MODELLING A SMALL OPEN ECONOMY: WHAT IS DIFFERENT? THE CASE OF LUXEMBOURG.

First draft

Comments welcome[*]

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[*] This paper describes the current version of modux, STATEC's econometric model of Luxembourg. Modux has been developed by STATEC and has benefited from the research undertaken at CREA (Cellule de Recherche en Economie Appliquée) at the University of Luxembourg for years. More recently, close cooperation with X. Timbeau and E. Heyer from Paris-based OFCE dynamised the development and helped set up the current version. My thanks go to all the researchers involved at those two Institutions as well as to the Economists from STATEC for past and future comments. All remaining errors are of course mine.

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1. Overview

1.1 Aim of the paper

Modux is STATEC's current macro-econometric model. It's an annual model, used for forecasting and policy simulation. The aim of the paper is to describe the structure and properties of modux. One focus lies on econometric results concerning the 50 endogenous variables. The lecture of that part of the paper might seem cumbersome due to the notations. But the latter is based on French acronyms of the variables it stands for (i.e. VAB = valeur ajoutée brute = gross value added). Some practice will help.

The theoretical underpinnings of the main behavioural relations in Modux have recently been improved through collaboration with Paris-based OFCE (Organisme Français des Conjonctures économiques). Whereas some parts seem well specified now, (factor demand) others need more research (presence of foreign workers in Luxembourg). In any case, the aim of the paper is not a theoretical derivation of the economic relations to be estimated but rather an ad-hoc approach, that puts a lot of emphasis on analogies and comparisons with other models. Comparative analysis shows that contemporary macro-econometric models, used for forecasting and policy simulation, are always a compromise between economic theory and data constraints imposed by national accounts or other sources.

Indeed, an important goal of this paper is to describe modux with respect to three models of three neighbouring countries, namely Belgium, France and the Netherlands. For the main behavioural equations, systematic parallels are drawn between SAFE (Netherlands, CPB[1]), e-mod.fr (OFCE, France[2]) and Modtrim II (Bureau du Plan, Belgium[3]). The results of two standard simulations (rise in world demand, multiplier effect of public expenses) are compared with respect to two of the models (SAFE, e-mod.fr).

1.2 Main results

We would like to put forward the following findings:

- It seems very well possible to develop a comprehensive and complex econometric model for Luxembourg. This has been done before (SEO/STATEC 1991) but long term properties of the former model "mod-L" lacked consistency as regarded long term properties (no error-correction equations).

[1] SAFE, A quarterly model of the Dutch economy for short-term analysis; CPB document no. 42, December 2003. The model will be referenced hereafter under it's name or under Chauvin CPB (2003).

[2] The model is e-mod.fr, the reference publication is Chauvin Valérie, Gaël Dupont, Eric Heyer, Mathieu PLance, Xavier Timbeau; *Le modèle France de l'OFCE, la nouvelle version: e-mod.fr*, Revue de l'OFCE no. 81, april 2002. The model will be referenced hereafter under it's name or under Chauvin et al. (2002).

[3] Hertveldt B., I. Lebrun; *MODTRIM II: A quarterly model for the Belgian economy*; Federal Planning bureau Working paper no. 6-03, may 2003. The model will be referenced hereafter under it's name or under Hertveldt (2003).

- This can be done with quite a lot of consistency as regards economic theory and econometric techniques.
- However, problems remain concerning short observation spans for some variables (hence, few degrees of freedom), structural breaks and instability of more recent data: this leads to parameter instability that asks for calibration in some cases.
- The work carried out allows to put emphasis on specificities of the small and open economy that is Luxembourg.
    - Exports are split into three separately modelled categories (goods, financial and non-financial services);
    - Two sectors (banking and other private sectors) are treated endogenously, resulting in respective factor demand and price equations;
    - Labour supply is endogenous – cross-border workers and migrations (in and out) depend on economic conditions in the neighbouring regions;
- The output-gap is an explaining variable for prices and external trade. Potential output is modelled endogenously which is consistent with endogenous labour supply. In forecasting and simulation exercises, it is derived iteratively from the successive model outcomes.
- Simulation of standard shocks reveals some basic properties of the Luxembourg economy:
    - the multiplier of public expenses is somewhat smaller than for the comparison models which is consistent with the openness of the economy;
    - a revival of world trade reveals a similar impact on GDP for Luxembourg but a much higher response of imports; the latter derives from the high import-content of all activities on the Luxembourg territory.
- Other shocks can help understand the functioning of the Luxembourg labour market as regards allocation of labour between resident and non-resident workers: a positive shock on the domestic economic that raises employment *and* revenues attracts more foreign workers which tends to annihilate to some extent the beneficial effects on the national (resident) labour market.

The structure of the remainder of the paper is as follows:

Section 2 deals with the main stylized facts of the Luxembourg economy and the challenges they impose on the model builder. Section 3 outlines the global structure of the model and explains data sources and properties. Section 4 comments most of the behavioural equations and gives some reference to theoretical underpinnings. Section 5

exposes the simulated shocks that allow to analyse the main properties of modux as all variables interact. Section 6 finally gives some hints on possible future developments.

[4] The model is e-mod.fr, the reference publication is Chauvin Valérie, Gaël Dupont, Eric Heyer, Mathieu PLance, Xavier Timbeau; *Le modèle France de l'OFCE, la nouvelle version: e-mod.fr*, Revue de l'OFCE no. 81, april 2002. The model will be referenced hereafter under it's name or under Chauvin et al. (2002).

[5] SAFE, A quarterly model of the Dutch economy for short-term analysis; CPB document no. 42, December 2003. The model will be referenced hereafter under it's name or under Chauvin CPB (2003).

[6] Hertveldt B., I. Lebrun; *MODTRIM II: A quarterly model for the Belgian economy*; Federal Planning bureau Working paper no. 6-03, may 2003. The model will be referenced hereafter under it's name or under Hertveldt (2003).

2. The stylized factors

The purpose of this part is to give an overview of the stylized factors and the main questions that arise in the analysis of the macro-economic relations in Luxembourg in the light of the model-builder.

2.1 High economic growth, high GNP per capita

Luxembourg is a special country in many respects. One of the smallest in the world, it has become among the richest in the last twenty years regarding GNP par capita (see figure 2.1). GNP figures however are affected by flows of factor income and may not be the best indicator for material well-being. However[7],

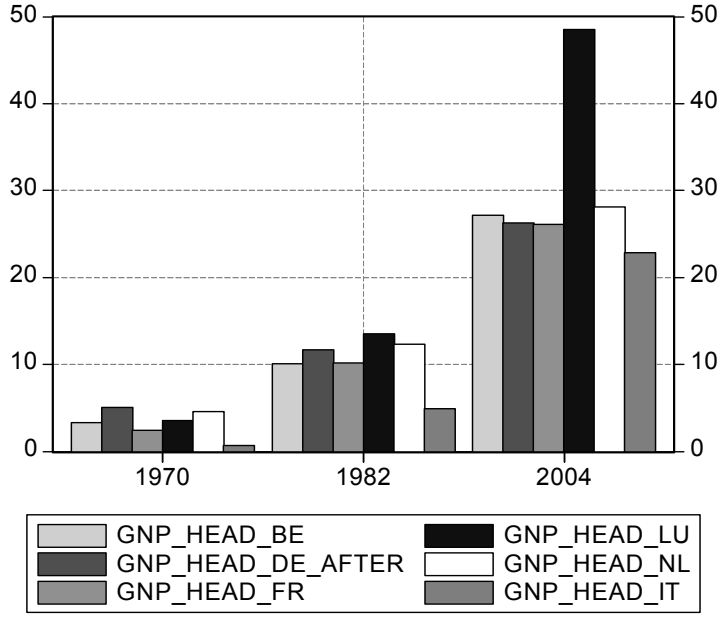
- Luxembourg has the highest revenue par household in purchasing power parities;
- it ranks third as regards the percentage of households that fall below 60% of the median disposable income (knowing that the latter is by far the highest among th 15 EU countries);
- it ranks fourth as regards the equality of income distribution as measured by the ratio of the revenue of the top 20% against the poorest 20% of households.

Since 1970, GDP growth has averaged 4.3% in volume; from 1985 to 2002, growth amounts to 5.1% per year. For the EU15, the corresponding figure is (an unchanged) 2.4%. Population has risen by 0.9% per year since 1970 and by 1.1% from 1985 to 2002.

The task of the model builder is to isolate the factors that have contributed to high growth and high household revenues.

[7] STATEC (2003), p. 169.

Figure 2.1: GNP / head of population, 1000 eur[8]



2.2 Economy dominated by two sectors over the last 30 years: iron/steel and banking

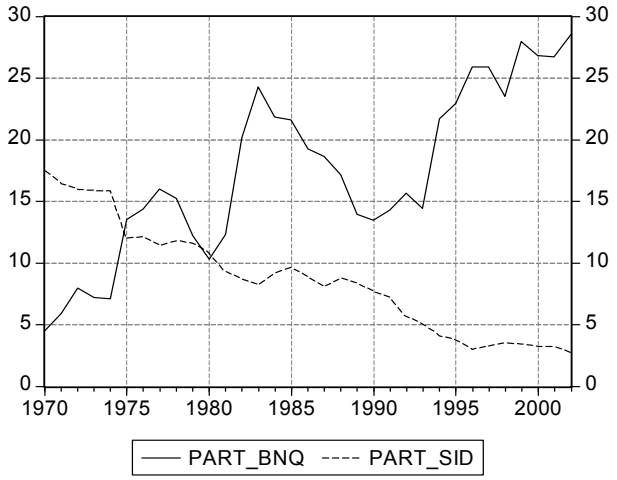
The question might arise as to what extent this economic success was due to one big industry. As a matter of fact, two sectors dominated the Luxembourg economy over the last 30 years. Until the beginning of the oil-shock induced crisis of the 1970's, the country relied heavily on iron and steel making. The part of the iron and steel industry in GDP culminated in the early seventies at close to 17% of GDP. It has declined to as little as 3% at the beginning of the 21st century.

When the steel crisis came to ask heavy intervention from the Luxembourg government to prevent mass-unemployment and help with restructuring, taxes collected in the starting-up banking sector were more than welcome. Today the banking sector amounts to about 25% of GDP and is an even more important source of government revenues.

This heavy reliance on two sectors that are export orientated requires separating exported goods from services and financial services from other services. It then demands a very precise definition of world demand for Luxembourg's exports. Indeed, because of specialization, the structure of the client countries' imports is very different from Luxembourg's exports.

[8] The sources for all data are either STATEC or Eurostat, except stated otherwise.

Figure 2.2: Parts of Banking (BNQ) and Iron&Steel (SID) in Value added



2.3 Very high degree of openness

Small countries are usually open economies. Luxembourg is in that respect again rather singular with a degree of openness of 150%. In Europe, the next following country is Ireland with about half that value.

The interesting feature of Luxembourg is that not only goods and services are being exchanged with the rest of the world but also production factors. Labour flows in massively from neighbouring regions; foreign workers can be resident or non resident: today, about 60% of the workforce is non-luxembourgish, 40% non-resident. In 2003, as little as 3% of net job creation was attributed to Luxembourgers by nationality. Very high FDI (Foreign direct investment) ratios signal huge inflows (as well as outflows) of capital. In 2001, one third of jobs in market branches were tied to inflowing FDI.

Thus, the task for the model-builder is to endogenize labour supply whereas it is commonly exogenous in most other models. Another question is how to take into account from a technical viewpoint substitutability or complementarity between nationals, other residents and cross-border workers. Probably, a production function with these different categories of labour would be the theoretical foundation for our empirical investigation. Furthermore, the question is how to explain economically labour inflows? It seems to be necessary to proxy reservation wages for residents and non-residents. Unemployment differentials should also play.

Figure 2.3: Degree of openness (X+M)/2*GDP

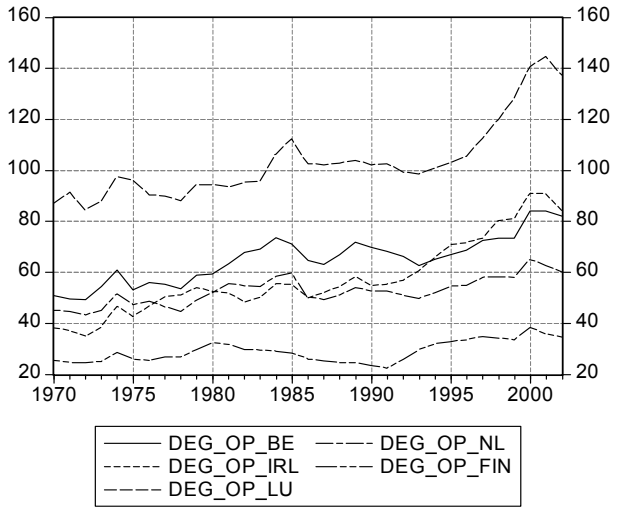


Figure 2.4: Split of the workforce by nationality and residence (luxembourgers, non-luxembourgers and cross-border workers)

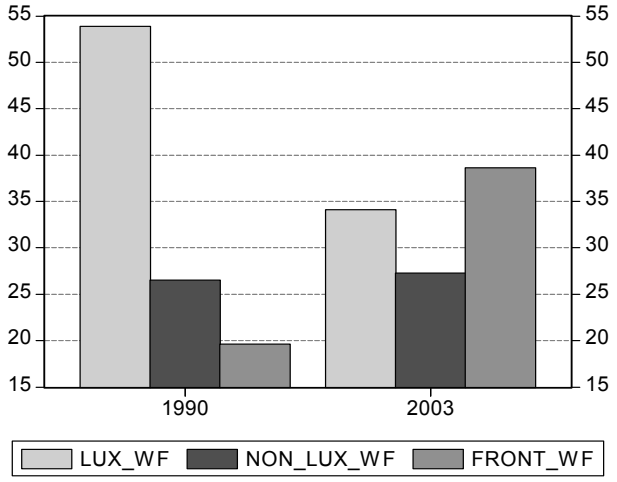
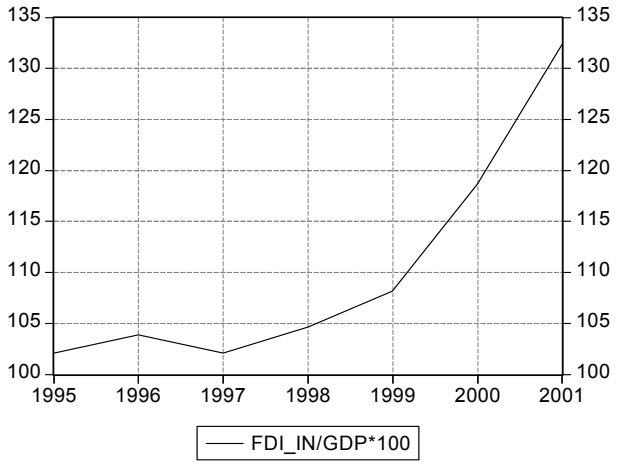


Figure 2.5: Inflowing FDI as % of GDP



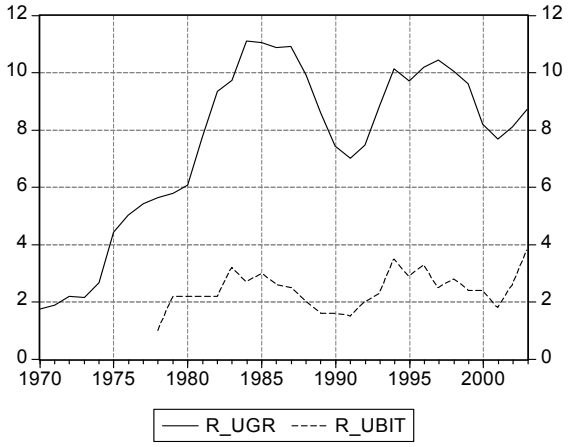
2.4 Luxembourg as the centre of the "Grande Région Saar-Lor-Lux"

The economic interactions of Luxembourg with the neighbouring "Länder", "départements" or "provinces" are of uttermost importance. Unemployment can be evaluated to at least as much as 200'000 people in the Grande Région, depending on the territories embraced. Although many people coming to work to Luxembourg have high qualifications and often are known to have had a job before, the unemployment rate in these regions, which lies in between 7% to 11% in 1985-2002, plays a proven role in the wage formation process in Luxembourg and in the competitiveness between residents and cross-border workers.

Across the border shopping has a high tradition in this area, in any direction. Pressure on the housing market in Luxembourg leads to higher housing prices (and wealth) in those regions.

The model builder has to quantify the economic forces and interactions at play with the "Grande Région". This is difficult due to the absence of regional statistics for many aggregates and/or long time series. On the other hand, it is impossible to model threshold effects like lower reservation wages in the neighbouring regions if there is not enough variance in the variables involved (the difference remains constantly high …).

Figure 2.6: Harmonised unemployment rates in the Grande Région (UGR) and in Luxembourg



2.5 Automatic indexation of wages and other social parameters

Luxembourg is the last EU15 country that has full and automatic wage indexation. Social parameters like child benefits or minimum wages are also indexed on the price of private consumption. In a country with such a high degree of openness, diverging value added (=export) and final consumption (=import) prices can create a severe competitiveness problem through terms of trade shocks.

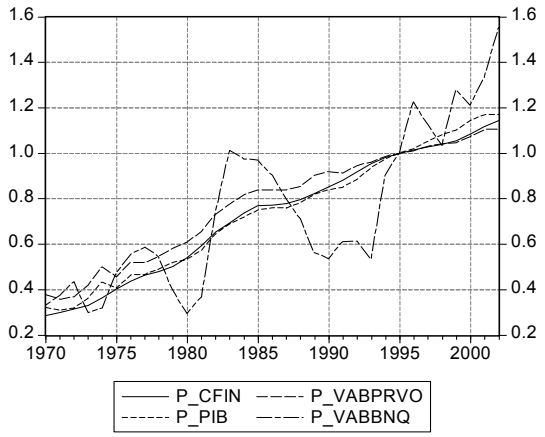
It has however to be stated that wage indexation can be temporarily outset – this happened indeed in the aftermath of the oil price shock of the beginning of the 1980'ies and following the devaluation of the Belgian/Luxembourg franc[9].

Data shows that from 1970 to 2002, consumer prices grew modestly faster than value added prices: about 0.4% per year and 0.2% since 1985.

How does wage indexation interfere with the wage formation process? What is the role of value added prices in the wage equation? Could we find out if there is there any difference in wage outcomes between countries with and without automatic wage indexation?

[9] In 1982, the Belgian/Luxembourg Franc was devaluated against other currencies of the EMS. From 1982 to 1984, it lost about 8% against the DM and the Dutch guilder (in nominal terms).

Figure 2.7: Private consumption, GDP, value added (banking and other market sectors) prices



3. Data and the structure of the model

3.1 Data and related problems

Data is annual, starting in 1970. ESA95[10] data has been published by STATEC for the period 1985-2003; unpublished (and unbalanced) data goes back to 1980. Data prior to 1980 exists in the ESA79 framework and has been used to back-cast the ESA95 series until 1970. This however has lead to a large statistical discrepancy between expenditures and resources. Estimation results with pre-1980 data have therefore to be taken carefully.

The annual frequency of the data is not a problem in itself. The problem lies in the short time span it covers and in the presence of structural breaks that cause estimation of valid relationships to be more difficult. The Luxembourg economy is indeed being characterized by at least two structural breaks:

- the switchover from the iron and steel sector to the banking sector as the driving force of the economy;
- the rise of (national) unemployment and its growing interference with the wage formation process.

Data on the Luxembourg economy is also incomplete. Sector accounts exist only for the public sector. Therefore, disposable income of households had to be proxied but does not comprise non-labour revenues (except imputed rentals for house owners). Unpublished data (i.e. not completely checked and balanced by the national accountants) concerns the capital stock and input-output type tables.

To some extent, progress in work over the last years has also revealed weak data due to high revisions: henceforth, estimated parameters tend to be unstable if degrees of freedom

[10] European system of (national) accounts.

are very low. If weak data should not be a problem in the absence of structural breaks or with data covering long time spans, it obviously is one in the case of Luxembourg. The careful use of dummy variables can be a remedy to correct outliers among the most recent observations.

High variability (standard errors) of the data can be ranged within the same category of problems: parameters otherwise significant, tend to appear as non-significant. Calibration can help but has to be used carefully.

3.2 Sectors and main variables

The economy is split into 5 sectors (data labels as in modux):

- government SNM (ESA95 sector code S13, national, local and social security taken together);
- resident households MEN (S14+S15, comprising NPISH[11]);
- banking and insurance firms BNQ (ESA95 sector code S12 or NACE 65-67);
- other private firms PRVO;
- rest of the world.

There do not exist sector accounts for households or private companies. Government sector accounts go back only to 1990.

Consumption is split into private (CFIN) and public (G). We distinguish four investment goods (I): housing (of all sectors) (RES), public (SNM), banking (BNQ) and “all the rest” (MEQ) i.e. mainly machinery and equipment and non housing construction by non-banking firms.

Exports (X) and imports (M) comprise four categories: goods (B) , financial services (COM for commissions or fees since the interest rate margin is not included), “other” services (SO) and consumption of non-resident households (CETR).

Employment (EMP) is split into resident (NAT) and non-resident (cross-border) (FRIN) and, by sector, into private non-banking, banking and public. A distinction is also being made between number of workers and total working time (L). Average hours worked (HO) are used to construct a measure of total labour input (L=HO*EMP).

Unemployment (U) derives from (resident) active population and employment. The unemployment rate is the harmonised rate (R_UBIT), according to the labour force survey. Active population (POPACT) derives from total population (POP) and is the sum of national employment (EMPNAT) and unemployed (UBIT). Labour supply is endogenous and therefore migration flows, in (MIGRIN) and out (MIGROUT), are modelled as well.

[11] Non-profit institutions serving households (ASBL or Associations sans but lucrative).

All variables exist (if relevant) in nominal and real terms (_R). Usually, Nominal = real * prices and prices are therefore modelled endogenously.

Some variables are expressed in "ratios" (such as the unemployment rate or the activity rate) and are symbolized by R_.

All in all, modux comprises 450 variables of which 300 are endogenous but only 50 are based on estimated equations (i.e. there are 250 definition equations).

3.3 The overall structure: five different blocks

We distinguish five different blocks:

- the determination of (volume) GDP;
- employment;
- wages and prices;
- population and unemployment;
- public sector;

Each block is described in more detail in the subsequent paragraphs. One sub-chapter is dealing with potential GDP and the output-gap as both concepts deserve special reference in the case of Luxembourg due to their non-standard treatment. Indeed, modux treats potential GDP endogenously in forecasting exercises which is coherent with endogenous labour supply.

3.3.1 Determination of volume GDP

GDP in volume (PIB_R) is being determined under the expenditure side. The following variables are treated endogenously (i.e. through estimated functions):

- private consumption (CFIN_R);
- demand for residential, machinery/equipment and banking sector investment goods (capital demand CAPN is the dependent variable of which investment I is derived with the intervention of the depreciation rate);
- exports (X) and imports (M) of goods (B) and other (non-financial services SO) as well as consumption of residents abroad (CLUX_R) and of non-residents in Luxembourg (CETR_R).

Together with the exogenous components (public consumption G and investment ISNM, exports of financial services XCOMM), this allows the determination of GDP under the expenditure side.

PIB_R = CFIN_R + CG_R + I_R + DST_R + XBS_R – MBS_R

where I_R = ISNM_R + IMEQ_R + IBNQ_R + IRES_R

and XBS_R = XB_R + XSO_R + XCOMM_R + CETR_R

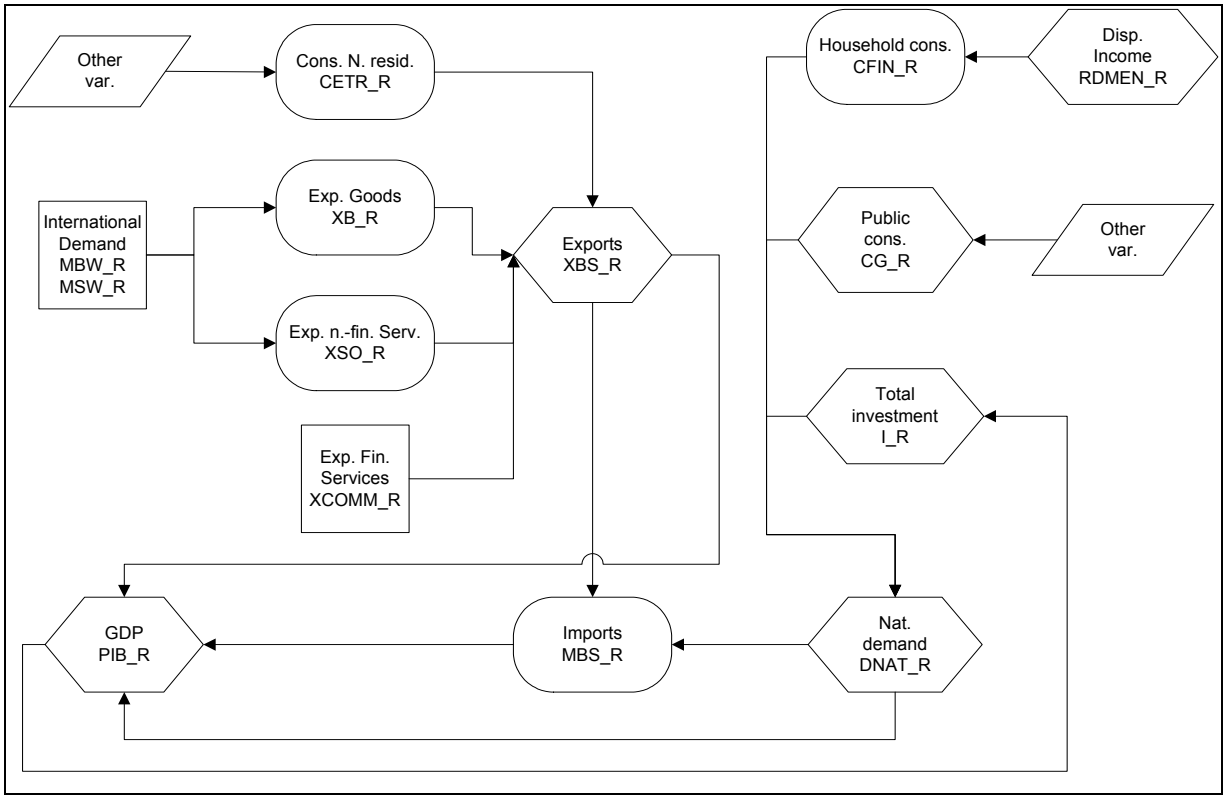
To sum up, _R stands for volumes and CFIN is final private consumption, CG public consumption, I investment or gross fixed capital formation, DST changes in stocks, XBS total exports and MBS total imports. ISNM is investment by the public sector, IMEQ is investment in machinery and equipment, IBNQ is investment by the banking sector and IRES is residential investment. XB are exports of goods, XSO exports of other (i.e. non-financial) services, XCOMM exports of banking fees and CETR consumption of non-residents in Luxembourg. Finally, CLUX is consumption of residents abroad.

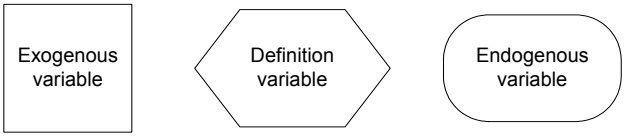
On the production side, public sector value added VABSNM is partly exogenous (it depends on wages that are endogenous and on employment that is exogenous as well as on other expenditure categories that are exogenous); financial services value added depends (more or less mechanically) on the relevant components of the expenditure side: hence, we can derive, by subtraction, private, non-banking value added.

VABPRVO_R = PIB_R – VABSNM_R – VABBNQ_R – IMPROD_R + SUBV_R + PRODI_R

where VABPRVO is private, non-banking value added, VABSNM non-market or public value added, IMPROD taxes linked to imports and production, SUBV subsidies and PRODI imputed banking services (interest margins or FISIM).

Figure 3.1: GDP from the expenditure side



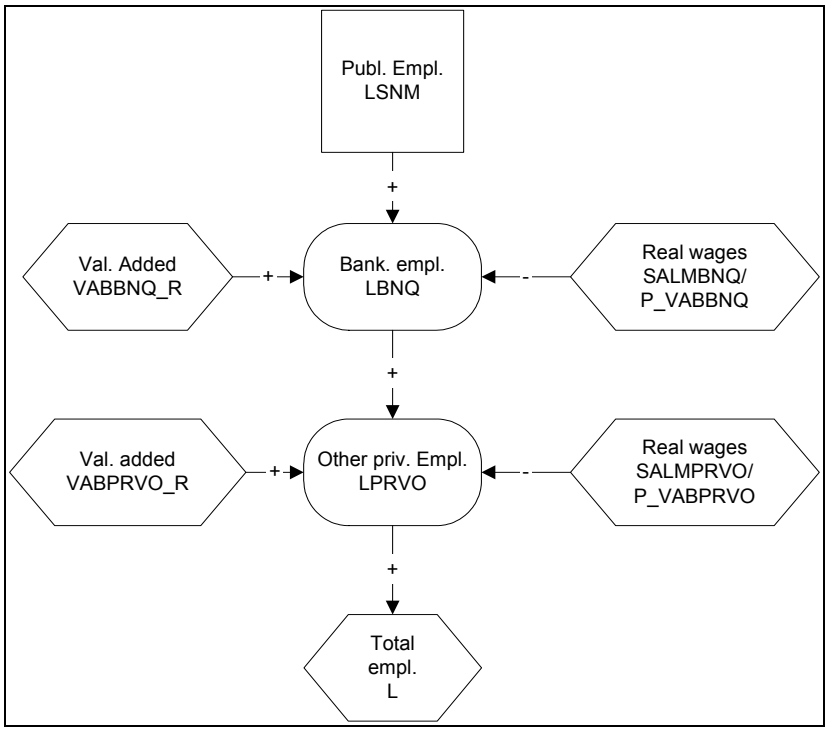


3.3.2 Employment

Employment, that is measured in effective terms (L=EMP*HO) depends on value added and real wages. A trend term is added that captures trend productivity. We derive employment endogenously for the private non banking sector and for the banking sector.

So the dependant variable is total hours worked per year, L. This entails that we do have a good observation of hours worked: as a matter of fact, they are derived from the yearly labour force survey that does not comprise cross-border workers which is a potential source of bias. Another statistical source however has been added to crosscheck the validity of the data: social security files comprise both resident and non-resident workers' "hours declared" which are not necessarily hours really worked. Both data sources do not contain however big differences and do henceforth not preclude the utilization of the LFS data. Public employment is exogenous, being one of the main decision variables of the Government.

Figure 3.2: Employment

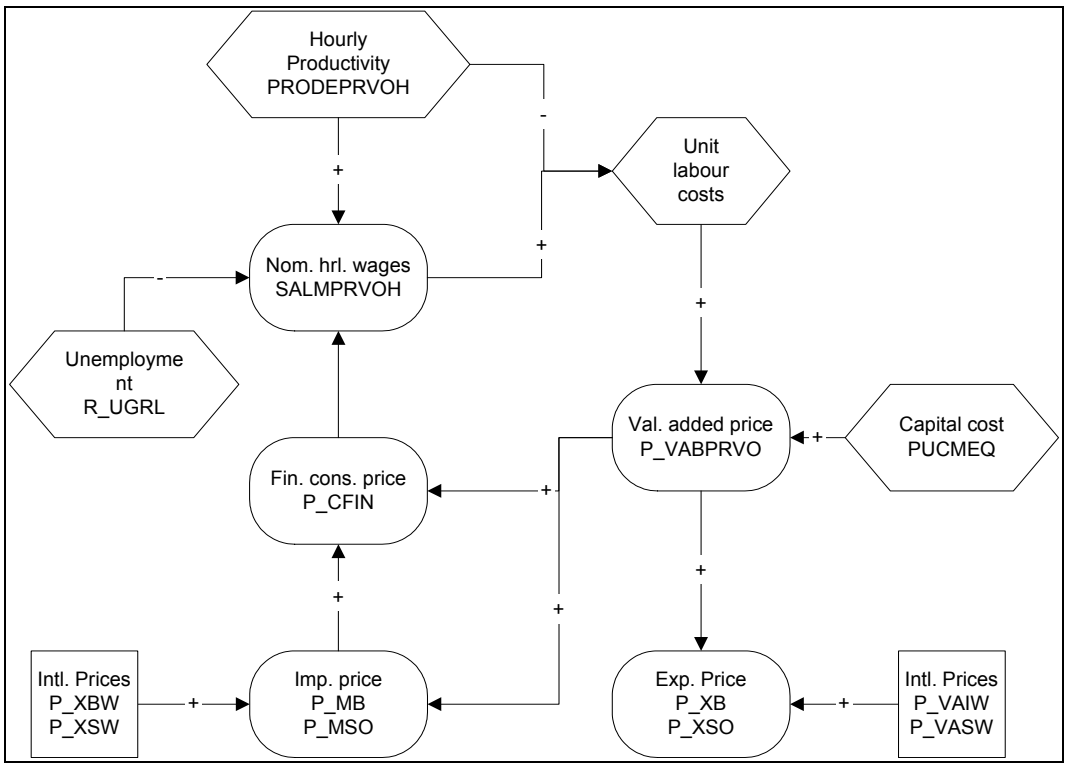


3.3.3 Prices and wages

All variables on the GDP expenditure side are being expressed in volume and value. Hence we need to model prices (P_). Very generally, prices depend on domestic (value added) prices and on foreign/international prices. Value added prices are modelled as a mark-up on unit labour costs and on capital services prices. In the short run, the output gap is an explaining variable of value added prices.

Foreign prices are expressed in national currencies and are being multiplied by nominal effective exchange rates. The latter respect the weights of the seven most important trading partners of Luxembourg (B, F, D, NL, I, UK, USA). Wages of the two private sectors are being treated endogenously.

Figure 3.3: Wage/price spiral (private, non-banking)

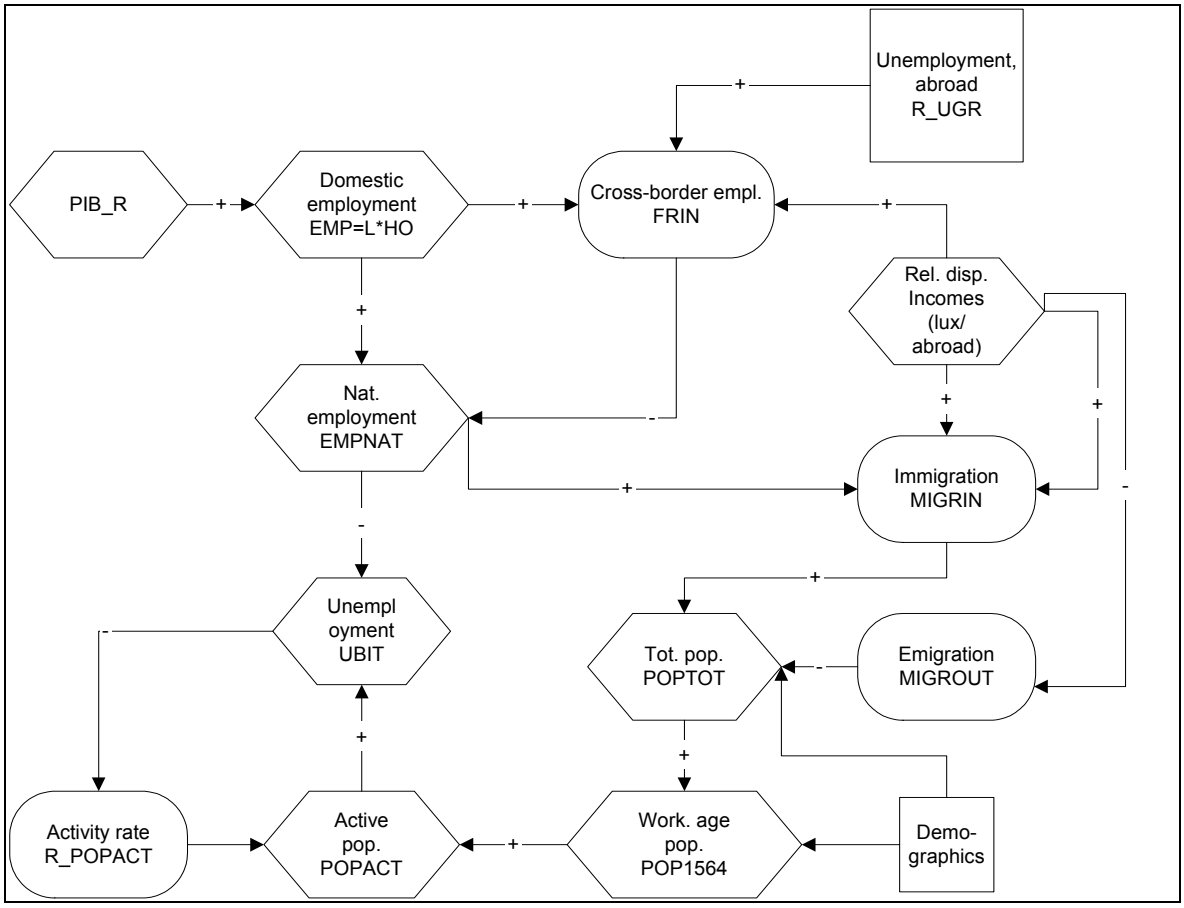


3.3.4 Population and unemployment

Total population (POPTOT) is endogenous because migration flows (MIGRIN and MIGROUT) are driven by job creation and relative real disposable incomes. Working age population (POP1564) is derived mechanically through a fixed coefficient from total population. Active population depends on working age population through the activity rate (R_POPACT) that is modelled endogenously. The activity rate depends on the unemployment rate and on the (exogenous) female activity rate. The latter has been trending upwards for some years now.

Unemployment, that we measure through the harmonised ILO concept UBIT[12], is the difference between active population and employment. But employment that has to be taken into account is resident employment (EMPNAT). The latter is the difference between total employment (EMP) and cross-border employment (FRIN)[13]. FRIN is modelled endogenously and depends on total employment as well as net real disposable income earned in Luxembourg and the neighbouring regions.

Figure 3.4: Population, employment and unemployment



[12] In Luxembourg, unemployment is commonly observed on a monthly basis through the registered rate R_U that is based on enrolled unemployed with the employment agency ADEM. For methodological reasons, we prefer to use the harmonised concept.

[13] Cross-border employment is a "net" concept since there are inflowing cross-border workers (FRIN) that are resident in the neighbouring countries and out-flowing cross-border workers (FONCT, FRLUX), i.e. residents of Luxembourg that work "abroad". "Abroad" in this case means the neighbouring countries (as matter of fact, only a minor part) or the international organisations established in Luxembourg, such as the European Commission.

3.3.5 Public sector

The public sector (SNM) is treated as one, comprising the Central Government, Local authorities and Social security administrations.

Most receipts of the public sector are endogenous and depend on the respective "bases" (i.e. consumption for VAT, salaries for household revenue taxes and social security contributions, operating surplus for companies' taxes). Implicit tax rates are calculated as the ratio between the receipts and their respective bases.

Expenditures are partly endogenous and partly exogenous. The exogenous variables are "decision" variables in a sense that they allow the Government to balance the Budget. Decision variables are investment (ISNM), employment (LSNM) and intermediate consumption (DPSNMCI). Wages are endogenous and depend on wages in the private sector through a weighted average of banking and non-banking sector wages.

Figure 3.5: Public sector

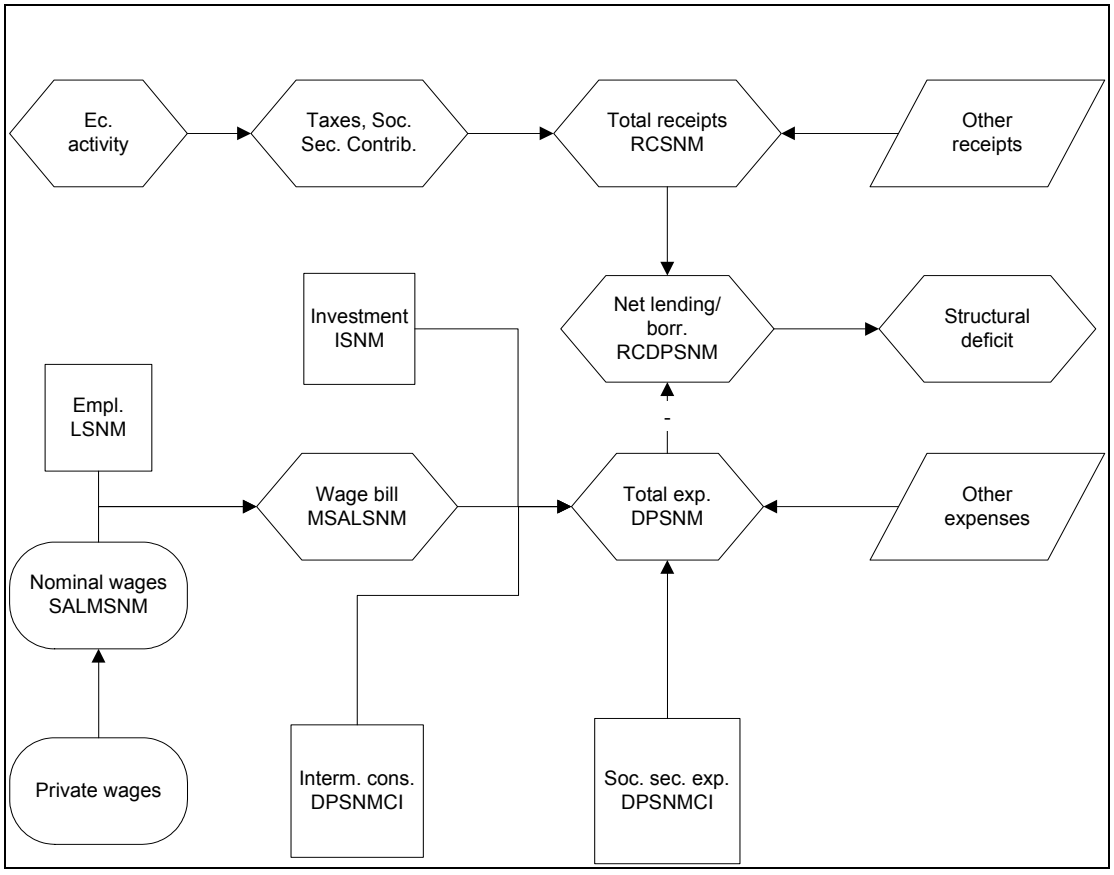
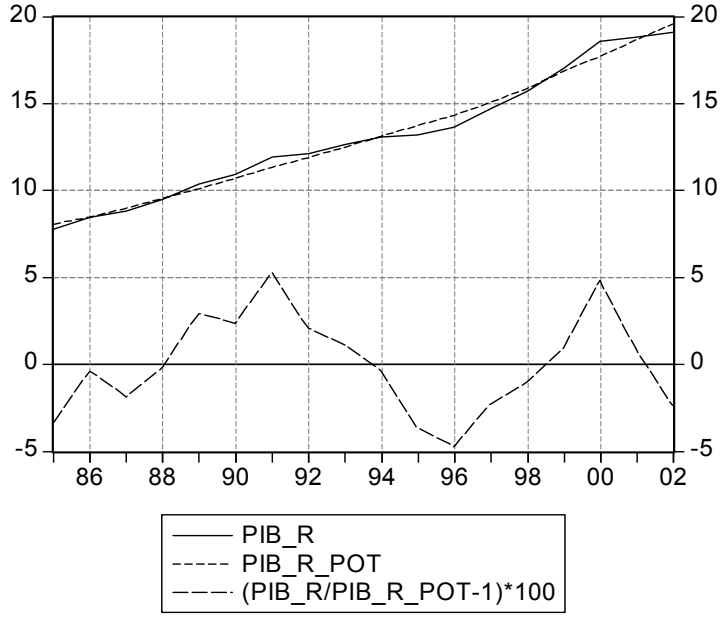


Figure 3.6: Potential GDP and the output-gap



3.4 Potential GDP and the output gap: some supply side economics

Potential GDP and the output-gap (OG) are concepts that are fully made use of in modux. The OG is an explaining variable in at least one important equation, namely the mark-up equation, defining value added prices. The output gap was found to be more or less significant in import and export functions. Shocking the potential output over the past proves it to have significant incidence on all main macro-economic variables present in modux, prices as well as volumes.

The elaboration of potential GDP rests on the very common production function methodology, as described in Adam (2003). The framework is a Cobb-Douglas production function, assuming perfect competition and constant returns to scale. This might somehow seem controversial with respect to the CES production functions that are assumed to underlie the endogenous sectors whose factor demands are modelled separately. Indeed, as we show in section 4.2, we admit a CES production function for both the private non-banking and the banking sector. The elasticity of substitution is found to be significantly different from one in both cases. We have not yet examined what might be the consequences of this apparent theoretical contradiction. One might argue that potential GDP is established for the whole economy and since it is a long-term concept, the special case of the Cobb-Douglas production function could be justified with respect to sectoral CES production functions… But some research needs to be undertaken in this domain.

The treatment of potential GDP and the output-gap in modux is different whether we refer to the past or to the future. Over the past, potential GDP is elaborated as commented in Adam (2003), resting on the common assumptions of the Cobb-Douglas (C-D) production function framework, etc… One point deserves special comments. According to this C-D

framework, "potential" labour is a main ingredient of potential output. In traditional economies, potential labour depends on the available labour force and a certain equilibrium unemployment rate. But since almost 40% of the domestic workforce is made up of non-resident, cross-border workers, that are not part of resident population, one cannot derive potential employment in a classical way in the case of Luxembourg:

$L\_POT = HO * EMP\_POT = HO * POP1564 * R\_POPACT * (1 - R\_U^*)$

L_POT being effective labour supply (man-hours), HO average working time, EMP_POT potential labour supply in persons, POP1564 resident working age population, R_POPACT the activity rate and R_U^* some equilibrium unemployment rate.

Indeed, since EMP = EMPNAT + FRONT (resident or national employment plus cross-border workers), one cannot apply the activity rates and unemployment rates to resident and non-resident workers simultaneously. Hence, the potential labour supply emanating from the "Grande Région" is simply its HP-filtered component:

$L\_POT = HO * (EMPNAT\_POT + FRONT\_POT)$

and

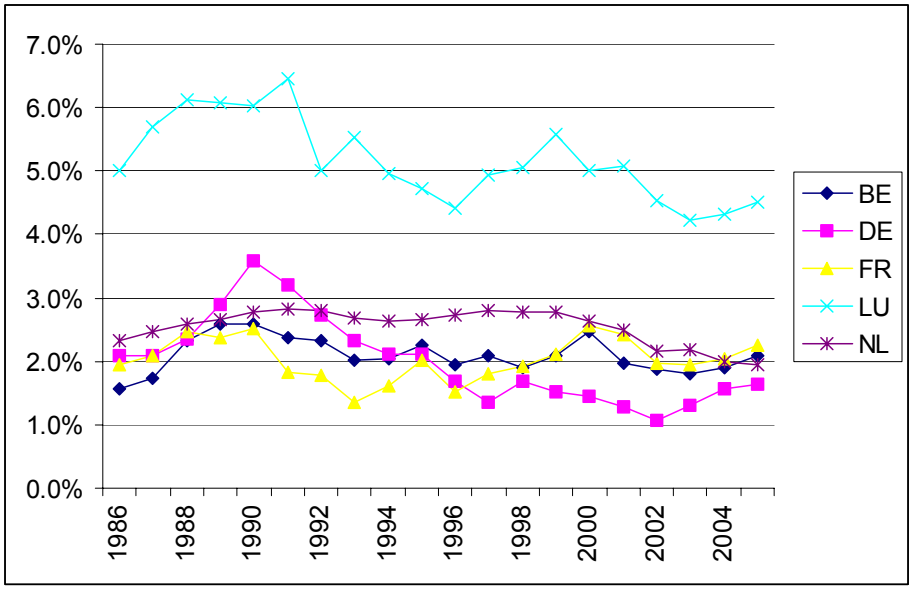
$EMPNAT\_POT = POP1564\_HP * R\_POPACT\_HP * (1 - R\_U^*)$

$FRONT\_POT = FRONT\_HP$

where HP demote Hodrick-Prescott filtered variables.

The elaboration of potential GDP for the future makes modux special with respect to other macro-econometric models. Indeed, as we assume that labour supply is endogenous, potential GDP has to be endogenous as well. In most other bigger economies, potential growth of the economy is more stable over the past and can be assumed to be fixed over the medium term forecasting horizon. In the case of the small and open economy, this assumption cannot be true anymore as factor supply (labour *and* capital) is elastic enough to generate rather large swings in potential GDP. As we show, the potential growth rate of Luxembourg has not been very stable over the past, in comparison to other economies:

Figure 3.7: Growth rates of potential GDP

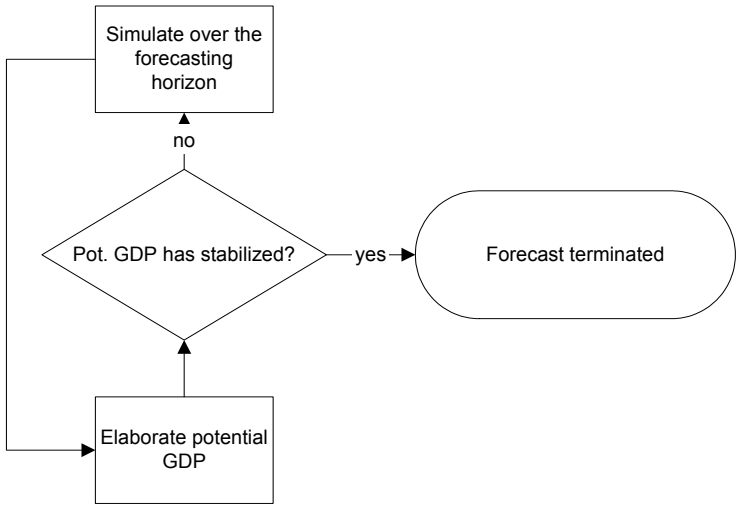


For Belgium, the Netherlands and France, the standard deviation of the potential growth rate is 0.3%. For Germany and Luxembourg it is 0.7%. Germany is clearly influenced by reunification. Once this shock is digested, potential GDP becomes smoother (standard deviation drops to 0.3% after 1991). Luxembourg keeps it's higher volatility of potential GDP as can be seen in the second half of the nineties.

But as potential GDP influences the aggregate outcome through it's presence in some crucial endogenous variables (as value added prices) it is not sufficient to calculate potential GDP once from the relevant forecasted variables that enter it's definition (potential labour, unemployment, capital stock, etc…). We have included in our program that executes the simulation a routine that makes potential GDP converge to a stable variable. From experience, we need not more than five iterations to have stable potential GDP[14].

[14] Potential GDP is "endogenous" only for the forecasting exercises. In the case of in-sample simulations (section 5), we admit that the shocks are small enough not to have a large influence on potential, respectively that we want the economy to return to potential after the effect of the shock fades out. On the other hand, endogenous potential GDP is a sufficiently interesting feature of a small open economy that we should try to incorporate it also in historical in-sample simulations in future work.

Figure 3.8: Iteration over potential GDP



4. Behavioural equations

4.1 Exports and imports

In section 4.1, we are going to describe export (X) and import (M) functions of modux. Exports are assumed to depend on a "demand" variable (M?W_R – world imports, ? standing for B/goods or S/services) as well as on relative prices.

4.1.1 Data

Data is from national accounts. We distinguish goods, financial and non-financial services and consumption of non-residents (table 4.1). International demand has been constructed with the help of the EU Commission's AMECO database (see p. 30).

Table 4.1: Structure of foreign trade in 2002 (% of total)

	Exports	Imports
Goods	30.5	44.3
Non-financial services	17.9	19.2
Financial services	44.6	34.6
Consumption of non-residents	7.0	1.9
TOTAL	100.0	100.0

Source: STATEC

We can see that the share of services is unusually high: this is due to the presence of the financial sector that represents about ¼ of GDP. Hence, modelling demand for financial services is highly important. In the present version of the model however, financial services are left exogenous[15]. On the contrary, other services (transport, communications) are modelled endogenously: this is a feature that most econometric models do not present to date. Consumption of non-residents in Luxembourg has some share as well: it is mainly composed of tobaccos, alcohol and fuel and it depends on the number of cross-border workers.

4.1.2 Theoretical background

Very conventionally[16], the following (neo-keynesian) assumptions are made in the context of modelling foreign trade:

- Domestic and foreign goods (and services[17]) are imperfect substitutes;

[15] This exogeneity of financial services is of course a major draw-back: it deprives the model from one of the economy's main growth engines. We argue that, as regards high volatility of these aggregates and their strong impact, we prefer to leave them outside temporarily until a valid theoretical background has been developed. Having financial services exogenous (whereas employment and wages are endogenous) allows us to construct scenarios which might be more useful in forecasting exercises than sticking to one (given) path for the sector (which might be model-dependent).

[16] For a formal development, see, for example (in French) Assouline et al., 1998

[17] Services are usually assumed to be non-tradable. However in the case of Luxembourg, some services (finance, transports, communications, consulting) can be assumed to be tradable because they are exported and have to compete with foreign firms on foreign markets. Even in the case of "sheltered" sectors, such as trade, there is some amount of across-the-border shopping which involves competition and hence substitutability.

- Consumers are constrained by their budget ("real revenue") and maximise utility by choosing between national and foreign goods and services on the basis of relative prices;
- Real revenue that determines exports and imports can be replaced by a more easy to measure variable: this can be foreign domestic demand (of which national producers satisfy a part) or (more directly) imports of "client" countries;

A few words about substitutability: Luxembourg's producers compete on world markets. Hence, there is substitutability on these markets between national (exported) products and foreign products on the basis of relative prices. On the other hand, it could be assumed that, due to the small size of the economy, there is no substitution between national producers and foreigners on the domestic market. This rests on the simplifying assumption that a small country imports virtually all it needs, i.e. consumption, intermediate and capital goods. But regression results show that relative prices seem to play some role in imports (hence substitutability) and that the output-gap, although not statistically significant, appears with the correct sign and influences marginally exports (hence "serving the home market first" would have some weak meaning).

The question of competition on foreign markets and of price dependency has been analysed in depth by CREA (Cellule de Recherche en Economie Appliquée at the University of Luxembourg). There has been found some evidence for price-maker ship in contrast to the common assumption that small countries are perfect price takers[18]. This question is being dealt with in the subsection on the formation of prices (pp. 57-73).

4.1.3 Exports of goods

Exports of goods (XB) depend on relevant world trade and relative prices. Relevant world trade is related to seven main client countries' imports, weighted by the size of the countries and the respective shares in Luxembourg's exports. The idea is that even if the USA count for only 3% of exports of goods, a one percent increase of their imports can have a bigger effect than an increase of the same order of magnitude of, say, Italy…Foreign prices are industrial value-added prices. It has to be noted that most models[19] have similar definitions of relevant world trade relying on imports (see box p. 30) whereas the quarterly model of the Dutch economy SAFE relates relevant world trade to competitors *exports* and respective prices.

Heavy structural change influences the relation between Luxembourg's goods exports and relevant world trade. To compensate the change in the composition of exports and world

[18] See www.cu.lu/crea/trav&pub.html for a complete list of work undertaken in that domain and particularly Krecké (1997-a and 1997-b).

[19] In order to compare our results with those for other countries, we have analysed models for three neighbouring (and therefore presumably similar) countries: SAFE for the Netherlands as in CPB (2003), Modtrim II for Belgium as in Hertveldt (2003) and e-mod.fr for France as in Chauvin et al. (2002). What's more, we made extensive use of a study comparing most models existing for France for France in 1998 (Assouline et al. 1998).

demand, one should weigh clients' countries imports by the domestic production structure but this has not been done so far in modux. It can be seen on the data that the 1975-1985 period is characterized by an instable relationship between demand, relative prices and exports. Parameter stability tests confirm this. What's more, in 1982, the Belgian/Luxembourg Franc was devalued. The relation is much more stable after 1985.

Estimating the goods export function between 1970 and 2002 has relative prices significant (elasticity of 0.5) but includes a trend with a negative coefficient: national producers would loose per annum about halve a percentage point of growth with respect to relevant world trade. This is coherent with what has been found for the other models and could be due to the decline of the steel industry whose importance climaxed in 1974. Only with the energy crisis of the 75-85 decade, this paramount industry lost thousands of workers: From constituting almost 20% of GDP, its share has come down to less than 3% in 2002…

To avoid structural breaks, we tried to estimate the long-term export function starting in 1975, 1980 or 1985 but this did not reveal relative prices significant anymore except if we dropped the trend term and imposed unitary elasticity between exports and world trade: price sensitivity however declined, with an estimated elasticity of 0.23. Separating re-exports from domestically manufactured exports could possibly solve this problem as re-exports are found to have much lower price elasticities (cf. CPB 2003, pp. 27-30[20]).

The retained estimated long run relation is

$$LOG(XB\_R) = LOG(MBW\_R) + \underset{(0.16)}{0.23}*LOG(P\_VAIW*TXEEXB/P\_XB) - \underset{(0.02)}{0.12}$$

where XB_R is volume exports of goods, MBW_R world demand, P_VAIW competitors prices (industrial value added prices), TXEE effective exchange rates and P_XB exports of goods prices. Estimated standard errors are in italic between brackets.

For the estimation of the ECM (error-correction model[21]), our approach was to fix the long term price elasticity to 0.4 by adding the standard error to the estimated mean of the long-run parameter: this value is coherent with the literature and easily "digested" by the data. We fit the long run estimated parameters into the ECM that we estimate by OLS:

Table 4.2: Exports of goods (volume)

[20] CPB argues that "the price sensitivity of re-exports is not only much lower than that of domestically produced exports but it manifests itself in a very different manner. [Re-exports'] relative price […] is an indicator of international demand for re-export products, and not of the competitiveness of the re-export sector in the Netherlands." This they derive from the fact that re-export prices contain a much smaller part of domestic costs since goods are only transiting and very few value-added is created (some 10 euro-cent per Euro of re-exports).

[21] If possible, all equations are introduced in modux in the well-known error-correction form: $\Delta y=\alpha\Delta x+\phi(y_{-1}-\beta x_{-1})+\varepsilon$ where (in this simplified example) y is the explained and x the explaining variable, greek letters are estimated coefficients and ε the error term. Due to insufficient sample size, most ECMs have been estimated in two steps (Maddala G. S. 2002, pp. 203-205). First the long-run relation is estimated, then the lagged terms of that equation together with the estimated β are introduced in the first difference equation. Testing for cointegration can be executed on the error-correction parameter ϕ of the complete ECM. The latter is the approach that we retained (Zivot 2000).

Dependent Variable: DLOG(XB_R)-0.3*DLOG(P_VAIW*TXEEXB/P_XB)
Method: Least Squares
Date: 04/02/04 Time: 11:42
Sample: 1975 2002
Included observations: 28
DLOG(XB_R)-0.3*DLOG(P_VAIW*TXEEXB/P_XB) = C_XB_R(1)
*DLOG(MBW_R) + C_XB_R(2)*LOG(PIB_R/PIB_R_POT)
+C_XB_R(5)*((LOG(XB_R(-1))-LOG(MBW_R(-1)))-0.4
*LOG(P_VAIW(-1)*TXEEXB(-1)/P_XB(-1))) + C_XB_R(9)
+EC_XB_R

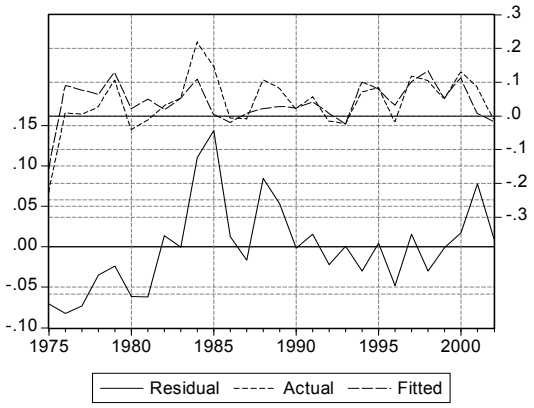
	Coefficient	Std. Error	t-Statistic	Prob.
C_XB_R(1)	0.958182	0.229073	4.182871	0.0003
C_XB_R(2)	-0.276073	0.439417	-0.628271	0.5358
C_XB_R(5)[22]	**-0.380347**	**0.105259**	**-3.613423**	**0.0014**
C_XB_R(9)	-0.044450	0.019506	-2.278770	0.0319

R-squared	0.543449	Mean dependent var	0.040514
Adjusted R-squared	0.486380	S.D. dependent var	0.081198
S.E. of regression	0.058192	Akaike info criterion	-2.718571
Sum squared resid	0.081272	Schwarz criterion	-2.528256
Log likelihood	42.05999	Durbin-Watson stat	0.949053

We had to calibrate the short-run price elasticity since it did not turn out significant; the same is found in the Belgian case. The output gap, although not significant, has the "right" sign and is added to the explaining variables: in case the economy is overheating, exporters seem to prefer to serve the home market first (or are constrained) which depresses, in the short term, exports[23].

The short run elasticity with respect to world demand is only slightly below unity but not statistically different from it. The error correcting process is highly significant but the overall R-squared is rather low. This seems to be due to unobserved variance for 1975-1985: for the subsequent years, the equation fits the data much better (see figure 4.1).

Figure 4.1: Residuals from the XB_R equation (table 4.2)



[22] In all tables containing regression results, the error-correcting term is bold and has the coefficient c_?(5).

[23] The effect seems however to be small. A positive output gap of 1% depresses export growth by 0.3%. In Luxembourg, at the peak of the cycle, the output gap can be as high as 4% of potential GDP (as in 2000) which would cut export growth by more than 1%. This figure has to be compared with an average growth rate of exports of goods of some 6%.

Table: 4.3: Exports and imports by country (% of total)

	Exports of goods	Imports of goods	Exports of non-financial services	Imports of non-financial services
Germany	25.3	27.4	17.5	13.2
France	20.2	13.7	18.5	19.4
Belgium	12.3	33.6	17.3	14.0
Netherlands	4.6	4.6	6.9	6.6
Italy	6.1	1.7	2.7	4.6
United Kingdom	8.5	3.3	8.2	8.7
USA	3.4	5.6	8.6	8.7
Switzerland	-	-	4.6	5.8
Other	19.6	10.1	15.6	19.0
Total	100.0	100.0	100.0	100.0

Source: STATEC

Computation of relevant world trade and it's prices

Relevant world trade for Luxembourg is defined with respect to its main trading partners which are Germany, France, Belgium, the Netherlands, UK, USA and Italy (plus Switzerland for services). The part of Luxembourg's exports and imports of goods and services to these countries in 2002 is reported in table 4.3.

Total demand per year for Luxembourg is expressed by

$M?W\_R = n^{-1} * \sum_i (M_i * s_i)$

M?W_R being world demand in volume (? standing for either B/goods or S/services), n the number of countries i, M_i imports of goods/services of country i per year expressed in volume at constant exchange rates and in absolute value of a common currency (euro) and s_i the share of the respective country in Luxembourg's total exports according to table 4.3.

For world demand, a distinction is made between goods and services. Concerning services, it has to be noted that financial services are included in client countries' imports whereas they are absent from Luxembourg's exports. Neither the trade variables nor their prices are re-weighted according to the goods/services composition, a potentially severe drawback given the high (and declining) part of steel products in Luxembourg's exports for example…

Prices are constructed in a similar manner. Export prices of Luxembourg depend on competitors prices which are defined by the respective countries Value added prices, a distinction being made again between goods and services. Import prices depend on export prices. Foreign prices are expressed in national currencies and are weighted by trade shares in Luxembourg trade statistics.

Foreign prices are multiplied by an effective exchange rate: the latter is a nominal rate that is weighted again by shares in national trade. Effective exchange rates are constructed in a way that an increase expresses a depreciation of Luxembourg's currency; i.e. that they can simply multiply foreign prices.

4.1.4 Exports of non-financial services

Non-financial services (XSO) are depending on a similarly constructed "relevant trade" variable and on relative prices. Exports of non-financial services are mainly transport and communication. Tourism (fuel, tobacco and alcohol) is comprised in non-resident's consumption (CETR). Non-financial services are growing much faster than relevant world trade[24]. This is probably due to structural growth, linked to the set up of the satellite industry or to liberalisation of the transport sector. On the other hand, exports of non-financial services are found to have a much higher price sensitivity.

The long-run estimated relation is as follows:

LOG(XSO_R) = LOG(MSW_R) + 1.2*LOG(P_VASW*TXEEXSO/P_XSO)
(0.1)

+0.023*@TREND(1980) + 0.37
(0.002) *(0.02)*

where XSO_R are volume exports of non-financial services, MSW_R is world demand for services, P_VASW competitors prices, TXEE nominal effective exchange rates and P_XSO own prices.

Table 4.5: Exports of non-financial services (volume)

Dependent Variable: DLOG(XSO_R)
Method: Least Squares
Date: 03/10/04 Time: 15:49
Sample(adjusted): 1981 2002
Included observations: 22 after adjusting endpoints
DLOG(XSO_R)=C_XSO_R(1)*DLOG(MSW_R)+C_XSO_R(2)
*DLOG(P_VASW*TXEEXSO/P_XSO)+C_XSO_R(3)*LOG(PIB_R
/PIB_R_POT)+C_XSO_R(5)*(LOG(XSO_R(-1))-LOG(MSW_R(-1))
-1.2*LOG(P_VASW(-1)*TXEEXSO(-1)/P_XSO(-1))-0.023
XSO_R_AJUST@TREND(1980))+C_XSO_R(8)*D91
+C_XSO_R(9)+EC_XSO_R

	Coefficient	Std. Error	t-Statistic	Prob.
C_XSO_R(1)	1.406896	0.217068	6.481372	0.0000
C_XSO_R(2)	0.855930	0.147318	5.810095	0.0000
C_XSO_R(3)	-0.181269	0.236434	-0.766678	0.4544
C_XSO_R(5)	**-0.931433**	**0.184294**	**-5.054061**	**0.0001**
C_XSO_R(8)	0.092020	0.026765	3.438065	0.0034
C_XSO_R(9)	0.336026	0.063681	5.276680	0.0001
R-squared	0.831961	Mean dependent var		0.085065
Adjusted R-squared	0.779449	S.D. dependent var		0.048495
S.E. of regression	0.022775	Akaike info criterion		-4.499338
Sum squared resid	0.008299	Schwarz criterion		-4.201781
Log likelihood	55.49272	Durbin-Watson stat		2.008850

In the short run, exports of non-financial services have a higher-than-unitary elasticity with respect to world demand. In the long run, the elasticity is constrained to one but exports are found to be growing about 2.3% faster than relevant world trade according to the included trend. Exports of non-financial services are more price-sensitive than exports of goods. The output-gap, although not significant, is left in the equation. A dummy had to be

[24] Due to very high specialisation of these services, relevant world trade as constructed is probably "not very relevant" for Luxembourg (see box). It should be weighted by the domestic production structure.

added to correct for an important outlier in 1991. Error-correction is quasi-instantaneous. The overall fit of the equation is excellent.

4.1.5 Imports of goods and non-financial services

Imports are supposed to depend on a demand variable and on relative prices. The role of prices is related to the question of substitutability between domestic production and imports. We find evidence for prices to play a role for imports of goods in the long run only. Weak significance might be due to high aggregation of data. Some categories of imports (final products) are supposed to have higher price elasticity than intermediate inputs or energy. But the value of the price elasticity is rather small (compared to other models, see box pp. 39-41) and should therefore translate low overall substitutability. Low substitutability should also be seen in a "small country" context where most national producers, due to economies of scale or diversity of preferences, export most of their production and consumers/investors import the biggest deal of what they need.

Relevant demand is domestic demand (DNAT_R) and exports (XSO_R or XB_R): the latter are present due to re-exports having gradually gained in importance over the last decade or so. Long term elasticities for demand categories are constrained to sum to 1.

For imports of goods, domestic demand is defined more precisely by those components of DNAT that have some import content, i.e.

DNATM_R = CFIN_R – LOYERMEN_R + IMEQ_R + IBNQ_R + (DPSNMCI + DPSNMSOCNAT)/P_CG

i.e. private consumption less imputed rental services for house owners, investment in machinery and equipment and by banks, intermediate government consumption and medication consumption (in volume as divided by public consumption prices).

For imports of non-financial services, only private consumption is considered in the domestic demand term.

Long term equations are:

LOG(MB_R) = 0.45*LOG(DNATM_R) + 0.55*LOG(XB_R)
(-) *(-)*

+ 0.35*[0.2*LOG(P_VABPRVO/P_MB)+0.8*LOG(P_VABPRVO(-1)/P_MB(-1))] + 0.12
(0.15) *(0.06)*

LOG(MSO_R) = 0.39*LOG(CFIN_R-LOYERMEN_R) + 0.61*LOG(XSO_R) - 0.38
(0.11) *(-)* *(0.09)*

where MB_R and MSO_R are imports of goods and non-financial services in volume terms, DNATM_R is a subset of national demand that has some import content, LOYERMEN_R is imputed rental services consumed by house-owners, XB_R and XSO_R are respective exports and P_VABPRVO/P_MB are relative import prices with respect to domestic production costs.

Elasticities with respect to demand in the exports of goods equation had to be calibrated (in accordance with the estimated values and their standard errors), probably due to a low number of observations (13 points). Relative prices are introduced with a lag in the goods' import function and they are absent for other services' imports. In both cases, external demand has a higher elasticity than national demand, a fact which translates the high openness of the economy as well as the growing importance of re-exports.

ECMs are as follows:

Table 4.6: Imports of goods (volume)

Dependent Variable: DLOG(MB_R)
Method: Least Squares
Date: 04/05/04 Time: 14:57
Sample(adjusted): 1991 2002
Included observations: 12 after adjusting endpoints
DLOG(MB_R)=C_MB_R(2)*DLOG(DNATM_R)+(1-C_MB_R(2))
*DLOG(XB_R)+C_MB_R(4)*LOG(PIB_R/PIB_R_POT)
+C_MB_R(5)*(LOG(MB_R(-1))-0.45*LOG(DNATM_R(-1))-0.55
LOG(XB_R(-1))-0.35(0.2*LOG(P_VABPRVO(-1)/P_MB(-1))+0.8
*LOG(P_VABPRVO(-2)/P_MB(-2))))+C_MB_R(9)+EC_MB_R

	Coefficient	Std. Error	t-Statistic	Prob.
C_MB_R(2)	0.418995	0.076812	5.454792	0.0006
C_MB_R(4)	0.326436	0.200737	1.626186	0.1426
C_MB_R(5)	**-0.823871**	**0.286695**	**-2.873683**	**0.0207**
C_MB_R(9)	0.104073	0.036367	2.861751	0.0211

R-squared	0.947241	Mean dependent var	0.051570
Adjusted R-squared	0.927457	S.D. dependent var	0.056961
S.E. of regression	0.015342	Akaike info criterion	-5.255288
Sum squared resid	0.001883	Schwarz criterion	-5.093652
Log likelihood	35.53173	Durbin-Watson stat	1.444979

Table 4.7: Imports of non-financial services (volume)

Dependent Variable: DLOG(MSO_R)-0.6*DLOG(XSO_R)-0.4*DLOG(CFIN_R-LOYERMEN_R)
Method: Least Squares
Date: 04/05/04 Time: 14:57
Sample(adjusted): 1986 2002
Included observations: 17 after adjusting endpoints
DLOG(MSO_R)-0.6*DLOG(XSO_R) -0.4*DLOG(CFIN_R
-LOYERMEN_R) = C_MSO_R(5)*(LOG(MSO_R(-1))-0.4
*LOG(CFIN_R(-1)-LOYERMEN_R(-1))-0.6*LOG(XSO_R(-1))) +
C_MSO_R(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_MSO_R(5)	**-0.401668**	**0.154283**	**-2.603442**	**0.0200**
C_MSO_R(9)	-0.169244	0.062713	-2.698714	0.0165

R-squared	0.311229	Mean dependent var	-0.011742
Adjusted R-squared	0.265311	S.D. dependent var	0.079471
S.E. of regression	0.068118	Akaike info criterion	-2.425026
Sum squared resid	0.069600	Schwarz criterion	-2.327001
Log likelihood	22.61272	Durbin-Watson stat	1.627022

Whereas imports of goods can be explained in a rather satisfactory way (high R-squared) this seems not to be the case for imports of non-financial services. For the latter, short-term elasticities had to be calibrated in order to be equal or inferior to one, always in accordance however with the estimated mean and standard error. There remains high

unexplained variance of this variable which might be due to the fact that those services, poorly measured, are often adjusted within equilibration in national accounting. For the time being, we are rather happy with the equation as it has more or less reasonable elasticities.

4.1.6 Consumption of residents abroad and of non-residents in Luxembourg

Luxembourg's national accounts distinguish consumption of non-residents in Luxembourg (CETR) and that of Luxembourgers abroad (CLUX). Consumption of non-residents in Luxembourg is important, amounting to some 10% of GDP and consists mainly of tobacco, fuel and alcohol. It should be explained by differences in price levels due to lower excise duties in Luxembourg. Consumption of Luxembourgers abroad amounts to some 2% of GDP or some 6% of total final consumption of households resident in Luxembourg.

Both can be explained in a rather a-theoretical and straightforward way. Consumption of resident households abroad depends on disposable income. Consumption of non-residents in Luxembourg depends positively on the number of cross-border workers travelling daily to Luxembourg and on fuel prices: the higher the latter, the more interesting it is for non-residents to fill the tank in Luxembourg… The estimated long-run relations are as follows:

LOG(CETR_R) = 0.33*LOG(FRIN) + 0.17*LOG(P_PETUS*BEFUS) - 1.01
(0.03) *(0.05)* *(0.12)*

where CETR_R is volume consumption of non-residents in Luxembourg, P_PETUS crude petrol prices in USD and BEFUS the LUF/USD exchange rate.

LOG(CLUX_R) = 0.82*LOG(RDMEN_R) -2.45
(0.12) *(0.24)*

where CLUX_R is consumption of Luxembourgers abroad and RDMEN_R is total disposable income.

Table 4.8: Consumption of residents abroad

Dependent Variable: DLOG(CLUX_R)
Method: Least Squares
Date: 04/02/04 Time: 15:51
Sample: 1990 2002
Included observations: 13
DLOG(CLUX_R)=DLOG(RDMEN_R)+C_CLUX_R(5)*(LOG(CLUX_R(-1))
-LOG(RDMEN_R(-1)))+C_CLUX_R(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_CLUX_R(5)	**-0.594344**	**0.163040**	**-3.645388**	**0.0039**
C_CLUX_R(9)	-1.676461	0.454123	-3.691643	0.0036

R-squared	0.373761	Mean dependent var	0.021226
Adjusted R-squared	0.316831	S.D. dependent var	0.050669
S.E. of regression	0.041880	Akaike info criterion	-3.367372
Sum squared resid	0.019293	Schwarz criterion	-3.280456
Log likelihood	23.88791	Durbin-Watson stat	1.775831

Table 4.9: Consumption of non-residents in Luxembourg

Dependent Variable: DLOG(CETR_R)
Method: Least Squares
Date: 04/02/04 Time: 15:57
Sample: 1985 2002
Included observations: 18
DLOG(CETR_R) = C_CETR_R(2)*DLOG(FRIN) + C_CETR_R(3)
*DLOG(P_PETUS*BEFUS) + C_CETR_R(5)*(LOG(CETR_R(-1))
-0.33*LOG(FRIN(-1))-0.17*LOG(P_PETUS(-1)*BEFUS(-1))) +
C_CETR_R(9)+EC_CETR_R

	Coefficient	Std. Error	t-Statistic	Prob.
C_CETR_R(2)	0.616863	0.537652	1.147327	0.2705
C_CETR_R(3)	0.122641	0.056905	2.155181	0.0490
C_CETR_R(5)	**-0.719383**	**0.199645**	**-3.603309**	**0.0029**
C_CETR_R(9)	-0.771694	0.216430	-3.565564	0.0031

R-squared	0.534531	Mean dependent var	0.021173
Adjusted R-squared	0.434788	S.D. dependent var	0.096132
S.E. of regression	0.072273	Akaike info criterion	-2.223614
Sum squared resid	0.073127	Schwarz criterion	-2.025754
Log likelihood	24.01253	Durbin-Watson stat	1.331033

The long run elasticity between consumption of Luxembourgers abroad and disposable income is less than one. This is somewhat astonishing since expenses abroad are commonly seen as luxury goods whose share rises with income and should henceforth have a higher than unitary elasticity. On the other hand, across-the-border shopping has a long tradition in the "Grande Région" and is not necessarily made up only of luxury goods and services… Adding a trend did not help… However, to have well-behaved long-run properties, we constrained both the long-run and the short-run income elasticities to one, a practice not rejected by the data.

Consumption of non-residents is explained by the number of cross-border workers and fuel prices. The long-run elasticity with respect to cross-border workers seems somewhat low… There must be other factors at play, like the increasing transit of freight-lorries and passenger cars. Again, adding a trend did not help.

4.1.7 Marshall-Lerner condition

The Marshall Lerner condition is concerned with the likelihood of successfully removing a trade balance deficit through a change in the exchange rate. If the exchange rate was to devalue (so that exports become more price competitive) then the relative price of exports and imports would change. The price of exports would fall relative to other countries, therefore, the quantity of exports will increase. The relative price of imported goods will increase, therefore, the demand will decrease. The outcome is that the trade balance will improve.

More precisely, the Marshall-Lerner condition (MLC) states that, after a devaluation of the national currency, the external equilibrium (exports of goods and services less imports in nominal terms) is higher than before. In other words, one tests whether competitive gains

due to devaluation in terms of volumes (rise of exports, fall of imports through substitution of national production to imports) are stronger than terms of trade losses i.e. price effects (cf. Assouline et al., 1998, pp. 65-66).

There are a few manners to test for the fulfilment of the MLC. One can for example (Chauvin et al., 2002, pp. 279-280) construct a condition based on the estimated elasticities (demand and price equations). We however tested the MLC through a 1% depreciation of the four effective exchange rates by simulating through the complete model. This has as an advantage that the whole bunch of interactions between the price and volume blocks are taken into account. The shocked effective exchange rates (TXEE) are nominal exchange rates with respect to the main trading partners of Luxembourg, weighted by export and import shares (see p 30). Effective exchange rates appear in the export functions for goods (XB_R) and non-financial services (XSO_R) They are part of the "competitiveness term" that is

$P^{*}e/P\_Xi$

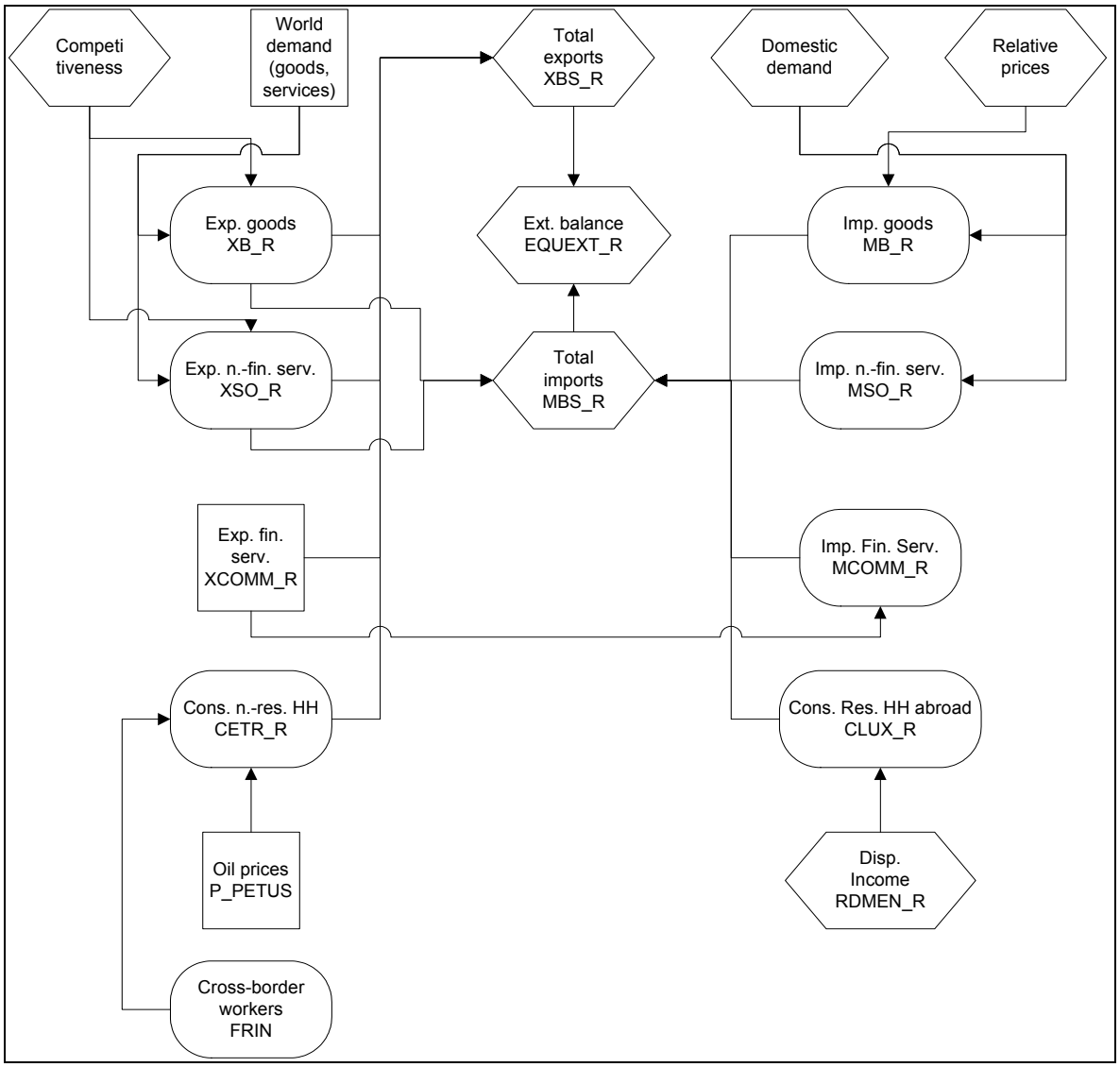
where i stands for exports (XB and XSO) and P^{*} are foreign prices. The coefficient of the competitiveness term is positive. That means that a depreciation (an increase in the nominal value of e) will increase exports, ceteribus paribus. But since export prices are supposed to react as well, they will eat up all/part of the competitiveness gains.

Indeed, effective exchange rates also appear indirectly in the import functions through relative prices. The latter are expressed as

P_VABPRVO/P_Mi

where P_VABPRVO are domestic value added prices and P_Mi are import prices. The coefficient is positive again, meaning that a depreciation (an increase in import prices that depend directly on effective exchange rates) diminishes imports (in volume). These elasticities translate the relative price's mechanisms in modux. A shift in the ratio of relative prices (domestic vs. foreign) has an impact on the real side of the economy. The results with respect to the MLC however depend on the trade balance, that is exports less imports in value. Therefore the reaction of the prices and the respective price elasticities have prime importance as well, aside to the volume effects, as we will see.

Figure 4.2: External relations



Distinguishing between goods and non-financial services, the results of the depreciation of 1% of the four effective exchange rates are as follows (figures 4.3-4.6 below):

Concerning goods, the MLC does not hold: the depreciation increases goods in volume terms more than imports, but relative prices change in a way that the nominal balance after the shock is worse than before. To be more precise: in the beginning, imports of goods increase more than exports because overall growth increases and increased demand leads to higher imports in a small open economy. From the third year onwards, imports start to decrease as the price effect (which is absent from the short-term part of the relevant import function) starts to play. So the *real* balance of goods improves with respect to the baseline. But as import prices increase more than export prices, the overall balance in nominal terms worsens. The sharper reaction of import prices has to be seen in the context of a small open economy: export prices depend less on international prices since

they comprise a greater domestic price component (value added prices are more important for export prices than for import prices).

One has to ask why the MLC does not hold for goods in the case of Luxembourg (as a small open economy) whereas it is true (for example) for France (for overall exports and imports). There are a few reasons. They have to be seen in the context of the comparative analysis of export functions and price equations as undertaken in chapter 4.1. Exports of goods do not show a high price elasticity with respect to other countries. The value of 0.4 (which is subject to some criticism as it is it not clearly established econometrically) is rather on the low side with respect to the models we analysed. Then, the elasticity of imports with respect to external demand is high, at a value of 0.55. Every increase of exports of 1% leads to an increase of imports of 0.55%, in the long run. This is due to the high import content of exports. Finally, imports are poorly affected by relative prices, the elasticity being only 0.35: every increase of import prices in excess of domestic prices does not result in a big shift of domestic production to replace imports. This is of course due to low substitutability in a small economy that imports virtually "all it needs" and exports a great part of its production.

In the case of non-financial services, the MLC holds. Let us state first that the econometric relations underlying the respective price equations are amongst the most questionable of modux, due to poor quality of data mainly. Some calibration is involved. It seems however established that those services' exports are more sensitive to prices than goods, the elasticity being above unity, but still in the range of the values found for other countries. Imports of those services do not depend on relative prices, they are explained exclusively by exports of the same services and national final consumption. They depend hence less on overall demand. There is an improvement of the nominal balance in absolute terms (EQUEXTSO) for the first eight years of the simulation and for the first three years concerning the relative balance, with respect to GDP (R_EQUEXTSO).

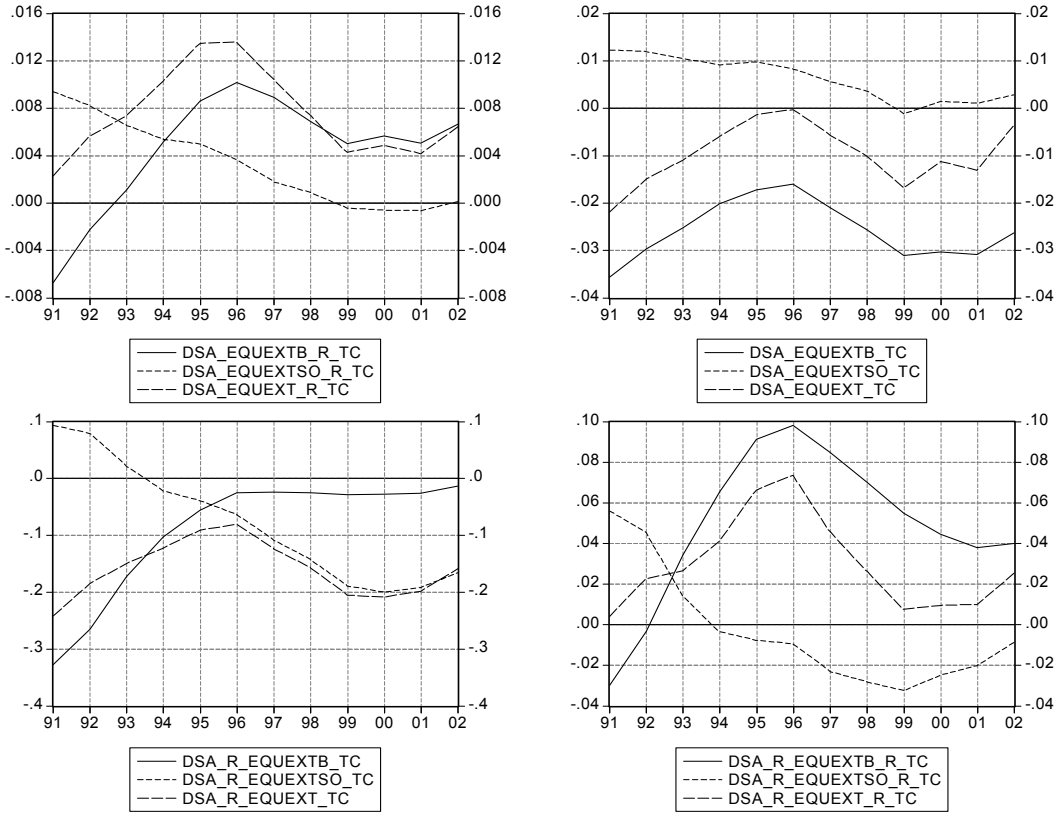
Adding up the balances for XB and XSO, we can draw the following conclusions:

- in volume terms, there is a clear improvement of the external balance, both for goods and for non-financial services;
- in nominal terms, the deterioration of the goods' balance cannot be compensated by an improvement in the balance of non-financial services.

These conclusions seem to hold regarding the estimated elasticities of the underlying export, import and price functions, i.e. they seem to replicate economic characteristics of Luxembourg with respect to other, bigger, more closed economies, as regards the block of external trade and prices as commented in the relevant chapters. For goods, the competitive gains seem to be outweighed by the deterioration of relative prices (terms of trade losses). For non-financial services, the dominant factor is the high price sensitivity of exports.

Finally, one has to remember that the Luxembourg economy has experienced de facto over the last 20 years very stable exchange rates. It's exports are concentrated on the neighbouring countries and depend, for example, much less on the dollar than other European economies. Hence modelling a phenomenon that the economy did only marginally experience has a high probability of not resulting in successful results.

Figures 4.3 – 4.6: Effect of a 1% depreciation of effective exchange rates (simulation of the Marshall-Lerner condition)



Notes: DSA stands for the absolute difference of simulated values with respect to baseline values; EQUEXT is external equilibrium; B is goods, SO is "other services"; _R is volume terms and R_ expresses a % of GDP; _TC denotes the simulation reference.

Some comparisons with other models

One of the goals of this contribution is to work in a comparing way: results for Luxembourg should be in principle close to those found for other European economies. In case they are different, it should be explained by some characteristic features of the very small and very open Luxembourg economy.

Relevant demand for export and import functions of modux is defined in a similar way to the French, Dutch and Belgian models that we evaluated. There are however some distinct features to be noted.

Dutch CPB calculates relevant world demand as competitors' exports whereas the Belgian and French model make it rely on client countries imports. The latter is also the case for Luxembourg with one notable difference. In e-mod.fr (OFCE, France), the imports of eighteen countries are weighted by the market shares of the French exporters in those countries (share of French exports in total imports of that country) whereas in modux, we weighted those countries imports by their share in Luxembourg's total exports. This is due to the fact that it does not seem to make sense to speak of market shares of a very small country in imports of say Germany or the USA.

A second feature of the Dutch model SAFE that is noteworthy is that world demand is weighted by the national production structure, a proceeding that should eliminate structural biases. This should make sense in the case of Luxembourg but it has not been done so far…

Another main difference with respect to the comparison models is that Luxembourg's exports of goods are not explained with the help of a trend variable, supposed to capture long term market share losses due to new entrants (SE Asia, East Europe,…) or other structural biases. Introducing a trend in Luxembourg's export of goods function leaves prices statistically insignificant. A trend is however present to explain exports of non-financial services but this one is positive, translating permanent market share gains, probably due to non-weighting of services' world demand.

Price sensitivity of Luxembourg's exports of goods (at 0.4) is rather on the low side with respect to the French model e-mod.fr (at 0.6) or SAFE, the Dutch model (higher than unity but a different definition because it excludes re-exports). It's close to the price elasticity found in the Belgian case and for both models, prices were not found to be significant in the short run.

Non-financial services' price elasticity is substantially higher (at 1.2) but still lower than what CPB found for Dutch manufactured exports (2.6).

Imports of goods and non-financial services depend on relevant demand. As in the Dutch case, we find evidence for high import content of exports (goods and services). Foreign models have re-weighted demand components according to their import content – this has yet to be done for modux. Relative prices are only playing for imports of goods – the

elasticity (at 0.35) is somewhat lower than what is found for neighbouring countries, except Belgium. Production capacity tensions have been retained in modux but are not statistically significant. They appear in a different manner as they are measured by the output gap in modux and through the capacity utilization rate of the manufacturing industry in other models.

To sum up: similarities are high between the specification of Luxembourg's export and import functions and those of other models of neighbouring countries. They concern the definition of world demand or the general specification of the equations. Differences lie in data elaboration (distinguishing re-exports, calculating import contents) and results. Luxembourg's exports and imports are less price sensitive than their Dutch and French counterparts and closer to the values found for the Belgian economy. Luxembourg's non-financial services are modelled separately which is a highly distinctive feature. Financial exports are yet to be modelled endogenously.

4.2 Factor demand

Factor demand (labour and capital) is modelled separately for the private, non-banking sector and for the banking sector. It relies on a theoretical framework which is made up of a constant elasticity-of-substitution (CES) production function.

4.2.1 The theoretical model

Assume that the economy is constituted of n goods (i=1…n) being imperfect substitutes. Each good is produced by a producer who acts as a monopolistic competitor. The production technology is of the CES (constant elasticity of substitution) type.

The production Y_i of the i^{th} firm is noted as

$Y_i = F_i(K,L) = [a * K_i^{1-1/\sigma} + (1-a) * (E*L_i)^{1-1/\sigma}]^{\sigma/(\sigma-1)}$

K_i being the productive capital stock, L_i efficient labour (hours worked) and E technical progress which is supposed to be Harrod-neutral and equal between firms.

Harrod-neutrality of technological progress

If the technological progress is exogeneous (the contrary is endogenous technological change, dealt with in endogeneous growth theory) it has to be introduced somehow "exogeneously" into the production process. As we show below, in case technological progress is assumed to be Harrod-neutral, it can be introduced as a time trend.

Indeed, technological progress can be labour saving, capital saving or not saving relatively more of any input. The latter case of technological progress is called "neutral" (Barro 2004, p. 52). Harrod defines an innovation as neutral if the relative input shares $(K*F_K)/(L*F_L)$ remain unchanged for a given capital-output ratio. It can be shown that this definition implies that the production function takes the form Y = F(K,T(t)*L), T(t) being the time-index of technology. This form of neutrality is labour augmenting because it raises output in the same way as an increase in the stock of labour. Supposing the technology evolves continuously, it can be expressed as a simple time trend.

The elasticity of substitution between labour and capital is σ. It shows by how much the ratio K/L changes with respect to a relative change of the marginal productivities' ratio:

$\sigma = El_{K/L} = dlog(K/L) / dlog(F_K/F_L)$,

F_i being marginal productivities i.e. first order derivatives of the production function with respect to factors.

Under the monopolistic competition assumption, each producer takes the price of labour and capital as given: he faces a demand curve for his product and, under the profit maximisation hypotheses, after developing, we find:

$k = y - \sigma * (c_K - p)$

$l = (y-e) - \sigma * (w-e-p)$

lower case letters denoting logarithms of the aforementioned variables.

Labour demand can be rewritten:

$l = y - \sigma *(w-p) + (\sigma-1)*e$

σ being positive but smaller than one, the coefficient on technical progress e will be negative. If technical progress increases, less labour will be needed to produce the same. Note that the factor price elasticity is the same for labour and capital.

Both equations taken together make up factor demand equations, depending on output and real factor prices, that we will try to estimate.

4.2.2 The data: decomposition of employment and investment

We distinguish two market sectors: banking and insurance on the one hand (BNQ) and all other private sectors on the other hand (PRVO): for both we estimate factor demand equations.

Investment goods are separated into four categories, in accordance with the sectoral breakdown:

- residential investment (IRES), regardless of which sector is the owner, which is endogenous;
- non-market investment by government (ISNM) which is mainly construction and held exogenous;
- banking investment (IBNQ) corresponding to all non-residential investment undertaken by banking and insurance companies, endogenous;
- private, non banking and non-residential investment (IMEQ), i.e. productive capital like machines, non-residential buildings, etc… that are held by the private, non-banking sectors and modelled endogenously.

Employment (L) is measured in effective units, i.e. number of people * average hours worked and its price is expressed in terms of hourly costs. L comprises both dependent (salaried) and independent employment. For simulation and forecasting exercises, non-market employment (LSNM) and independent employment (INDEP, regardless of the sector) are held exogenous. So we model total employment in the banking sector (LBNQ) and in the other private sectors (LPRVO). Exogenous technical progress is measured as a time trend. We allow for breaks in the slope of this trend as indicated by observed labour productivity.

Table 4.10: Investment and employment breakdown (2002, % of total)

Investment		Labour (efficient, persons * average working time)	
Residential (IRES)	12.2	Banking (LBNQ)	11.9
Machinery and equipment (IMEQ)	59.2	Other private (LPRVO)	76.9
Banking (IBNQ)	7.2	Non-market (LSNM)	11.2
Non-market (ISNM)	21.4		
TOTAL	100.0	TOTAL	100.0

4.2.3 Estimation results for the private non-financial sector

Regressing efficient volume of labour on value added, real wages and a time trend does not show a unitary elasticity between labour and volume value added (as suggested by the theoretical model). Real wages seem not to be significant. Recursive estimation however shows that the elasticity on value added is converging towards one. Fixing it to one and allowing for a change in the slope of the time trend that stands for exogenous productivity now reveals an elasticity with respect to real wages of -0.75. This elasticity has to be consistent with the capital demand equation.

Estimation results for the capital demand equation show an elasticity with respect to volume value added of 0.8 regressing from 1975 to 2002 and of 0.94 (standard error - s.e. - 0.04) regressing from 1980 to 2002. Recursive estimation shows that the latter value is converging towards one. Constraining it to unity gives an own price elasticity for capital demand of -0.30 (s.e. 0.06).

We have to compromise between the two values of the price elasticity found in the labour demand equation (-0.75, s.e. 0.12) and in the capital demand equation (-0.30, s.e. 0.06). We do so by estimating ECM's for both factor demand equations while taking into account results for other countries (see box p. 48) as well as stability aspects of the ECM's[25]. We come up with an own-price elasticity of -0.35 for both factors. Calibrating the elasticities is digested by the data as shown by results of the ECMs.

Long run relations are as follows:

$$LOG(LPRVO) = LOG(VABPRVO\_R) - 0.35*LOG(SALMPRVOH/P\_VABPRVO)$$
$$(-)$$
$$-0.024*@TREND(1975) + 0.011*(@TREND(1990)*(@TREND(1990)>=0)) + 4.51$$
$$(0.001) \qquad (0.003) \qquad (0.01)$$

where LPRVO is efficient labour in the private non banking sector (L=EMP*HO, EMP being total employment and HO average working time), VABPRVO_R real value added and SALMPRVOH/P_VABPRVO real hourly labor costs. The time trend stands for exogenous productivity that rises at 2.4% between 1975 and 1990 and at 2.4%-1.1%=1.3% after 1990. Those values are consistent with the observed evolution of hourly labor productivity.

[25] Estimation of both ECMs shows a strong autoregressive component in the short run part. It can be shown (internal note by OFCE for STATEC) that if the coefficient on the lagged dependant variable expressed in first differences (the autoregressive term) is too high with respect to the error correction term, oscillations can arise that have the power to disturb the short run properties of the respective ECM and postpone adjustment to the long run equilibrium path. Since

LOG(CAPNMEQ_R) = LOG(VABPRVO_R) - 0.35*LOG(PUCMEQ/P_VABPRVO) - 0.47
(-) *(0.02)*

where CAPNMEQ_R is volume capital stock in machinery and equipment and PUCMEQ the nominal user cost of capital.

Nominal user cost of capital is defined in a very conventional way[26]:

PUCMEQ = P_CAPNBNQ * [TILTDM/100 – dlog(P_CAPNMEQ) + R_CCMEQ/100]

where PUC is nominal user cost of capital, P_CAPN the deflator of the capital stock, TILDM the nominal long term interest rate on the DM (EURO from 1999 onwards), R_CC the depreciation rate. User cost of capital rises with the price of one unit of capital, the *real* interest rate and the depreciation rate.

After fitting the long term estimated respectively constrained values in ECMs we obtain the following results:

Table 4.11: Labour demand: private non-banking

Dependent Variable: DLOG(LPRVO)
Method: Least Squares
Date: 04/07/04 Time: 10:37
Sample: 1975 2002
Included observations: 28
DLOG(LPRVO)=C_LPRVO(1)*DLOG(LPRVO(-1))+C_LPRVO(2)
*DLOG(VABPRVO_R) + C_LPRVO(3)*LOG(CSUPRVO_R(-1)
/CSUPRVO_R_HP(-1)) +C_LPRVO(4)*DLOG(SALMPRVO
/P_VABPRVO/HOPRVO) +C_LPRVO(5)*(LOG(LPRVO(-1))
-LOG(VABPRVO_R(-1))+0.35*LOG(SALMPRVO(-1)
/P_VABPRVO(-1)/HOPRVO(-1))+0.024*@TREND(1980)-0.01
@TREND(1990)(@TREND(1990)>=0)) + C_LPRVO(7)

	Coefficient	Std. Error	t-Statistic	Prob.
C_LPRVO(1)	0.389563	0.099294	3.923315	0.0007
C_LPRVO(2)	0.287018	0.054043	5.310901	0.0000
C_LPRVO(3)	-0.180176	0.059811	-3.012431	0.0064
C_LPRVO(4)	-0.290069	0.065880	-4.403010	0.0002
C_LPRVO(5)	**-0.259271**	**0.062679**	**-4.136474**	**0.0004**
C_LPRVO(7)	1.148545	0.276682	4.151143	0.0004

R-squared	0.871308	Mean dependent var	0.018027
Adjusted R-squared	0.842060	S.D. dependent var	0.022386
S.E. of regression	0.008897	Akaike info criterion	-6.418905
Sum squared resid	0.001741	Schwarz criterion	-6.133432
Log likelihood	95.86467	Durbin-Watson stat	2.427056

In the short run, elasticities are lower and there is some auto-regressiveness. We have added a profitability term CSUPRVO_R/CSUPRVO_R_HP that represents real unit labour costs' deviation from trend. It's coefficient is negative, translating the fact that if real unit labor costs are relatively high, labor demand is depressed. In other words, if profitability is high, firms are reluctant to depress labor in the short run. Introducing this variable has the ability to stabilize forecasts. It can also explain some of the labor hoarding in recent years

different long term elasticities fitted in the ECM result in different values for the critical parameters that are at the origin of the oscillations, the process of finding the "optimal" elasticity had to be undertaken very carefully.

[26] It is established the same way for all three types of capital modelled endogenously.

as profitability was above trend from 1997 to 2000 (note that it enters with a one-year lag in the short run).

Table 4.12: Capital demand: private non-banking

Dependent Variable: DLOG(CAPNMEQ_R)
Method: Least Squares
Date: 04/07/04 Time: 10:49
Sample: 1975 2002
Included observations: 28
DLOG(CAPNMEQ_R)=0.4*DLOG(CAPNMEQ_R(-1))
+C_CAPNMEQ_R(2)*DLOG(VABPRVO_R)+C_CAPNMEQ_R(3)
*LOG(CSUPRVO_R/CSUPRVO_R_HP)+C_CAPNMEQ_R(4)
*DLOG(PUCMEQ/P_VABPRVO)+C_CAPNMEQ_R(5)
*(LOG(CAPNMEQ_R(-1))-LOG(VABPRVO_R(-1))+0.35
LOG(PUCMEQ(-1)/P_VABPRVO(-1)))+C_CAPNMEQ_R(8)(D92
-D99)+C_CAPNMEQ_R(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_CAPNMEQ_R(2)	0.598200	0.141264	4.234612	0.0003
C_CAPNMEQ_R(3)	0.239317	0.140196	1.707016	0.1019
C_CAPNMEQ_R(4)	-0.037496	0.015835	-2.367965	0.0271
C_CAPNMEQ_R(5)	**-0.201032**	**0.048299**	**-4.162219**	**0.0004**
C_CAPNMEQ_R(8)	-0.036353	0.010887	-3.339037	0.0030
C_CAPNMEQ_R(9)	-0.100620	0.025420	-3.958377	0.0007

R-squared	0.868991	Mean dependent var	0.030049
Adjusted R-squared	0.839216	S.D. dependent var	0.037358
S.E. of regression	0.014980	Akaike info criterion	-5.376848
Sum squared resid	0.004937	Schwarz criterion	-5.091376
Log likelihood	81.27587	Durbin-Watson stat	1.019378

The short run auto-regressive parameter had to be constrained to a somewhat lower value (in accordance with the standard error) since this equation features oscillations in the short run as the autoregressive parameter is higher than the error correction term. We included the profitability term and it came out barely significantly but with a parameter whose value is in accordance with the labour demand equation and has the opposite sign: if profitability is low (real unit labour costs above trend) firms expand capital to the damage of labour which translates some short run substitution between labour and capital. Profitability acts instantaneously on capital demand whereas it acts with a lag on labour. This could translate rigidities in the labour market. Note also that real user costs are significant in the short run but with a very low coefficient (-0.04 with respect to –0.35 in the long run).

Capital demand has to be corrected by two dummies standing for statistical outliers. Indeed, gross fixed capital formation fluctuates already heavily in “normal” economies; it fluctuates even more in Luxembourg being a small open economy. The dummies do not alter significantly the coefficients.

4.2.4 Estimation results for the banking sector

Results for the banking sector are somewhat more difficult to obtain. Probably, from a theoretical viewpoint, the banking sector needs to be modelled differently; there are many reasons to think that it's way of combining capital, labour and other – financial – inputs

makes it singular with respect to other firms. This will be done in a later step, for the moment we admit the CES framework described earlier.

Without setting the coefficient on value added to one in the labour demand equation, nothing reasonable comes out. Doing this, the elasticity on real wages is not significant. Turning to capital demand, we find an almost unitary indexation on value added and the real user cost shows up with a significantly negative elasticity. Fixing the elasticity with respect to demand in both equations to one turns out with an own-price elasticity of –0.07 resp. –0.10, statistically different from zero but not significant at the 10% level. We force the elasticities at the upper bound of the confidence interval at a value of –0.15; by doing so the residuals from the long run regression keep being stationary, denoting probably cointegration. This imposed price-elasticity of factor demand for the banking sector is somewhat lower then the one obtained for the rest of the economy: due to labour intensive work processes, substitutability between labour and capital is probably lower in the banking sector. The autonomous rise of productivity is found to be 1.1% per year; the latter is indeed the observed value between 1985 and 2000. Productivity fluctuates a lot in the banking sector; this has to do with the measurement of *real* output, a thorny issue for the banking sector. Indeed, it decreased by about 15% in total in 2001 and 2002…

The long-run retained relations are:

LOG(LBNQ) = LOG(VABBNQ_R) - 0.15*LOG(SALMBNQH/P_VABBNQ)
(-)
- 0.011*@TREND(1985)+2.67
(0.003) *(0.03)*

where LBNQ is efficient labour (persons multiplied by average working time) in the banking sector, VABBNQ_R volume value added and SALMBNQH/P_VABBNQ real hourly labor costs (deflator: value added prices).

LOG(CAPNBNQ_R) = LOG(VABBNQ_R) - 0.15*LOG(PUCBNQ/P_VABBNQ) - 0.95
(-) *(0.03)*

where CAPNBNQ_R is volume capital in the banking sector and PUCBNQ/P_VABBNQ is the real user cost of capital as defined previously.

We estimate the corresponding ECMs:

Table 4.13: Labour demand: banking

Dependent Variable: DLOG(LBNQ)-.3*DLOG(LBNQ(-1))
Method: Least Squares
Date: 04/07/04 Time: 14:24
Sample: 1985 2002
Included observations: 18
DLOG(LBNQ)-.3*DLOG(LBNQ(-1))=C_LBNQ(2)*DLOG(VABBNQ_R)
+C_LBNQ(3)*DLOG(VABBNQ_R(-1))+C_LBNQ(5)*(LOG(LBNQ(
-1))-LOG(VABBNQ_R(-1))+0.15*LOG(SALMBNQ(-1)/P_VABBNQ(
-1)/HOBNQ(-1))+0.011*@TREND(1985))+C_LBNQ(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_LBNQ(2)	0.203078	0.094470	2.149662	0.0495
C_LBNQ(3)	0.294080	0.098810	2.976209	0.0100

C_LBNQ(5)	**-0.236069**	**0.074633**	**-3.163072**	**0.0069**
C_LBNQ(9)	0.640452	0.198536	3.225882	0.0061
R-squared	0.643200	Mean dependent var		0.043955
Adjusted R-squared	0.566743	S.D. dependent var		0.032742
S.E. of regression	0.021551	Akaike info criterion		-4.643635
Sum squared resid	0.006502	Schwarz criterion		-4.445774
Log likelihood	45.79271	Durbin-Watson stat		1.291513

The short run autoregressive parameter on LBNQ(-1) had to be adjusted somewhat in order to prevent too many oscillations emanating from the equation. Value added has more influence on employment with a lag of one year. In the short run, the profitability ratio as used in the labour demand equation for the other private sectors does not come out with the correct sign nor does the real wage.

Table 4.14: Capital demand: banking

Dependent Variable: DLOG(CAPNBNQ_R)
Method: Least Squares
Date: 04/07/04 Time: 14:25
Sample: 1985 2002
Included observations: 18
DLOG(CAPNBNQ_R)=C_CAPNBNQ_R(2)*DLOG(VABBNQ_R)
+C_CAPNBNQ_R(3)*DLOG(PUCBNQ/P_VABBNQ)
+C_CAPNBNQ_R(4)*LOG(CSUBNQ_R/CSUBNQ_R_HP)
+C_CAPNBNQ_R(5)*(LOG(CAPNBNQ_R(-1))-LOG(VABBNQ_R(
-1))+0.15*LOG(PUCBNQ(-1)/P_VABBNQ(-1)))
+C_CAPNBNQ_R(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_CAPNBNQ_R(2)	0.320484	0.115574	2.772981	0.0158
C_CAPNBNQ_R(3)	-0.062281	0.028022	-2.222569	0.0446
C_CAPNBNQ_R(4)	0.059489	0.032789	1.814288	0.0928
C_CAPNBNQ_R(5)	**-0.216772**	**0.086698**	**-2.500315**	**0.0266**
C_CAPNBNQ_R(9)	-0.135531	0.081059	-1.672004	0.1184
R-squared	0.475560	Mean dependent var		0.081185
Adjusted R-squared	0.314194	S.D. dependent var		0.026197
S.E. of regression	0.021695	Akaike info criterion		-4.593334
Sum squared resid	0.006119	Schwarz criterion		-4.346009
Log likelihood	46.34001	Durbin-Watson stat		1.695857

The short-run part of the capital demand equation shows a bit more economic content: apart from activity that enters contemporaneously, the real user cost pushes capital demand downwards whereas a squeeze in the profitability rate (as measured by real unit labour costs rising above trend) pushes it up, favouring capital for labour substitution.

Some comparisons with other models

Remember that we try to compare our results with those found for the Netherlands (model SAFE by CPB), France (model e-mod.fr by OFCE) and Belgium (model Modtrim II by FPB).

In the case of e-mod.fr, production factors are assumed to be complementary whereas we admit substitutability in the case of Luxembourg (as in most models). For e-mod.fr, this has as a consequence that factor prices do not intervene directly in the factor demand equations and there is no immediate substitutability. But this does not mean that a modification in prices and/or salaries does not have any impact on factor demand: simply the transmission channel is different because it is indirect, passing through demand components. Another difference is that investment is modelled directly, whereas it is derived from capital demand in the standard framework. Long term elasticities with respect to output are unitary in the long run as for all models. Technogical progress is introduced in the classical way, through an exogenous time trend.

The design of factor demand equations in modux is closest to the Dutch case (although the latter is much more elaborate). It has the same underlying CES technology, with imperfect substitutability of production factors and labour-saving technological progress. CPB implemented a more sophisticated indicator of profitability in the short run (based on average costs, production being divided into the sum of wages and the costs of capital) and the user cost of capital contains a measure of corporate taxation. The elasticity of substitution between capital and labour is –0.32, a value very close to the one retained in modux for non-banking firms (-0.35).

The Belgian model Modtrim II relies on a Cobb-Douglas technology, having therefore high substitutability between labour and capital (the elasticity is one by assumption). Since however the short run elasticity of labour demand with respect to real wages is relatively low, at –0.11 and the error correction process extremely slow (-0.06, the model is quarterly) there is not much difference in practice between the Dutch, Belgian or Luxembourgish case, at least for short run forecasting. FPB also modelled investment directly, after deducting the long-run relation for investment from capital demand, using the accounting identity between investment, capital and depreciation.

To sum up, characteristics of the production factor demand equations in the case of Luxembourg do show high similarities with respect to some recent models for neighbouring countries, with a degree of sophistication in the case of Luxembourg close or even higher than for some of these countries.

4.3 Migration and cross-border workers: a word or two about labour supply and activity rates

In most models, labour supply is taken as exogenous. This is a reasonable assumption given the use of those models for short to medium term projections and the inertia that characterizes the evolution of the population. In Luxembourg however, there is a high dependence on inflowing workers, be it migrants or cross-border workers (people that live abroad but travel daily to Luxembourg to work).

In "normal" economies, less open and bigger than Luxembourg, after having determined labour demand and taking labour supply (or demographics) as exogenous, one would be able to derive unemployment:

U = POPACT – EMP

where U = unemployment, POPACT = active population and EMP = total domestic employment (i.e. employment hired by domestic firms).

In case of Luxembourg however, labour supply is partly endogenous, through migrations (Luxembourg has a net migration rate of about 0.5% over the last 20 years) and cross-border workers (the latter make up almost 40% of total domestic employment in 2003). Unemployment cannot be derived properly without taking these flows of workers into account endogenously[27].

Hence we model inflows and outflows of migrating workers and endogenize the stream of cross-border workers by taking into account some economic characteristics (net wages, unemployment) of the wider economic region where Luxembourg draws its workers from.

Our approach is as follows:

- Firms decide in the first step how many workers they need: labour demand depends on output and real wages as seen above.
- In the second step they allocate jobs between resident and cross-border workers. The latter are rapidly "at disposal" provided that their net wage (comprising travel "costs") is higher in Luxembourg than in their home region (or country). Resident workers are "first served" but cross-border workers are readily available if no resident takes the job. This also admits perfect substitutability between resident and cross-border workers (Allegrezza, 1997).
- Lastly, not all the jobs can be filled by resident or cross-border workers, due to qualifications mismatch, for example. Labour has to be found further away and those people move to Luxembourg to work *and live* there: they are immigrants.

[27] To deal correctly with the whole question of migrating flows of workers, we would also need to take into account the age structure of the population. This would however go beyond the scope of the current model.

4.3.1 Cross-border workers

Let FRIN be the number of incoming cross-border workers and NSAL total salaried employment (cross-border workers are dependent workers by assumption):

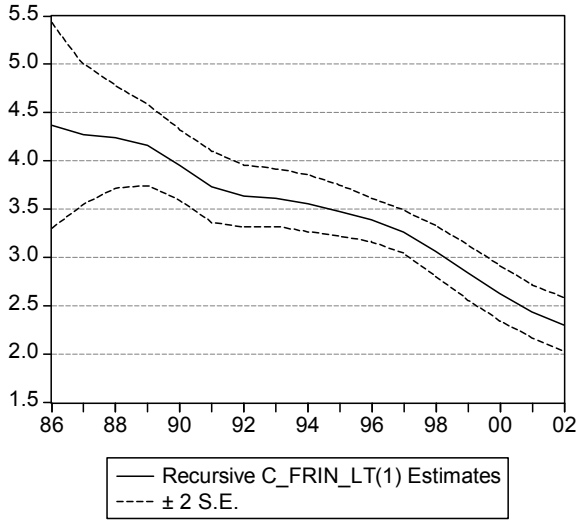
In the long run, FRIN should depend on NSAL, on relative real disposable income in Luxembourg with respect to the cross border region[28] and on the unemployment rate prevailing in the "Grande Région". We estimate the following long-run relation:

FRIN = α*NSAL + β*R_RDMENBFDN + γ*R_UGR + δ

R_RDMENBFDN being real disposable income perceived in Luxembourg over that of the greater region. In the current state of the model, disposable income is measured by *national* net wages. Further data mining has to be undertaken in order to stick closer to the economic conditions prevailing in the Grande Region but it is very difficult to obtain long-run time-series statistics for Europe's regions (except for the labour market).

There is no reason to assume that the elasticity α between FRIN and NSAL is constant over the estimation period. Indeed, as more and more cross-border workers flow into Luxembourg, this elasticity should converge towards 1. Recursive estimation shows indeed that this parameter was close to 4.5 around 1985 and has since moved towards 2.

Figure 4.7: recursive elasticity between inflowing cross-border workers and total dependent employment



To deal with the declining elasticity between total salaried employment and incoming cross-border workers (CBW), we fixed it to one (the long run value under the assumption the part of CBW increases steadily) and added a time trend, allowing for a break. The estimated relation is as follows:

[28] The theoretical work underlying this part has been developed together with Xavier Timbeau and Eric Heyer from OFCE/Paris.

log(FRIN/NSAL) = 0.81*log(R_RDMENBFD) + 0.048*@trend(1990)*(@trend(1990)>=0)
(0.31) *(0.003)*
- 0.046*@trend(2001)*(@trend(2001)>=0) + 0.0073*R_UGR – 1.81
(0.022) *(0.0045)* *(0.07)*

where FRIN are incoming cross-border workers, NSAL total salaried employment, R_UGR the unemployment rate in the cross-border region and R_RDMENBFD = (RDMENL/P_CFIN)/(RDMENBFD/P_C) the ratio of real disposable wage in Luxembourg over that of the Grande Region. The latter is however measured by country-wide disposable wages as no figures are readily available for the sole regions around Luxembourg.

In the long run, a rise of 1% of the net real wage in favour of Luxembourg increases the part of CBW by 0.8%. The latter has passed from 9.7% in 1980 to 38% in 2002, an annual increase of 6.4%. At the same time, net real wages in Luxembourg grew by 1.7% in excess of those in the neighbouring countries. Finally, a rise of cross-border unemployment by 1 ppt raises the ratio FRIN/NSAL by some 0.8% as well, in the long run.

The “autonomous” increase of the ratio of cross-border workers due to the time trend adds 4.8% each year until 2001 (to be compared with the average growth rate of 6.4%). After 2001, the break in the slope of the time trend denotes almost reversion to a flat line: there should apparently be no more trend-induced increases of the ratio of CBW to total salaried employment. But the statistical insecurity surrounding the "break" term is relatively high and leaves some scope for calibration. To estimate the ECM, we fixed it to 0.034, a value lying in the lower bound of the confidence interval. Hence, FRIN/NSAL increases autonomously by some 4.8% between 1990 and 2001 and by 4.8-3.4=1.4% afterwards.

The results for the estimated ECM are as follows:

Table 4.15: Inflowing cross-border workers

Dependent Variable: DLOG(FRIN)
Method: Least Squares
Date: 04/23/04 Time: 10:08
Sample: 1990 2002
Included observations: 13
DLOG(FRIN)=C_FRIN(1)*DLOG(NSAL) + C_FRIN(2)*DLOG((RDMENLN
/P_CFIN)/(RDMENBFDN/P_PIBUE)) + C_FRIN(5)*(LOG(FRIN(-1)
/NSAL(-1))-0.77*LOG((RDMENLN(-1)/P_CFIN(-1))/(RDMENBFDN(
-1)/P_PIBUE(-1)))-0.048*@TREND(1990)*(@TREND(1990)>=0)
+0.034*@TREND(2001)*(@TREND(2001)>=0)-0.0083*R_UGR(-1))
+ C_FRIN(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_FRIN(1)	0.387839	0.285780	1.357125	0.2078
C_FRIN(2)	0.541276	0.205135	2.638631	0.0270
C_FRIN(5)	**-0.756792**	**0.119736**	**-6.320478**	**0.0001**
C_FRIN(9)	-1.333480	0.218929	-6.090919	0.0002

R-squared	0.879413	Mean dependent var	0.098612
Adjusted R-squared	0.839218	S.D. dependent var	0.029728
S.E. of regression	0.011920	Akaike info criterion	-5.773476
Sum squared resid	0.001279	Schwarz criterion	-5.599646
Log likelihood	41.52760	Durbin-Watson stat	1.418706

Error-correction is rapid and highly significant. Short-term elasticities are lower than their long-run counter-parts.

4.3.2 Immigration and emigration

In the long run, immigration depends on net jobs not being filled by cross-border workers ("disposable" jobs for immigrants and residents) and on net real relative wages. Furthermore, the lower the part of working age population in total population (R_POP1564), the higher immigration. Note that MIGRIN is a *flow* and hence has to depend on *changes* in employment. Outflows of migrants (MIGROUT) depend on population in working age and (negatively) on relative real disposable incomes. The long run relations are as follows:

log(MIGRIN) = 3.98*dlog(EMP-FRIN) + 1.39*log(R_RDMENBFDN) - 1.69*log(R_POP1564)
(2.09) *(0.15)* *(1.12)*

+9.08
(4.72)

log(MIGROUT) = 4.36*log(POP1564) – 1.16 * log(R_RDMENBFDN) – 22.3
(0.65) *(0.29)* *(3.59)*

where MIGRIN are immigrants and MIGROUT emigrants, R_RDMENBFD = (RDMENL/P_CFIN)/(RDMENBFD/P_C) the ratio of real disposable wage in Luxembourg over that of the Grande Region, POP1564 working age population and R_POP1564 the ratio of the latter with respect to total population.

A 1% *acceleration* of national employment (total less cross-border) *growth* increases immigration by almost 4%. The elasticity between out-flowing migrants and total working age population is found to be of the same order of magnitude. Elasticities on real relative net wages are found to be of almost equal values. The short run error-correction equations are as follows:

Table 4.16: Immigration

Dependent Variable: DLOG(MIGRIN)
Method: Least Squares
Date: 04/23/04 Time: 08:04
Sample(adjusted): 1982 2002
Included observations: 21 after adjusting endpoints
DLOG(MIGRIN) =C_MIGRIN(1)*DLOG(MIGRIN(-1)) + C_MIGRIN(2)
*DLOG((RDMENLN/P_CFIN)/(RDMENBFDN/P_PIBUE))
+C_MIGRIN(5)*(LOG(MIGRIN(-1))-2.5*(DLOG(EMP(-1)-FRIN(-1)))
-1.3*LOG((RDMENLN(-1)/P_CFIN(-1))/(RDMENBFDN(-1)
/P_PIBUE(-1)))+2.4*LOG(R_POP1564(-1))) + C_MIGRIN(8)*(D90
-D00) + C_MIGRIN(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_MIGRIN(1)	0.556318	0.126749	4.389145	0.0005
C_MIGRIN(2)	0.386514	0.223609	1.728525	0.1031
C_MIGRIN(5)	**-0.475491**	**0.118018**	**-4.028981**	**0.0010**
C_MIGRIN(8)	0.106552	0.027379	3.891748	0.0013
C_MIGRIN(9)	5.762197	1.427322	4.037069	0.0010
R-squared	0.746520	Mean dependent var		0.026986
Adjusted R-squared	0.683150	S.D. dependent var		0.066775

S.E. of regression	0.037587	Akaike info criterion	-3.520054
Sum squared resid	0.022605	Schwarz criterion	-3.271358
Log likelihood	41.96057	Durbin-Watson stat	2.205270

Table 4.17: Emigration

Dependent Variable: DLOG(MIGROUT)
Method: Least Squares
Date: 04/23/04 Time: 10:37
Sample(adjusted): 1981 2002
Included observations: 22 after adjusting endpoints
DLOG(MIGROUT) = C_MIGROUT(1)*DLOG(POP1564) +
C_MIGROUT(2)*DLOG((RDMENLN/P_CFIN)/(RDMENBFDN
/P_PIBUE)) + C_MIGROUT(5)*(LOG(MIGROUT(-1))-4.5
*LOG(POP1564(-1))+1*LOG((RDMENLN(-1)/P_CFIN(-1))
/(RDMENBFDN(-1)/P_PIBUE(-1)))) + C_MIGROUT(9)+
C_MIGROUT(8) *(D84+D95-D91)

	Coefficient	Std. Error	t-Statistic	Prob.
C_MIGROUT(1)	4.569369	3.838480	1.190411	0.2502
C_MIGROUT(2)	-0.770628	0.257322	-2.994805	0.0081
C_MIGROUT(5)	**-0.404725**	**0.127151**	**-3.183036**	**0.0054**
C_MIGROUT(9)	-9.362922	2.937185	-3.187720	0.0054
C_MIGROUT(8)	-0.103541	0.025440	-4.069942	0.0008

R-squared	0.654744	Mean dependent var	0.020635
Adjusted R-squared	0.573507	S.D. dependent var	0.066792
S.E. of regression	0.043619	Akaike info criterion	-3.229912
Sum squared resid	0.032345	Schwarz criterion	-2.981947
Log likelihood	40.52903	Durbin-Watson stat	1.897834

Note that some dummies had to be added, probably detecting non-economic migrations as those due to the war in former Yugoslavia involving high numbers of refugees in Luxembourg during the nineties. Both error correction terms present satisfactory values and appropriate statistical significance. As usual, short-run elasticities are somewhat lower that their long-run counterparts.

4.3.3 Activity rate

After having determined total employment, cross-border employment and migration flows, we should now be able to derive resident employment and total resident population, taking birth and death rates as exogenous. To derive unemployment we can apply

U = POPACT – EMPNAT

where EMPNAT = EMP – FRIN is resident employment! This relation exhibits the well known feature that unemployment is a resident phenomenon and that it derives from resident employment and active population. Cross-border workers are neither taken into account in the (resident) employment figures nor in the unemployment figures.

Total population is obtained through

$POPTOT = POPTOT_{-1} + SLDNAT + SLDMIGR$

where SLDNAT is the natural movement (births – deaths) which is exogenous and SLDMIGR = MIGRIN – MIGROUT is the net migration flow.

Working age population depends through a fixed (exogenous) coefficient on total population

POP1564 = R_POP1564 * POPTOT

and active population depends in the same way on working age population:

POPACT = R_POPACT * POP1564

R_POPACT being the standard activity rate. We know that the latter usually has a pro-cyclical behaviour and/or displays some long run (usually upward-sloping) trends. The economic rationales are that the better the state of the economy, the more people are willing to work: this is what the French call "effet de flexion". Long-run phenomena that are usually taken into account are the increase of the female activity rate or the decrease of the elderly (aged 55-65) workers' activity rate.

The estimated long run relation in the case of Luxembourg is as follows:

log(R_POPACT) = 0.27*log(R_POPACTFEM) – 0.023*log(R_UBIT) + 3.13
(0.042) *(0.011)* *(0.16)*

Over the last 15 years, the activity rate has been upward-trending; this phenomenon is taken completely into account by the female activity rate, no time trend had to be added.

The pro-cyclical behaviour of the activity rate is captured by the unemployment rate. If the latter increases, less people are willing to work. A decrease of 0.5 percentage points (ppt) of the unemployment rate from, say, 4% to 3.5% induces an increase of 12.5*0.023 = 0.3% of the activity rate. The latter being around 60%, this increase corresponds to some 0.2 ppt, a rather small value.

The short run ECM is as follows:

Table 4.18: Activity rate

Dependent Variable: DLOG(R_POPACT)
Method: Least Squares
Date: 04/23/04 Time: 09:17
Sample: 1990 2002
Included observations: 13
DLOG(R_POPACT)=C_R_POPACT(1)*DLOG(EMPNAT)
+C_R_POPACT(2)*D(R_POPACTFEM)+C_R_POPACT(5)
*(LOG(R_POPACT(-1))-0.25*LOG(R_POPACTFEM(-1))+0.023
*LOG(R_UBIT(-1)))+C_R_POPACT(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_R_POPACT(1)	0.708070	0.139145	5.088703	0.0007
C_R_POPACT(2)	0.001116	0.001077	1.036076	0.3272
C_R_POPACT(5)	**-0.528390**	**0.167193**	**-3.160360**	**0.0115**
C_R_POPACT(9)	1.679278	0.533057	3.150279	0.0117

R-squared	0.809204	Mean dependent var	0.004114
Adjusted R-squared	0.745606	S.D. dependent var	0.008728
S.E. of regression	0.004402	Akaike info criterion	-7.765873
Sum squared resid	0.000174	Schwarz criterion	-7.592042
Log likelihood	54.47817	Durbin-Watson stat	2.449076

In the short run, it is not unemployment but domestic job creation that drives the activity rate; the first order difference of the female activity rate exhibits only weak statistical significance.

4.4 Wages, prices and unemployment

4.4.1 Wages

4.4.1.1 Theoretical background

Two theories dominate the wage formation process: the Phillips curve literature and the WS/PS framework. The Phillips curve literature goes back to the seminal article by A. W. Phillips in 1958 and is purely empirical in its origin. Phillips linked observed growth of wages to the level of unemployment and found a negative relation: the higher the level of unemployment, the lower the growth rate of wages. These findings have since then been theorised and the general model has been extended to include explanatory variables like prices, productivity, etc… (see for example Gordon's triangular model, Gordon 1997).

The second theory is more recent and has been developed mainly by Layard/Nickell/Jackman (1991) at the end of the eighties. It is based on microeconomic foundations and on an optimizing behaviour of firms and households. The basic equations we are interested in are price and wage equations: The latter link the observed level of wages to prices, productivity and unemployment.

Recently, there have been efforts to reconcile both theories: one example is Blanchard and Katz (1999) who formally derive the Phillips relation from a WS/PS equation under the condition that the reservation wage (which affects wages) is homogenous of degree one in the real wage and productivity.

In both cases, the theoretical relations are straightforward in their simplest expression:

Phillips: $\Delta w = \alpha_P * \Delta p + \beta_P * \Delta q/l + \gamma_P * \Delta x + \phi_P * u$

WS/PS: $w = \alpha_W * p + \beta_W * q/l + \gamma_W * x + \phi_W * u$

w being nominal (per capita) wages, p prices (see box p. 57), q/l observed labour productivity, x other variables and u the unemployment rate. Other variables could be reservation wages (unemployment benefits) or the tax wedge.

Different concepts of unemployment

As in most countries, there is a difference between "official" unemployment (UE), also called registered UE and census UE, obtained through statistical enquiries. Census UE is based on a regular survey, the so-called labour-force survey (LFS) whereas official UE reproduces the number of unemployed registered with unemployment agencies. The latter varies according to the changes in legislation whereas the former is based on clear methodological concepts and definitions, that, in an ideal world, are invariant in time. This International Labour Organization (ILO) definition of unemployment actually covers people who are:

- out of work;
- want a job;

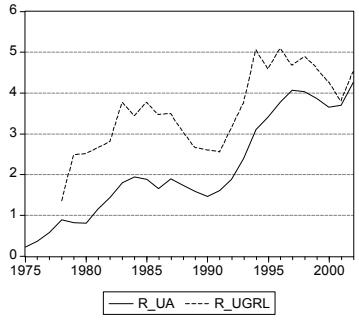
- have actively sought work in the previous four weeks, and,
- are available to start work within the next fortnight.

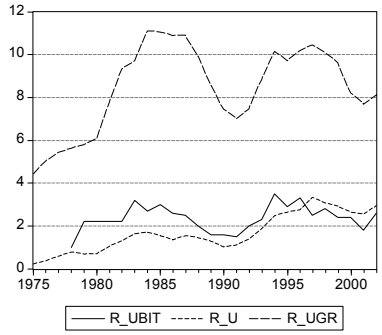
There are two series for official UE in modux, U and UA: UA being an extended version including jobless workers that are in paid training or other occupational measures. Thus U should be close to UBIT that is registered UE obtained from the LFS. If recently the levels of the series U and UBIT (see figures below) are rather close, that was not the case from 1975 to 1985 where survey UE was on average twice as high as registered UE.

As on average some 2/3 of newly created jobs are occupied by cross-border workers, the UE rate in the surrounding regions (Grande Région) could have some influence on the wage formation process in Luxembourg. Cross-border workers reside mostly very close to Luxembourg. To construct our measure of cross-border unemployment (UGR), we relied on the regional split-up of country LFS results. The regions we are including are the provinces of Liège and Luxembourg in Belgium, the "Regierungsbezirk" Trier and the Saarland in Germany and the departments Moselle and Meurthe-et-Moselle in France (see Notes de Conjoncture no. 3-2001 and 4-2002 at www.statec.lu). In those regions, unemployment is notably higher than in Luxembourg, both in absolute figures and expressed relative to the active population (see graph and table).

Last but not least we constructed a weighted average of regional and national unemployment using UGR and UBIT. This series should take into account the growing importance of the Grande Région as weights consist of the number of cross-border respectively national employed. This UE is most promising in estimation and should also be more useful in forecasting exercises.

Figures 4.8 and 4.9: Unemployment rates





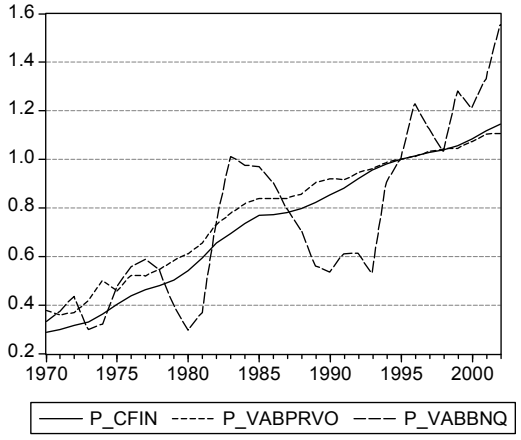
Which prices to use to explain wages?

In the literature on wage and price formation, there is not often made a difference between consumer prices and value added prices to explain wages. The reason is probably that it does not matter for big, rather closed economies as both prices should trend together due to low import penetration. In small open economies however, value added prices can diverge notably from consumer prices (see figure 4.10). Higher value added prices can give rise to higher wages, ceteris paribus, through rent-sharing aspects. (see Aka 2004).

We found evidence for the inclusion of value added prices in wage equations in the Dutch "Safe" model in an indirect way, through the wedge (the difference between consumer and producer wages) that can be decomposed into a price component and a tax component.

In the case of Luxembourg, as our results show, value added prices seem to play a role in explaining wages of the banking sector but not of the other private sectors.

Figure 4.10: value added prices and consumer prices



4.4.1.2 Model selection issues

Testing for the Phillips curve against the WS/PS framework implies first some econometrics. In order to estimate a well behaved long-run relation, the considered variables need to be integrated of the same order of magnitude and form a cointegrating vector. There exists some evidence that in the French case for example, wage and price inflation are not stationary but I(1), i.e. that price levels are I(2). In that case, there exists of course a strong presumption to implement the Phillips framework, in its "augmented" version, i.e. including productivity and other explaining variables.

Testing of the Luxembourg data confirms this presumption of wages and prices to be I(2) for the period 1975-2002, all other variables being found to be probably I(1)[29]. For that time-span, we should therefore estimate a long run equation explaining first differences of wages according to the Phillips framework. In doing so, α_P (the coefficient on consumer prices) is found to be far from equal to 1, in fact, depending on the unemployment rate we use, it is more or less half of the desired value. If there is no a priori reason for wages to be indexed completely on prices, the socio-political reality of Luxembourg, which has automatic wage indexation on consumer prices, speaks strongly in favour of… Estimating an ECM does still not reveal unitary indexation of wages on prices in the long run. Constraining this elasticity to 1 works only with the unemployment rate of the Grande Région R_UGR.

Our conclusion is that explaining wages for Luxembourg with the Phillips curve is not a valid option unless one accepts that, in the long run, a 1% increase of consumer prices has a much lower effect on wages and that wages in Luxembourg are explained only by cross-border unemployment.

We turn now towards the WS/PS framework. We can do so only by estimating after 1980, preferably from 1985 onwards, since, for the years before, wages and prices are not difference-stationary. For all five unemployment rates, we find a valid relation with wages indexed unitarily on consumer prices (Wald tests) and unemployment significant with a negative coefficient. The coefficient on (trend) productivity lies around 0.50, significantly inferior to 1.

Which unemployment rate to choose since all are significant? We rule the “official” rates out since they are less precise in measuring economic unemployment; they are notoriously influenced by legislation. The coefficients on harmonised unemployment (UBIT) and weighted unemployment (UGRL) are about twice as high as that of unemployment for the sole Grande Région (UGR). Our option is to take the mixed or weighted unemployment rate R_UGRL. It takes better into account the economic reality of the labour market, characterized by as much as 40% of domestic labour constituted by cross-border workers. By construction, in forecasting exercises, it can account for a rising share of cross-border workers in domestic employment.

4.4.1.3 The wage curve

Wages in the private non banking sector

Building on the findings commented above, we estimate a wage equation for the private non-banking sector including R_UGRL, starting in 1985. Results tend to reject unitary indexation on prices and (trend) productivity. Wald tests suggest that the long term elasticity between wages and prices is at least 1.05. Considering the existence of the

[29] Tests of the order of integration have been carried out with the ADF test, in the descending order.

indexation mechanism in Luxembourg and the short estimation period, we however fix it to one and obtain the following long-run relation:

log(SALMPRVOH)=log(P_CFIN) + 0.58*log(PRODEPRVOH_HP) – 0.014*R_UGRL + 5.13
(0.025) *(0.0036)* *(0.084)*

where SALMPRVOH are hourly wages in the private non-banking sector, PRODEPRVOH_HP filtered (hourly) labour productivity, R_UGRL the weighted unemployment rate for Luxembourg and the Grande Région.

We retain the estimated coefficients for the ECM:

Table 4.19: Wage equation, private non-banking

Dependent Variable: DLOG(SALMPRVOH)
Method: Least Squares
Date: 04/26/04 Time: 10:46
Sample: 1985 2002
Included observations: 18
DLOG(SALMPRVOH)=C_SALMPRVO(1)*DLOG(P_CFIN)
+C_SALMPRVO(2)*DLOG(PRODEPRVOH)+C_SALMPRVO(3)
D(R_UGRL)+C_SALMPRVO(5)(LOG(SALMPRVOH(-1))
-LOG(P_CFIN(-1))-0.58*LOG(PRODEPRVOH(-1))+0.014
*R_UGRL(-1))+C_SALMPRVO(9)+EC_SALMPRVO

	Coefficient	Std. Error	t-Statistic	Prob.
C_SALMPRVO(1)	0.890682	0.240685	3.700614	0.0027
C_SALMPRVO(2)	0.288257	0.107353	2.685136	0.0187
C_SALMPRVO(3)	-0.006056	0.005443	-1.112742	0.2860
C_SALMPRVO(5)	**-0.447733**	**0.192231**	**-2.329134**	**0.0366**
C_SALMPRVO(9)	2.306947	0.986263	2.339079	0.0360

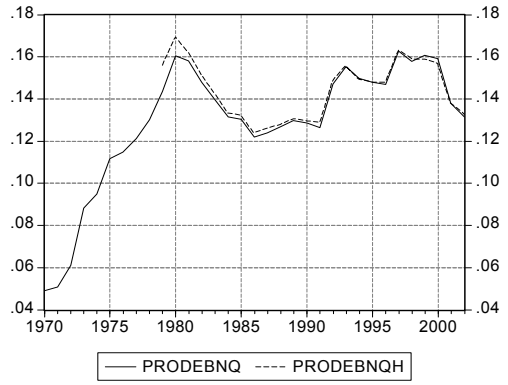
R-squared	0.636544	Mean dependent var	0.037339
Adjusted R-squared	0.524712	S.D. dependent var	0.016228
S.E. of regression	0.011188	Akaike info criterion	-5.917862
Sum squared resid	0.001627	Schwarz criterion	-5.670537
Log likelihood	58.26076	Durbin-Watson stat	1.984464

The short-run coefficients are consistently smaller than their long-run counterparts. We supplemented observed productivity for its smoothed value, in the short and the long-run. R-squared is relatively. One has the feeling that this equation is somewhat incomplete: trying to add value added prices, the GDP deflator, minimum wages or banking sector wages did however not consistently improve it. We retain this equation since the coefficients take values that are very close to those found in the literature and it seems to be a true representation of the Luxembourg socio-economic reality.

Wages in the banking sector

Productivity in the banking sector, as measured by volume value added per person (PRODEBNQ) or per hour (PRODEBNQH), does not trend upwards linearly (see figure 4.11). We are not trying to investigate or to comment on the economic or methodological causes for this. By applying a HP filter with a high parameter (1000 or more) we can extract an almost linear trend from the banking sector productivity and circumvent the consequences of declining productivity for some years (1980-1987 for example).

Figure 4.11: Productivity in the banking sector (volume value added per person/hour)



We find one similarity for the banking sector with respect to the other private sector, namely that a valid relation between wages, prices, productivity and unemployment emerges (and stabilises) only after 1985. Some "creative estimation" had to be undertaken in order to detect a valid relation: after some trial and error we found that, with *smoothed* productivity, the coefficient on consumer prices was not statistically different from one. Restraining it to that value and re-introducing *observed* productivity, the latter came out with a significant coefficient, not statistically different from 1 either. Unemployment however could not found to be significant.

log(SALMBNQH) = log(P_CFIN) + 0.83*log(PRODEBNQH) + 5.69
(0.17) *(1.57)*

We now estimated an ECM, restraining both long term parameters to one, but introducing filtered productivity again[30]. The absence of unemployment is bothering so we add the R_UGRL variable with a calibrated parameter equal to that obtained for the other private sectors.

Table 4.20: Wages of the banking sector

Dependent Variable: DLOG(SALMBNQH)
Method: Least Squares
Date: 06/15/04 Time: 09:06
Sample: 1985 2002
Included observations: 18
DLOG(SALMBNQH)=C_SALMBNQ(1)*DLOG(P_CFIN) +
C_SALMBNQ(2)*DLOG(PRODEBNQH) + C_SALMBNQ(3)
DLOG(P_VABBNQ) + C_SALMBNQ(5)(LOG(SALMBNQH(-1))
-LOG(P_CFIN(-1))-0.83*LOG(PRODEBNQH_HP(-1))+0.015
R_UGRL(-1)) + C_SALMBNQ(8)(D88+D95)+ C_SALMBNQ(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_SALMBNQ(1)	1.003740	0.358529	2.799609	0.0161
C_SALMBNQ(2)	0.178606	0.075905	2.353013	0.0365
C_SALMBNQ(3)	0.057288	0.026521	2.160127	0.0517
C_SALMBNQ(5)	**-0.132825**	**0.050941**	**-2.607406**	**0.0229**
C_SALMBNQ(8)	-0.055100	0.012827	-4.295514	0.0010
C_SALMBNQ(9)	0.783633	0.292468	2.679381	0.0201

R-squared	0.804964	Mean dependent var	0.043277
Adjusted R-squared	0.723699	S.D. dependent var	0.032178

[30] Observed productivity induced an error correction process that was not statistically significant.

S.E. of regression	0.016914	Akaike info criterion	-5.060157
Sum squared resid	0.003433	Schwarz criterion	-4.763366
Log likelihood	51.54141	Durbin-Watson stat	1.860790

Error correction is slow. We accept however this equation since all coefficients have reasonable values, close to those for the other sectors or to those found in the literature. It is clear however that more research on the macro-economic functioning on the baking sector needs to be undertaken.

The unemployment rate is still not significant in the short run. We added two dummies to correct for possible outliers: their inclusion did not alter the value of the other parameters but improves the overall fit. Finally, in the short run, banking sector wages can be explained by value added prices, although the elasticity is very small;

Public sector wages

It is sometimes argued that wages in the public sector have a leading role in the wage formation process. Private companies would or should adapt their wage contracts to those prevailing in the public sector. High wage increases in the latter would spill over on private companies and could depress competitiveness… This might be true for isolated short periods, but in the long run, wages of the private sector should depend on the economic factors that we have listed before (productivity, prices, unemployment). In case the wage growth "initiated" by the public sector can be supported by the private companies, there must be economic factors that allow it. In case public sector wages should drive private wages too high, there would indeed be a loss in competitiveness that would depress production and private wages, feeding back into public tax receipts and affecting the sustainability of that policy.

Our purpose is to model public sector wages by making them dependent on private sector wages. Our results show that in the long run, the elasticity with respect to banking sector wages is 0.7 and that with respect to other private sectors is 0.3. Both elasticities have been constrained to sum to 1:

LOG(SALMSNMH) = 0.32* LOG(SALMPRVOH) + 0.68*LOG(SALMBNQH)
(-) *(0.01)*

The constant proved not to be significant. The elasticity is very stable as recursive estimation shows, increasing marginally from 0.6 in the beginning of the eighties to roughly 0.7 in the nineties… This translates the raising importance of the financial sector for the determination of wages in Luxembourg which can be linked to two factors:

- The banking sector has been the driving force of the economy since the beginning of the eighties and has executed a drain on the labour market, especially for high qualifications;

- The qualification mix of the banking sector is probably closer to that of the public sector than to that of other private sectors.

The short run ECM is as follows:

Table 4.21: Public sector wages

Dependent Variable: DLOG(SALMSNMH)
Method: Least Squares
Date: 04/26/04 Time: 11:52
Sample: 1987 2002
Included observations: 16
DLOG(SALMSNMH)=DLOG(P_CFIN)+DLOG(SALMBNQH/P_CFIN) + C_SALMSNM(1)*DLOG((SALMPRVOH/P_CFIN)/(SALMBNQH /P_CFIN)) + C_SALMSNM(5)*(LOG(SALMSNMH(-1))-0.3 *LOG(SALMPRVOH(-1))-0.7*LOG(SALMBNQH(-1))) + C_SALMSNM(9)+EC_SALMSNM

	Coefficient	Std. Error	t-Statistic	Prob.
C_SALMSNM(1)	0.487175	0.215087	2.265010	0.0412
C_SALMSNM(5)	**-0.553869**	**0.212523**	**-2.606153**	**0.0218**
C_SALMSNM(9)	0.005175	0.005792	0.893493	0.3878

R-squared	0.485200	Mean dependent var	0.046019
Adjusted R-squared	0.406000	S.D. dependent var	0.029285
S.E. of regression	0.022570	Akaike info criterion	-4.577010
Sum squared resid	0.006622	Schwarz criterion	-4.432150
Log likelihood	39.61608	Durbin-Watson stat	1.748040

In the short run we separated the influence of consumer prices from that of real wages to take better into account direct impact of the wage indexation system based upon consumer prices. The sum of the elasticities on banking and non banking sector *real* wages is again fixed to one and this time, both elasticities are roughly equal one to each other, thus non-banking wages having a slightly higher impact in the short run.

4.4.2 Value added prices

In most econometric models, value added prices depend on factor costs. Usually, the value added price equation is a markup equation, explaining by how much final prices are fixed in excess of costs.

4.4.2.1 Data definitions

In modux, factor costs are taken into account by unit labour costs (ULC) and the prices of capital services (user cost of capital, UCC). ULC (or CSU in the French notation of modux) are simply derived from per capita wages and productivity:

CSU= MSAL/VAB_R = SALM/PRODE

MSAL being the total wage bill, VAB_R real value added, SALM and PRODE per capita wages and productivity. Note that in order to obtain SALM, MSAL is divided by NSAL (number of dependent workers) whereas VAB_R is divided by total employment EMP, including independent workers. As all labour is measured in terms of numbers of persons, ULC are divided by hours worked to enter the VA price equation.

UCC depend on interest rates, depreciation rates and factor prices. Nominal user cost of capital is obtained through the following identity:

PUC=P_CAP * [TI/100 – dlog(P_CAP) + R_CC/100]

Where P_CAP is the price of one unit of capital, TI is a long term interest rate and R_CC the depreciation rate.

In the current state of the model, only the non-banking private sector value added prices are treated according to the above description. Banking sector value added prices are not specified according to a mark-up equation but depend instead on prices from the expenditure side of GDP.

4.4.2.2 Estimation results

We constrain the sum of the long run elasticities to 1:

LOG(P_VABPRVO) = 0.86*LOG(SALMPRVOH/PRODEPRVOH_HP)
(0.04)
+ 0.14*LOG(PUCMEQ) – 5.1
(-) *(0.33)*

where SALMH denotes per hour nominal wages, PRODEH observed HP-filtered hourly productivity and PUC the user cost of capital. Note that we make the somewhat simplifying assumption that the only capital the PRVO sector uses is MEQ (machinery and equipment, exclusive of for example buildings) whereas VABPRVO comprises the imputed rents on the private residential capital stock.

We then estimate a short run ECM by fixing the long run parameters to their estimated values.

Table 4.22: Private non-banking value added prices

Dependent Variable: DLOG(P_VABPRVO)
Method: Least Squares
Date: 04/29/04 Time: 11:21
Sample: 1990 2002
Included observations: 13
DLOG(P_VABPRVO)=C_P_VABPRVO(1)*LOG(PIB_R/PIB_R_POT) +
C_P_VABPRVO(5)*(LOG(P_VABPRVO(-1))-0.85
*LOG((SALMPRVO(-1)/HOPRVO(-1))/PRODEPRVOH_HP(-1))
-0.15*LOG(PUCMEQ(-1))) + C_P_VABPRVO(3) +
C_P_VABPRVO(4)*(D89-D91)+EC_P_VABPRVO

	Coefficient	Std. Error	t-Statistic	Prob.
C_P_VABPRVO(1)	0.241046	0.088254	2.731293	0.0232
C_P_VABPRVO(5)	**-0.156797**	**0.075538**	**-2.075733**	**0.0677**
C_P_VABPRVO(3)	-0.770724	0.379889	-2.028816	0.0731
C_P_VABPRVO(4)	0.037886	0.009453	4.007925	0.0031

R-squared	0.660382	Mean dependent var	0.015641
Adjusted R-squared	0.547176	S.D. dependent var	0.011379
S.E. of regression	0.007657	Akaike info criterion	-6.658637
Sum squared resid	0.000528	Schwarz criterion	-6.484806
Log likelihood	47.28114	Durbin-Watson stat	2.450636

Note that this equation is estimated with 13 observations only! In the short run part, factor costs are absent; the only variable explaining value added prices being the overall output gap (PIB_R/PIB_R_POT). But the latter is far from being highly significant. We had to estimate from 1990 onwards in order to find a significant and sensible elasticity[31]. In terms of estimated elasticities, it makes almost no difference in taking the only output gap for the private PRVO sector (obtained through HP filtering) with respect to the whole-economy output gap (production function methodology). It is preferably to stick to the whole-economy out-put gap as tensions in the banking sector could spill over to the other sectors. Also the latter is it based not exclusively on filtering methods and shows therefore some short-term variance.

Note that the 1989/1991 dummies are probably due to the observed per capita series of nominal wages that shows strong outliers for both years that might be due to a measurement bias. These dummies had to be added in other equations as well to correct for the biases. Not letting them in makes the coefficient on the output gap become very small, not statistically different from zero. We argue however that the inclusion of the output-gap adds explanatory power to the equation.

We conclude from these results that the error correction process is slow, maybe not indicating a cointegrating relation. They also seem to point out that there has been a structural break in the Luxembourg economy at around 1985-1990, in the sense that disequilibrium mechanisms were gradually emerging[32]. The same conclusion can be drawn from the estimation results of the wage equations. Knowing that potential output is "measured" with error, this even more in small and open economies and that national accounts data of Luxembourg are subject to frequent and high revisions, one should not be surprised if this relation showed some evolution over the next years…

[31] Estimating from 1985 onwards diminishes the elasticity on the output-gap by 0.05 but does not change the standard error.

[32] It is possible to find an ECM starting in 1970 and including the OG as well as (differenced) unit labour costs in the short run part, without having to rely on these dummies. But the coefficient on the OG is relatively high (0.40), the R-squared rather low and the error-correction mechanism still not significant. This equation cannot explain much of the price variations over the 1975-1985 period as static simulation shows nor over the more recent years. But it seems to indicate that the output gap might have been an element explaining inflation over the whole horizon (1970-2002).

Some comparisons for the wage-price spiral

We are comparing our results to those of three econometric models, namely e-mod.fr by OFCE, SAFE by CPB and Mod-trim by the Belgian Bureau Fédéral du Plan.

Concerning e-mod.fr, the wage equation is an augmented Phillips curve, with an indexation on (value-added) prices inferior to one (0.7). The coefficient on unemployment is -0.14: a 1% increase in the unemployment rate raises wage *inflation* directly by some 0.14%. Indexation on productivity is close to the value in modux, at 0.56. In the long run, value added prices – defined as a mark-up equation – depend on unit labour costs (long-term elasticity equal to one) and the utilisation rate of the capital stock of the manufacturing industry (elasticity at 0.4). Except for the non-unit indexation of wages on (value-added) prices, there is a good deal of similarity between e-mod.fr and modux concerning wages and value added prices. Remember however that in modux, wages depend on consumer prices which depend on value added prices.

In SAFE, price equations are determined in a very similar way. The system is however far more complex and detailed than in modux and also to some extent than in e-mod.fr. CPB distinguishes prices for twelve output categories and four categories of unit costs (labour, capital, imported intermediaries, natural gas). Cost categories are weighted by the shares in total costs per output category according to the latest Input-output table. The share of labour costs is roughly between 40% and 60%, that of capital between 10% and 20%. On top of costs, output prices depend on foreign prices (where relevant) and on the capacity utilization rate. The SAFE wage equation is specified according to a "right-to-manage" model. In the long run, wages of the market sector depend on value added prices (elasticity: 1), productivity (1), the wedge (0.34) and unemployment (-2.0). The high value of the elasticity on unemployment is striking[33] as well as the unit-elasticity on productivity[34]. The introduction of the wedge allows wages to depend on value added prices and on consumer prices (as well as on the tax burden). This feature is quite interesting as in e-mod.fr, wages depend on value added prices and in modux, the depend on consumer prices (the latter depending on value added prices, dependence is indirect). SAFE seems then to be an intermediary case, with an indexation on value added prices of 0.66 and on consumer prices on 0.34…

In MODTRIM II, the Belgian model, wages are exogenous. This is motivated by the fact that the horizon of the model is mainly short-run (6-8 quarters) and that wage increases exclusive of indexation are largely determined by bi-annual collective agreements between social partners (and can hence be assumed to be invariant over the forecasting/simulation horizon with respect to the other variables).

[33] It has to be assumed that an unemployment rate of 5% is expressed as 0.05 against 5.0 as in modux…

[34] While estimating the wage equation in modux, testing unitary indexation of productivity was rejected by the data. But by enforcing it, the coefficient on unemployment rises substantially, although not as high as in the Dutch case (about half the value).

4.4.3 Consumer prices

Private consumption prices depend on import prices and on domestic value added prices. Imports include goods (MB) and services (MSO) of which a price increase can generate domestic inflation. Indeed, private final consumption (CFIN) includes abroad consumption that consists of goods but also of services (recreational). In the long run, we want the sum of the elasticities on the three explaining variables (P_VABPRVO, P_MB, P_MSO) to sum to 1.

Estimating this relation from 1980 to 2002 gives:

Log(P_CFIN) = 0.47*log(P_VABPRO) + 0.11*log(P_MB) + 0.42*log(P_MSO)
(0.12) *(0.11* *(-)*

where P_CFIN = national consumer prices, P_VABPRVO = domestic value added prices, P_MB = imported goods prices and P_MSO = imported services prices (exclusive of financial services).

One could be surprised of the high value of the coefficient on prices of imported services. One has to know that the correlations between the four variables at play are extremely high: between 0.86 and 0.99. By regressing the first differences, one eliminates the problem of high correlation but, as the results show, this does not alter the high coefficient on P_MSO. Specifying an ECM, again, we find that the only variable for which the long term parameter is significant are services' import prices, at the same value found before, close to 0.5…

We finally retain these long-run coefficients, knowing that there is some room for calibration in case simulation or forecasting results would be inconsistent.

Table 4.23: Final private consumption prices

Dependent Variable: DLOG(P_CFIN)
Method: Least Squares
Date: 05/03/04 Time: 08:42
Sample(adjusted): 1981 2002
Included observations: 22 after adjusting endpoints
DLOG(P_CFIN)=+C_P_CFIN(1)*DLOG(P_MB)+C_P_CFIN(2)
*DLOG(P_MSO)+C_P_CFIN(3)*DLOG(P_VABPRVO)
+C_P_CFIN(5)*(LOG(P_CFIN(-1))-0.11*LOG(P_MB(-1))-0.42
*LOG(P_MSO(-1))-0.47*LOG(P_VABPRVO(-1)))+C_P_CFIN(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C_P_CFIN(1)	0.077116	0.089817	0.858591	0.4025
C_P_CFIN(2)	0.640914	0.138268	4.635304	0.0002
C_P_CFIN(3)	0.316966	0.139342	2.274738	0.0362
C_P_CFIN(5)	**-0.579383**	**0.215649**	**-2.686690**	**0.0156**
C_P_CFIN(9)	-0.009374	0.005624	-1.666831	0.1139
R-squared	0.921369	Mean dependent var		0.034089
Adjusted R-squared	0.902868	S.D. dependent var		0.024849
S.E. of regression	0.007745	Akaike info criterion		-6.686937
Sum squared resid	0.001020	Schwarz criterion		-6.438973
Log likelihood	78.55631	Durbin-Watson stat		2.107743

The R-squared is very high and this equation explains very well the observed inflation for the period 1980-2002 (RMSE of 0.006, mean absolute percentage error 0.6, to be compared with a standard deviation of the growth rate of consumer price inflation of 2.7%).

The interesting conclusion should be that in the long run, consumer price inflation is explained at a 50:50 rate by domestic prices and by import prices. This dependence on import prices should be recurrent for small and open economies and marks a clear difference with respect to the three bench-mark models we analysed. Indeed, in the case of Belgium, France and the Netherlands, the coefficient on domestic prices lies in a rather between 0.7 an 0.9, substantially higher than in Luxembourg, even when considering the upper bound of the confidence interval (0.47+0.12=0.59).

4.4.4 Other prices

4.4.4.1 Import and export prices

Import and export prices are all defined according to the same scheme: domestic influences (represented by P_VABPRVO) mix together with price taking behaviour on the international side. The latter is captured by a relevant price (export or value added price of trading partners) and effective exchange rates. Concerning export prices, there is an arbitrage to be taken between mark-up behaviour and price-taker-ship (cf. Bourgain 2004).

Export prices

Export prices are assumed to depend on domestic costs (measured by value added prices) and on foreign competitors' prices. This is the most common way of modelling export prices for the Belgian and French models. For the most recent Dutch quarterly model we found evidence that export prices are solely determined by domestic costs in the long run. The estimated long-run relations are as follows:

LOG(P_XB) = 0.36*LOG(P_VAIW*TXEEXB) + 0.64*LOG(P_VABPRVO)
(-) *(0.17)*
- 0.019*@TREND(1985)*(@TREND(1985)>0) + 0.18
(0.001) *(0.01)*

LOG(P_XSO) = 0.71 *LOG(P_VASW*TXEEXSO) + 0.29*LOG(P_VABPRVO) - 0.0039
(-) *(0.07)* *(0.004)*

where P_XB and P_XSO are prices for exports of goods and of non-financial services; P_VA?W stands for relevant competitors value added prices; TXEE are effective exchange rates and P_VABPRVO are domestic value added prices (exclusive of financial services). The estimated relation for P_XSO however is not the one retained in the final ECM (see below) but the following:

LOG(P_XSO) = 0.45*LOG(P_VASW*TXEEXSO) + 0.55*LOG(P_VABPRVO)

Export of goods prices are estimated for the 1975-2002 period, exports of non-financial services prices only from 1985 onwards. A trend starting in 1985 had to be added to explain goods' export prices. This could be due to the different product mix that characterises both exports and world demand[35]. Long run elasticities are constrained to sum to 1; in the short run however, this constrain is relaxed. In case of P_XSO, we did not retain the estimated coefficients on foreign resp. domestic prices (0.71 and 0.29) but calibrated to values closer to the ones observed for goods' export prices and more in accordance with what can be found for other models. The coefficients on foreign prices remain relatively high with respect to other models.

Table 4.24: Export price elasticities

Variable	Competitors prices		Value added prices	
	Short run	Long run	Short run	Long run
P_XB	0.45	0.36	0.55	0.64
P_XSO	0.45	0.45	0.44	0.55

Import prices

As export prices, import prices are supposed to depend on international prices but also on domestic prices: imports are possible substitutes to domestic production and are therefore sensitive to domestic prices. There is also some value added produced by retailers. Foreign prices are measured by export prices of main trading partners, expressed in national (i.e. foreign) currency. In comparison to some French models, foreign prices seem to have high elasticities, well above 0.5 and domestic prices seem not to play at all for imports of non-financial services (which can be explained by the fact that they do not depend on national retailers). The sum of elasticities on domestic and foreign prices is constrained to sum to 1 in the long run. It should be noted that no valid relation could be estimated for the long-run evolution of non-financial services' prices and elasticities as reported below are therefore calibrated. We assume that those imports are even more determined by international prices as there is no interference with domestic retailers.

LOG(P_MB) = 0.7*LOG(P_XBW*TXEEMB) + 0.30*LOG(P_VABPRVO)
(-) *(0.04)*
- 0.008*@TREND(1995)*(@TREND(1995)>0) - 0.0047
(0.002) *(0.006)*

where P_MB = goods' import prices, P_XBW = main trading partners export prices, TXEEMB effective exchange rates (weighted according to goods imports by region), P_VABPRVO domestic value added prices (exclusive of financial services).

[35] Finding a lon-run relation explaining exports of goods' prices is not easy. There seems to be a significant downward pressure on export prices following the year 1985 that can only be captured by a trend. This could be due to globalisation. Similar effects have been described for the Dutch economy. Then, domestic value added prices seem to play a more important role in explaining export prices after 1985: this could be due to increased pricing power due to the declining steel industry that has been notably price-taking in the past (Krecké 1997-b). Due to high collinearity of explained and explaining variables and low number of observations, no valid relation emerged from non-constrained estimation.

In order to find an acceptable long-run relation for goods' import prices, a trend starting in 1995 had to be added. It could be linked to increased trade with re-exports. This trend depresses import prices by 0.8% per year from 1995 onwards. No valid relation could be found for the long run evolution of non-financial services import prices. Elasticities as included in table (4.25) are hence calibrated values. Difficulties linked to finding appropriate elasticities for prices of exports and imports of non-financial services can be linked to two reasons: those products are often adjusted within the equilibration process of national accounting because they are supposed to be measured with high imprecision and are therefore subject to some arbitrary evolution and/or higher residuals or outliers; there is a high discrepancy between the national product mix of these branches resp. consumed services and foreign competitors' imports respectively exports.

Table 4.25: Import price elasticities

Variable	World export prices		Value added prices	
	Short run	Long run	Short run	Long run
P_MB	0.59	0.70	0.22	0.30
P_MSO	0.50	0.90	0.25	0.10

Investment prices

Investment prices depend on value added prices and on import prices (goods). Most of the long term equations could not be estimated without constraining the parameters to some extent or adding selective trends. Most of the added trends however can be rationalised by economic developments. The estimated long-run relations are as follows:

LOG(P_IMEQ) = 0.46*LOG(P_MB) + 0.54*LOG(P_VABPRVO) - 0.003
(0.18) *(-)* *(0.01)*

LOG(P_IRES) = LOG(P_VABPRVO) + 0.013*@TREND(1975) - 0.30
(0.002) *(0.04)*

LOG(P_ISNM) = LOG(P_VABPRVO) + 0.009*@TREND(1975) - 0.21
(0.0008) *(0.01)*

LOG(P_IBNQ) = 0.10*LOG(P_MB) + 0.90*LOG(P_VABPRVO) -
(-) *(0.20)*
0.0741*@TREND(1994)*(@TREND(1994)>=0) + 0.11
(0.004) *(0.02)*

Investment in machinery and equipment prices (P_IMEQ) depend roughly to the same extent on import prices and on domestic prices. Prices of construction investment (IRES=residential and ISNM=public i.e. mainly building) depend with a unit elasticity on domestic prices only. A trend had to be added to take into account persistent tensions on the housing market, spilling over into construction prices. The spill over effect is higher for the housing market than for public investment that is composed also of other (non-construction) goods. Prices for banking investment (IBNQ) also depend on import prices but to a much lesser extent than machinery and equipment: banking investment comprises

a good deal of construction elements (offices). From 1994 onwards, a trend had to be added; this could be due to the continuous fall in ITC goods' prices in the late 1990's.

It should be mentioned, that, concerning the investment prices for the banking sector, the estimated long-run elasticities did not result in a properly specified ECM. The had to be revised, substantially, beyond the bounds indicated by the confidence intervals (see table 4.26).

Table 4.26: Investment price elasticities

Variable	Imports of goods		Value added prices	
	Short run	Long run	Short run	Long run
P_IMEQ	0.75	0.46	-	0.54
P_IRES	-	-	0.67	1.00
P_ISNM	-	-	0.15	1.00
P_IBNQ	-	0.5	0.56	0.5

4.5 Rounding up: private and public consumption, taxes

4.5.1 Private consumption

Due to missing household accounts, private consumption is more difficult to model. A proxy can be constructed for disposable income, taking into account wages, taxes and social contributions as well as transfers received from the government. But since capital revenues are absent, disposable income is lower than final private consumption and the resulting savings rate is negative. What's more, this series can only be established for the years after 1990. To take into account to some degree household revenues from capital markets, we included in our long-run specification the stock market index Euro-Stoxx 50. We also included in the long-run equation the inflation rate as well as the unemployment rate. Estimating from 1990 to 2002 produces the following result:

LOG(CFIN_R)= 0.98*LOG(RDMEN_R) - 2.01*DLOG(P_CFIN) - 0.035*R_UBIT
(0.07) *(0.67)* *(0.01)*
+ 0.052*LOG(STOXX50/(PIBUE_R*P_PIBUE)) + 0.17
(0.02) *(0.14)*

where CFIN_R is private national consumption, RDMEN_R real disposable household income, P_CFIN consumer prices (in level, entering the equation in first differences), R_UBIT the (harmonized) unemployment rate, STOXX50 the top-50 stock market index of Europe, deflated by nominal GDP of the EU15 (PIBUE_R*P_PIBUE).

It is remarkable that all variables have the anticipated sign and are significant at the 5% level (except for the constant). The elasticity of real consumption with respect to real disposable household income is found to be not statistically different from 1. The coefficient on inflation seems to be a bit high (an acceleration of inflation of 1% would depress consumption by more than 2%) and it had to be revised downwards for simulation and forecasting according to the confidence bounds. In any case, since the inflation rate can be assumed to be stationary, it only depresses the level of consumption temporarily. Few data points could generate parameter instability so we should not rely too much on the estimated elasticities but compare them with the values found in the literature. What's more, estimating an ECM with so few observations should reveal tricky. Some simulation exercises however showed this equation to be reliable.

Table 4.27: Private consumption

Dependent Variable: DLOG(CFIN_R)
Method: Least Squares
Date: 05/04/04 Time: 16:27
Sample: 1990 2002
Included observations: 13
DLOG(CFIN_R) = C_CFIN_R(1)*DLOG(RDMEN_R) + C_CFIN_R(2)
*D(R_UBIT) + C_CFIN_R(3)*DLOG(STOXX50/(PIBUE_R
P_PIBUE)) + C_CFIN_R(5)(LOG(CFIN_R(-1))-LOG(RDMEN_R(
-1))+1.4*DLOG(P_CFIN(-1))+0.03*R_UBIT(-1)-0.055
*LOG(STOXX50(-1)/(PIBUE_R(-1)*P_PIBUE(-1)))) + C_CFIN_R(8)
*D92+C_CFIN_R(9)

	Coefficient	Std. Error	t-Statistic	Prob.

C_CFIN_R(1)	0.720422	0.281009	2.563696	0.0373
C_CFIN_R(2)	-0.009263	0.008541	-1.084523	0.3141
C_CFIN_R(3)	0.037114	0.024145	1.537096	0.1682
C_CFIN_R(5)	**-0.631602**	**0.276963**	**-2.280458**	**0.0566**
C_CFIN_R(8)	-0.046119	0.016094	-2.865614	0.0241
C_CFIN_R(9)	0.075525	0.020297	3.720903	0.0074
R-squared	0.790740	Mean dependent var		0.033913
Adjusted R-squared	0.641268	S.D. dependent var		0.023019
S.E. of regression	0.013787	Akaike info criterion		-5.426119
Sum squared resid	0.001331	Schwarz criterion		-5.165373
Log likelihood	41.26978	Durbin-Watson stat		2.132125

The error correction term might not significant in order to denote cointegration. It has to be remembered that this equation is estimated with 7 degrees of freedom! The other short-term parameters are not really significant except for the revenue. All have lower elasticities in the short run than in the long run. We believe that given data constraints, this equation is a sufficient explanation of private consumption. The general fit can be improved by adding a dummy in 1992, the year where the VAT rate had been raised[36].

4.5.2 Government consumption

Explaining government consumption is mainly a story of definitions. Few variables are endogenous, in fact only wages are estimated. Some variables are important decision variables like employment, investment or social contributions. There are a few less important exogenous variables.

By definition, government consumption CG equals indirectly measured non-market production plus social security expenses in kind (“en nature”, other than cash).

CG = PRODSNMIND + DPSNMSOCNAT

Indirectly measured non-market production is total non market production less receipts for market production:

PRODSNMIND = PRODSNMNRC – PRODSNMNRCPAY

and

PRODSNMIND = MSALSNM + DPSNMCI + CCSNM – PRODSNMNRC_AJUST

where MSAL is the total wage bill NSALSNM*SALMSNM, DPSNMCI is intermediate consumption, CCSNM is capital consumption and PRODSNMNRC_AJUST is an adjustment factor due to expenses for market production (salaries or intermediate consumption) that are not counted as public consumption.

Value added is straightforward:

VABSNM = PRODSNM – DPSNMCI

where PRODSNM is total, market and non-market, public sector production.

[36] Private consumption rose sharply by 6.7% (on volume) in 1991, the year before the harmonisation of VAT rates. The latter passed from 12% to 15% as regards the normal rate.

These identities are sufficient to integrate public consumption into the model, knowing the endogenous variable SALMSNM (average wage, cf. part 4.4.1.3) and the main exogenous decision variables NSALSNM (employment), ISNM (investment), DPSNMCI (intermediate consumption) and DPSNMSOCNAT (social expenditures in kind).

Prices of value added and consumption are linked directly to wages.

4.5.3 Government surplus/deficit – structural balance

Government surplus/deficit is obtained by subtracting expenses (DPSNM) from receipts (RCSNM). The following table shows the respective series' names and definitions.

Table 4.28: receipts and expenditures of the public sector

Expenditures	Explanation	Value in 2002 (10^6 EUR)	Receipts	Explanation	Value in 2002 (10^6 EUR)
DPSNMCI	Intermediate consumption	798	PRODSNMMRC	Market production	278
ISNM	Investment	1 080	PRODSNMNRCPAY	Receipts for on-market production	206
MSALSNM	Wage bill	1 965	IMPM	Taxes on imports and production	3 062
DPSNMIMPROD	Taxes on imports and production	1	RCSNMSUB	Subsidies received	0
DPSNMSUB	Subsidies paid	377	RCSNMPROP	Property income, received	391
DPSNMPROP	Property income, paid	56	IMRW	Taxes on income and wealth	3 660
DPSNMIMRW	Taxes on revenues and wealth	0	COSOC	Social security contributions	2 777
DPSNMSOCLQ	Social transfers, cash	3 513	RCSNMTRC	Transfers, received	38
DPSNMSOCNAT	Idem, in kind	1 134	RCSNMCAP	Capital transfers, received	43
DPSNMTRC	Current transfers	720			
DPSNMCAP	Capital transfers	304			
DPSNMANF	Change in valuation of assets	0			
DPSNM	Total expenditures	9 948	RCSNM		10 456

The surplus/deficit is then

RCDPSNM = RCSNM – DPSNM

In an optimal econometric model, taxes are completely endogenous and imputed tax rates (i.e. receipts divided by their tax base) are a function of the nominal tax rates (cf. Chauvin 2002). Modux however has not yet reached that state of development. Some error-correction equations have been established but they are useless to simulate tax policy changes. A better and simpler option to simulate the effect of tax policy changes is to fix the imputed rate at the historical value (for the base-line simulation simulations) and then to shock it.

The tax system of Luxembourg is at first sight difficult to model because there are some sources for tax revenues (fuel, alcohol, tobacco, investment funds) that are designed in a way to optimize the revenues of the government given the geographical and political specificities of Luxembourg.

We distinguish the following endogenous tax sources with their respective bases:

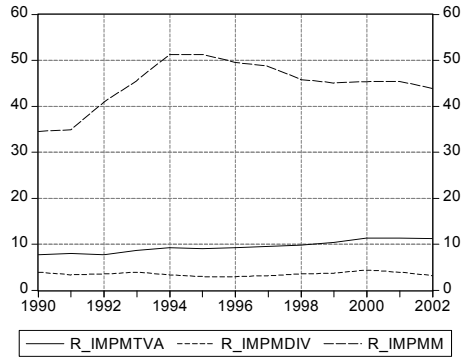
Table 4.29: Taxes and social security contributions

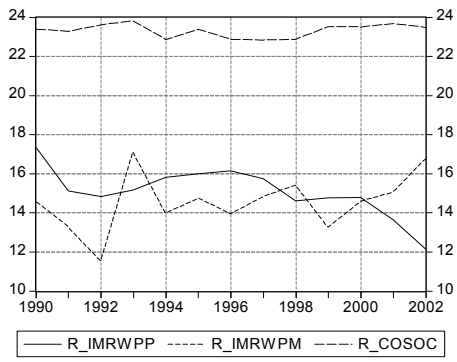
Name	Explanation	Value in 2003 (10^9 EUR)	Tax base	Explanation	Value in 2003 (10^9 EUR)
IMPMTVA	Value added tax receipts	1.35	CFIN+CETR–CLUX+ISNM+IRES+DPSNMCI-LOYERMEN	See note 1	12.0
IMPMM	Taxes on imports (on alcohol, tobacco, fuel products)	1.1	CETR	Consumptions of non-resident households	2.39
IMPMDIV	Other taxes on production and imports = IMPMDIVABO + IMPMDIVMOB + IMPMDIVDIV	0.67	VABPRV	Value added of the private sector	21.4
IMPMDIVABO	"Taxe d'abonnement"	0.38	(not modelled separately)		
IMPMDIVMOB	Taxes on financial assets	0.19	(not modelled separately)		
IMPMDIVDIV	Other taxes on production and imports than ABO or MOB	0.09	(not modelled separately)		
IMRWPP	Taxes on revenue and wealth of individual persons	1.5	MSAL –COSOC + DPSNMSOCLQ	Wages less social security contributions plus social transfers (money)	12.6
IMRWPM	Taxes on revenues of companies	1.9	EBEPRV	Operating surplus, enterprises	11.5
COSOC	Social security contributions	2.8	MSAL	Total wage bill	11.8

1: Private consumption (on the territory) + public consumption + public investment + residential investment + intermediate consumption by the government – imputed rental services.

The related imputed tax rates look as follows:

Figures 4.12 and 4.13: Implicit taxation rates





The structural balance is established according to a methodology recommended and used by the European Commission (2004) and Van den Noord (2000).

Let RCSNM be total receipts of the government, DPSNM total expenditures, RCDPSNM and R_RCDPSNM the budget balance (nominal resp. as a % of GDP):

In that case, the papers cited above state that

R_RCDPSNM_ST = R_RCDPSNM - ε * (PIB_R/PIB_R_POT)

where R_RCDPSNM_ST = cyclically adjusted balance ("solde structurel"), PIB_R and PIB_R_POT observed resp. potential GDP and ε the so-called "budget sensitivity" parameter (EC 2004, p. 5).

The elaboration of the output-gap is commented on pages 19 to 22. It is established according to a production function method as recommended by the EC and used for the monitoring of the stability and growth pact.

The sensitivity parameter ε is equal to

$\varepsilon = \varepsilon_R - \varepsilon_D$

where ε_R and ε_D are the respective receipts (R) and expenditure (D) sensitivities. Both are defined by the Commission as

$\varepsilon_R = \eta_R$ * RCSNM/PIB

and

$\varepsilon_D = \eta_D$ * DPSNM/PIB

where η_R and η_D are the true elasticities of receipts and expenditures with respect to nominal GDP (PIB).

η_R and η_D are in principle obtained through estimation, either by regressing the level of receipts (expenditures) on nominal GDP or by estimating an ECM. Estimation results may be influenced by the short observation span (1990-2003) in the case of Luxembourg and the yearly frequency of data. It should be noted that OECD suggests a more refined methodology, based on specifying elasticities for four categories of receipts, namely corporate taxes, personal income taxes, social security taxes and indirect taxes. For the time being, we stick to one aggregate measure of overall tax revenues. The elasticity of total taxes or receipts (in modux notation: RCSNM) with respect to GDP is found to be 0.96 according to a simple level regression. A slightly higher value (0.97) emanates from the estimation of a simple ECM. Probably, one does not make a big mistake assuming that overall taxes are characterized by a unit elasticity with respect to nominal GDP.

Table 4.30: Elasticity of government receipts with respect to nominal GDP

Dependent Variable: LOG(RCSNM)
Method: Least Squares
Date: 05/10/04 Time: 11:02
Sample(adjusted): 1990 2003
Included observations: 14 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(PIB)	0.961083	0.017819	53.93658	0.0000
C	-0.662815	0.048747	-13.59703	0.0000

R-squared	0.995892	Mean dependent var	1.949970
Adjusted R-squared	0.995550	S.D. dependent var	0.305492
S.E. of regression	0.020380	Akaike info criterion	-4.817008
Sum squared resid	0.004984	Schwarz criterion	-4.725714
Log likelihood	35.71906	F-statistic	2909.155
Durbin-Watson stat	1.099892	Prob(F-statistic)	0.000000

For the elaboration of the sensitivity of expenditures, OECD takes solely into account "unemployment related spending". In the case of Luxembourg, we defined the latter as the sum of[37]

- unemployment benefits (including part-time unemployed/"chômage partiel" and bad-weather-unemployed/"chômage pour intempéries");
- expenses in favour of young unemployed or employment-seekers ("actions pour combattre le chômage des jeunes");
- expenses to favour employability (training, employment subsidies)[38].

The elaboration of the elasticity of these expenses with respect to GDP is more tricky. In practice, regressing them on GDP produces a positive elasticity because both series are trending upwards simultaneously. One would however expect a negative elasticity, denoting a rise of the spending involved in case growth slows down. One possibility is to add a trend in the respective equation which results in an elasticity of –3.8. This value is very close those found for other countries by OECD in Van den Noord (2000).

We tried however to apply exactly the methodology as adopted by OECD (cf. table A.7 p. 25). In that case we find an elasticity of –5.9 for unemployment related expenditures with respect to output and of –0.17 for overall primary expenditures[39]. The value of –0.17 (or –0.2) has to be compared with an average value of –0.3 for the other OECD countries and values of –0.4 and –1.0 for Belgium and Netherlands.

Finally, we can derive the sensitivity parameter

$\varepsilon = \eta_R$ * RCSNM/PIB - η_D * DPSNM/PIB
= 0.96*0.46 – –0.17*0.013
= 0.44.

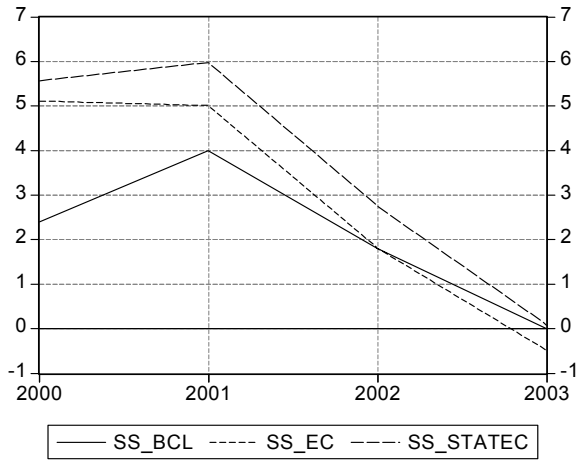
For practical reasons, we retained a value of 0.4.

[37] Cf. Budget de l'Etat 2004, pp. 669+670. It includes mainly all expenses of the "Fonds pour l'emploi", except those to the benefit of the steel industry.

[38] Unfortunately, the latter category includes expenses for early retirement outside the steel industry.

[39] The analyses carried out by OECD is restricted to primary expenditures, i.e. total expenditures less interest payments and capital spending.

Figure 4.14: Structural public finance balances (SS), three sources



NB.: BCL = Central Bank of Luxembourg; EC = European Commission

5. Simulations

In order to take fully into account the properties of the whole system of equations, the model has to be solved with respect to some variations on endogenous or exogenous variables. One typically distinguishes "shocks" from "scenarios". A shock is executed on one single variable, possibly knowing that the implemented deviation of the shocked variable is not completely realistic. Constructing a scenario involves shocking several, related variables. Typical scenarios concern the exchange rates or the oil prices. Indeed, it is not sufficient for example, to implement a depreciation on the nominal exchange rate in order to derive the complete result for a single country. Due to interrelatedness, the same depreciation has some effect for trading partners in Europe or even in Asia and the USA and it shifts henceforth global demand and prices. Without taking into account in the scenario the path towards a new equilibrium between countries as concerns global demand and prices, one severely underestimates the effects of the depreciation on the home country!

As it was the case for the endogenous equations, we still want to compare our results to those from other countries/models. We therefore rely on the different shocks and scenarios simulated for France with the "Moisaïque" model (no scenarios exist for OFCE's current more recent model e-mod.fr) and for the Netherlands with the SAFE model[40]. We have to take into account shocks that can be reproduced by modux. For the time being, we implement only two such shocks, namely an increase in relevant world trade and a rise in public spending. Those two shocks should suffice to illustrate the sensitiveness of modux in the most visible domains.

What's more, we will outline the results of some purely national shocks that have been undertaken on more typical variables figuring in modux, as the economic conditions in the neighbouring regions or a rise in wages. This will enable us to point to some of the most prominent features of modux concerning for example the endogenous character of labour supply.

As for the other models, the shocks are implemented upon a baseline scenario that has to been seen as the best fit of the model over a certain time span in the past, given the values of all the endogenous variables. Modux is solved over the 1991-2002 horizon whereas Mosaïque is solved from 1995 onwards. The longer horizon of modux is justified by the annual periodicity that translates into lower adjustment of the error correction equations. The SAFE model is simulated over a much more recent horizon namely from 2002 onwards, over the forecasting horizon of that moment.

[40] For Belgium, in the Modtrim II model, the simulations are carried out over five quarters only.

5.1 Comparison shocks

As stated before, our comparison sums up to two main shocks: a rise in relevant world demand of 1% and an increase of public spending of 1% of GDP. The domestic shock reveals the "multiplier" of public expenses. The latter translates by how much an economy can create supplementary value added with respect to an increase in public spending of, say, 1% of GDP. The multiplier should be bigger than one, at least in the short run, because higher spending induces higher production and investment that provoke higher revenues and re-enforce – potentially – the initial effect. The negative side of the medal is a collateral increase in the public deficit… The rise of world demand is typically one of the main channels through which a small and open economy can experience a recovery, as it has no power on interest rates and as – we will show it later – the multiplier effect of public expenses is rather low.

5.1.1 The multiplier effect of a small and open economy

Through increased private expenses (consumption, investment) a 1% increase in public spending (in terms of GDP) can temporarily result in an increase of GDP above 1%. The counterpart is a higher fiscal deficit. According to OECD (Dalsgaard 2001), the multiplier is higher than one for the US, Japan and Germany in the first one or two year following the shock, afterwards it drops rapidly… For all other countries examined in that paper (F, I, UK, CAN) it is lower than one from the first year onwards. These results are somewhat counterfactual to what our main comparison models reveal for France, namely multipliers well above (F) respectively somewhat below (NL) unity. Table 5.1 compares those results with the ones we found for modux.

As we expected, the multiplier for Luxembourg is smaller than for France and the Netherlands. For France it is above unity still five years after the initial shock. In the Netherlands, it amounts to 0.9 over the three simulated years. This reveals already one of the features of a small open economy (the Netherlands being smaller and more open than France) namely that there is a higher proportion of additional public demand that has to be imported and that reduces the beneficial effects on the domestic economy[41]. So for Luxembourg, the multiplier is 0.7 in the first year and drops to 0.5 after five years.

At this point we have to put emphasis on one crucial feature of modux in this context, namely the presence of the output-gap in the short run parts of the export and import functions. As we described the equations in parts 4.1.3-4.1.5, the output gap is not significant in the export functions but it is so (only just, 14% probability) in the imports of goods function. The reason for letting it in the equations is precisely that without, the

[41] In Mosaïque, there are two implemented shocks on public spending, one on goods and another on services. Concerning goods, the multiplier is also below unity as a higher proportion of additional spending gives rise to imports. In the case of services, the multiplier is above unity. We reported in table 5.1 the average of the two multipliers which might of course be a distortion of reality in case weights are far from 50:50.

multiplier for Luxembourg rises above unity. To our comfort, it is the presence/absence in the imports of goods' function that is most determinant.

Table 5.1 Rise of 1% of public spending in terms of nominal GDP: the multiplier effect of public spending

	1 year			2 years			3 years			5 years		
	Modux	Mosaique	SAFE	Modux	Mosaique	SAFE	Modux	Mosaique	SAFE	Modux	Mosaique	SAFE
										Baseline deviation, volumes, in %		
GDP	0.7	1.0	0.9	0.6	1.2	0.9	0.7	1.1	0.9	0.5	1.1	.
Final private consumption	0.2	0.4	0.2	0.4	0.8	0.5	0.7	0.9	0.8	1.0	0.9	.
Capital formation												.
- Private, non residential	3.6	5.1	1.3	3.3	3.6	2	2.3	2.2	1.8	1.4	1.8	.
- Residential	0.1	-0.3	-	0.6	-0.5	0.2	1.3	-0.3	0.6	1.3	0.1	.
Imports	0.7	1.7	0.5	0.7	1.7	0.6	0.7	1.5	0.6	0.8	1.5	.
Exports	-0.2	-	-0.2	-0.2	-0.1	-0.4	-0.3	-0.1	-0.5	-0.4	-0.1	.
										Baseline deviation, in %		
Total employment	0.2	0.5	0.2	0.4	0.9	0.8	0.6	1.0	0.8	0.7	0.9	.
										Baseline deviation, % points		
Unemployment rate	-0.1	-0.3	-0.3	-0.2	-0.5	-0.6	-0.3	-0.5	-0.5	-0.3	-0.5	.
										Baseline deviation, in %		
GDP deflator	0.2	0.3	0.2	0.4	0.6	0.6	0.5	0.6	1.0	0.7	0.8	.
Consumption prices	0.1	0.3	0.1	0.2	0.5	0.3	0.3	0.6	0.5	0.4	0.8	.
Labour productivity (per capita)	0.5	0.5	0.8	0.1	0.1	0.2	-	-0.1	0.2	-0.2	-	.
Nominal per capita wages	0.2	0.2	0.6	0.3	0.5	1.1	0.3	0.7	1.9	0.5	1.1	.
Import prices	0.1	0.4	.	0.1	0.5	.	0.1	0.5	.	0.2	0.6	.
Export prices	0.1	0.3	0.1	0.1	0.3	0.3	0.2	0.3	0.5	0.3	0.4	.
										Baseline deviation, % points		
Public surplus/deficit (% GDP)	-0.8	-0.6	-0.8	-0.7	-0.3	-0.6	-0.6	-0.3	-0.6	-0.6	-0.4	.

Notes: . not applicable; - nil or smaller than abs(0.05)

France: average of impact due to rise in consumption of services and manufactures

France: wages are hourly wages

Netherlands: Exports and imports are goods only; employment and productivity are for market sector only

Luxembourg: private capital formation without banking sector

The results for most other important macro variables for Luxembourg are close to what can be found for the other two countries. Employment rises, a bit less in Luxembourg than elsewhere and unemployment drops, proportionally. The effect on GDP prices is similar but private consumption prices in Luxembourg rise less. This has to do with the fact that they are less dependant on domestic prices and more on import prices. This remarkable for the Netherlands where the coefficient on unemployment in the wage equation is high which leads to a stronger rise in wages, than for example in France or Luxembourg. This spills then over in GDP prices which rise more in the Netherlands despite higher openness than France.

The public deficit worsens, accordingly, but a bit less than the initial shock (0.3 - 0.6 percentage points of GDP after three years), since increased activity creates increased revenues. In no case however, the shock can it finance itself. Since the multiplier is highest in France, the deficit worsens less in that country.

5.1.2 A rise in world demand by 1%

We compare the effects of a permanent rise in relevant world demand of 1% for the Netherlands, France and Luxembourg. World demand is defined slightly differently in the three cases (see section 4.1). Nevertheless, the effect on GDP is almost the same in the three cases: 0.2-0.3% after three years. In table 5.2, we can see that exports rise less in the case of Luxembourg than for the neighbouring countries. This has several reasons. The first is that overall exports comprise close to 45% of financial services (see table 4.1 page 23). As financial services' demand is not shocked, the aggregate reaction on exports is much smaller. Exports of goods react rather slowly (+0.6% deviation from baseline after three years); this has to do with the short run elasticity (0.96) and the error-correction parameter that is not extremely high (0.38). Exports of non-financial services react quicker with a deviation of 0.9% after three years.

In the case of Luxembourg, imports rise almost as much as exports whereas for France and Belgium, the rise of exports is substantially higher than the rise of imports. Since Luxembourg is more open, additional exports create more imports. But a higher part of exports and imports in GDP (150%) and a bigger external surplus induce a higher multiplier effect on GDP.

The reactions of all the other variables in table 5.2 are rather close for the three countries examined and do not incite additional comments.

Table 5.2: Increase in relevant world trade of 1%

	1 year			2 years			3 years			5 years		
	Modux	Mosaïque	SAFE	Modux	Mosaïque	SAFE	Modux	Mosaïque	SAFE	Modux	Mosaïque	SAFE
										Baseline deviation, volumes, in %		
GDP	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.2	.
Final private consumption	-	-	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.4	0.1	.
Capital formation												
- Private, non residential	0.8	1.7	0.5	1.6	1.2	0.8	0.8	1.2	0.8	0.7	1.1	.
- Residential	-	-	-	0.2	-0.1	0.1	0.4	-	0.2	0.5	-	.
Imports	0.3	0.5	0.7	0.4	0.5	0.8	0.4	0.5	0.7	0.5	0.4	.
Exports	0.3	0.8	1.0	0.4	0.8	0.9	0.4	0.8	0.8	0.4	0.8	.
										Baseline deviation, in %		
Total employment	-	0.1	0.1	0.1	0.1	0.3	0.2	0.2	0.3	0.3	0.2	.
										Baseline deviation, % points		
Unemployment rate	-	-	-0.1	-	-0.1	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	.
										Baseline deviation, in %		
GDP deflator	-	-	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.3	0.2	.
Consumption prices	-	-	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	.
Labour productivity (per capita)	0.1	0.1	0.3	0.1	-	0.1	-	-	0.1	-	-	.
Nominal per capita wages	0.1	-	0.3	0.1	0.1	0.4	0.1	0.1	0.6	0.2	0.2	.
Import prices	-	0.1	.	-	0.1	.	-	0.1	.	0.1	0.2	.
Export prices	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	.
										Baseline deviation, % points		
Public surplus/deficit (% GDP)	-	-	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	.

Notes: . not applicable; - nil or smaller than abs(0.05)

France: wages are hourly wages

Netherlands: Exports and imports are goods only; employment and productivity are for market sector only

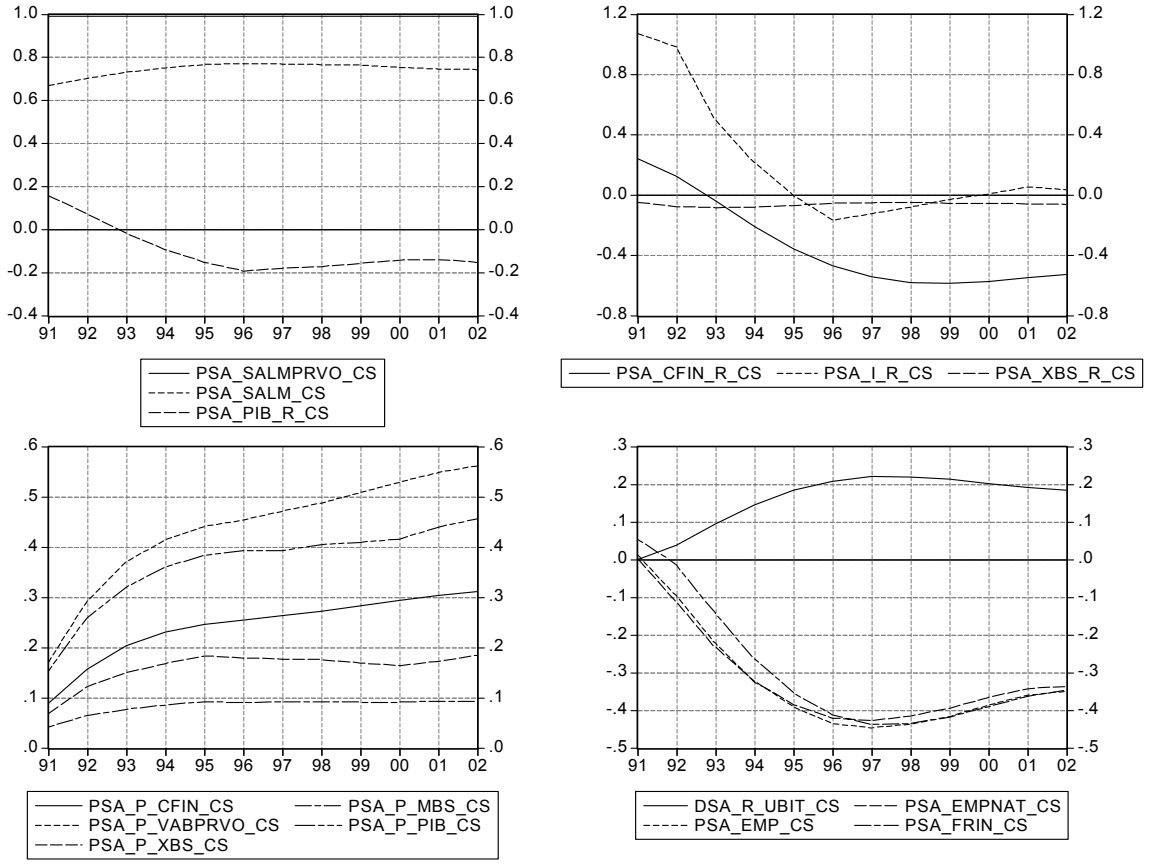
Luxembourg: private capital formation without banking sector

5.2 Some shocks for Luxembourg only

5.2.1 A rise in private sector wages of 1%

We exogenised the endogenous wages in the private non-financial sector and shocked them by 1% over the whole simulation horizon with respect to the baseline scenario. We expect a rise of private consumption in the short run and loss of competitiveness in the longer run. Since labour becomes more expensive with respect to capital, there should be some substitution. Unemployment should rise as well as overall prices.

Figures 5.1-5.4: Effect of a 1% rise in private non-financial wages (deviations from baseline)

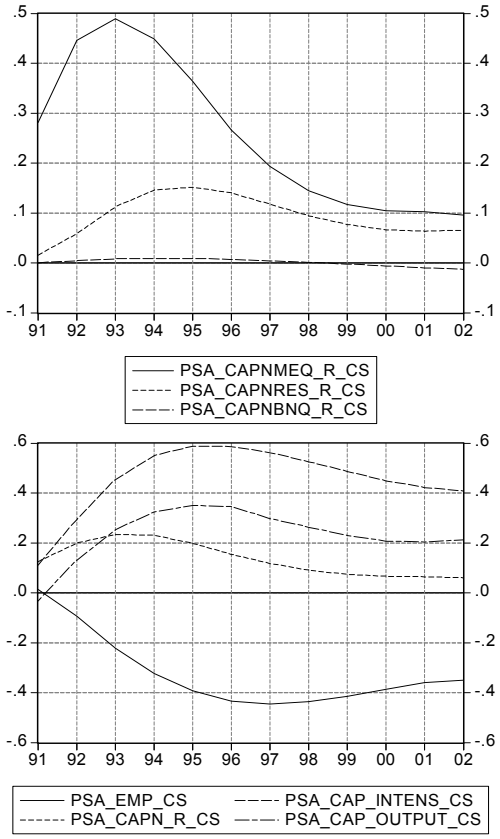


Notes: PSA is % difference from baseline; DSA difference in percentage points. _CS is the suffix characterising the implemented shock. SALMPRVO are private non-financial wages, SALM whole-economy wages, PIB_R is volume GDP, CFIN private consumption, I total investment, XBS total exports of goods and services. P_ denotes prices, P_VABPRVO are private, non-financial value added prices. R:_UBIT is the harmonised unemployment rate, EMP total employment and EMPNAT resident or national employment. FRIN are incoming cross-border workers.

In the short run, GDP increases, due to higher private consumption and higher investment spending. The latter derives from capital to labour substitution but in th long run the (negative) multiplier effect dominates. Exports decrease slightly over the whole horizon due to competitiveness losses. All prices rise, to various degrees. Private value added prices and GDP prices rise most due to higher content of labour.

Employment decreases and unemployment increases. Cross-border employment decreases a bit less since higher wages in Luxembourg attract more cross-border workers. This point will be dealt with in more detail in the next simulation.

Figures 5.5-5.6: Effect of a 1% rise in private non-financial wages on capital and employment (deviations from baseline)



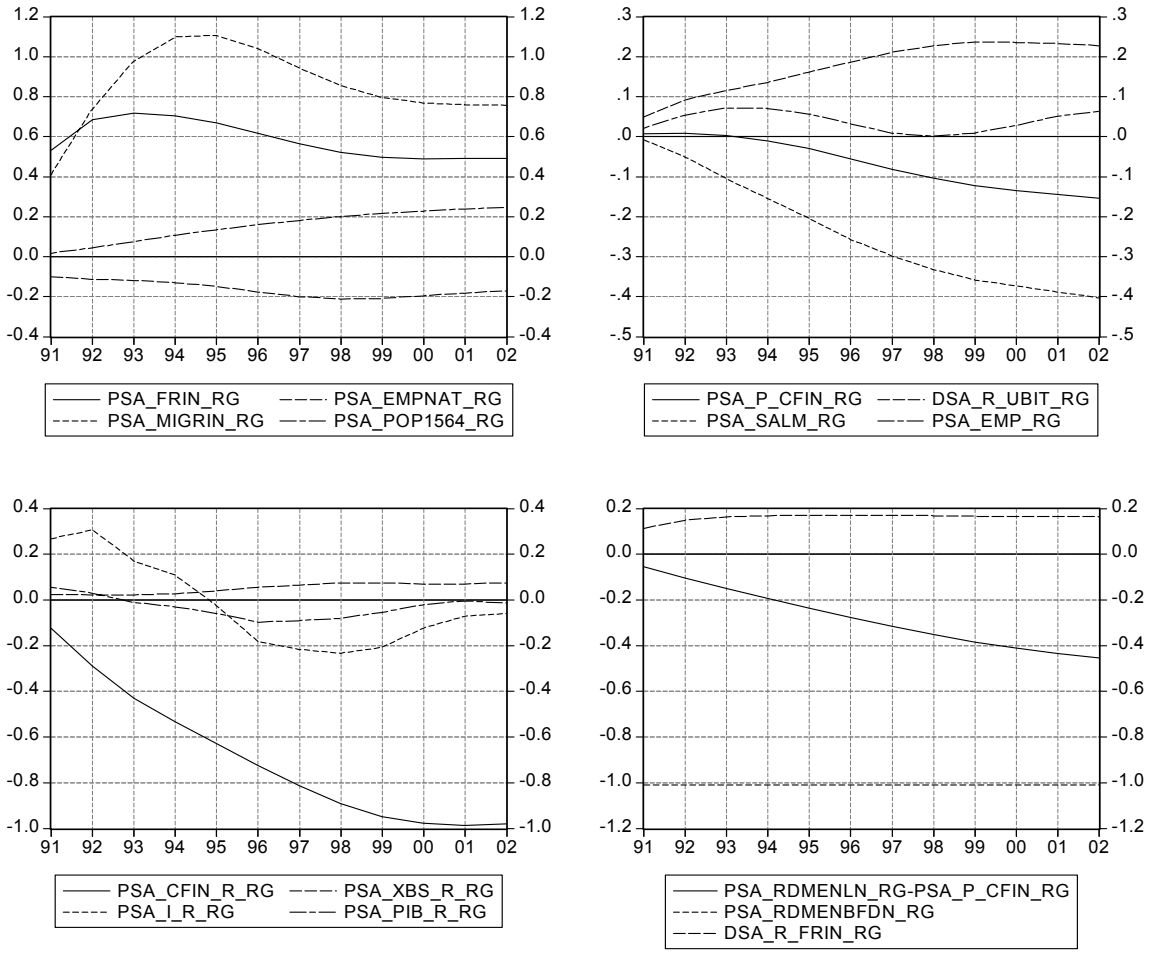
Notes: PSA is % difference from baseline; _CS is the suffix characterising the implemented shock. CAPNMEQR is machinery and equipment capital, CAPNRES is residential construction and CAPNBNQ is the capital stock of the banking sector. CAP_INTENS is capital intensity (capital/employment) and CAP_OUTPUT is the capital/output ratio.

Figures 5.5 and 5.6 show capital for labour substitution. It is highest after five years and decreases only slowly afterwards.

5.2.2 A fall in household's disposable income in the neighbouring regions

A fall in disposable income around Luxembourg should make Luxembourg a more attractive region to work since reservation wages have fallen for crossborder workers. Unemployment should rise and prices fall.

Figures 5.7-5.10: Effect of a fall in disposable income in the regions surrounding Luxembourg (deviations from baseline)



Notes: PSA is % difference from baseline; DSA is the difference in percentage points, _RG is the suffix characterising the implemented shock. FRIN are inflowing cross-border workers, EMPNAT is resident employment, MIGRIN immigrating workers (a flow!) and POP1564 working age population. RDMENLN is net nominal household income in Luxembourg and RDMENBFDN is net nominal household income in the neighbouring regions (simple non-weighted average). R_FRIN is the part in cross-border workers in the stock of total employment EMP.

We see that there is substitution between resident and non-resident workers. Resident employment falls whereas cross-border employment rises. Immigration also rises which makes the working age population increase. There is however an apparent paradox between the fall in resident employment and the rise in immigration and resident working age population. It can be solved by knowing that the employment and activity rates fall due to higher unemployment.

Wages and prices fall as higher unemployment works through the wage curve and the whole system of price equations. Overall employment first increases due to higher in-

coming workers and lower wages (labour-capital substitution comes into effect) but then it comes back to the baseline level.

Private consumption decreases due to the fall in wages that translates directly into lower disposable income and due to lower resident employment. Exports rise due to increased competitiveness whereas the multiplier effect on investment reacts with respect to GDP: first there is an increase but soon GDP starts to fall and pulls investment down again. The initial rise in GDP can be attributed to the positive contribution of the external balance over the whole horizon. Afterwards, the fall in the domestic components push GDP down.

The last figure shows relative real incomes in Luxembourg and in the Greater region. It shows that the fall in net income in the Greater Region pulls net revenues in Luxembourg down as well. This goes together with an increased penetration of cross-border workers.

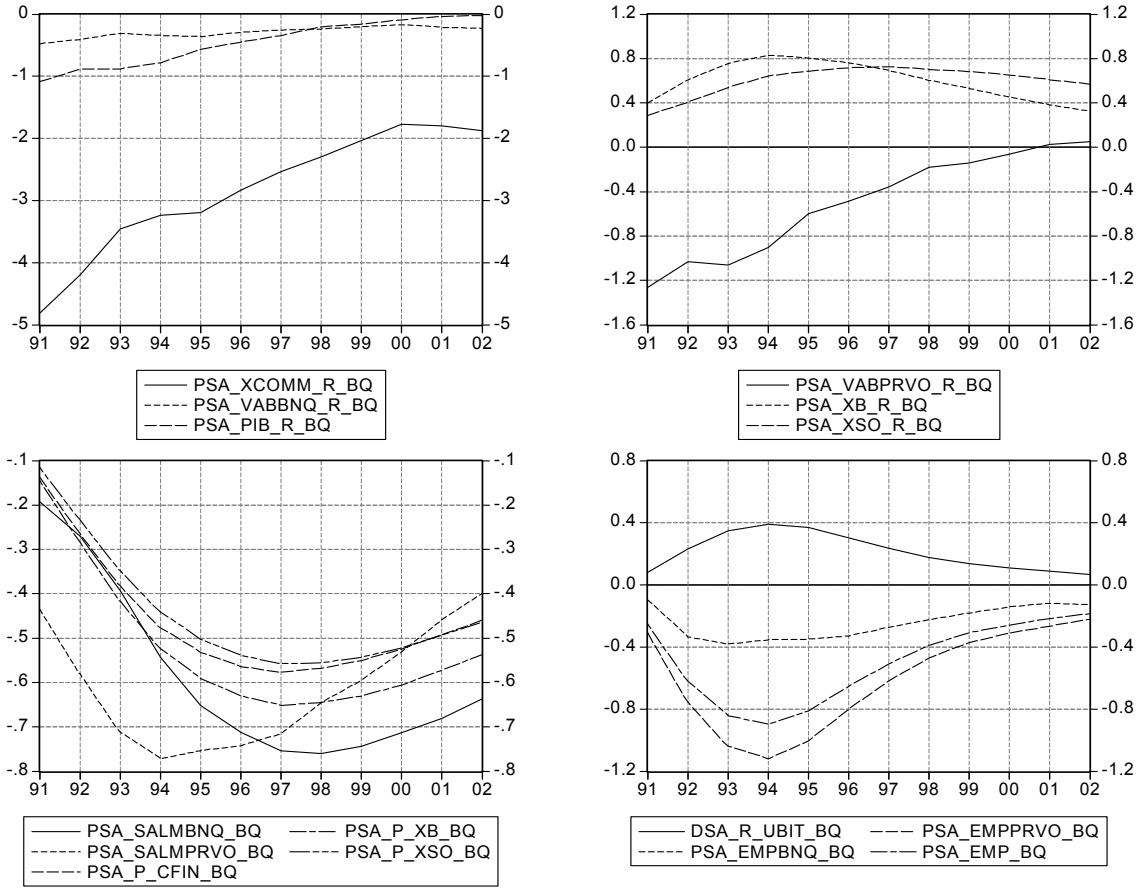
To sum up, one should retain that the main effect of the fall in revenues in the Greater Region (or the rise of the latter in Luxembourg) substitutes non-resident employment for resident employment, inducing a rise in national unemployment. The effect on overall GDP is small with respect to the effects on prices and employment.

5.2.3 A fall in activity in the banking sector

We simulate a decrease of exports of financial services of 1% of (real) GDP. In the short run, GDP falls by about the same amount but soon it decreases less: some ten years after the shock, the fall of GDP is annihilated. This is due to the fact the that the fall in activity in the banking sector reduces wages and prices (through higher unemployment) and improves henceforth competitiveness. On the other hand, lower GDP means a lower output-gap (if positive) which translates into higher export capacities.

The impact from the shock on the financial sector on other domestic sectors can be seen through the decrease in private, non-financial value added. The latter diminishes by a bit more than 1% in the beginning but recovers quickly. These sectors are free to export more which we see in exports of goods and non-financial services. It should be noted that the impact on the other private sectors suffers from the absence of the inclusion of technical (input-output related) coefficients. The feed-back relies upon the sole estimations and identities included in modux. Relying on (dynamic?) input-output coefficients would make these results more trustworthy.

Figures 5.11-5.14: Impact of a negative shock in the banking sector (deviations from baseline)



Notes: PSA is % difference from baseline; DSA is the difference in percentage points, BQ is the suffix characterising the implemented shock. XCOMM are exports of financial services, VABBNQ is banking sector value added. VABPRVO is non-finacial private sector value added, XB are exports of goods, XSO exports of non-financial services. SALM is average par capita wage, P_ denotes implicit prices, EMP employment and R_UBIT is the harmonised unemployment rate.

6. Some ideas about future developments

As any major academic work, the set-up of a macro-econometric model is never finished. We would however like to point out some weaknesses of the current version of modux (call it version 1.0) that deserve to be mended in the first place.

- Main aggregates of the financial sector are exogenous under the expenditure side of GDP. Exports of financial fees and the interest rate margin that constitute the main sources of revenues of the banking sector and one of the driving forces of the economy in the modux set-up need to be endogenized. This could be done with recent quarterly data that could avoid the period of structural breaks in the middle of the eighties.

- The equations determining exports of goods and other services need to revised. Re-exports of goods need to separated from manufactured goods' exports. The Luxembourg product structure should be used to re-weight foreign demand. The question of the role of relative prices (competitiveness) should be reconsidered.

- The whole system of taxes needs to be integrated in price and factor cost equations. For the time being, we cannot simulate in a direct way the effect of changed VAT or social security rates. Implicit taxation rates should be made dependent on nominal rates.

- Use could be made of input-output type relations in order to improve import functions and prices equations.

- The external supply of labour should be considered differently, possibly by taking into account not only net revenues in countries of origin (as in the current version) but also costs in Luxembourg. A more direct impact of reservation wages could be possible. This could be done by relying on a nested CES production function. Some theoretical work needs to be carried out.

- Finally, quarterly accounts are on the verge of being published for Luxembourg. This opens a new horizon as the problem of structural breaks could be circumvented. Parameter instability could however subsist since quarterly data will not exist prior to 1995.

Finally, modux being a single country model, it would be beneficial to link it to a multi-country model. It would render the construction and analysis of multiple-variable scenarios much easier. Most international exogenous variables figuring in modux could be linked to the outcomes of such a multi-country model.

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