_{sgv} \cdot KSK_{sgv} \quad (1.12.225)$$

2.3.13.7 Labour market

$$PLAVR \cdot (LSR - UNEMP) = PL \cdot [\sum_s (1+premLSK_s) \cdot LSK_s - LSW \cdot (1+premLSKF)] \quad (1.12.226)$$

$$PLAVRT \cdot (LSR - UNEMP) = \sum_s \{PL \cdot [1+tl_s/(1-tl_s)] \cdot (1+premLSK_s) \cdot LSK_s\} - PL \cdot LSW \cdot (1+premLSKF) \quad (1.12.227)$$

$$LSR = LSRI \cdot [(PLAVR \cdot (1\text{-}ty) \cdot PCINDEXZ)/(PLAVRZ \cdot (1\text{-}tyz) \cdot PCINDEX)]^{elasLS} \quad (1.12.228)$$

$$log\left(\frac{LSW_t - LSW_{t-1}}{EMPI_t}\right) = \beta_1 \cdot log\left(\frac{PLAVR_t \cdot (1-ty)}{PLAVRGR_t \cdot ER_t}\right) + \beta_2 \cdot log\left(\frac{\sum_{cre} P_{cre,t}}{PIMMOGR_t \cdot ER_t}\right) + \beta_3 \cdot log\left(\frac{UNRATE}{UNRATEGR}\right) + \beta_4 \quad (1.12.229)$$

$$PLAVRLUX\_GR = PLAVR \cdot (1-ty) / (PLAVRGR \cdot ER) \quad (1.12.230)$$

$$PIMMOLUX\_GR = \sum_{cre} P_{cre} / (PIMMOGR \cdot ER) \quad (1.12.231)$$

$$log(PLAVR/PCINDEX) = elasU \cdot log(UNRATE) + err \quad (1.12.232)$$

$$EMPI = LSR - UNEMP + LSW \quad (1.12.233)$$

$$EMPN = LSR - UNEMP \quad (1.12.234)$$

$$UNRATE = UNEMP/LSR \quad (1.12.235)$$

2.3.13.8 Trade and transport margins

$$MARGTM_{ctm} = \sum_c [tchtm_{ctm,c} \cdot C_c + tcitm_{ctm,c} \cdot \sum_s INVCPv_{s,c} + tcetm_{ctm,c} \cdot EN_c + tcrextm_{ctm,c} \cdot REXP_c] + \sum_{s,nen} tcictm_{ctm,nen} \cdot io_{nen,s} \cdot XD_s + \sum_{s,eng} tcictm_{ctm,eng} \cdot ENINP_{eng,s} \quad (1.12.236)$$

2.3.13.9 Market clearing equations

$$\sum_s LSK_s = LSR + LSW - UNEMP \quad (1.12.237)$$

$$X_{nctmn} = \sum_s io_{nctmn,s} \cdot XD_s + C_{nctmn} + CG_{nctmn} + \sum_{nsgv} INVCPv_{nsgv,nctmn} + \sum_{sgv} INVCPb_{sgv,nctmn} + SV_{nctmn} \quad (1.12.238)$$

$$X_{eng} = \sum_s ENINP_{eng,s} + C_{eng} + CG_{eng} + SV_{eng} \quad (1.12.239)$$

$$X_{ctm} = \sum_s io_{ctm,s} \cdot XD_s + C_{ctm} + CG_{ctm} + SV_{ctm} + MARGTM_{ctm} \quad (1.12.240)$$

$$EN_c = END_c \quad (1.12.241)$$

2.3.13.10 Zero profit conditions

$$PD_s \cdot XD_s \cdot (1 - tp_s + tsp_s) = \sum_{nen} \{io_{nen,s} \cdot XD_s \cdot [(1 - tsic_{nen}) \cdot P_{nen} + \sum_{ctm} tcictm_{ctm,nen} \cdot P_{ctm}] \cdot (1 + tic_{nen} + texcic_{nen}) \cdot (1 + tvaic_{nen})\} + PKLE_s \cdot KLE_s \quad (1.12.242)$$

$$PKLE_s \cdot KLE_s = PENER_s \cdot ENER_s + PKL_s \cdot KL_s \quad (1.12.243)$$

$$PENER_s \cdot ENER_s = \sum_{enel}\{[(1-tsic_{enel})\cdot P_{enel} + \sum_{ctm} tcictm_{ctm,enel}\cdot P_{ctm}]\cdot(1+tic_{enel}+ texcic_{enel})\cdot(1+tvaic_{enel})\cdot ENINP_{enel,s}\} + PENERNE_s \cdot ENERNE_s \quad (1.12.244)$$

$$PKL_s \cdot KL_s = [PK_s\cdot(1+tk_s)+d_s\cdot PI_s]\cdot KSK_s + PL\cdot(1+premLSK_s)\cdot [1+tl_s/(1-tl_s)]\cdot LSK_s \quad (1.12.245)$$

$$PENERNE_{nsel}\cdot ENERNE_{nsel} = \sum_{ennel}\{[(1-tsic_{ennel})\cdot P_{ennel} + \sum_{ctm} tcictm_{ctm,ennel}\cdot P_{ctm}]\cdot (1+tic_{ennel}+texcic_{ennel})\cdot(1+tvaic_{ennel})\cdot ENINP_{ennel,nsel}\} \quad (1.12.246)$$

$$PENERNE_{sel}\cdot ENERNE_{sel} = \sum_{ng}\{[(1-tsic_{ng})\cdot P_{ng} + \sum_{ctm} tcictm_{ctm,ng}\cdot P_{ctm}]\cdot (1+tic_{ng}+texcic_{ng})\cdot(1+tvaic_{ng})\cdot ENINP_{ng,sel}\} + PENERCO_{sel}\cdot ENERCO_{sel} \quad (1.12.247)$$

$$PENERCO_{sel}\cdot ENERCO_{sel} = \sum_{enco}\{[(1-tsic_{enco})\cdot P_{enco} + \sum_{ctm} tcictm_{ctm,enco}\cdot P_{ctm}]\cdot (1+tic_{enco}+texcic_{enco})\cdot(1+tvaic_{enco})\cdot ENINP_{enco,sel}\} \quad (1.12.248)$$

$$PD_s = \sum_c ioC_{s,c}\cdot PDDE_c \quad (1.12.249)$$

$$PDDE_c\cdot XDDE_c = PDD_c\cdot XDD_c + PE_c\cdot EN_c \quad (1.12.250)$$

$$P_c\cdot X_c = PM_c\cdot MN_c + PDD_c\cdot XDD_c \quad (1.12.251)$$

2.3.13.11 Price definitions

$$PCINDEX = \sum_c\{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\cdot CZ_c\} / \sum_c\{[(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot(1+tvacz_c)\cdot CZ_c\} \quad (1.12.252)$$

$$PM_c = (1+tm_c)\cdot PWM_c\cdot ER \quad (1.12.253)$$

$$PE_c = (PEFOB_c - \sum_{ctm} tcetm_{ctm,c}\cdot P_{ctm})\cdot(1-tvae_c) \quad (1.12.254)$$

$$PREXP_c = (PWM_c\cdot ER + \sum_{ctm} tcrextm_{ctm,c}\cdot P_{ctm})\cdot(1+texce_c)\cdot(1+tvarexp_c) \quad (1.12.255)$$

$$RINT_t = \{\sum_{nsgv}[(PK_{nsgv,t}/PD_{nsgv,t})\cdot KSK_{nsgv,t}]/\sum_{nsgv} KSK_{nsgv,t} + 1\}/(1+RINF_t) - 1 \quad (1.12.256)$$

$$PKavr = \sum_{nsgv}[(PK_{nsgv}/PCINDEX)\cdot KSK_{nsgv}]/\sum_{nsgv} KSK_{nsgv} \quad (1.12.257)$$

$$PCT_c = [(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c) \quad (1.12.258)$$

2.3.13.12 GDP at current and constant market prices and GDP deflator

$$GDPC = \sum_{c}\{C_c \cdot [(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)+ CG_c\cdot P_c\} + \sum_{nsgv,c}\{INVCPv_{nsgv,c}\cdot[(1-tsi_c)\cdot P_c+\sum_{ctm} tcitm_{ctm,c}\cdot P_{ctm}]\cdot(1+ti_c)\cdot(1+tvai_c)\}+ \sum_{sgv,c} INVCPb_{sgv,c}\cdot P_c + \sum_c SV_c\cdot P_c - \sum_c (MN_c\cdot PWM_c\cdot ER + REXP_c\cdot PWM_c\cdot ER)+ \sum_c (EN_c\cdot PEFOB_c + REXP_c\cdot PREXP_c)$$ (1.12.259)

$$GDP = \sum_{c}\{C_c \cdot [(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot(1+tvacz_c)+ CG_c\cdot PZ_c\} + \sum_{nsgv,c}\{INVCPv_{nsgv,c}\cdot[(1-tsiz_c)\cdot PZ_c+\sum_{ctm} tcitmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tiz_c)\cdot (1+tvaiz_c)\}+\sum_{sgv,c} INVCPb_{sgv,c}\cdot PZ_c + \sum_c SV_c\cdot PZ_c - \sum_c (MN_c\cdot PWMZ_c\cdot ERZ + REXP_c\cdot PWMZ_c\cdot ERZ)+\sum_c (EN_c\cdot PEFOBZ_c + REXP_c\cdot PREXPZ_c)$$ (1.12.260)

$$GDPDEF = GDPC/GDP$$ (1.12.261)

2.3.13.13 Components of GDP at constant prices

$$CT = \sum_{c}\{C_c \cdot [(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot(1+tvacz_c)\}$$ (1.12.262)

$$CGT = \sum_c CG_c\cdot PZ_c$$ (1.12.263)

$$IT = \sum_{c}\{[(1-tsi_c)\cdot PZ_c + \sum_{ctm} tcitmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tiz_c)\cdot(1+tvaiz_c)\cdot\sum_{nsgv} INVCPv_{nsgv,c}\}+ \sum_{sgv,c} INVCPb_{sgv,c}\cdot PZ_c + \sum_c SV_c\cdot PZ_c$$ (1.12.264)

$$ET = \sum_c (EN_c\cdot PEFOBZ_c + REXP_c\cdot PREXPZ_c)$$ (1.12.265)

$$MT = \sum_c [MN_c\cdot PWMZ_c\cdot ERZ + REXP_c\cdot PWMZ_c\cdot ERZ]$$ (1.12.266)

$$BPT = ET - MT$$ (1.12.267)

2.3.13.14 Equivalent variation in income

$$VU = \{CBUD - \sum_{c}\{[(1-tsc_c)\cdot P_c + \sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\cdot\mu H_c\}\}\cdot \prod_c\{\alpha H_c/\{[(1-tsc_c)\cdot P_c+\sum_{ctm} tchtm_{ctm,c}\cdot P_{ctm}]\cdot(1+tc_c+texc_c)\cdot(1+tvac_c)\}\}^{\alpha H_c}$$ (1.12.268)

$$EV = \prod_{c}\{\{[(1-tscz_c)\cdot PZ_c + \sum_{ctm} tchtmz_{ctm,c}\cdot PZ_{ctm}]\cdot(1+tcz_c+texcz_c)\cdot(1+tvacz_c)\}/ \alpha H_c\}^{\alpha H_c}\cdot(VU-VUI)$$ (1.12.269)

$$EVYH = EV/YH\cdot 100$$ (1.12.270)

2.3.13.15 Implicit energy prices

$$PENINP_{eng,s} = PENINPZ_{eng,s} \cdot ((P_{eng} / GDPDEF) / (PZ_{eng} / GDPDEFZ)) \quad (1.12.271)$$

$$PENINPH_{eng} = PENINPHZ_{eng} \cdot [(P_{eng} / GDPDEF) / (PZ_{eng} / GDPDEFZ)] \quad (1.12.272)$$

2.3.13.16 Energy intensity indicators

$$ENEFFB_{ntrs} = \sum_{eng} (ENINP_{eng,ntrs} / PENINP_{eng,ntrs}) / KL_{ntrs} \quad (1.12.273)$$

$$ENEFFB_{trs} = \sum_{eng} (ENINP_{eng,trs} / PENINP_{eng,trs}) / GDP \quad (1.12.274)$$

$$ENEFFH = \sum_{eng} (C_{eng} / PENINPH_{eng}) / (YHD / PCINDEX) \quad (1.12.275)$$

2.3.13.17 GHG emissions

$$CO2EMISEN_{ennel,s} = (ENINP_{ennel,s} / PENINP_{ennel,s}) \cdot CO2GJ_{ennel,s} \quad (1.12.276)$$

$$N2OEMISEN_{ennel,s} = (ENINP_{ennel,s} / PENINP_{ennel,s}) \cdot N2OGJ_{ennel,s} \quad (1.12.277)$$

$$CH4EMISEN_{ennel,s} = (ENINP_{ennel,s} / PENINP_{ennel,s}) \cdot CH4GJ_{ennel,s} \quad (1.12.278)$$

$$GHGEMISEN_{ennel,s} = CO2EMISEN_{ennel,s} + N2OEMISEN_{ennel,s} + CH4EMISEN_{ennel,s} \quad (1.12.279)$$

$$CO2EMIS_{trs} = \sum_{nenfl} CO2EMISEN_{nenfl,trs} + \sum_{enfl,s} CO2EMISEN_{enfl,s} + \sum_{enfl} CO2EMISENH_{enfl} \quad (1.12.280)$$

$$N2OEMIS_{trs} = \sum_{nenfl} N2OEMISEN_{nenfl,trs} + \sum_{enfl,s} N2OEMISEN_{enfl,s} + \sum_{enfl} N2OEMISENH_{enfl} \quad (1.12.281)$$

$$CH4EMIS_{trs} = \sum_{nenfl} CH4EMISEN_{nenfl,trs} + \sum_{enfl,s} CH4EMISEN_{enfl,s} + \sum_{enfl} CH4EMISENH_{enfl} \quad (1.12.282)$$

$$CO2EMIS_{ntrs} = \sum_{nenfl} CO2EMISEN_{nenfl,ntrs} \quad (1.12.283)$$

$$N2OEMIS_{ntrs} = \sum_{nenfl} N2OEMISEN_{nenfl,ntrs} \quad (1.12.284)$$

$$CH4EMIS_{ntrs} = \sum_{nenfl} CH4EMISEN_{nenfl,ntrs} \quad (1.12.285)$$

$$GHGEMIS_{s} = CO2EMIS_{s} + N2OEMIS_{s} + CH4EMIS_{s} \quad (1.12.286)$$

$$CO2EMISTRF = \sum_{enfl,s} CO2EMISEN_{enfl,s} + \sum_{enfl} CO2EMISENH_{enfl} \quad (1.12.287)$$

$$N2OEMISTRF = \sum_{enfl,s} N2OEMISEN_{enfl,s} + \sum_{enfl} N2OEMISENH_{enfl} \quad (1.12.288)$$

$$CH4EMISTRF = \sum_{enfl,s} CH4EMISEN_{enfl,s} + \sum_{enfl} CH4EMISENH_{enfl} \quad (1.12.289)$$

$$GHGEMISTRF = CO2EMISTRF + N2OEMISTRF + CH4EMISTRF \quad (1.12.290)$$

$$CO2EMISTRHE = \sum_{nenfl,ntrs} CO2EMISEN_{nenfl,ntrs} \quad (1.12.291)$$

$$N2OEMISTRHE = \sum_{nenfl,ntrs} N2OEMISEN_{nenfl,ntrs} \quad (1.12.292)$$

$$CH4EMISTRHE = \sum_{nenfl,ntrs} CH4EMISEN_{nenfl,ntrs} \quad (1.12.293)$$

$$GHGEMISTRHE = CO2EMISTRHE + N2OEMISTRHE + CH4EMISTRHE \quad (1.12.294)$$

$$CO2EMISS = \sum_{s} CO2EMIS_{s} \quad (1.12.295)$$

$$N2OEMISS = \sum_{s} N2OEMIS_{s} \quad (1.12.296)$$

$$CH4EMISS = \sum_{s} CH4EMIS_{s} \quad (1.12.297)$$

$$GHGEMISS = CO2EMISS + N2OEMISS + CH4EMISS \quad (1.12.298)$$

$$CO2EMISENH_{ennel} = (C_{ennel} / PENINPH_{ennel}) \cdot CO2HGJ_{ennel} \quad (1.12.299)$$

$$N2OEMISENH_{ennel} = (C_{ennel} / PENINPH_{ennel}) \cdot N2OHGJ_{ennel} \quad (1.12.300)$$

$$CH4EMISENH_{ennel} = (C_{ennel} / PENINPH_{ennel}) \cdot CH4HGJ_{ennel} \quad (1.12.301)$$

$$GHGEMISENH_{ennel} = CO2EMISENH_{ennel} + N2OEMISENH_{ennel} + CH4EMISENH_{ennel} \quad (1.12.302)$$

$$CO2EMISH = \sum_{nenfl} CO2EMISENH_{nenfl} \quad (1.12.303)$$

$$N2OEMISH = \sum_{nenfl} N2OEMISENH_{nenfl} \quad (1.12.304)$$

$$CH4EMISH = \sum_{nenfl} CH4EMISENH_{nenfl} \quad (1.12.305)$$

$$GHGEMISH = CO2EMISH + N2OEMISH + CH4EMISH \quad (1.12.306)$$

$$CO2EMISTOT = CO2EMISS + CO2EMISH \quad (1.12.307)$$

$$N2OEMISTOT = N2OEMISS + N2OEMISH \quad (1.12.308)$$

$$CH4EMISTOT = CH4EMISS + CH4EMISH \quad (1.12.309)$$

$$GHGEMISTOT = GHGEMISS + GHGEMISH \quad (1.12.310)$$

2.3.13.18 Capital accumulation

$$ROR_{nsgv,t} = -1+(PK_{nsgv,t}/PI_{nsgv,t}+1)/(1+RINT_t) \quad (1.12.311)$$

$$\alpha ROR_{nsgv,t} = e^{(ROR_{nsgv,t}-RORH_{nsgv})\cdot(KSKgmax_{nsgv}-KSKgmin_{nsgv})/[(KSKgmax_{nsgv}-KSKtrend_{nsgv})\cdot(KSKtrend_{nsgv}-KSKgmin_{nsgv})]} \quad (1.12.312)$$

$$INVPv_{nsgv,t} = KSK_{nsgv,t}\cdot[\alpha ROR_{nsgv,t}\cdot KSKgmax_{nsgv}\cdot(KSKtrend_{nsgv}-KSKgmin_{nsgv})+ KSKgmin_{nsgv}\cdot(KSKgmax_{nsgv}-KSKtrend_{nsgv})]/[\alpha ROR_{nsgv,t}\cdot(KSKtrend_{nsgv}-KSKgmin_{nsgv})+ (KSKgmax_{nsgv}-KSKtrend_{nsgv})]+d_{nsgv}\cdot KSK_{nsgv,t} \quad (1.12.313)$$

$$S_t - \sum_c SV_{c,t}\cdot P_{c,t} - TRGPvKN_t = \sum_s INVPv_{s,t}\cdot PI_{s,t} \quad (1.12.314)$$

$$KSK_{nsgv,t+1} = (1-d_{nsgv})\cdot KSK_{nsgv,t} + INVPv_{nsgv,t} \quad (1.12.315)$$

$$KSK_{sgv,t+1} = (1-d_{sgv})\cdot KSK_{sgv,t}+INVPb_{sgv,t} \quad (1.12.316)$$

2.3.14 Endogenous variables

ACQUISN	acquisitions less disposals of non-produced non-financial assets expressed in nominal terms (K.2)
BPT	foreign balance at constant prices
CBUD	household budget disposable for consumption
C_c	consumer demand for commodity *c*
CGBUDN	government final consumption expenditure (P.3) in nominal terms
CG_c	government final consumption expenditure (P.3) by type of commodity
CGT	total government final consumption expenditure at constant prices
$CH4EMISEN_{ennel,s}$	CH4 emissions on fuel combustion by fuel and branch of activity expressed in Kt
$CH4EMISENH_{ennel}$	CH4 emissions on fuel combustion in the residential sector by fuel expressed in Kt
CH4EMISH	total CH4 emissions on fuel combustion in the residential sector expressed in Kt
$CH4EMIS_s$	CH4 emissions on fuel combustion by branch of activity expressed in Kt
CH4EMISS	total CH4 emissions on fuel combustion by branches of activity expressed in Kt
CH4EMISTOT	total CH4 emissions on fuel combustion in Kt
CH4EMISTRF	CH4 emissions on fuel combustion by the transport sector expressed in Kt - only the transport part
CH4EMISTRHE	CH4 emissions on fuel combustion by the transport sector expressed in Kt - only the heating part
$CO2EMISEN_{ennel,s}$	CO2 emissions on fuel combustion by fuel and branch of activity expressed in Kt
$CO2EMISENH_{ennel}$	CO2 emissions on fuel combustion in the residential sector by fuel expressed in Kt

CO2EMISH	total CO2 emissions on fuel combustion in the residential sector expressed in Kt
$CO2EMIS_s$	CO2 emissions on fuel combustion by branch of activity expressed in Kt
CO2EMISS	total CO2 emissions on fuel combustion by branches of activity expressed in Kt
CO2EMISTOT	total CO2 emissions on fuel combustion in Kt
CO2EMISTRF	CO2 emissions on fuel combustion by the transport sector expressed in Kt - only the transport part
CO2EMISTRHE	CO2 emissions on fuel combustion by the transport sector expressed in Kt - only the heating part
CT	total private consumption at constant prices
$DEPPb_s$	depreciation related to public capital stock
DEPPbTN	consumption of fixed capital - public administration in nominal terms (K.1)
$DEPPv_s$	depreciation related to private capital stock
E_c	total exports of commodity *c*
EMPI	domestic employment
EMPN	national employment
EN_c	export supply to the rest of the world (net of re-exports)
END_c	export demand from the rest of the world (net of re-exports)
$ENEFFB_s$	energy intensity indicators by branch of activity defined in terms of energy consumption (TJ) per value added for manufacturing and services sectors and energy consumption per GDP for the transport sector
ENEFFH	energy intensity for the residential sector defined in terms of energy consumption (TJ) per household income
$ENERCO_{sel}$	coal-oil bundle used in the production process by the electricity sector
$ENERNE_s$	non-electric energy bundle used in the production process by branch of activity
$ENER_s$	energy bundle used in the production process by branch of activity
$ENINP_{eng,s}$	energy inputs used in the production process by branch of activity
ER	real exchange rate
ET	total exports at constant prices
EV	equivalent variation in income
EVYH	equivalent variation in per cent of household income
GDP	gross domestic product at constant prices
GDPC	gross domestic product at current market prices
GEXP	total government expenditures
$GHGEMISEN_{ennel,s}$	GHG emissions on fuel combustion by fuel and branch of activity expressed in Kt

$GHGEMISENH_{ennel}$	GHG emissions on fuel combustion in the residential sector by fuel expressed in Kt
GHGEMISH	total GHG emissions on fuel combustion in the residential sector expressed in Kt
$GHGEMIS_s$	GHG emissions on fuel combustion by branch of activity expressed in Kt
GHGEMISS	total GHG emissions on fuel combustion by branches of activity expressed in Kt
GHGEMISTOT	total GHG emissions on fuel combustion in Kt
GHGEMISTRF	GHG emissions on fuel combustion by the transport sector expressed in Kt - only the transport part
GHGEMISTRHE	GHG emissions on fuel combustion by the transport sector expressed in Kt - only the heating part
GREV	total government revenues
IGTN	capital formation by the government in nominal terms (P.5)
$INVCPb_{s,c}$	public investment demand for commodities by branch of activity
$INVCPv_{s,c}$	private investment demand for commodities by branch of activity
$INVPb_s$	public investments carried out in different branches of activity
$INVPv_s$	private investments carried out in different branches of activity
IT	total gross capital formation at constant prices
KLE_s	capital-labour-energy bundle (excluding taxes less subsidies on production)
KL_s	value-added by branch (excluding taxes less subsidies on production)
KSK_s	capital demand by branch (capital stock)
LSK_s	number of employees in branch *s*
LSR	active population
LSW	number of commuters
$MARGTM_c$	trade and transport margins by type (trade services and transport services)
M_c	total imports of commodity *c*
MN_c	import demand (net of re-exports) of commodity *c*
MPS	household propensity to save
MT	total imports at constant prices
$N2OEMISEN_{ennel,s}$	N2O emissions on fuel combustion by fuel and branch of activity expressed in Kt
$N2OEMISENH_{ennel}$	N2O emissions on fuel combustion in the residential sector by fuel expressed in Kt
N2OEMISH	total N2O emissions on fuel combustion in the residential sector expressed in Kt
$N2OEMIS_s$	N2O emissions on fuel combustion by branch of activity expressed in Kt
N2OEMISS	total N2O emissions on fuel combustion by branches of activity expressed in Kt

N2OEMISTOT	total N2O emissions on fuel combustion in Kt
N2OEMISTRF	N2O emissions on fuel combustion by the transport sector expressed in Kt - only the transport part
N2OEMISTRHE	N2O emissions on fuel combustion by the transport sector expressed in Kt - only the heating part
P_c	price level of domestic sales (composite commodities coming from imports and domestic production)
PCINDEX	consumer price index
PCT_c	consumer prices (including taxes)
PDD_c	price level of domestic production delivered to home market
$PDDE_c$	price level of domestic production delivered to home and foreign markets
PD_s	price index of domestic production by branch of activity
PE_c	domestic price of exports received by the domestic producers
$PEFOB_c$	domestic price of exports free on board
$PENERCO_{sel}$	price index corresponding to the coal-oil bundle used in the production process by the electricity sector
$PENERNE_s$	price index corresponding to non-electric energy bundle
$PENER_s$	price index corresponding to energy bundle
$PENINP_{eng,s}$	implicit price level of energy vector by branch of activity expressed in mil euro per TJ (net of taxes)
$PENINPH_{eng}$	implicit price level of energy vector consumed by the household, expressed in mil euro per TJ (net of taxes)
PICG	price index corresponding to government final consumption expenditure
PIG	composite price index corresponding to gross capital formation by the government
PIMMOLUX_GR	price of real estate in Luxembourg relative to the price of real estate in Grande Region
PI_s	price index corresponding to investments by branch of activity
PKavr	real average return to capital received by the household
$PKLE_s$	price index corresponding to capital-labour-energy bundle
PKL_s	price index corresponding to value-added by branch of activity (excluding taxes less subsidies on production)
PK_s	return to capital by branch of activity
PL	average wage rate corresponding to domestic employment (net of social security contributions)
PLAVR	national average wage (net of social security contributions)
PLAVRLUX_GR	net wages in Luxembourg relative to net wages in Grande Region

PLAVRT	national average wage (including social security contributions)
PM_c	domestic price of imports (including tariffs)
$PREXP_c$	domestic price of re-exports free on board
rCGBUDGDP	government final consumption expenditure (P.3) to GDP ratio
rIGTGDP	capital formation by the government in nominal terms (P.5) to the GDP ratio
RINT	average return to capital corresponding to firms
ROR_s	normal rate of return to capital
rSGBALGDP	government net lending (+) net borrowing (-) (B.9) to GDP ratio
rSWGDP	balance of the current account to the GDP ratio
rTRLGDP	actual social contributions (D.611) to GDP ratio
rTRVATCGDP	value added type taxes on private final consumption (D.211) to GDP ratio
rTRYHGDP	taxes on individual or household income (D.51A) to GDP ratio
S	total private savings
SGBAL	government net lending (+) net borrowing (-) (B.9) in real terms
SGBALN	government net lending (+) net borrowing (-) (B.9) in nominal terms
SH	household savings
SV_c	change in inventories
SW	balance of the current account
TRGPvKN	government capital transfers receivable (D.9) in nominal terms
TRGWOTHN	other current transfers (D.7) - received by the government from the ROW in domestic currency
TRGWPROPN	property income (D.4) - received by the government from the ROW in domestic currency
TRHG	total transfers received by the household from the government
TRHGOTHN	other current transfers (D.7) - received by the household from the government in nominal terms
TRHGPROPN	property income (D.4) - received by the household from the government in nominal terms
TRHGSB	social benefits other than social transfers in kind (D.62)
TRHGSBOTH	social benefits other than social transfers in kind (D.62) excluding unemployment benefits in real terms
TROPERS	operating surplus (B.2) corresponding to the government
TRPROD	taxes on production and imports (D.2)
TRPRODC	taxes on products (D.21)
TRPRODOTH	taxes on products except VAT and import taxes (D.214)

TRPRODPP	other taxes on production (D.29)
TRPRODTM	taxes and duties on imports excluding VAT (D.212)
TRPRODVAT	value added type taxes (VAT) (D.211)
TRPRODVATFC	value added type taxes on final consumption (D.211)
TRPRODVATIC	value added type taxes on intermediate consumption (D.211)
TRPROP	current taxes on income wealth etc. (D.5)
TRPROPF	taxes on the income or profits of corporations and other current taxes (D.51B+D.59)
$TRPROPFS_s$	taxes on the income or profits of corporations and other current taxes (D.51B+D.59) by branch
TRPROPH	taxes on individual or household income (D.51A)
TRPvGKN	government capital transfers payable (D.9) in nominal terms
TRSOC	actual social contributions (D.611)
TRSOCIN	imputed social contributions (D.612) in nominal terms
$TRSOCS_s$	actual social contributions (D.611) by branch
TRSOCT	social contributions (D.61)
TRST	subsidies by the government on products and production (D.3)
UNEMP	number of unemployed
UNRATE	unemployment rate
VU	level of indirect utility corresponding to the household
X_c	domestic sales of composite commodities coming from imports and domestic production
XDD_c	domestic production delivered to home market
$XDDE_c$	domestic production delivered to home and foreign markets (by type of commodity)
XD_s	domestic production by branch of activity
YH	household income (before tax)
YHD	net household income (after tax)
$\alpha ROR_{s,t}$	parameter in the supply of capital function

2.3.15 Exogenous variables

ACQUIS	acquisitions less disposals of non-produced non-financial assets expressed in real terms (K.2)
CGBUD	government final consumption expenditure (P.3) in real terms
$ENDI_c$	benchmark level of export demand from the rest of the world (net of re-exports)
err	error term in the wage curve

GDPDEF	GDP deflator
IGT	capital formation by the government in real terms (P.5)
LSRI	active population - benchmark level
MPSI	average propensity to save - benchmark level
PIMMOGR	price of real estate in the Grande Région
PLAVRGR	net wages in the Grande Région
PWE_c	world price of exports
PWM_c	world price of imports
$REXP_c$	re-exports by commodity
$RINF_t$	current rate of inflation
shTRHGSBOTH	share of social benefits other than social transfers in kind (D.62) excluding unemployment benefits in total government expenditures
tc_c	tax rate corresponding to other taxes on private consumption
$texc_c$	excise duties on private consumption
$texce_c$	excise duties on re-exports
$texcic_c$	excise duties on intermediate consumption
ti_c	tax rate corresponding to other taxes on investment goods
tic_c	tax rate corresponding to other taxes on intermediate consumption
tk_s	corporate tax rate
tl_s	social security contributions rate
tm_c	tariff rate
tp_s	tax rate on production
TRGPvK	government capital transfers receivable (D.9) in real terms
TRGWOTH	other current transfers (D.7) - received by the government from the ROW in foreign currency
TRGWPROP	property income (D.4) - received by the government from the ROW in foreign currency
TRHGOTH	other current transfers (D.7) - received by the household from the government in real terms
TRHGPROP	property income (D.4) - received by the household from the government in real terms
TRPvGK	government capital transfers payable (D.9) in real terms
TRSOCI	imputed social contributions (D.612) in real terms
tsc_c	subsidy rate on private consumption
tsi_c	subsidy rate on investment goods

$tsic_c$	subsidy rate on intermediate consumption
tsp_s	subsidy rate on production
$tvac_c$	VAT rate on private consumption
$tvae_c$	VAT rate on exports
$tvae_c$	VAT rate on net exports (net of re-exports)
$tvai_c$	VAT rate on investment goods
$tvaic_c$	VAT rate on intermediate consumption
$tvarexp_c$	VAT rate on re-exports
ty	personal income tax rate
UNRATEGR	unemployment rate in the Grande Région
VUI	level of indirect utility corresponding to the household - benchmark level
αH_c	marginal budget shares in the Stone-Geary utility function of the household
$\beta 1$	elasticity of wage differential between Luxembourg and Grande Région in the supply equation for commuters
$\beta 2$	elasticity of price differential for real estate between Luxembourg and Grande Region in the supply equation for commuters
$\beta 3$	elasticity of unemployment rate differential between Luxembourg and Grande Region in the supply equation for commuters
$\beta 4$	intercept in the supply equation for commuters
μH_c	subsistence level out of consumer demand for commodities

2.3.16 Other parameters

aA_c	efficiency parameter in the Armington function for imports
$aENERCO_{sel}$	efficiency parameter of CES production function of the electricity sector (fourth nest)
$aENER_s$	efficiency parameter of CES production function of the firm (third nest)
$aENINP_s$	efficiency parameter of CES production function of the firm (fifth nest for the electricity sector and forth nest for all the other branches)
aF_s	efficiency parameter of CES production function of the firm (third nest)
$aKLEN_s$	efficiency parameter of CES production function of the firm (second nest)
$aKLE_s$	Leontief parameter - share of capital-labour-energy bundle in domestic production (first nest)
aT_c	efficiency parameter in the CET function for exports
d_s	depreciation rate by branch of activity
$elasE_c$	elasticity of export demand

$elasY_c$	income elasticities of demand for commodities
$io_{c,s}$	technical coefficients corresponding to intermediate consumption
$ioCG_c$	Leontief parameter for the allocation of government final consumption expenditures between different goods and services
$ioC_{s,c}$	shares of domestic production delivered to home and foreign markets by branch of activity and commodity
$ioI_{c,s}$	efficiency parameter corresponding to the Leontief function for the private investments by branch of activity and commodity
$ioIG_s$	efficiency parameter corresponding to the Leontief function for the public investments by branch of activity
$KSKgmax_s$	maximum possible growth rate of capital stock in branch *s*
$KSKgmin_s$	minimum possible growth rate of capital stock in branch *s* (equal to the negative of the rate of depreciation in branch *s*)
$limINV_s$	parameter to limit investments carried out in different branches of activity to reasonable values
premLSKF	wage premium for non-resident employees (commuters)
$premLSK_s$	wage premium by branch
shYKG	share of operating surplus (B.2) corresponding to the government
shYKH	share of operating surplus (B.2) corresponding to the household
svr_c	share of inventories in domestic sales
$tcetm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of net exports (net of re-exports)
$tchtm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of private consumption
$tcictm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of intermediate consumption
$tcitm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of investment goods
$tcrextm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of re-exports
$tcetmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of net exports (net of re-exports) – benchmark level
$tchtmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of private consumption – benchmark level
$tcictmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of intermediate consumption – benchmark level
$tcitmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of investment goods – benchmark level

$tcrextmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of re-exports – benchmark level
tcz_{c}	tax rate corresponding to other taxes on private consumption – benchmark level
$texcez_{c}$	excise duties on re-exports – benchmark level
$texcicz_{c}$	excise duties on intermediate consumption – benchmark level
$texcz_{c}$	excise duties on private consumption – benchmark level
$ticz_{c}$	tax rate corresponding to other taxes on intermediate consumption – benchmark level
tiz_{c}	tax rate corresponding to other taxes on investment goods – benchmark level
tkz_{s}	corporate tax rate – benchmark level
tlz_{s}	social security contributions rate – benchmark level
tmz_{c}	tariff rate – benchmark level
tpz_{s}	tax rate on production – benchmark level
trep	replacement rate out of net wage
$tscz_{c}$	subsidy rate on private consumption – benchmark level
$tsicz_{c}$	subsidy rate on intermediate consumption – benchmark level
$tsiz_{c}$	subsidy rate on investment goods – benchmark level
$tspz_{s}$	subsidy rate on production – benchmark level
$tvacz_{c}$	VAT rate on private consumption – benchmark level
$tvaez_{c}$	VAT rate on exports – benchmark level
$tvaez_{c}$	VAT rate on net exports (net of re-exports) – benchmark level
$tvaicz_{c}$	VAT rate on intermediate consumption – benchmark level
$tvaiz_{c}$	VAT rate on investment goods – benchmark level
$tvarexpz_{c}$	VAT rate on re-exports – benchmark level
tyz	personal income tax rate – benchmark level
$\gamma A1_{c}$	CES distribution parameter for the domestic demand from the domestic producers in the Armington function
$\gamma A2_{c}$	CES distribution parameter for imports in the Armington function
$\gamma ENERCO_{sel}$	CES distribution parameter for coal-oil bundle in the production function of the electricity sector (fourth nest)
$\gamma ENEREL_{eng,s}$	CES distribution parameter for electricity in the production function of the firm (third nest)
$\gamma ENERNE_{s}$	CES distribution parameter for non-electric energy bundle in the production function of the firm (third nest)

$\gamma ENER_s$	CES distribution parameter for energy bundle in the production function of the firm (second nest)
$\gamma ENINP_{eng,nsel}$	CES distribution parameter for energy inputs in the production function of the firm (forth nest for all branches of activity except the electricity sector)
$\gamma ENINPG_{eng,sel}$	CES distribution parameter for natural gas in the production function of the electricity sector (fourth nest)
γFK_s	CES distribution parameter for capital in the production function of the firm (third nest)
γFL_s	CES distribution parameter for labor in the production function of the firm (third nest)
γKL_s	CES distribution parameter for value added in the production function of the firm (second nest)
$\gamma T1_c$	CET distribution parameter for domestic production delivered to home markets
$\gamma T2_c$	CET distribution parameter for exports
σA_c	substitution elasticities for the Armington function
$\sigma ENERCO_{sel}$	CES substitution elasticity between the coal-oil bundle and natural gas in the production function of the electricity sector (fourth nest)
$\sigma ENER_s$	CES substitution elasticity between electricity and the non-electric energy bundle in the production function of the firm (third nest)
$\sigma ENINP_s$	CES substitution elasticity between energy inputs in the production function of the electricity sector (fifth nest) and the production function of all other branches of activity (fourth nest)
σF_s	CES substitution elasticity between capital and labour in the production function of the firm (third nest)
$\sigma KLEN_s$	CES substitution elasticity between value added and energy bundle in the production function of the firm (second nest)
σT_c	elasticities of transformation in the CET function

2.3.17 List of sets and subsets used in the model

c	a subscript for one of the commodities (20 types of commodities)
cc	the same as c (used for exposition purposes)
cre	a subscript for the real estate services (1 type of service)
ctm	a subscript for the wholesale and retail trade services and transport services (2 types of services)
enco	a subscript for products of mining and quarrying of energy and refined petroleum products (4 types of commodities)
enel	a subscript for electricity (1 type of commodity)
enfl	a subscript for fuels (1 type of commodity)
eng	a subscript for the energy vector (6 types of commodities)
ennel	a subscript for non-electric energy inputs (5 types of commodities)
nctmn	a subscript for all commodities except energy inputs and trade and transport services (12 types of commodities)
nen	a subscript for all the commodities except the energy vector (14 types of commodities)
nenfl	a subscript for all non-electric energy inputs except fuels (4 types of commodities)
ng	a subscript for the natural gas (1 type of commodity)

nsel	a subscript for all the other branches except the electricity, gas, steam, etc. sector (15 branches of activity)
nsgv	a subscript for all the other branches except the public administration, education and health and social work (13 branches of activity)
ntrs	a subscript for all branches except transport, storage and communication sector (15 branches of activity)
s	a subscript for one of the production activities (16 branches of activity)
sel	a subscript for the electricity, gas, steam, etc. sector (1 branch of activity)
sgv	a subscript for public administration, education and health and social work (3 branches of activity)
t	a subscript for year *t*
trs	a subscript for the transport, storage and communication sector (1 branch of activity)

2.3.18 Value of Luxgem parameters

A CGE model can be written as a system of equations containing a set of unknown parameters θ, such that a vector of exogenous variables, X, produces a vector of endogenous variables Y (Adams and Higgs, 1990):

$$F(Y, X, \theta, \varepsilon) = 0$$

where ε is a vector of stochastic disturbances of either known, partially known or unknown distribution.

The calibration approach implies that:

$$\varepsilon = 0$$

Therefore, the resulting system of equations can be solved for the vector of parameters θ, using only one observation for the base year. The base year data represent the benchmark equilibrium data set or, more specifically, the Social Accounting Matrix. Parameters whose values cannot be inferred from the benchmark equilibrium data set (such as elasticities of substitution in most cases) are either econometrically estimated, or determined through expert knowledge, or obtained from the literature.

The restriction $\varepsilon = 0$ implies that calibration can be interpreted as a non-stochastic approach, as opposed to the stochastic approach of econometrics. This does not mean that economic reality is seen as deterministic when calibrating the CGE models. However, the CGE modeling analyzes the systematic, not the random, responses of economic variables to exogenous stimuli. Thus, ideally, the set of parameters θ of the CGE model produces the systematic part of the total response in Y, with a given X.

A number of parameters in Luxgem are based on a literature survey:

- the elasticity of substitution between capital and labor;
- the elasticity of substitution between imports and domestic goods;
- the elasticity of substitution between exports and domestic goods;
- the price elasticity of export demand;
- the income elasticity of demand for consumption goods;
- the elasticity of real wages to the unemployment rate;
- the real wage elasticity of labor supply;
- the elasticity of savings with respect to the net-of-tax rate of return;

There is little agreement on the magnitude of the substitutability between capital and labor in production. Most studies focus on the US economy. Using capital stock data has generally produced estimates ranging between zero and unity (Arrow, Chenery, Minhas and Solow, 1961; Harrison, Jones, Kimbell and Wigle, 1993; Berndt, 1991; Jorgenson and Yun, 2001). Chirinko, Fazzary and Meyer (2004) estimate an elasticity of approximately

0.40, while Klump, McAdam and Willman (2007) also find that the elasticity of substitution is significantly below unity (between 0.5 and 0.6). Using a new data set from the Bureau of Economic Analysis, Balistreri, McDaniel and Wong (2003) estimate substitution elasticities for 28 industries that cover the entire US economy. Their range of point estimates is between 0.307 and 3.736, higher than the range of existing estimates: 0.16–1.33 (Eisner and Nadiri, 1968).

For the EU countries, to our knowledge, the only available detailed estimates for the elasticity of substitution between labor and capital relate to Finland and Germany. Controlling for biased technical change, Jalava, Pohjola, Ripatti and Vilmunen (2005) find that the elasticity of substitution is significantly below one for Finland, in the range of 0.40-0.50, during 1945-2003.

Kemfert and Welsch (2000) consider two different data sets for the German industry: an aggregate time series data for the entire German industry for the period 1970-1988 and a disaggregated time series data for the period 1970-1988 for seven industrial sectors: chemical products, stone and earth, iron, nonferrous metal, transport, food and paper. Their estimate for the whole industry is approximately 0.79, while the estimates by branch are low for the transport (0.17) and nonferrous metal (0.20) industries and in the range of 0.52-0.58 for the other five industries.

Multi-country CGE models typically employ values of elasticities ranging between 0.12 and 1.68, with lower elasticity values in the agricultural branches and higher values in the services sectors (Burniaux, Nicoletti and Oliveira-Martins, 1992; Weyerbrock, 1998; Lejour, Veenendaal, Verweij and van Leeuwen, 2006; Dimaranan, McDougall and Hertel, 2006).

The choice of the elasticity values in Luxgem is presented in Table 3. Their values are consistent with the literature survey. We use lower elasticity of substitution values for agriculture, transport sector and nonferrous metal industry and higher estimates for the services. The average elasticity value is typically lower than found in the literature, which is more consistent with the Modux estimates.

Table 3: Values of the elasticities of substitution in Luxgem

LuxMod parameters	σKLEN	σF	σENER	σENINP	σENERCO
Agriculture, etc	0.40	0.24	0.50	0.30	0.00
Mining and quarrying of energy producing materials	0.00	0.00	0.00	0.00	0.00
Manufacture of coke, refined petroleum products, etc.	0.00	0.00	0.00	0.00	0.00
Manufacturing	0.50	0.32	0.50	0.30	0.00
Electricity, gas, steam, etc	0.40	0.35	0.50	0.30	0.95
Construction	0.40	0.35	0.50	0.30	0.00
Wholesale and retail trade services	0.40	0.35	0.50	0.30	0.00
Hotels and restaurants	0.40	0.35	0.50	0.30	0.00
Transport, storage and communication	0.40	0.35	0.50	0.30	0.00
Financial sector	0.40	0.35	0.50	0.30	0.00
Real estate services	0.40	0.35	0.50	0.30	0.00
Business services	0.40	0.35	0.50	0.30	0.00
Public administration	0.40	0.35	0.50	0.30	0.00
Education	0.40	0.35	0.50	0.30	0.00
Health and social work	0.40	0.35	0.50	0.30	0.00
Other services	0.40	0.35	0.50	0.30	0.00

Note: σKLEN stands for the elasticity of substitution between value added and the energy bundle; σF stands for the elasticity of substitution between capital and labour; σENER stands for the elasticity of substitution between electricity and the non-electric energy bundle; σENINP stands for the elasticity of substitution between non-electric energy inputs; σENERCO stands for the elasticity of substitution between the coal-oil bundle and natural gas in the production function of the electricity sector.

CGE models typically employ elasticities of substitution between domestic goods and imports from econometric work that uses time series variation in prices (Alaouze et al., 1977; Stern et al., 1976; Gallaway et al., 2003). These estimates take the price variation as exogenous in estimating the import demand functions, ignoring the

quality variation, and therefore tend to systematically understate the true elasticity (Hertel, Hummels, Ivanic and Keeney, 2007).

Recent work by Hertel, Hummels, Ivanic and Keeney (2007) employ a cross-section data set, built by Hummels (1999), drawing on tariffs and bilateral transportation costs for goods traded internationally. The reason for taking into account transportation costs is that in cross-section they vary more widely than tariffs do, allowing more accurate estimation for the trade elasticities. Compared to the previous estimates, the average of the estimates at 40 industry level is 7.0, larger than the average corresponding to previous estimates (around 5.3). Even though the difference between the two average estimates is rather small, there is much greater variation in the econometrically estimated elasticities by industry. The elasticities of substitution between imports and domestic goods in Luxgem draw on Hertel, Hummels, Ivanic and Keeney (2007).

The elasticity of substitution between exports and domestic goods and the price elasticity of export demand in Luxgem are consistent with the assumption of a very open economy (the case of Luxembourg) and in line with the values used by Burniaux et al. (1992) and Weyerbrock (1998) for the EU (Table 4).

Table 4: Values of the elasticities of substitution and income elasticity of demand in Luxgem

LuxMod parameters	σA	σT	elasY	elasE
Agriculture, etc	5.80	-8.00	0.13	10.00
Natural gas	17.00	-1.90		10.00
Other products of mining and quarrying of energy	17.00	-1.90		10.00
Liquid fuels	4.20		1.22	
Fuels	4.20	-5.00	1.22	10.00
Other products of coke, refined petroleum, etc.	4.20	-5.00	1.22	10.00
Manufacturing	7.00	-6.00	1.07	10.00
Production and distribution of electricity	5.60	-5.00	1.22	10.00
Other gas, steam and hot water supply			1.22	
Construction			1.22	
Wholesale and retail trade services	3.80	-4.00	1.22	10.00
Hotels and restaurants	3.80	-4.00	1.22	10.00
Transport, storage and communication	3.80	-4.00	1.16	10.00
Financial sector	3.80	-4.00	1.22	10.00
Real estate services	3.80	-4.00	1.15	10.00
Business services	3.80	-4.00	1.22	10.00
Public administration		-4.00	1.22	10.00
Education	3.80		1.07	
Health and social work	3.80		1.23	
Other services	3.80	-4.00	1.22	10.00

Note: σA stands for the elasticity of substitution between composite imports and domestic goods; σT stands for the elasticity of substitution between composite exports and domestic goods; elasY stands for the income elasticity of demand for consumption goods; elasE stands for the price elasticity of export demand.

The income elasticities of demand for consumption goods (Table 4) rely on estimates by Seale, Regmi and Bernstein (2003). They use a two-stage, cross-country demand system fit to the 1996 International Comparison Project (ICP) data to estimate income elasticities for nine broad categories of consumption across 114 countries. The consumption groups include: food, beverage and tobacco; clothing and footwear; education; gross rent, fuel and power; house furnishings and operations; medical care; recreation; transport and communications; and other items.

The elasticity of real wages with respect to the unemployment rate in Luxgem draws on the estimate by Sanz-de-Galdeano and Turunen (2006) for the euro area (Table 5). They use longitudinal micro data to examine the wage curve for the euro area over the period 1994-2001.

Table 5: Values of other parameters in Luxgem

LuxMod parameters	Value
Unemployment elasticity	-0.10
Wage elasticity of labor supply	0.20
Net-of-tax rate of return elasticity of private savings	0.40

The wage elasticity of labour supply plays an important role, especially in evaluating the magnitude of the efficiency cost of income taxation. A large number of studies have estimated the uncompensated elasticity of labour supply. However, the variation in the results and the methodologies to estimate the elasticity is large: see Blundell and MaCurdy (1999) for an extensive review. Furthermore, no such study is available for Luxembourg. Two robust findings about the elasticity can be drawn from the literature: first, the real wage elasticity of labour supply of women exceeds that of men and secondly, the elasticity regarding the decision to participate (the extensive margin) is larger than the elasticity of the decision regarding the hours worked (the intensive margin). Evers, Mooij and van Vuuren (2005) construct a "meta sample" using empirical estimates of the elasticity found in the literature with the aim to identify the sources of variation in empirical estimates of the uncompensated labour supply elasticity. The variation in elasticity values are explained by study characteristics, running meta regressions. Using a sample of 239 elasticities drawn from 32 empirical studies in the literature they conclude that: the assumption regarding the relation between the hours worked and the wage rate (linear, quadratic, log-linear or double-log) does not have a significant impact on the elasticity estimates; the difference between elasticities among countries is small; females have a larger labour supply elasticity than males, even after controlling for participation rates. Drawing on their analysis, the wage elasticity of labour supply (for both women and men) used in Luxgem is provided in Table 5. Other studies (Immervoll et al., 2005) employ even lower values corresponding to wage elasticity of labour supply for Luxembourg (around 0.1).

The range of empirical results corresponding to the effects of the net-of-tax rates of return on savings is also wide. From a theoretical point of view, an increase in the rate of return generates both an income and a substitution effect which go in opposite directions. Elmendorf (1996) underlines an additional "wealth" effect that positively contributes to the elasticity of savings with respect to the rate of return, by inducing revaluations of existing wealth. Although the "wealth" effect reinforces the substitution effect it does not resolve the theoretical ambiguity regarding the sign of the net effect. Empirical estimates range from negative, insignificant or clustered around zero (Blinder and Deaton, 1985; Hall, 1988; Skinner and Feenberg, 1990; Bosworth and Burtless, 1992) to rather large values: 0.2-0.6 (Boskin, 1978; Barro, 1992; Feldstein, 1995). A review of the existing studies on the interest elasticity of savings is provided by Boadway and Wildasin (1995). Despite the uncertainty regarding this elasticity, Elmendorf (1996) underlines that models that are likely to describe the behavior of people that account for most of the aggregate saving generally imply positive interest elasticities. Based on a basic life-cycle model with empirically-supported parameters, Elmendorf (1996) generates an elasticity of about 0.5. However, its magnitude is sensitive to the exact parameter choices. The choice of the elasticity of savings with respect to the rate of return in Luxgem is provided in Table 5, which is consistent with the typical values found in the CGE literature.

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Annexe I: Note sur la matrice de comptabilité sociale de Luxgem

1. Introduction

La matrice de comptabilité sociale (MCS) est la base de données sur laquelle reposent les modèles d'équilibre général calculables (EGC). Elle retrace l'ensemble des transactions qui ont lieu dans une économie donnée. Le modèle est calibré sur les données contenues dans la MCS, et les équations du modèle doivent reproduire fidèlement ces données à l'année de base. Cette procédure (calibration) permet de tester la cohérence à la fois des données et des équations du modèle théorique. Un des avantages des modèles EGC par rapport aux modèles économétriques ou les modèles DSGE est qu'ils reposent souvent sur une MCS désagrégée et détaillée comprenant toutes les branches économiques. Cette structure désagrégée permet d'obtenir les impacts sectoriels des chocs de politique économique.

La structure de la MCS repose sur celle des tableaux "Ressources-Emplois" (TRE) qui sont des matrices fournissant une description détaillée des processus de production intérieurs et des transactions en produits de l'économie nationale par branche d'activité et par groupe de produits. Ils donnent un aperçu:

- de la structure des coûts de production;
- des revenus générés dans le processus de production;
- des flux de biens et services produits dans l'économie nationale;
- des flux de biens et services en provenance et vers l'étranger.

La matrice de comptabilité sociale (MCS) comprend 40 branches d'activité et 51 biens et services.
La matrice est composée des blocs ou comptes suivants:

- compte des produits (biens et services);
- compte de production (branches d'activité);
- compte des facteurs de production;
- comptes (secteurs) institutionnels;
- compte en capital;
- compte du reste du monde;
- autres comptes.

Nous présentons les comptes en colonnes étant donné la symétrie de la matrice. Par ailleurs nous associerons, si nécessaire, à chaque bloc les lignes utilisées pour faciliter la lecture et la compréhension.

2. Compte de production (branches d'activité)

En ce qui concerne le compte de production, la MCS du Luxembourg est constituée des consommations intermédiaires des branches d'activité et de la valeur ajoutée. Les consommations intermédiaires aux prix d'acquisition proviennent du tableau des emplois. Les consommations intermédiaires des vecteurs énergétiques proviennent du fichier"

CI_Energie_2007oct", feuille "EurAggBr2004" fourni par le STATEC.

Les valeurs ajoutées (au prix de base) des branches d'activité proviennent également du tableau des emplois. Les données relatives aux taxes sur le travail (D.611) et sur le capital (D.51B + D.59) proviennent du fichier global

des comptes nationaux (feuille d1430)[1], fourni par le STATEC. Les taxes sur le travail (D.611) ont été ventilées par branche d'activité suivant les taux moyens de cotisations sociales provenant des statistiques de l'Inspection Générale de la Sécurité Sociale (IGSS) pour l'année 2003. Les taxes sur le capital (D.51B + D.59) ont été ventilées proportionnellement à l'excédent net d'exploitation (B.2n) par branche d'activité. Par différence entre les rémunérations du travail (capital) et les taxes sur le travail (capital) par branche d'activité, nous avons obtenu les rémunérations nettes du travail (du capital) par branche. Les taxes et les subventions sur la production proviennent du tableau des emplois.

3. Compte des produits (biens et services)

Les livraisons de chaque branche d'activité sont ventilées par types de produits selon les données contenues dans le tableau des ressources. La MCS comprend ainsi 51 biens et services parmi lesquels 14 vecteurs énergétiques.

Les vecteurs énergétiques disponibles dans la MCS sont:

1. la houille;
2. le lignite;
3. le gaz naturel;
4. les autres produits d'extraction des produits énergétiques.

Pour la branche "Extraction des produits énergétiques":

5. les combustibles liquides (y.c. le mazout);
6. les carburants;
7. les cokes et goudrons;
8. les produits des industries nucléaires;
9. les autres produits du raffinage;
10. les autres produits de la cokéfaction, raffinage et industries nucléaires.

Pour la branche "Cokéfaction, raffinage et industries nucléaires":

11. l'électricité;
12. les combustibles gazeux distribués;
13. les supports énergétiques;
14. les autres produits gazeux, de vapeur et d'eau chaude.

Pour la branche "Production et distribution d'électricité, de gaz, de vapeur et d'eau chaude".

Les vecteurs énergétiques proviennent du STATEC. Les vecteurs 4, 10 et 14 sont obtenus par différence entre la valeur totale de la branche et la valeur totale des autres vecteurs disponibles dans la branche. Ces vecteurs représentent des valeurs quasi nulles (environ 1 million d'euro).

Pour des raisons de disponibilité des données et de pertinence des vecteurs énergétiques, la MCS agrégée comprend 20 biens et services parmi lesquels 7 vecteurs énergétiques. Les 7 vecteurs énergétiques disponibles dans la MCS 2004 agrégée sont:

1. le gaz naturel;
2. les autres produits d'extraction des produits énergétiques;

[1] Tous les codes se rapportent à la nomenclature officielle du STATEC relative aux comptes nationaux tels que figurant dans les fichiers publiés sur le site de diffusion. www.statistiques.public.lu.

3. les combustibles liquides (y.c. mazout);
4. les carburants;
5. les autres produits de la cokéfaction, du raffinage et des industries nucléaires;
6. l'électricité;
7. les autres produits gazeux, de vapeur et d'eau chaude.

Le vecteur 2 représente l'agrégation des vecteurs énergétiques "Houille" et "Lignite" et les "Autres produits d'extraction des produits énergétiques". Le vecteur 5 représente l'agrégation des vecteurs énergétiques "Cokes et goudrons", "Produits des industries nucléaires", "Autres produits du raffinage" et "Autres produits d'extraction des produits énergétiques". Le vecteur 7 représente l'agrégation des vecteurs énergétiques "Combustibles gazeux distribués", "Supports énergétiques" et "Autres produits gazeux, de vapeur et d'eau chaude".

Pour les taxes sur les produits nous distinguons actuellement:

- TVA sur la consommation intermédiaire (D.214);
- Impôts sur les produits, à l'exclusion de la TVA et des impôts sur les importations;
(D.214) perçus sur la consommation intermédiaire;
- Droits d'accise sur la consommation intermédiaire (D.2122C);
- TVA sur la consommation finale des ménages (D.211);
- TVA sur les investissements (D.211);
- TVA sur les exportations nettes (D.211);
- TVA sur les réexportations (D.211);
- Droits d'accise sur les exportations (D.2122C);
- Impôts sur les produits, à l'exclusion de la TVA et des impôts sur les importations;
(D.214) perçus sur la formation brute de capital fixe
- Impôts sur les produits, à l'exclusion de la TVA et des impôts sur les importations;
(D.214) perçus sur la consommation finale des ménages
- Droits d'accise sur la consommation finale des ménages (D.2122C);
- Droits sur les importations (D.2121);
- Subventions sur les importations (D.311) sur la consommation intermédiaire;
- Subventions sur les importations (D.311) sur la consommation finale des ménages;
- Subventions sur les importations (D.311) sur la formation brute de capital fixe;

La ventilation des impôts et droits sur les importations à l'exclusion de la TVA par bien et service (autres que les vecteurs énergétiques) est faite selon les données fournies par le STATEC.

Les valeurs des taxes et des subventions sur les vecteurs énergétiques proviennent du fichier "CI_Energie_2008Fev" contenant le tableau "Make and use, produits énergétiques, 2004, prix courants, mio EUR" dans la feuille "ERE2004". Les importations des vecteurs énergétiques appartenant à la branche d'activité "Cokéfaction, raffinage et industries nucléaires" ont été ajustées suite à la différence entre les données de consommation finale totale des ménages provenant du tableau des emplois et celles du fichier "CI_Energie_2008Fev". Ainsi, nous avons augmenté la consommation finale des ménages pour les vecteurs énergétiques de cette branche d'activité afin d'atteindre la consommation finale des ménages provenant du tableau des emplois.

La ventilation des marges de commerce et de transports entre consommation intermédiaire et composantes de la demande finale (consommation finale des ménages, formation brute de capital fixe, exportations) s'est faite au prorata. Les valeurs des marges sur les exportations ont été annulées pour certains biens car elles étaient négligeables et les exportations nulles.

4. Compte des facteurs de production

Les rémunérations des travailleurs entre les résidents et les non résidents s'est faite grâce aux données sur les rémunérations des non résidents provenant du fichier global des comptes nationaux (feuille d1100) fourni par le STATEC. Les rémunérations du capital appartiennent intégralement aux ménages résidents (faute d'information de la ventilation entre ménages et firmes).

5. Comptes (secteurs) institutionnels

Les données sur la consommation finale des ménages et des administrations publiques proviennent du tableau des emplois (aux prix d'acquisition). Les transferts des administrations publiques vers les ménages comprennent les "revenus de la propriété (D.4)", les "prestations sociales autres que transferts sociaux en nature (D.62)", et les "autres transferts courants (D.7)". Le transfert des ménages vers les administrations publiques représente les cotisations sociales imputées (D.612). Ce montant à été légèrement ajusté afin d'équilibrer le compte des administrations publiques. Les données proviennent du fichier global des comptes nationaux (feuille d1400) fourni par le STATEC. L'impôt sur les revenus des ménages provient du fichier global des comptes nationaux (feuille d1430) fourni par le STATEC. L'épargne nette des administrations publiques provient du fichier global des comptes nationaux (feuille d1400) fourni par le STATEC. L'épargne des ménages est obtenue par solde entre les recettes et les dépenses des ménages.

6. Compte en capital

Le compte en capital se compose de la formation brute de capital fixe (FBCF) du secteur privé, de la FBCF du secteur public et de la variation de stocks. Les données sur la formation brute de capital fixe proviennent du tableau des emplois. La formation brute de capital fixe du secteur public provient du fichier "Luxgem_Dimaria" provenant du STATEC. En effet, la FBCF du secteur public représente la FBCF des "Administrations publiques, services collectifs généraux et sécurité sociale obligatoire (AP 75)", "Education (AP 80)" et "Santé et action sociale (AP 85)".

Nous avons procédé à un ajustement de la FBCF de "Métallurgie" et "Construction" suite à la valeur négative des acquisitions nettes d'objets de valeur dans la "Métallurgie" et par conséquent une valeur négative de la FBCF de cette dernière. Cet ajustement est compensé par un ajustement dans la "Construction". Les formations brutes de capital de la "Métallurgie" et de la "Construction" restent inchangées suite à l'ajustement via la variation des stocks.

Les transferts en capital payés et reçus proviennent du fichier global des comptes nationaux (feuille d1130). Les transferts en capital à payer contiennent également les "acquisitions moins cessions d'actifs non financiers non produits (K.2)".

7. Comptes du reste du monde

Les exportations proviennent du tableau des emplois alors que les importations proviennent du tableau des ressources. Les importations comme les exportations ont été ajustées pour passer de la définition de la "consommation intérieure" à la définition de la "consommation nationale". Dès lors, d'une part nous avons soustrait la consommation des non résidents de la consommation finale des ménages et nous l'avons ajoutée aux exportations et, d'autre part nous avons soustrait la consommation des résidents à l'étranger des importations et nous l'avons ajoutée à la consommation finale des ménages.

L'épargne du reste du monde est obtenue par solde entre les recettes et les dépenses des comptes respectifs. D'autres ajustements ont été simultanément faits sur les importations et les exportations afin de tenir compte des biens et services réexportés. Les réexportations représentent l'excédent des exportations sur la production domestique. Le solde des exportations nettes (exportations totales moins importations totales) reste inchangé. La modélisation des comportements des agents économiques et de l'économie est décrite à l'annexe III.

8. Les autres comptes

Les autres comptes contiennent les détails relatifs au système fiscal de l'économie luxembourgeoise. Ils contiennent également les taxes et les subventions sur les produits et la production. Les statistiques présentes dans ce bloc proviennent des blocs production, produits et secteurs institutionnels présentés ci-dessus.

Annexe II: La matrice de comptabilité sociale du Luxembourg

MATRICE DE COMPTABILITE SOCIALE DU LUXEMBOURG

ANNEE 2004 Million d'EURO

			Commodities																		
			Agriculture, etc	Natural gas	Other products of mining & quarrying of	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Manufacturing	Production and distribution of Electricity	Other gas, steam & hot water supply	Construction	Wholesale and retail trade services	Hotels and restaurants	Transport, storage & communication	Financial sector	Real estate services	Business services	Public administration	Education	Health and social work	Other services
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Commodities	Agriculture, etc	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Natural gas	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other products of mining and quarrying of energy	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Liquid fuels	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fuels	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other products of coke, refined petroleum, etc.	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manufacturing	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Production and distribution of electricity	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other gas, steam and hot water supply	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Construction	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wholesale and retail trade services	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hotels and restaurants	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport, storage and communication	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Financial sector	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Real estate services	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Business services	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public administration	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Education	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Health and social work	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other services	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Production sectors	Agriculture, etc	21	276	0	0	0	0	0	10	0	0	3	0	6	0	0	0	0	0	0	0	0
	Mining & quarrying of energy producing materials	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manufact.of coke, refined petrol. products, etc.	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manufacturing	24	0	0	0	0	0	0	7 917	1	1	4	100	0	11	0	49	81	0	0	0	2
	Electricity, gas, steam, etc	25	0	0	0	0	0	0	0	335	255	46	3	0	5	0	2	32	0	0	0	0
	Construction	26	0	0	0	0	0	0	0	0	0	3 655	9	0	0	0	8	29	0	0	0	0
	Wholesale and retail trade services	27	0	0	0	0	0	0	10	0	0	1	3 854	6	15	0	49	249	0	0	0	0
	Hotels and restaurants	28	0	0	0	0	0	0	0	0	0	0	5	978	0	0	4	3	0	0	0	1
	Transport, storage and communication	29	0	0	0	0	0	0	10	0	0	186	29	3	5 428	4	9	33	0	0	0	0
	Financial sector	30	0	0	0	0	0	0	3	0	0	0	5	0	0	28 207	69	0	0	0	0	0
	Real estate services	31	0	0	0	0	0	0	1	0	0	24	2	20	0	0	2 938	9	0	0	0	6
	Business services	32	0	0	0	0	0	0	19	1	0	0	31	0	11	0	19	3 964	0	1	0	6
	Public administration	33	0	0	0	0	0	0	7	0	0	8	0	0	63	0	11	3	1 920	0	3	0
	Education	34	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	1 107	0	0
	Health and social work	35	0	0	0	0	0	0	0	0	0	0	0	15	0	0	3	2	0	0	1 708	3
	Other services	36	0	0	0	0	0	0	6	0	0	0	9	6	4	0	5	7	0	2	0	1 546
Factors of production	Labour	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Capital	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Institutions	Firms	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Households	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Governments	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other accounts	VAT on intermediate consumption	42	0	0	0	4	1	0	47	2	2	62	1	4	20	11	23	227	0	3	0	4
	Other taxes on intermediate consumption	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103	0	0	0	0
	Excise duties on intermediate consumption	44	0	0	0	0	176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VAT on households consumption	45	9	0	0	8	98	0	472	7	4	8	12	17	24	9	8	15	0	1	2	18
	VAT on investments	46	0	0	0	0	0	0	28	0	0	196	0	0	0	0	0	5	0	0	0	0
	VAT on net exports	47	0	0	0	0	0	0	0	0	0	0	0	0	172	57	0	0	0	0	0	0
	VAT on re-exports	48	0	0	0	0	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Excise duties on exports	49	0	0	0	0	359	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other taxes on investments	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0
	Other taxes on products on consumption	51	1	0	0	0	0	0	66	10	0	0	0	2	0	27	0	16	0	0	0	22
	Excise duties on household consumption	52	0	0	0	0	263	0	464	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tariffs	53	1	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subsidies on intermediate consumption	54	-25	0	0	0	0	0	0	-2	0	0	0	0	-56	0	0	0	0	0	0	-14
	Subsidies on households consumption	55	-9	0	0	0	0	0	0	-1	0	0	0	0	-160	0	0	0	0	0	-1	-5
	Subsidies on investments	56	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taxes on labour	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taxes on capital	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taxes on income	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taxes on production	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subsidies on production	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trade margins on interm. Consumption	62	17	0	0	5	62	1	384	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trade margins on househ. Consumption	63	91	0	0	17	91	1	1 719	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trade margins on GFCF	64	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trade margins on exports	65	7	0	0	0	125	1	560	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport margins on interm. consumption	66	1	0	0	0	1	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport margins on househ. consumption	67	0	0	0	0	1	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport margins on GFCF	68	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport margins on exports	69	1	0	0	0	1	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital – Private		70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital – Public		71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Changes in stocks		72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROW		73	358	186.2	8.0	102.3	1 053.8	30	12 580	149	0	0	142	126	1 526	13 341	158	4 358	0	89	42	454
Total		74	727	186	9	136	2 302	34	24 534	504	262	4 192	4 201	1 187	7 064	41 656	3 355	9 187	1 920	1 203	1 754	2 044

Production sectors																Factors of producti		Institutions		
Agriculture, etc	Mining & quarrying of energy producing	Manufacture of coke, refined	Manufacturing	Electricity, gas, steam, etc	Construction	Wholesale and retail trade services	Hotels and restaurants	Transport, storage and communication	Financial sector	Real estate services	Business services	Public administration	Education	Health and social work	Other services	Labour	Capital	Firms	Households	Governments
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
35	0	0	229	0	1	0	38	0	0	0	0	2	1	1	0	0	0	0	265	0
0	0	0	0	186	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	11	0	0	6	1	5	4	0	3	3	5	7	5	0	0	0	82	0
4	0	0	17	1	15	17	1	391	2	0	10	3	0	3	5	0	0	0	791	0
0	0	0	14	2	4	1	0	3	1	0	0	1	1	3	1	0	0	0	13	0
88	0	0	4 286	80	623	132	227	302	182	10	180	34	34	180	75	0	0	0	4 945	160
5	0	0	143	5	5	24	17	23	17	0	10	8	2	15	13	0	0	0	116	0
0	0	0	60	41	1	4	4	18	21	1	2	32	2	6	5	0	0	0	65	0
2	0	0	35	20	16	28	8	72	75	47	21	248	25	61	34	0	0	0	61	0
0	0	0	135	0	3	228	3	22	1	1	19	2	1	3	13	0	0	0	138	0
0	0	0	12	1	3	20	2	46	25	1	23	7	2	61	4	0	0	0	684	0
0	0	0	30	3	10	53	4	1 193	480	2	70	19	1	9	23	0	0	0	313	76
8	0	0	124	9	50	139	24	374	19 581	129	85	26	2	21	28	0	0	0	523	0
0	0	0	52	1	176	198	44	37	160	158	107	60	10	10	16	0	0	0	1 607	0
3	0	0	683	39	1 257	984	90	614	2 102	182	962	153	23	86	239	0	0	0	138	39
0	0	0	0	0	0	0	0	0	19	0	0	4	0	0	0	0	0	0	13	1 879
0	0	0	4	0	0	3	1	23	2	0	13	2	15	6	11	0	0	0	112	1 011
4	0	0	0	0	0	0	0	0	0	0	0	3	1	16	0	0	0	0	445	1 284
3	0	0	27	1	6	31	16	30	15	1	78	5	1	12	408	0	0	0	552	194
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	1 196	66	774	943	224	889	2 057	53	1 335	839	720	704	378	0	0	0	0	0
54	0	0	370	101	354	736	128	686	1 658	1 327	467	17	5	152	70	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6 358	6 034	0	0	5 022
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	0	222	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	366	17	238	277	69	276	564	15	364	258	199	197	107	0	0	0	0	0
15	0	0	105	29	101	209	36	195	471	377	133	5	1	43	20	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 825	0
1	0	0	4	0	3	3	0	4	427	13	2	1	0	1	1	0	0	0	0	0
-24	0	0	-36	0	-13	-13	-1	-14	-1	-66	-12	0	-3	-8	-11	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	294	76	71	162	51	512	422	749	178	0	0	0	139	0	0	0	4 504	-326
0	0	0	0	0	0	0	0	0	0	0	0	286	63	142	0	0	0	0	0	1 071
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 842	0	0	0	0
295	**0**	**0**	**8 167**	**678**	**3 701**	**4 184**	**990**	**5 701**	**28 285**	**2 999**	**4 052**	**2 016**	**1 113**	**1 732**	**1 585**	**10 200**	**6 125**	**0**	**17 414**	**10 411**

Other accounts																												Capital	Capital	Change	ROW	Total
VAT on intermediate consumption	Other taxes on intermediate	Excise duties on intermediate	VAT on households	VAT on investments	VAT on net exports	VAT on re-exports	Excise duties on exports	Other taxes on investments	Other taxes on products on consumption	Excise duties on household consumption	Tariffs	Subsidies on intermediate consumption	Subsidies on households consumption	Subsidies on investments	Taxes on labour	Taxes on capital	Taxes on income	Taxes on production	Subsidies on production	Trade margins on interm. Consumption	Trade margins on househ. Consumption	Trade margins on GFCF	Trade margins on exports	Transport margins on interm. consumption	Transport margins on househ. consumption	Transport margins on GFCF	Transport margins on exports					
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	73
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	146	727
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	186
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	136
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1 035	2 302
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-12	2	34
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 527	169	104	11 197	24 534
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	504
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	262
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 318	978	143	0	4 192
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	470	1 918	154	692	0	0	0	0	0	0	0	399	4 201
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	298	1 187
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	12	3	28	0	0	0	4 709	7 064
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20 531	41 656
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	719	3 355
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	571	30	22	968	9 187
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1 920
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 203
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 754
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	2	644	2 044
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	295
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8 167
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	678
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 999
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 016
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 732
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 585
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10 200
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6 125
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17 414
411	103	176	712	229	229	71	359	51	144	727	17	-97	-177	-1	2951	1740	1825	461	-202	0	0	0	0	0	0	0	0	0	0	0	370	10 411
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	411
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-177
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 951
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 740
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	461
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-202
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	470
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 918
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	154
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	692
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	441	0	-2 577	4 762
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	1 618
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	271	0	0	0	271
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38 545
411	103	176	712	229	229	71	359	51	144	727	17	-97	-177	-1	2 951	1 740	1 825	461	-202	470	1 918	154	692	23	12	3	28	4 762	1 618	271	38 545	

Annexe III: Tableaux synoptiques sur la consommation d'énergie et les émissions de gaz à effet de serre

Energy consumption by branches of activities

	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass	Other Fuels	Total
	TJ	TJ	TJ	TJ	TJ	
Agriculture / Forestry / Fisheries	1,017.68			70.00		1,087.68
Public Electricity and Heat Production	164.79		24,526.81		1,571.31	26,262.91
Iron and Steel		12.42	4,546.83			4,559.25
Non-Ferrous Metals	656.99					656.99
Chemicals						
Pulp, Paper and Print						
Food Processing, Beverages and Tobacco						
Other Industries	4,266.89	3,381.75	12,832.75			20,481.39
Civil Aviation	9.97					9.97
Road Transportation	95,241.37					95,241.37
Railways	294.12					294.12
Navigation	80.00					80.00
Commercial / Institutional	4,890.60	38.41	4,936.16	184.03		10,049.19
Residential	4,923.00	38.41	4,936.16	184.03		10,081.59

Source: UNFCCC Reporting tables for Luxembourg for the year 2004, Submission 2007 v3.1

Share of the different energy inputs by branches of activities

	Other products of mining and quarrying of energy	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Production and distribution of electricity	Other gas, steam and hot water supply
Agriculture, etc	98.41%	100.00%	0.33%	1.59%	100.00%	100.00%
Mining and quarrying of energy producing materials	0.00%	0.00%	0.00%	0.00%		0.00%
Manufacture of coke, refined petroleum products, etc.	0.00%	0.00%	0.00%	0.00%		0.00%
Manufacturing	33.37%	100.00%	1.32%	66.63%	100.00%	100.00%
Electricity, gas, steam, etc	0.00%	100.00%	0.08%	100.00%	100.00%	100.00%
Construction	0.02%	0.99%	1.22%	31.57%	3.91%	1.08%
services	0.00%	14.96%	1.36%	7.46%	17.55%	3.74%
Hotels and restaurants	2.71%	2.60%	0.10%	0.26%	12.33%	4.40%
communication	0.00%	12.75%	30.99%	17.64%	16.89%	18.85%
Financial sector	0.00%	11.09%	0.12%	3.80%	12.77%	22.30%
Real estate services	0.00%	0.18%	0.03%	0.20%	0.36%	1.28%
Business services	0.00%	8.21%	0.82%	1.45%	7.70%	2.24%
Public administration	0.35%	6.43%	0.21%	4.93%	5.91%	33.02%
Education	0.00%	12.43%	0.04%	4.75%	1.83%	1.90%
Health and social work	0.00%	18.38%	0.25%	20.13%	11.22%	6.07%
Other services	0.00%	11.99%	0.40%	4.74%	9.54%	5.11%
Households	0.00%	100.00%	62.72%	100.00%	100.00%	100.00%

Source: Luxgem Social Accounting Matrix for 2004 and own calculation

Energy consumption by branch of activities using the Luxgem model disaggregation

	Other products of mining and quarrying of energy	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Production and distribution of electricity	Other gas, steam and hot water supply
	TJ	TJ	TJ	TJ	TJ	TJ
Agriculture, etc	0.00	1,017.68	317.63	0.00	302.23	0.00
Mining and quarrying of energy producing materials	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of coke, refined petroleum products, etc.	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing	1,132.67	4,923.88	1,258.10	2,261.51	15,084.67	17,379.57
Electricity, gas, steam, etc	0.00	164.79	80.55	0.00	1,195.10	24,526.81
Construction	0.01	48.29	1,170.99	12.13	167.63	53.40
Wholesale and retail trade services	0.00	731.60	1,298.70	2.86	751.63	184.72
Hotels and restaurants	1.04	127.09	95.28	0.10	527.94	217.11
Transport, storage and communication	0.00	623.41	29,638.96	6.78	723.54	930.52
Financial sector	0.00	542.29	115.27	1.46	546.89	1,100.84
Real estate services	0.00	9.02	27.94	0.08	15.43	63.39
Business services	0.00	401.45	782.26	0.56	329.60	110.77
Public administration	0.14	314.39	203.20	1.89	252.95	1,630.15
Education	0.00	608.12	37.62	1.82	78.23	93.67
Health and social work	0.00	898.66	239.02	7.73	480.48	299.57
Other services	0.00	586.28	384.06	1.82	408.80	252.00
Households	0.00	4,923.00	59,975.88	38.41	2,904.67	4,936.16

Source: own calculation

CO2 emissions factors by branch of activity and fuel type

	Other gas, steam and hot water supply	Other products of mining and quarrying of energy	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Production and distribution of electricity
	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Agriculture, etc	0.00	0.00	73.82	73.03	0.00	0.00
Mining and quarrying of energy producing materials	56.08	97.33	77.91	73.03	97.33	0.00
Manufacture of coke, refined petroleum products, etc.	56.08	97.33	77.91	73.03	97.33	0.00
Manufacturing	56.08	97.33	77.91	73.03	97.33	0.00
Electricity, gas, steam, etc	56.10	0.00	74.10	73.03	0.00	0.00
Construction	56.10	97.50	74.10	73.03	97.50	0.00
Wholesale and retail trade services	56.10	97.50	74.10	73.03	97.50	0.00
Hotels and restaurants	56.10	97.50	74.10	73.03	97.50	0.00
Transport, storage and communication	56.10	97.50	74.10	73.03	97.50	0.00
Financial sector	56.10	97.50	74.10	73.03	97.50	0.00
Real estate services	56.10	97.50	74.10	73.03	97.50	0.00
Business services	56.10	97.50	74.10	73.03	97.50	0.00
Public administration	56.10	97.50	74.10	73.03	97.50	0.00
Education	56.10	97.50	74.10	73.03	97.50	0.00
Health and social work	56.10	97.50	74.10	73.03	97.50	0.00
Other services	56.10	97.50	74.10	73.03	97.50	0.00
Households	56.10	97.50	74.10	73.03	97.50	0.00

Source: UNFCCC Reporting tables for Luxembourg for the year 2004, Submission 2007 v3.1 and own calculation

N2O emissions factors by branch of activity and fuel type

	Other gas, steam and hot water supply	Other products of mining and quarrying of energy	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Production and distribution of electricity
	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Agriculture, etc	0.0000	0.0210	0.2626	0.0000	0.0000	0.0000
Mining and quarrying of energy producing materials	0.2100	0.1604	0.2626	0.2100	0.0000	0.0210
Manufacture of coke, refined petroleum products, etc.	0.2100	0.1604	0.2626	0.2100	0.0000	0.0210
Manufacturing	0.2100	0.1604	0.2626	0.2100	0.0000	0.0210
Electricity, gas, steam, etc	0.0000	0.0126	0.2626	0.0000	0.0000	0.0221
Construction	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Wholesale and retail trade services	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Hotels and restaurants	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Transport, storage and communication	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Financial sector	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Real estate services	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Business services	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Public administration	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Education	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Health and social work	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Other services	0.2100	0.2100	0.2626	0.2100	0.0000	0.1050
Households	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000

Source: UNFCCC Reporting tables for Luxembourg for the year 2004, Submission 2007 v3.1 and own calculation

CH4 emissions factors by branch of activity and fuel type

	Other gas, steam and hot water supply	Other products of mining and quarrying of energy	Liquid fuels	Fuels	Other products of coke, refined petroleum, etc.	Production and distribution of electricity
	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Agriculture, etc	0.0000	0.0000	0.1848	2.7240	0.0000	0.0000
Mining and quarrying of energy producing materials	0.0682	0.4650	0.3567	2.7240	0.4650	0.0000
Manufacture of coke, refined petroleum products, etc.	0.0682	0.4650	0.3567	2.7240	0.4650	0.0000
Manufacturing	0.0682	0.4650	0.3567	2.7240	0.4650	0.0000
Electricity, gas, steam, etc	0.2648	0.0000	0.3100	2.7240	0.0000	0.0000
Construction	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Wholesale and retail trade services	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Hotels and restaurants	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Transport, storage and communication	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Financial sector	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Real estate services	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Business services	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Public administration	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Education	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Health and social work	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Other services	0.0310	0.4650	0.1860	2.7240	0.4650	0.0000
Households	0.0003	0.0001	0.0063	0.0000	0.0001	0.0000

Source: UNFCCC Reporting tables for Luxembourg for the year 2004, Submission 2007 v3.1 and own calculation