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DELFI

DNB's Macroeconomic Policy Model of the Netherlands

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Foreword

This Occasional Study presents DELFI, a new macroeconomic model of the Dutch economy for forecasting and policy analysis. Macroeconomic modelling at de Nederlandsche Bank started some 25 years ago, when Martin Fase and his team built MORKMON, which was quite novel at the time due to the inclusion of a monetary sector. For many years, this model was used fruitfully as an instrument for forecasting, scenario analysis and policy simulation, and its acronym survived during all those years.

But the times have changed and so has the economic environment. Already when MORKMON was introduced in 1984, the then president of de Nederlandsche Bank, Wim Duisenberg, noted how our understanding of the economy is never perfect. Indeed, changes in the economic environment and new insights led to various minor and major adjustments to the structure of MORKMON, up to a point where it was decided to build a completely new model.

DELFI is the result of a collective effort by researchers and statisticians at the Economics & Research Division of de Nederlandsche Bank. In my view, the team has created a worthy successor of MORKMON. And while history learns that a model is never perfect or finished, I am confident DELFI is in a position to take over the prominent position that MORKMON had so many years within the set of analytical instruments of de Nederlandsche Bank.

Lex Hoogduin

Contents

1 Introduction

In this study we present DELFI, DNB's new macroeconomic policy model of the Netherlands. DELFI stands for *Dutch Economic Linkages: a Forecasting Instrument*. The new model replaces MORKMON, which served policy and forecasting purposes from the early 1980s on. This study summarizes our present understanding of the working of the Dutch economy at the macro level. As the economy is constantly changing and new pieces of evidence on its working become available over time, a model is in fact under permanent construction.

In the next chapters, we present the core elements of our new model of the Netherlands. In Chapter 2, we take a bird's eye view and discuss why a new model was needed. In Chapter 3, we discuss the model in greater detail. Chapter 4 discusses possible future extensions of the model. The proof of the pudding is in the eating. Therefore in Chapter 5, we demonstrate DELFI's main simulation properties by shocking the model. We show how the economy responds to various shocks, such as an oil price shock, an increase in world trade, changes in the interest rates and credit rationing of firms or households. The Appendix summarizes the most important model equations and includes a number of statistical tests.

2 A bird's eye view

Need for a new model

DELFI's predecessor MORKMON was developed at de Nederlandsche Bank (DNB) in the early 1980s and has undergone various changes and extensions over the years. The structure of the latest version of the previous

model is described in Van Els and Vlaar (1996). Since then, equations have been updated in the light of recent economic history when necessary, but broadly speaking the model remained unaltered. Its developers adopted an eclectic approach, in some cases giving priority to data replication and forecasting power and in others giving more weight to theoretical considerations. Modern macroeconomic models have tighter microeconomic foundations. From that perspective, the old model was no longer state of the art. The main motivation for developing a new macroeconomic model was therefore to improve the theoretical foundation and consistency. At the same time, our new model should be broadly consistent with historic data.

The modelling of the economy in DELFI combines the neoclassical approach to economics - with optimizing rational economic agents and clearing markets - with new-Keynesian elements, in which imperfections and frictions affect the short-run dynamics of product markets, the labour market and financial markets. In DELFI, we put emphasis on the description of the supply side of the economy, which is crucial for understanding long-term developments. As in the new-Keynesian models, the market of goods and services is characterized by monopolistic competition. This market structure enables producers to set a markup on the cost price and earn a profit. In the short run, output is determined by demand. Aggregate demand for goods may deviate from the long-run equilibrium level of output. Such deviations trigger wage and price adjustments, which drive the economy towards equilibrium again.

In addition to an explicit and consistent modelling of the supply side, DELFI provides a rich description of financial transmission mechanisms, with an explicit role for pension funds, credit risk spreads and quantity

rationing in loans to firms and mortgage credit. These channels provide a direct link between the financial sector and the real economy, allowing the user to analyze the effects of financial turmoil. If pension funds see their funding ratios drop below the regulatory minimum, they might decide to raise the pension premium or reduce benefits. Both actions affect the real economy, either by increasing production costs or by lowering disposable income. Credit risk spreads depend on firms' profitability and affect investment through their impact on the cost of borrowing. Quantity rationing in credit markets is particularly important during times of financial stress. In these circumstances, a regime shift occurs and the standard equation for other private investment can be replaced by an alternative equation in which the amount of investment depends on credit supply conditions. The supply of mortgage credit to households determines the development of house prices in the long run. This reflects current practice in the Dutch housing markets, where house buyers generally first check the maximum mortgage that can be supported by their income before they start looking for a house.

The other main improvements are:

- a better theoretical foundation of the supply side throughout the model, with well defined measures for potential output and the equilibrium level of unemployment, from which tension variables can be derived that play an important role in the short run dynamics and the adjustment processes driving the economy back to equilibrium;
- the presence of energy in the production function as a separate factor of production;
- a deeper and more realistic modelling of the external sector, treat-

ing re-exports separately and modelling factor income and income transfers;

- a more detailed description of government transactions;
- a household sector that distinguishes optimizers and rule-of-thumb households;
- price setting with flexible markups in the long-run and sticky prices in the short run.

The new model is fully compatible with ESA-95 National Accounts standards. In principle, the behavioural equations are estimated on quarterly data from the National Accounts over the period 1977:Q1 to 2008:Q4. This is also the source for the figures and tables presented in this document, unless indicated otherwise. Moreover, the new model must fulfil new information needs of policymakers, both inside and outside DNB. This has become particularly relevant after the establishment of the ECB. Central banks in the EMU jointly produce detailed euro area macro economic forecasts. In order to compute aggregated EMU figures from national projections, country data must have the same content and level of detail.

Estimation methodology

The econometric methodology that was used is the co-integration framework. This methodology explicitly distinguishes short-term dynamics from long-term equilibrium relationships. Departures from equilibrium induce corrections that move the economy back towards its equilibrium path. This is called the error correction mechanism. The methodology provides an estimate of the mean reverting speed. The long-run relationships are derived from underlying economic theory. Often these relationships involve (levels

of) economic variables that exhibit a high degree of time persistence (slow or absence of mean reversion). Co-integration tests are performed to exclude the possibility of spurious correlations. The finding that variables are co-integrated shows that the relationship is actually economically meaningful and represents an equilibrium relationship. If variables were expected to strongly interact across equations or if parameter restrictions across equations needed to be imposed, a simultaneous estimation approach was adopted. As in forecasting, model building carries elements of judgement. In case free estimation of equations produced unlikely parameter values or implausible simulation outcomes, we relied on insights from other sources, or implemented other ad-hoc solutions such as shorter estimation periods.

3 A closer look at the model

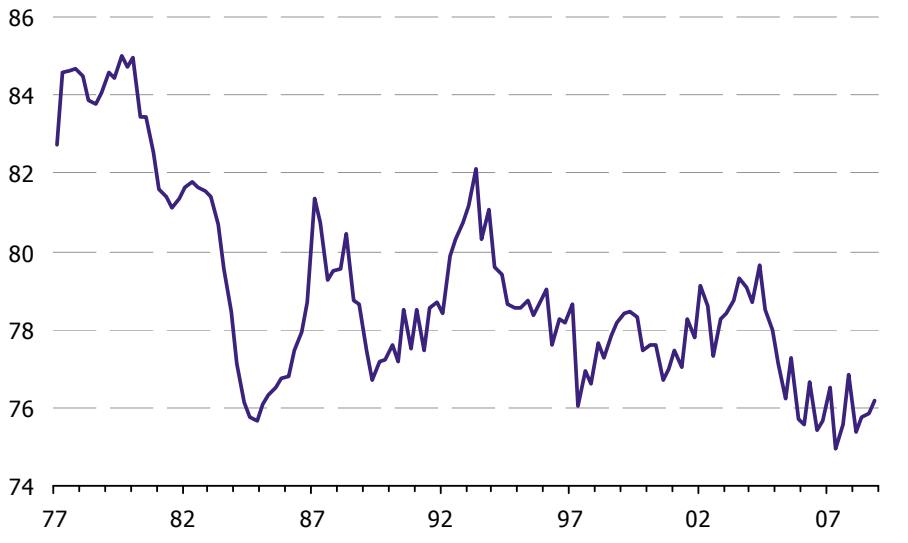
3.1 Firms

The production sector of DELFI consists of profit-maximizing firms that transform the inputs of labour, capital services and energy into final goods. The presence of energy as a separate factor of production is an important feature of the model, allowing producers to react to changes in energy prices. Producers choose the optimal volumes of the inputs while they take the prices of labour, capital and energy as given. Monopolistically competitive goods markets imply that producers have some pricing power in the product markets in which they apply a variable markup to their cost price.

To capture the fundamental changes (i.e. wage moderation, increased labour supply, technological progress, decline in the labour to income ratio, see Figure 1) that we have seen in the Dutch economy over the past

Figure 1: Labour income ratio

Percentages



few decades, the production function needs to be sufficiently flexible in the substitution between the production factors capital, labour and energy. A production function with CES (Constant Elasticity of Substitution) technology allows us to estimate the elasticity substitution between factors of production, instead of imposing an elasticity equal to one as is the case with Cobb Douglas technology[1]. The model allows for labour-, capital- and energy-saving technological progress. The long-run relationships for the demand for labour, capital and energy follow from the first-order conditions for the profit maximizing producers. We estimate these factor demand equations, together with the production function, using a normalized supply-side system approach, cf. Klump et al. (2007). The estimation

[1]For recent applications of the CES production function, see the special issue 'The CES production function in the theory and empirics of economic growth' of the *Journal of Macroeconomics*, 2008(2).

results demonstrate that labour demand (measured in full-time equivalent workers) increases proportionally with output and decreases with real product wages in the long run. The short-run dynamics show that the demand for labour becomes stronger when the price markup, output or labour supply increases. Demand for capital goods increases with higher output and decreases with the real user cost of capital. DELFI allows the user to choose between two regimes for the short-run dynamics of investment. In normal times, the short-run dynamics of investment in capital goods is driven by the development of output, profitability of firms and by the MSCI World Index. As mentioned in the introduction, in times of financial stress, when credit supply restrictions are binding, we use another equation for investment which is discussed in Section 3.4.

The elasticity of substitution between the production factors labour and capital is estimated at 0.39, implying that a 10 percent change in the ratio of the price of labour to capital induces a shift in the ratio of volumes of the inputs of 3.9 percent. The demand for energy depends on output and on the real price of energy. The elasticity of substitution between energy on the one hand and labour and capital on the other, is estimated at 0.12. This elasticity is low compared to the elasticity of 0.39 that we estimated for the substitution between labour and capital, but for large swings in energy prices, the effect is sizeable: if energy becomes 10 percent more expensive compared to labour and capital, producers will use 1.2 percent less energy and more capital and labour per unit of output. The constant rates of progress in labour-saving and capital-saving technologies are estimated at 1.8 percent per annum and 0.8 percent per annum, respectively. We use quadratic technological progress for energy saving to reflect the empirical finding that progress in energy saving levelled off around 2001.

Potential output in the private sector is explicitly modelled in DELFI and is determined by substitution of the equilibrium level of employment, the existing capital stock, and the structural level of technological progress into the production function. The structural level of technological progress is estimated using the HP-filter. Actual output depends on demand from households (for private consumption and housing investment), the government (for consumption and investment), firms (for investment) and exports. The difference between actual output and potential output defines the output gap[2]. The output gap is a measure of tension in the market for goods and services and is a driving factor of short-term adjustment towards the long-run equilibrium. The price markup that monopolistically competitive firms charge over production costs also depends on the output gap. A positive output gap puts upward pressure on prices and reduces demand. Price formation is discussed in detail in Section 3.3.

The unit cost price of final goods depends on input prices: capital costs, cost of energy and labour costs. The unit cost price of output follows directly from the factor prices and the CES production function. The cost of capital is determined by long-term interest rates, the credit spread, taxes and amortizations. Firms finance investment with 25 percent equity and 75 percent debt. The required return on equity is equal to the long-term interest rate plus five percent equity premium and the cost of debt is the long-term interest rate plus the credit spread. The credit spread depends on the spread on US BAA rated corporate bonds and on the profitability of firms in the Netherlands, which is an endogenous variable in DELFI. A more profitable firm is more creditworthy and pays a lower premium for

[2]Regarding the government sector, we assume that potential output always equals actual output.

credit risk. This feedback from the financial position of firms to the user cost of capital is one of the linkages between financial variables and real variables that are included in DELFI. Labour costs depend on the wage rate in the private sector that follows from negotiations between firms and trade unions. Wage formation is discussed in detail in section 3.3. The cost of energy is related to the price of oil in euro.

Firms hold inventories to cope with short-run fluctuations in demand. The level of inventories depends positively on expected future demand. Higher labour costs and current demand have a negative impact on the level of inventories. The effect of the real interest rate on inventory investment appears to be marginal.

3.2 Households

Households maximize utility from current and future private consumption. We distinguish two types of households: optimizing households and rule-of-thumb households (RoT in short), cf. Campbell and Mankiw (1989). The optimizers maximize utility subject to an intertemporal budget constraint whereas RoT-households simply consume their entire disposable income every period. The share of optimizers in the household sector is calibrated, based on estimates by other institutions and data on the wealth distribution provided by Statistics Netherlands: 20 percent of all households are supposed to be optimizers, 80 percent are RoT consumers.

Optimizers invest in houses, accumulate financial wealth in stocks and bonds and have access to credit markets. They borrow and save to absorb shocks and smooth their consumption over time. The optimizing households pay interest on their debt and own a portfolio of bonds and

deposits that yield interest-income and shares on which they earn dividend. The optimizing households adjust the composition of the portfolio according to the relative performance of shares and deposits. The net-income from interest and dividends received is part of their disposable income. RoT-households have no access to financial markets and consume their entire income every period. Consequently, they do not accumulate financial wealth and shocks to their disposable income directly affect their consumption. Although RoT-households have no access to credit markets and accumulate no financial assets, we make one exception and allow them to own a house. In the model, the RoT-households own about 30 percent of net housing wealth. These houses are financed by mortgages, on which the RoT-households pay interest and redemption out of their income. Of course, RoT-households also participate in the occupational pension system, which means that they accumulate compulsory savings.

Table 1: Dutch household sector balance sheet 2008

Billions of euros; year end[1]

Housing property	1091.0	Mortgages	588.2
Shares and other equities	171.0	Short term loans	125.5
Bonds and other financial assets	422.2	Net wealth	970.4
Total assets	1684.1	Total liabilities	1684.1

[1] Excluding pension wealth.

The amount of labour supplied by households is determined by demographic factors affecting the size of the working age population and by the participation rate. In the long run, the participation rate depends on exogenous trends that capture the impact of policy and the level of the equilibrium rate of unemployment. In the short-run, lower actual unem-

ployment and higher real wages raise the participation rate.

Our estimation results suggest that optimizers adopt a planning horizon of approximately nine years. Moreover, we find that the marginal propensity to consume (mpc) out of housing wealth (5.6 percent both for optimizers and RoT) is larger than for financial wealth (4.1 percent only for optimizers). The mpc for total wealth lies around 4.8 percent. In the short-run, changes in the level of unemployment - which is an important driver of consumer confidence - are relevant in explaining the dynamics in spending. In addition, changes in housing wealth and the value of stock holdings affect spending in the short-run. Asymmetric responses to changes in net asset holding at macro level were not found, despite existing micro evidence of loss aversion in the Netherlands (Berben et al. (2006)).

Housing investment and private consumption co-move one-to-one in the long run. When the price of housing investment falls relative to private consumption, households move their expenditures more towards housing investment. A rise in households' housing wealth will give rise to a temporary shift from consumption towards housing investment.

3.3 Wages and prices

Wage formation

Nominal wages are the outcome of a bargaining process in which trade unions and firms negotiate the wage, cf. Broer et al. (2000). Firms maximize profits and trade unions are assumed to maximize the utility of their members. Employees' utility is defined as the difference between net wages and the reservation wage. The reservation wage is defined as a weighted average of the actual wage and the level of unemployment benefits, with

the weight depending on the unemployment rate. The higher the unemployment rate, the smaller the probability of finding a job and the weaker the employees' bargaining power. The empirical results reveal that the wage rate, measured as total compensation per employee in the private sector, depends in the long run on the producer price (with an elasticity of one), productivity (also with an elasticity of one), the unemployment rate, the replacement rate and the wedge, which is a mix of the value added tax rate and social security premium rates paid by employees and employers. A one percentage point rise in the unemployment rate lowers the wage level by 1.2 percent; a 10 percent decline in the replacement rate weakens the position of the workers in the wage negotiations and will result in a 3.1 percent wage decline; a 10 percent smaller wedge leads to a 1.8 percent wage decline. We find no evidence for an asymmetric response of the wage to the level of unemployment. The short-run dynamics of contractual wages differs from the dynamics of incidental wage components. The contractual wages in the private sector are driven by differences between the actual wage level and the long run wage level. In case of positive (negative) differences, wages will drop (rise) in the short run. The adjustment takes place slowly. The incidental wage component strongly reacts to short-term movements in the unemployment rate, labour productivity, and the rate of workers on sickness leave. Contractual and incidental wages in the public sector are linked to developments in the private sector.

Price formation

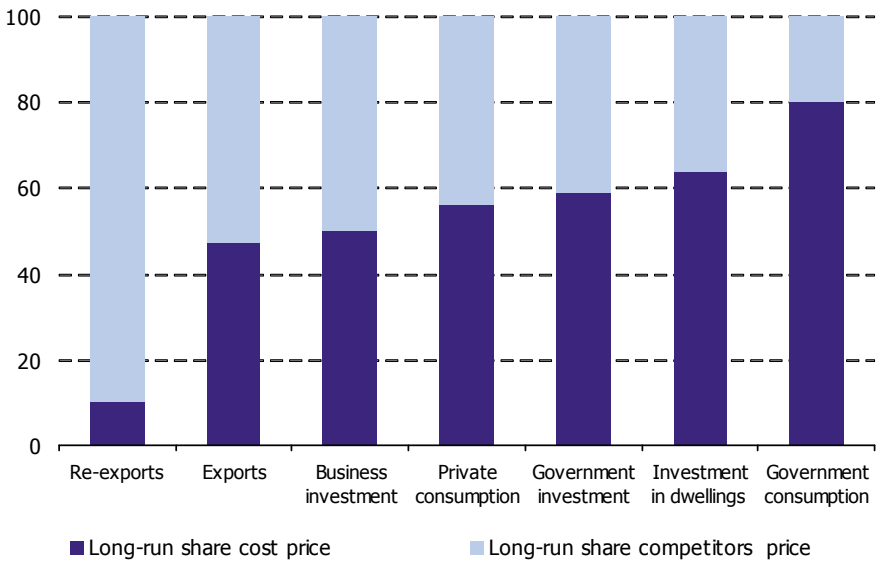
Firms operate in a monopolistically competitive market and set prices as a markup over the cost price. The markup set by domestic firms is flexible and depends on the prices charged by foreign competitors, cf. Bergin and Feenstra (2000). This behaviour reflects the situation in the Netherlands

and other small open economies where domestic firms face competition from foreign firms. In the long run, the price charged by a domestic firm is a function of the cost price and foreign competitors' price. In the short run, the markup also depends on the output gap. When aggregate demand falls short of potential output, the output gap is negative and there will be downward pressure on prices through shrinking markups. With positive output gaps, firms have an opportunity to raise prices. As prices are sticky in the short run, it takes time for prices to adjust to their underlying equilibrium levels.

Our estimation results support the presence of flexible long-term markups in price setting, a result that is in line with other empirical findings for the Netherlands, see Hoeberichts and Stokman (2009). The elasticity of domestic prices with respect to foreign competitors' prices varies from 0.10 to 0.80 (see Figure 2). Foreign competitors' prices are particularly important in the price setting of exports. For goods in less competitive markets - like government consumption and housing investment - the role of competitors' prices is much smaller. The long-term price-setting of private consumption goods takes an intermediate position. An important implication of flexible markups is that international competition will affect prices through lower markups. Competitor prices also matter for foreign firms selling their goods in the Netherlands. Foreign companies take price levels prevailing on Dutch domestic markets into account when setting their prices (*pricing-to-market*). This is an important feature of the price block in DELFI that contrasts with other models that treat import prices mostly as an exogenous variable. The estimation results show that the prices of exports and investment goods converge relatively quickly to their long run levels. The speed of price adjustment is slower for prices of private

Figure 2: Weight of competitors' prices in long term price setting

Percentages



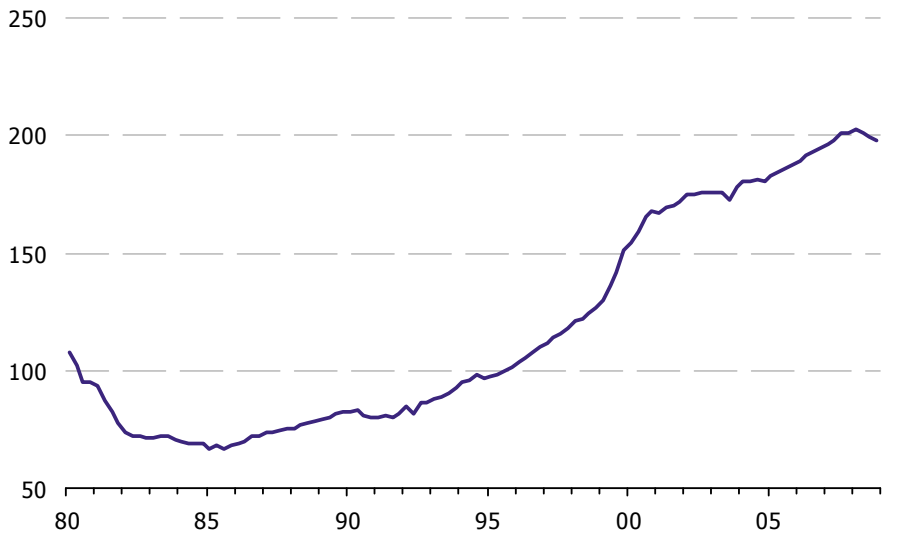
consumption goods and of goods purchased by the government.

3.4 House prices and borrowing by the private sector

Ownership of houses represents over 50 percent of Dutch households' total assets. For the optimizing households, the development of housing wealth or house prices is an important determinant of their consumption pattern. House prices in the Netherlands have risen sharply, especially during the late 1990s (see Figure 3). In the Netherlands, house prices are primarily driven by fluctuations in demand or, more specifically, by the amount of mortgage credit. Reflecting this situation, we model mortgages and house prices as cointegrated variables, with developments in mortgage credit causing changes in house prices. This rather unconventional way to model house price dynamics captures the Dutch data remarkably well.

Figure 3: Real house prices in the Netherlands

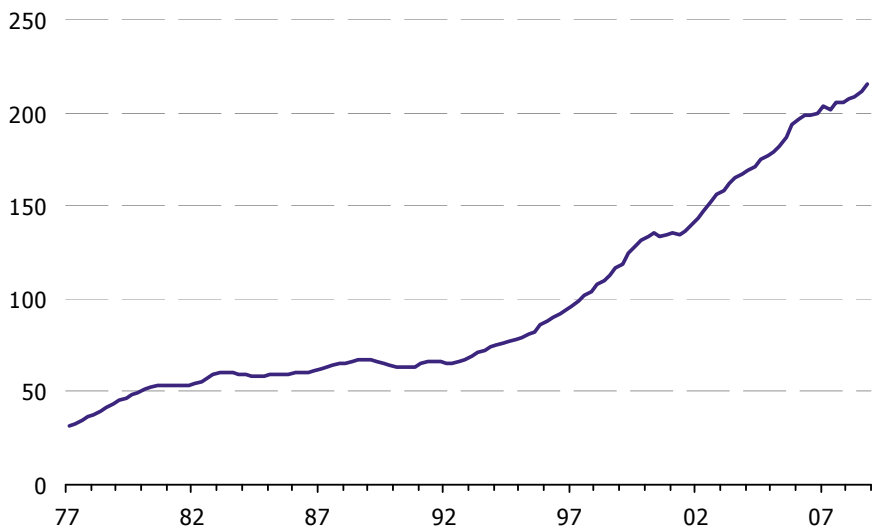
1980=100, deflated by consumer price



The short-run dynamics of house prices depend on mortgage interest rates and the unemployment rate. The bulk of Dutch households' borrowing consists of long-term mortgage loans. As a starting point for modelling households' mortgage borrowing, we assume that in the long run, after-tax mortgage interest payments are a fixed fraction of the households' disposable income. This assumption reflects the current practice of mortgage lending in the Netherlands. The long-run determinants of mortgage debt are therefore disposable income (with an elasticity of one) and the mortgage interest rate net of the tax rate in the highest income tax bracket (elasticity of -0.24). Banks' easing of lending standards in the early 1990s caused a substantial upward shift in mortgage lending (see Figure 4). This development is captured by an exogenous (logistic) trend. In the short run, mortgage borrowing is also affected by changes in unemployment (-) and housing investment (+).

Figure 4: Mortgage lending by households

% disposable income



The other loans, i.e. other than mortgages, are a heterogeneous group that consists of 25 percent short-term loans and 75 percent long-term loans. Accordingly, we use a weighted average of short and long-term interest rates as the relevant interest rate. These loans are more sensitive to changes in income and to the interest rate. The adjustment towards equilibrium levels is faster. In the short run, changes in the level of unemployment and the share index are relevant variables.

Firms borrow to finance investment in capital goods. In the long run, the amount of borrowing is determined by the level of investment. The short-run dynamics of borrowing are also affected by producer confidence and the capital ratio of the banking system. As mentioned in section 3.1, investment is not affected by the amount of borrowing in normal times. However, during times of financial stress, the regime shifts and banks are sometimes reluctant to provide loans to firms regardless of what interest

rate firms are prepared to pay. This rationing of credit happens when the banks' capital ratios are too low, or for other reasons that banks report in the Bank Lending Survey. These credit-supply constraints limit the amount of investment by firms and thereby reduce aggregate demand immediately and potential output in the future. DELFI contains an alternative specification for investment that is applicable in times of credit supply constraints. In this alternative equation, investment depends on the capital ratio of the banking sector, credit supply conditions as reported in the Bank Lending Survey and producer confidence.

3.5 Current account transactions

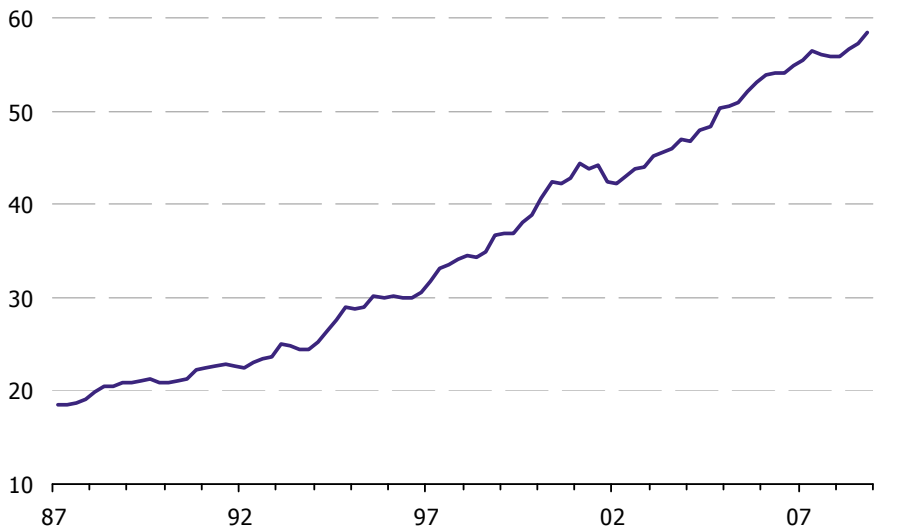
Exports and imports of goods and services

The long-run determinants of home-made exports excluding energy are foreign demand (with an elasticity of one) and price competitiveness (elasticity of -1.6). Estimation of the price elasticity has always been difficult, generally delivering implausibly low and insignificant parameter values. If, however, we take account of the simultaneity of exports and export prices, exports' sensitivity to price competitiveness rises. The 1.6 is close to the 'Tinbergen's two', cf. Tinbergen (1952). In the short run, exports growth is also significantly affected by foreign demand and price competitiveness.

We model separately the volume of home-made exports and re-exports, because re-exports make up a large share of total exports and have a different composition. Almost 50 percent of total exports of goods and services are re-exported goods that are bought and imported by Dutch companies and exported again. These goods cross Dutch mainland because of the attractive location (harbours, rivers) and the advanced distribution system, and

Figure 5: Re-exports

% total volume of exports of goods



to some extent the Dutch competitiveness. The composition of re-exports differs from the composition of home-produced exports. Computers, other IT-products and semiconductors are the main re-exported products. The large share of IT-products explains the explosive growth of re-exports since the early 1990s. At present, the level of re-exports is close to the level of home-made exports of goods (see Figure 5). Re-exports depend positively on world trade, reflecting mainly world demand for semiconductors, and positively on the level of investment in the Netherlands relative to Europe. The latter is a proxy for the Netherlands' attractiveness as a transit port for Europe. The volume of re-imports directly follows from the volume of re-exports.

Imports for domestic use (excluding energy) depend on weighted final demand (demand components weighted by their import shares). These imports are modelled along the same lines as home-made exports, with

domestic demand and price competitiveness as the two main explanatory variables. The estimation results show that imports are less sensitive to changes in price competitiveness than exports. One explanation is that exports contain more bulk products. In the short run, imports are also positively related to the output gap. If the Dutch economy experiences shortages in production capacity, imports rise; with overcapacity, imports decline.

Other current account transactions

The current account distinguishes two other broad categories apart from trade in goods and services: factor income and current transfer income from abroad (and vice versa). Income transactions cover almost 30 percent of all current account transactions, current transfers about 3 percent (see Table 2). By adding up the net values of these three balances, we get a country's current account position. A current account surplus (deficit) corresponds to a national savings surplus (deficit). Other things equal, current account surpluses (deficits) give rise to an improvement (deterioration) of the net foreign assets' position of a country.

Table 2: Current account transactions in 2008

Billions of euros

	receipts	payments	balance
1. Goods and services	457.3	407.6	49.8
Re-exports	178.0	160.7	17.3
2. Income account	196.3	212.0	-15.7
3. Current transfers account	7.9	17.1	-9.2
4. Adj. for equity in pension funds reserves			0.3
5. Current account (1+2+3+4)	661.6	636.7	25.2

Cross border income flows arise because Dutch sectors (including the financial sector) hold foreign assets, and vice versa, foreign parties own domestic assets. To a large extent, the income balance consists of investment income from foreign direct investment, from saving accounts and credit (interest) and from foreign stock holdings (dividends). We adopt a stylized model to describe the income flows arising from these cross-border investment holdings. Investment income receipts (as a percentage of foreign assets) are explained by German and US interest rates, OECD GDP growth and the dollar exchange rate, because a substantial part of the foreign assets are investments in the US. Investment income payments (as a percentage of foreign liabilities) are determined by Dutch interest rates and GDP growth in the Netherlands.

Current transfers are conducted by governments (official foreign aid, EU-contributions, military presence abroad etc) and by private parties (foreign aid, remittances by emigrant or immigrant workers, gifts, etc). In DELFI, the size of income transfers is related to a country's or region's wealth (measured by a country's GDP per capita) and also to a country's or region's openness (region's trade over region's GDP). These two broad measures determine long-term developments in Dutch cross-border income transfers. Deviations from the long-term trends often relate to policy changes, and can only be implemented on an ad hoc basis.

3.6 Pension funds

The vast majority of Dutch employees saves for retirement by compulsory participation in an occupational pension scheme. Total assets managed by these pension funds amount to more than EUR 740 bln, or more than 120 percent of GDP in 2009 (DNB (2010)). The pension sector is an important

link between the financial sphere and the real economy. The representative pension fund modelled in DELFI receives contributions from employers and employees. The pension fund invests the contributions in stocks, bonds and other assets. The pension fund's liabilities consist of (future) claims of current and future pensioners. We closely follow the requirements of the regulatory framework for pension funds, under which the present value of the pension sector's assets and liabilities is based on market valuation. The market value of the assets is determined by the performance of the stockmarket for the fraction of assets that is invested in stocks and by the long-term interest rate, the duration of the assets and the credit spread for bonds and other assets. The present value of the liabilities reflects the value of the promise to pay pensions to current participants and pensioners in the future and depends on the long-term interest rate, the duration of the liabilities, demographics and indexation. The pension fund's liabilities have a duration of about 15 years, which is much longer than the five-year duration of the pension fund's bond portfolio. This duration gap makes the pension fund extremely sensitive to changes in the long-term interest rate. A one percentage point drop in the interest rate pushes up the present value of the fund's liabilities by much more than it increases the market value of its bond portfolio, and it reduces the *funding ratio* of the pension fund by about ten points.

Pension funds' *funding ratio*, which is the ratio of the present value of the assets to the present value of the nominal liabilities, is the key driver of pension funds' decisions on indexation and premia. The dynamic behaviour of this ratio is endogenous in DELFI. When the funding ratio is above 140 percent, so that the present value of the assets exceeds the present value of the nominal liabilities by 40 percent, the pension sector applies

full indexation of payments to current pensioners as well as of promised payments to future pensioners. The indexation ambition is to increase pensions with a weighted average of consumer price inflation and wage inflation. Fluctuations in the stock market or in the long-term interest rate affect the funding ratio. If the funding ratio falls below a critical level, pension funds have to present a plan to restore it. To this end, pension funds can cut indexation or increase the pension premium.

If pension funds decide to give only partial indexation of pension obligations, pensioners will experience a drop in their disposable income. This affects household income and hence aggregate demand. If the funding ratio of pension funds drops below 125 percent, pension funds might propose increasing the pension premia besides cutting indexation of pension payments. The discretionary decision to increase pension premia is not part of the standard model, but DELFI includes an option to adjust the pension premium that is paid. The premium will be adjusted in such a way that the pension fund returns to a funding ratio of 125 in 15 years time. The pension premium is paid partly by employers and partly by employees. Employers treat the increase in pension contributions as an increase in labour costs, affecting labour demand and the cost price of output. For the employees, a higher pension premium means lower disposable income. Pensioners will receive the indexation they missed because of the pension fund's insufficient funding ratio as 'postponed indexation', up to ten years back, once the pension fund has a funding ratio of 145 percent or higher. Only if all the missed indexations over the past ten years have been repaired and the funding ratio is above 160 percent, can pension funds start reducing the pension premia. Either through the effect of lower pensions on demand or through the effect of higher premia on production costs,

the measures that the pension sector takes to restore the funding ratio will have a negative effect on the profitability of Dutch firms. This will affect the risk premium that firms have to pay on their loans and firms' investment decisions.

3.7 Government and social security

The government sector in DELFI consists of the government sector in a narrow sense and social security funds. Table 3 summarizes the most relevant types of transactions, though the model offers a more detailed description. On the revenue side, receipts by the government or social security funds follow from combining endogenous income flows (like salaries, sales, property income) or wealth with exogenous tax- or premium schemes. However, non-tax receipts like government revenues from gas exploitation are also modelled.

On the expenditure side, we take the latest stance of policy measures into account. These are optional in DELFI. For example, the default is that contractual civil service wages follow directly from contractual wages in the private sector. We have incorporated a stylized version of the 'real expenditure framework'[3]. If government expenditure is growing more rapidly than potential growth, its development will be adjusted towards a more sustainable pace. For government expenditure, there is clear evidence of such a mechanism in the data. Although such mechanisms are also present in social security funds, there is no systematic pattern. Therefore, social security premiums by employers and employees are exogenous in DELFI. Social security and assistance benefits depend on contractual wages or

[3]See: 'Budget practices in the Netherlands', Dutch Ministry of Finance, available on english.minfin.nl

the minimum wage and on the number of people unemployed or disabled. The most important government budget categories, like government investment, government consumption and spending on health care, are endogenous. The amount that the government spends on health care is explained by income, demographic developments and a measure of innovations in health care.

Table 3: General government revenue and expenditure in 2008

Billions of euros

Revenue		Expenditure	
Taxes	141.6	Compensation of employees	54.5
on production & imports	72.4	Intermediate consumption	44.1
on income & wealth	69.2	Capital formation	20.7
Property income	20.2	Subsidies	7.2
interest received	3.7	Property income	12.7
other	16.5	interest paid	12.7
Social contributions	90.6	Social security benefits	91.0
Other	25.1	in cash	41.4
		in kind of market producers	49.6
		Social assistance benefits	24.9
		in cash	16.1
		in kind of market producers	8.8
		Other	18.4
Total revenues	277.6	Total expenditures	273.6

4 Future developments

This study describes the state of the macroeconomic model DELFI at the time of writing, end 2010. DELFI is fully operational and the main tool for DNB's macroeconomic projections. DELFI is also used to analyze the effects of monetary and economic policy measures on the economy and for the analysis of financial stability. As mentioned in the introduction, the model is never finished and permanently under construction. DELFI contains feedback mechanisms from the financial sector to the real economy through credit supply to firms and to households, through the financial position of pension funds and through the credit risk spread for loans to firms. Our plan is to develop the interaction between the real economy and financial sector further and to include more financial features into the model.

5 Scenario analysis using DELFI

The scenarios which will be presented in this chapter illustrate the workings of DELFI. The basis of each scenario is a 'what if' question. There are many hypothetical questions which can be studied using DELFI. One type of scenario concentrates on exogenous assumptions. For instance, section 5.1 uses DELFI to analyse how the Dutch economy would develop if the volume of world trade would permanently be one percent percent higher. A second type of scenario concerns changes in policy instruments. How strongly, for instance, would an increase in government spending affect economic growth (section 5.2)? Or, to what extent does the government balance change if wage and income taxes are decreased (section 5.3)? Finally, there is a large heterogeneous set of hypothetical questions which

can be addressed. For instance, two sections analyze how a restriction of credit supply, either to firms or households, would affect the Dutch economy. Each of the scenarios presented in this chapter focuses on the effects of changes in one particular variable at a time. Of course, in practice this is not always the case. For instance, it is likely that an oil price shock will have a related effect on world trade. Results from the individual scenarios can be combined to answer these more complicated 'what if' questions.

The scenario results are presented in the form of tables which compare differences between two cases. The first case is the so-called 'central projection', which is the development of the Dutch economy without a shock to a specific variable. The second case is the scenario outcome which tracks the changing economy after one variable has been changed with respect to the central projection. For most variables, the table presents the percentage difference between the level of a variable in the scenario and the central projection in a given year. The effect on the growth of a variable in that year can be assessed by taking first differences. The exception is the government balance, where effects are presented as differences in ratio's to GDP between scenario outcomes and the central projection. The scenario results are computed over a horizon of eight years. Results are shown for four moments in time. Year 1 (the time at which the shock starts) and year 2 illustrate short-run effects, whereas years 4 and 8 show medium to long-run effects.

5.1 World trade +1 %

In line with the increased volume of world trade, Dutch exporters are initially able to sell around 0.9 percent more goods and services abroad. Because exports respond stronger to the shock than imports, net exports

contribute positively to GDP growth. Domestic demand also pushes up GDP volume in year 1. Overall, the initial GDP-effect amounts to 0.2 percent.

Initially, higher output is generated by higher labour productivity. In later years, firms increase investment in capital goods and hire more workers, which leads to a tighter labour market and drives up the contractual wages. The tight labour market and the increase in real wages drive up unit labour costs. The higher costs of production are gradually passed on to customers, leading to an increase in the price level of around 0.4 percent in year 8. The higher price level reduces price competitiveness of Dutch exports and has a negative effect on the volume of domestically produced exports. As a consequence, the level of exports is only 0.8 percent above the baseline in year 8.

Households' disposable income increases as a consequence of higher employment and higher wages. This increase in disposable income is reflected in a similar increase in consumption. Private consumption and private investment take over from net exports as the main driver of higher domestic demand. Government budget balance improves due to lower expenditures and mainly due to higher revenues because of higher wages, higher employment and higher consumption.

Table 4: World trade +1 %

	1	2	4	8
Volumes				
GDP	0.20	0.21	0.22	0.11
Private consumption	0.03	0.15	0.33	0.21
Housing investment	0.02	0.17	0.46	0.24
Other private investment	0.28	0.77	0.26	-0.31
Imports	0.80	0.96	0.90	0.72
Exports	0.96	0.91	0.81	0.70
Re-exports	1.16	1.16	1.20	1.21
Prices and wages				
HICP	0.03	0.09	0.20	0.43
Wages (contractual) private sector	0.02	0.14	0.34	0.57
House prices	0.01	0.20	0.57	0.61
Cost price (including energy)	0.01	0.09	0.29	0.51
Other items				
Government balance	0.02	0.10	0.09	0.01
Total employment	0.03	0.16	0.16	0.06

[1] Percent deviation from central projection.

5.2 Government consumption +1 % GDP

This scenario assumes that government consumption (excluding wages and social benefits) will be permanently higher by an amount equal to 1 percent of GDP. Higher government spending has a direct effect on aggregate demand. In year 1 the total effect on the volume of GDP is close to 0.75 percent. Apart from government consumption, which increases by over 4.5 percent in year 1, a major contribution to GDP growth is other private investment, which grows by well over 1 percentage point.

The strong uptick in GDP sets off two mechanisms in DELFI. First, the output gap widens, which starts to exert upward pressure on prices as firms increase markups. The initial effect on HICP is limited, but already in year 4 the price level is almost 0.9 percentage points than in the central projection. The increase in the price level has strong, negative ef-

fects on the level of exports in the longer run, as the price competitiveness deteriorates. A second effect is an increase in contractual wages. This reflects, among other things, the increased bargaining position of workers whose productivity has markedly improved. The increase in productivity follows somewhat mechanically from the dynamics of the model. Whereas GDP has strongly increased, the adjustment in the level of employment has been limited, at least initially. For households the higher wages as well as greater employment opportunities result in a strong boost to real disposable income. However, over time the increase in the price level has a negative effect on real disposable income and the overall effect on consumption stabilizes around 0.9 percent.

The additional government consumption lead to a sharp deterioration in government finances. The government balance fluctuates somewhat, but is always at least 0.5 percent lower than in the central projection. In year 8 the balance is 0.69 percent lower. Overall, the long-term effect of increase in government spending is limited. In year 8 the volume of GDP is a little over 0.60 percent higher than in the baseline scenario, which means a large portion of the initial stimulus has dissipated. A main explanation is the negative effect of higher labour costs on the competitiveness of exporters and firm profitability.

Table 5: Government consumption +1 % GDP

	1	2	4	8
Volumes				
GDP	0.74	0.76	0.91	0.62
Private consumption	0.12	0.54	1.15	0.88
Housing investment	0.09	0.62	1.70	1.20
Other private investment	1.21	2.55	1.32	-0.90
Imports	0.75	1.41	1.37	0.49
Exports	0.00	0.03	-0.09	-0.53
Re-exports	0.00	0.01	-0.03	-0.16
Prices and wages				
HICP	0.13	0.32	0.85	2.19
Wages (contractual) private sector	0.08	0.51	1.29	2.64
House prices	0.03	0.83	2.12	2.96
Cost price (including energy)	0.01	0.32	1.05	2.35
Other items				
Government balance	-0.88	-0.55	-0.50	-0.69
Total employment	0.15	0.54	0.64	0.37

[1] Percent deviation from central projection.

5.3 Wage and income tax -1 % GDP

This scenario analyses the effect of a permanent decrease in wage and income taxes equal to 1 percent of GDP. The tax relief gives a strong, immediate boost to real disposable income, which enables households initially to increase private consumption with nearly 0.5 percent. Over the years employment increases as more workers are needed to meet higher aggregate demand. Higher employment, in turn, gives an additional stimulus to disposable income and private consumption. Stronger demand also incites producers to increase investment, although the effect somewhat lags that of consumption. The effect on contractual wages is limited, but the overall cost of labour rises somewhat as higher productivity leads to higher wage drift.

After some years production costs start to increase which puts upward

pressure on the price level. The HICP index has increased by close to 0.8 percent in year 8. Higher prices feed through in firms' user cost of capital and firms start to cut back on their investments. As a result, other private investment lies close to half a percent below baseline in year 8.

The tax relief policy leads to a marked decline in government finances, although the increase in production somewhat compensates for this. Also the government expenditures are below baseline due to lower social benefits. Still, the government balance is well below baseline during the entire simulation horizon. As in the government consumption scenario, a large portion of the initial stimulus has disappeared in year 8. In this case the volume of GDP is close to 0.75 percent higher in year 8.

Table 6: Wage and income tax -1 % GDP

	1	2	4	8
Volumes				
GDP	0.11	0.35	0.83	0.73
Private consumption	0.45	1.32	3.10	3.56
Housing investment	0.14	0.74	2.79	3.86
Other private investment	0.12	0.63	1.77	-0.54
Imports	0.21	0.69	1.73	1.47
Exports	0.00	0.01	0.04	0.02
Re-exports	0.00	0.00	0.02	0.02
Prices and wages				
HICP	0.01	0.07	0.24	0.78
Wages (contractual) private sector	0.00	0.02	-0.01	0.09
House prices	0.00	0.11	1.05	2.30
Cost price (including energy)	0.00	0.00	0.09	0.40
Other items				
Government balance	-0.95	-1.13	-0.85	-0.45
Total employment	0.01	0.10	0.49	0.65

[1] Percent deviation from central projection.

5.4 Labour supply +1 %

This scenario assumes that labour supply increases by 1 percent. This shock is implemented by assuming an exogenous shock to the size of the Dutch population. Most of the additional workers fail to find immediate employment, so the direct effect is an increase in the level of unemployment by nearly 0.6 percentage points. The fact that more people are willing to work puts strong downward pressure on contractual wages. In the end, by the adjustment of the price of labour, the additional workers nearly all manage to find suitable employment. In year 8 total employment is up by 0.9 percent compared to the central projection.

Wages are a main component of the producers' overall costs, which strongly decline over the simulation horizon. In line with lower costs the price level is lower, with an overall effect of well over a percentage point in year 8. A main driver of the volume of GDP, which is around half a percent higher over the years, is other private investment, as firms see lower wage bills, higher profitability and increased demand.

Lower prices have a positive effect on real disposable income. However, due to lower wages, the overall change in real disposable income is only slightly positive and the increase in volume of private consumption is limited to some 0.3 percent. The drop in prices also improves price competitiveness leading to higher exports over the simulation horizon. The government balance initially deteriorates as the outlays for unemployment increase. This effect, however, is temporary. As time proceed, the government balance improves, also due to higher tax revenues and the lower wage bill for government employees.

Table 7: Labour supply +1 %

	1	2	4	8
Volumes				
GDP	0.16	0.33	0.54	0.54
Private consumption	-0.31	-0.20	0.26	0.28
Housing investment	-0.21	-0.82	0.07	0.17
Other private investment	0.26	1.42	2.28	2.02
Imports	-0.40	-0.52	-0.07	0.12
Exports	0.01	0.04	0.11	0.30
Re-exports	0.01	0.02	0.04	0.08
Prices and wages				
HICP	-0.14	-0.38	-0.71	-1.09
Wages (contractual) private sector	-0.20	-0.50	-0.92	-1.49
House prices	-0.57	-0.98	-0.27	-0.70
Cost price (including energy)	-0.29	-0.37	-0.85	-1.34
Other items				
Government balance	-0.11	0.04	0.12	0.14
Total employment	0.25	0.69	0.84	0.89

[1] Percent deviation from central projection.

5.5 Oil price +20 %

This scenario assesses the effects of an oil price which is permanently 20 percent higher than in the central projection. In DELFI, energy is one of the three key inputs in the production process. The steep increase in oil prices leads, therefore, immediately to higher production costs. In year 1, production costs are 0.65 percent higher. To protect their profit margins, firms react to higher production costs by increasing prices. The higher prices have a negative impact on domestic demand, which is around 0.5 percent lower in the long run. Households' real disposable income is hit by the higher prices that directly follow the oil price increase. Nominal wages increase, but real wages fall because of higher prices. As a result of lower disposable income, consumption decreases. The effect of higher oil prices on employment is small, even though output is substantially lower.

Factor substitution is one explanation for this phenomenon: since energy becomes more expensive relative to labour, firms will use less energy and more labour (and capital) per unit of production. Labour productivity (measured as input of labour over output of final goods) is falling as a result of the factor substitution. Another reason is that firms are operating with a higher markup one year after the shock. The higher markup induces firms to hire more labour.

Table 8: Oil price +20 %

	1	2	4	8
Volumes				
GDP	-0.03	-0.10	-0.21	-0.46
Private consumption	-0.17	-0.39	-0.50	-0.74
Housing investment	-0.02	-0.08	-0.26	-0.42
Other private investment	-0.05	-0.13	-0.10	-0.58
Imports	-0.10	-0.29	-0.35	-0.64
Exports	-0.09	-0.10	-0.21	-0.60
Re-exports	-0.02	-0.05	-0.10	-0.25
Prices and wages				
HICP	0.32	0.50	0.81	1.73
Wages (contractual) private sector	0.01	0.15	0.52	1.22
House prices	0.00	0.03	0.13	0.88
Cost price (including energy)	0.65	0.65	0.97	2.12
Other items				
Government balance	0.08	0.15	0.13	0.12
Total employment	0.00	-0.02	0.00	-0.02

[1] Percent deviation from central projection.

5.6 Credit rationing of firms (-1 % yearly shock to loans to firms)

DELFI contains an alternative specification for other private investment that can be used to simulate bank credit supply effects on the real economy. When banks are in distress, they can be reluctant to provide loans to the private sector. Under such circumstances, credit supply constraints

limit other private investment and aggregate demand, and in the long run potential output.

When bank lending to firms is given an annual shock of -1 percent, firms cannot obtain enough funding, and lower investment in fixed assets. The resulting loss of employment has a negative effect on households' disposable income and consumption, lowering domestic demand and GDP. Firms react by cutting prices. The drop in investment limits the growth of the capital stock and hence the productive capacity of the economy. As a result, GDP falls below the baseline in the longer run.

Imports drop, since a large fraction of imports consists of investment goods. As exports do not change as a result of credit rationing, net exports increase.

Table 9: Credit rationing of firms

	1	2	4	8
Volumes				
GDP	-0.01	-0.03	-0.07	-0.15
Private consumption	0.00	-0.01	-0.06	-0.15
Housing investment	0.00	-0.01	-0.07	-0.19
Other private investment	-0.31	-0.66	-1.33	-2.55
Imports	-0.04	-0.09	-0.15	-0.27
Exports	0.00	0.00	0.00	0.03
Re-exports	0.00	0.00	0.00	0.01
Prices and wages				
HICP	0.00	-0.01	-0.03	-0.17
Wages (contractual) private sector	0.00	-0.01	-0.06	-0.22
House prices	0.00	-0.01	-0.09	-0.32
Cost price (including energy)	0.00	0.00	-0.05	-0.20
Other items				
Government balance	0.00	-0.01	-0.02	-0.03
Total employment	0.00	-0.01	-0.04	-0.09

[1] Percent deviation from central projection.

5.7 Credit rationing on mortgages (-1 % yearly shock to mortgage loans)

For many house buyers, financing constraints are binding, so that a reduction in the availability of mortgage credit has a large impact on house prices. If the amount of mortgage credit provided by banks is shocked annually by -1 percent, house prices drop considerably. The resulting loss of households' wealth induces households to consume less and save more. The downward pressure on the housing market also negatively impacts housing investment.

The drop in domestic demand induces firms to cut back output and employment. The latter has a negative effect on households' income, which cause a further reduction in consumption and domestic demand.

Imports for domestic use fall even more than domestic demand, while exports are initially flat, leading to an increase in net exports. Higher unemployment puts a downward pressure on wages and labour costs, enabling firms to lower prices. Government expenditure increases due to a rising unemployment, negatively affecting the government budget.

Table 10: Credit rationing on mortgages

	1	2	4	8
Volumes				
GDP	-0.01	-0.03	-0.10	-0.18
Private consumption	-0.02	-0.12	-0.41	-0.93
Housing investment	-0.06	-0.35	-0.78	-1.16
Other private investment	0.00	0.01	0.05	0.26
Imports	-0.01	-0.07	-0.23	-0.35
Exports	0.00	0.00	0.00	0.03
Re-exports	0.00	0.00	0.00	0.01
Prices and wages				
HICP	0.00	-0.01	-0.05	-0.27
Wages (contractual) private sector	0.00	0.00	-0.06	-0.30
House prices	-0.40	-1.35	-3.36	-6.32
Cost price (including energy)	0.00	0.00	-0.05	-0.27
Other items				
Government balance	0.00	-0.02	-0.08	-0.18
Total employment	0.00	-0.01	-0.05	-0.11

[1] Percent deviation from central projection.

5.8 Long term interest rate +1 %-point (including price adjustment abroad)

The increase in interest rates has a strong effect on capital costs incurred by firms. As a result, there is a strong initial reduction in other private investment. Producers are able to pass on part of the higher production costs to consumers, resulting in lower profitability. Lower demand for investment goods leads firms to reduce production and demand less labour. Although there is some delay related to the time it takes to negotiate wages are negatively effected in the long run. Lower employment, lower wages and higher prices reduce households' real disposable income and consumption, further depressing domestic demand.

Higher interest rates also push up mortgage rates, which reduces the borrowing capacity of households and leads to lower house prices. Lower

housing wealth induces optimizing households to increase saving and reduce consumption, which has an additional downward effect on domestic demand.

In this scenario, we assume that higher interest rates are an international phenomenon that not only affects the Dutch economy but also the economies of our main trading partners. Therefore, there is no significant change in the terms of trade. Still, net exports increase because imports consist for a large part of investment goods, so the falling demand for investment goods affects imports more than it affects exports.

Table 11: Long term interest rate +1 %-point

	1	2	4	8
Volumes				
GDP	-0.12	-0.41	-0.75	-0.62
Private consumption	-0.19	-0.73	-1.77	-1.73
Housing investment	-0.49	-1.70	-2.95	-2.72
Other private investment	-0.29	-1.18	-1.85	0.46
Imports	-0.39	-1.11	-1.70	-1.10
Exports	-0.32	-0.70	-0.82	-0.65
Re-exports	-0.32	-0.71	-0.76	-0.58
Prices and wages				
HICP	0.04	0.11	0.10	-0.57
Wages (contractual) private sector	0.00	0.00	-0.23	-0.81
House prices	-0.82	-2.63	-5.04	-5.15
Cost price (including energy)	0.69	0.62	0.40	-0.08
Other items				
Government balance	-0.04	-0.18	-0.41	-0.31
Total employment	-0.03	-0.17	-0.59	-0.67

[1] Percent deviation from central projection.

5.9 5 % appreciation of the effective euro exchange rate

A 5 percent appreciation in the effective exchange reduces price competitiveness of Dutch firms, causing exports to fall sharply. Firms respond to lower demand by hiring less labour and by reducing investment. Lower

demand for labour implies that households' labour income and disposable income both fall. Lower demand for labour also causes a rise in the level of unemployment. With more people being unemployed, the workers' position in wage negotiations is weakened, thus putting further downward pressure on contractual wages.

On the one hand, goods and services acquired abroad are now relatively cheap. Still, overall the volume of imports falls. As domestic demand has fallen, there is less goods and services that need to be imported. On balance, net exports fall. The appreciation of the Euro implies cheaper imports of energy. Energy is an important input in the production process, which means there is downward effect on production costs. Part of this reduction is passed on to consumers by firms.

After four years, wages have fallen so much that firms start hiring workers again. Private consumption, however, does not yet show a strong reaction. This is related to the relatively flat profile displayed by disposable income, which, in turn, is due to contractual wages which remain low. Meanwhile, firms already start rebuilding their capital stock which gives a boost to other private investment. As demand increases, the economy gradually recovers. Still, after eight years the volume of GDP is still 0.3 percent lower than in the baseline.

Table 12: 5 % appreciation of the effective euro exchange rate

	1	2	4	8
Volumes				
GDP	-0.24	-0.45	-0.50	-0.30
Private consumption	0.01	-0.05	-0.47	-0.46
Housing investment	-0.03	-0.20	-0.93	-0.99
Other private investment	-0.36	-1.28	-1.26	0.79
Imports	-0.21	-0.52	-0.92	-0.40
Exports	-0.40	-0.76	-0.99	-0.52
Re-exports	-0.05	-0.17	-0.28	-0.12
Prices and wages				
HICP	-0.16	-0.44	-1.21	-3.27
Wages (contractual) private sector	-0.02	-0.28	-1.32	-3.28
House prices	-0.01	-0.30	-1.53	-3.47
Cost price (including energy)	-0.06	-0.04	-1.25	-3.14
Other items				
Government balance	-0.05	-0.20	-0.34	-0.23
Total employment	-0.04	-0.24	-0.52	-0.42

[1] Percent deviation from central projection.

5.10 Share prices +20 %

In this scenario we analyze the effects of a permanent, worldwide 20 percent increase in share prices. A 20 percent increase in stock prices makes consumers wealthier. Moreover, households receive more dividends, leading to higher disposable income. Pension funds benefit from the higher share price and the funding ratio improves significantly. We assume, however, that the pension premium is not adjusted.

Higher wealth and higher disposable income induce agents to consume more. This effect on consumption builds up during the first three years and is very persistent. Households smooth consumption by saving more in the years right after the shock. For firms, higher share prices imply a lower cost of capital. Higher demand from consumers and lower cost of capital

leads induce firms to invest in capital goods and to employ more labour. The effect on investment is rather strong in the first few years after the shock, but then diminishes quickly.

Due to the tighter labour market, wages and households' labour income increase. Following the shift in the relative prices of labour and capital, we see firms substituting some labour input for input of capital. Imports increase because of higher demand for consumption and investment goods, leading to a worsening trade balance.

Government finances improve due to higher tax receipts and lower expenditures. Inflation increases due to higher production costs, which are caused by higher wages. House price show a light increase.

Table 13: Share prices +20 %

	1	2	4	8
Volumes				
GDP	0.18	0.36	0.38	0.23
Private consumption	0.46	0.97	1.22	1.21
Housing investment	0.13	0.75	1.57	1.11
Other private investment	1.75	2.74	1.43	-0.58
Imports	0.41	0.83	0.73	0.28
Exports	0.00	0.01	-0.00	-0.14
Re-exports	0.00	0.01	-0.00	-0.04
Prices and wages				
HICP	0.02	0.11	0.21	0.65
Wages (contractual) private sector	0.00	0.09	0.40	0.75
House prices	0.01	0.39	1.66	1.49
Cost price (including energy)	-0.00	0.03	0.40	0.70
Other items				
Government balance	0.14	0.31	0.28	0.20
Total employment	0.02	0.16	0.27	0.09

[1] Percent deviation from central projection.

5.11 Wages +1 %

This scenario shows the effects of a permanent 1 percent increase in nominal wages. Wages are endogenously determined in DELFI and follow from bargaining between employers and employees. We have permanently increased the autonomous part of the wage equation to implement the scenario. Higher wages lead to higher disposable income and to higher consumption. Companies react to higher wage costs by hiring less labour and investing less in fixed capital. Firms face higher costs of production, which they partially pass on to their customers by increasing prices. Higher prices lead to higher wages, causing a wage-price spiral.

Exporting firms and firms with foreign competitors have limited room for price increases, so part of the increase in production costs is absorbed by lower profitability. Exports fall due to loss of competitiveness. Lower profitability and lower demand reduce firms' incentive to invest, so we see a substantial and persistent fall in demand for capital goods. GDP is slightly lower after the shock because the negative effects of lower exports and lower investment outweigh the positive effects of higher consumption. Government finances worsen because of higher expenditures for unemployment benefits. Higher government expenditures are only partially offset by higher receipts due to higher income taxes.

Table 14: Wages +1 %

	1	2	4	8
Volumes				
GDP	-0.05	-0.03	-0.16	-0.29
Private consumption	0.15	0.30	0.24	0.07
Housing investment	0.07	0.41	0.98	-0.10
Other private investment	-0.26	-0.99	-1.64	-1.54
Imports	-0.01	0.01	-0.15	-0.46
Exports	-0.03	-0.13	-0.35	-0.57
Re-exports	-0.03	-0.07	-0.11	-0.16
Prices and wages				
HICP	0.05	0.32	1.31	1.33
Wages (contractual) private sector	1.25	1.83	2.36	2.64
House prices	-0.01	-0.07	0.69	-0.16
Cost price (including energy)	0.94	1.10	1.61	2.03
Other items				
Government balance	-0.05	-0.18	-0.13	-0.29
Total employment	-0.07	-0.23	-0.48	-0.81

[1] Percent deviation from central projection.

5.12 Pension premiums +10 %

This scenario describes the consequences of a 10 percent permanent increase in the pension premium. The burden of a higher contribution to pension funds is shared between firms and employees. For firms, the higher premium means higher production costs, which are partially passed on to customers. For employees, higher contributions to pension funds reduce the disposable income and consumption. The fall in GDP is persistent, because of persistently lower domestic demand from consumption and - to a lesser extent - investment. Firms react to lower demand by employing less labour and capital. Higher unemployment depresses consumption even more and also puts downward pressure on wages. The government balance decreases because of lower income taxes.

The negative effect on consumption and investment lead to lower im-

ports and, because the effect on exports is very small, to higher net exports. Higher contributions to pension funds lead to a higher funding ratio of 2.3% in the long run. By assumption, the improved financial position of pension funds does not affect pension benefits.

Table 15: Pension premiums +10 %

	1	2	4	8
Volumes				
GDP	-0.02	-0.00	-0.15	-0.26
Private consumption	-0.07	-0.28	-0.85	-1.49
Housing investment	-0.01	-0.12	-0.71	-1.66
Other private investment	-0.15	-0.31	-0.27	0.35
Imports	-0.11	-0.32	-0.66	-0.71
Exports	-0.02	-0.05	-0.10	-0.04
Re-exports	-0.01	-0.02	-0.03	0.00
Prices and wages				
HICP	0.02	0.08	0.20	-0.25
Wages (contractual) private sector	-0.12	-0.30	-0.57	-1.27
House prices	-0.02	-0.23	-0.76	-1.86
Cost price (including energy)	0.44	0.30	0.37	-0.09
Other items				
Government balance	-0.04	-0.13	-0.18	-0.26
Total employment	-0.05	-0.12	-0.20	-0.35

[1] Percent deviation from central projection.

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A The model equations

This appendix presents the model equations in detail. The appendix consists of seven sections: firms, households, wages and labour market, prices, rest of world, pension funds and government and social security. Most behavioural equations have been estimated on data starting in the early 1980s and ending 2008Q4; further details are provided directly below each equation. To cope with outlying observations, which in some cases were due to known policy changes, dummy variables have been added to a number of the estimated equations. To enhance readability, these dummy variables are not shown here. As a rule, numbers in parentheses are t-statistics, unless explicitly stated otherwise. $p(LM_4)$ denotes the p-value of an LM test for remaining autocorrelation, allowing for four lags. $p(JB)$ denotes the p-value of the Jarque-Bera test for normality.

A.1 Firms

Firms operate a nested CES production function which combines inputs of labour, capital and energy. We allow both for labour-augmenting, capital-augmenting and energy-augmenting technical progress. Hence, all inputs enter in efficiency units. We use sample averages, indicated by bars, to normalize the production function.

We combine capital and labour first, cf. Van der Werf (2008). Labour is measured in hours worked. Capital is private sector capital stock less dwellings. We include a measure of capacity utilisation to account for the fact that production factors not always operate at full capacity. We estimate the elasticity with respect to capacity utilisation in the manufacturing industry to be less than one, indicating utilisation rates across the private sector tend to be less volatile than in this particular sector of the economy. Labour-augmenting technical progress is quantitatively more important than capital-augmenting technical progress. There are no economies of scale. The elasticity of substitution between capital and labour is estimated to be 0.386, which is at the lower end of the range found in the academic literature

(Chirinko (2008)).

$$y_{va}^{pr} = \bar{y}_{va}^{pr}\, cu^{\alpha} \left[\theta^{\frac{1}{\sigma}} \left(e^{\nu_L t/\bar{t}} \frac{L}{\bar{L}} \right)^{\frac{\sigma-1}{\sigma}} + (1-\theta)^{\frac{1}{\sigma}} \left(e^{\nu_K t/\bar{t}} \frac{K}{\bar{K}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\eta\sigma}{\sigma-1}} \quad (1)$$

y_{va}^{pr}, volume of private sector value added at basic prices

$L = ep * hp$, private sector employment in fte multiplied by hours worked per fte

$K = ko$, private sector capital stock less dwellings

cu, rate of capacity utilisation in manufacturing industry

$\nu_L = 0.275$ (0.006), labour-augmenting technical progress

$\nu_K = 0.122$ (0.029), capital-augmenting technical progress

$\alpha = 0.302$ (0.045), elasticity with respect to rate of capacity utilisation in manufacturing industry

$\eta = 1.000$ (0.000), economies of scale

$\sigma = 0.386$ (0.010), elasticity of substitution between capital and labour

$\theta = 0.851$, sample average share of labour income in sum of capital income and labour income.

Standard errors are in parentheses.

Next, we combine value added with energy, which is measured in Petajoule. The elasticity of substitution between energy and the capital-labour composite is estimated to be low, and substantially lower than the elasticity of substitution between capital and labour. This is consistent with other evidence for the Netherlands presented in Van der Werf (2008). Energy-augmenting technical progress is increasing until the early 2000s, and has since diminished slightly.

$$y_{va}^{pr} + ce = (\bar{y}_{va}^{pr} + \overline{ce}) \left[\zeta^{\frac{1}{\gamma}} \left(e^{\nu_E^1 t/\bar{t} + \nu_E^2 (t/\bar{t})^2} \frac{ce}{\overline{ce}} \right)^{\frac{\gamma-1}{\gamma}} + (1-\zeta)^{\frac{1}{\gamma}} \left(\frac{y_{va}^{pr}}{\bar{y}_{va}^{pr}} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \quad (2)$$

ce, volume of domestic use of energy

$\zeta = 0.040$, sample average share of energy costs in total factor income

$\gamma = 0.121$ (0.036), elasticity of substitution between energy and capital-labour composite

$\nu_E^1 = 0.017$ (0.002), energy-augmenting technical progress, linear part

$\nu_E^2 = -0.000092$ (0.00001), energy-augmenting technical progress, quadratic part. Standard errors are in parentheses.

We assume optimizing behaviour on the part of firms, and use equations (1) and (2) to derive the long term equations for **private sector employment** (ep), **private sector capital less dwellings** (ko), **use of energy** (ce) .

$$\begin{aligned} \ln(ep) &= \frac{1}{\eta}\left[\ln(y_{va}^{pr}+ce) - \gamma \ln\left(\frac{cy}{cye}\right)\right] - \sigma \ln\left(\frac{ple}{cy}\right) - \nu_L t \\ &\quad - \ln(hp) - \alpha \ln(cu) \end{aligned} \tag{3}$$

$$\begin{aligned} \ln(ko) &= \frac{1}{\eta}\left[\ln(y_{va}^{pr}+ce) - \gamma \ln\left(\frac{cy}{cye}\right)\right] - \sigma \ln\left(\frac{pke}{cy}\right) - \nu_K t \\ &\quad - \alpha \ln(cu) \end{aligned} \tag{4}$$

$$\ln(ce) = \ln(y_{va}^{pr}+ce) - \gamma \ln\left(\frac{pcee}{cye}\right) - \nu_E^1 t - \nu_E^2 t^2 \tag{5}$$

cy, minimum cost price based on production function combining capital and labour

cye, minimum cost price based on production function combining capital, labour and energy

ple, price of labour in efficiency units

pke, user cost of capital in efficiency units

$pcee$, price of use of energy in efficiency units

The **minimum cost price** (cy) and the **minimum cost price including energy** (cye) are derived from the production function, and are defined as:

$$cy = \left[\theta ple^{1-\sigma} + (1-\theta) pke^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{6}$$

$$cye = \left[(1-\zeta) cy^{1-\gamma} + \zeta pcee^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{7}$$

The **price of labour in efficiency units** (ple) is defined as the hourly wage adjusted for labour-augmenting technical progress.

$$ple = \frac{W^{pr} + W^s}{ep * hp}\, e^{-\nu_L t/\bar{t}} \tag{8}$$

The **user of cost of capital in efficiency units** (pke) is defined as the **user cost of capital** (pk) adjusted for capital-augmenting technical progress. The expression for pk contains the conventional Jorgensonian user-cost elements such

as the depreciation rate (δ^o), the expected rate of change of the deflator of (other private) investment (pio^e). We assume 25 percent of the capital stock is financed using equity and 75 percent using (bank) loans. The equity premium is fixed at 5 percentage points. Firms pay an interest rate on their (bank) loans equal to the risk free long term interest rate (rl) plus a time-varying credit spread ($spread$). We assume the credit spread for Dutch firms depends both on developments in international financial markets, approximated by the credit spread on US corporate bonds ($spreadus$), and on the level of profitability of Dutch firms ($profq$) compared to its historical average. We do not disaggregate private sector capital stock less dwellings further into specific types of capital goods. Yet, the composition of the capital stock has changed markedly over time. To account for the increasing share of ICT products in the capital stock, we include the share of ICT investment in total investment (ict) in the definition of the user cost of capital in efficiency units.

$$\begin{aligned} pk &= pio * \frac{1-\tau^{subs}-\tau^{firms}*0.6}{1-\tau^{firms}} * \\ &\quad \left[\frac{1}{4}(rl+5)+\frac{3}{4}(rl+spread)(1-\tau^{firms})+\delta^o-pio^e\right] \end{aligned} \tag{9}$$

$$pke = pk\ e^{-1.947ict/\overline{ict}+0.969(ict/\overline{ict})^2-\nu_K t/\bar{t}} \tag{10}$$

$$spread = spreadus - 0.398\sum_{i=2}^{9}\left(profq_{-i}-\overline{profq}\right) \tag{11}$$

$$profq = (Z-Z^{hh})/(py*y) \tag{12}$$

Assuming a constant capital-output ratio in the long term allows us to derive the long term equation for the **volume of other private investment** (io) from the long term equation for capital.

$$\begin{aligned} \ln(io) &= \frac{1}{\eta}\left[\ln(y_{va}^{pr}+ce)-\gamma\ln\left(\frac{cy}{cye}\right)\right]-\sigma\ln\left(\frac{pke}{cy}\right)-\nu_K t \\ &\quad -\alpha\ln(cu)+\ln(\delta^o+\mu) \end{aligned} \tag{13}$$

where μ denotes the sample average growth rate of $y_{va}^{pr}+ce$.

The **private sector capital stock less dwellings** (ko) cumulates according to a perpetual inventory condition, with depreciation rate δ^o.

$$ko = (1-\delta^o)ko_{-1}+io \tag{14}$$

In the short term, **employment in the private sector** (ep) is affected by changes in private sector value added, changes in the real cost of labour in efficiency units, the markup of the value added deflator over the cost price, and labour supply (ls). If firms are able to increase their markup, part of the additional profit is used to increase employment. We assume that when the labour market is doing well, part of the workers that flow into the market are sufficiently qualified to almost immediately find a job. This channel is only operative when labour supply is increasing, in which case $I_A = 1$. If the labour supply variable is not increasing ($I_A = 0$), this channel is switched off.

$$\begin{aligned}\Delta \ln ep \quad = \quad & \underset{(0.8)}{0.10} + \underset{(5.5)}{0.45}\frac{1}{4}\sum_{i=2}^{5}\Delta \ln y^{pr}_{va,-i} - \underset{(2.0)}{0.10}\frac{1}{4}\sum_{i=2}^{5}\Delta \ln\left(\frac{ple_{-i}}{cye_{-i}}\right) \\ & + \underset{(4.3)}{0.07}\frac{1}{4}\sum_{i=0}^{3}\ln\left(\frac{py^{pr}_{va,-i}}{cy_{-i}}\right) + \underset{(5.9)}{0.76}\ I_A\frac{1}{2}\sum_{i=2}^{3}\Delta \ln ls_{-i} - \underset{(2.7)}{0.06} * ECM_{-1}\end{aligned} \tag{15}$$

$\bar{R}^2 = 0.69$; $S.E. = 0.003$; $p(LM_4) = 0.00$; $p(JB) = 0.55$

Estimation period: 1981Q1 - 2008Q4

In the short term, the **volume of other private investment** (io) is affected by profitability, world stock prices, and private sector value added. The latter variable reflects the classical accelerator mechanism.

$$\begin{aligned}\Delta \ln io \quad = \quad & \underset{(1.3)}{0.17} - \underset{(2.9)}{0.10} * ECM_{-1} - \underset{(5.2)}{0.44} * \Delta \ln io_{-1} + \underset{(2.8)}{3.18} * \frac{1}{4}\sum_{i=1}^{4}\Delta \ln y^{pr}_{va,-i} \\ & + \underset{(2.5)}{0.01}\ * \ \frac{1}{4}\sum_{i=1}^{4} profq_{-i} + \ \underset{(2.2)}{0.19}\ * \frac{1}{2}\sum_{i=1}^{2}\Delta \ln ps^{wo}_{-i}\end{aligned} \tag{16}$$

$\bar{R}^2 = 0.25$; $S.E. = 0.04$; $p(LM_4) = 0.49$; $p(JB) = 0.53$

Estimation period: 1981Q1 - 2008Q4

In the short term, the **use of energy** (ce) is affected by lagged changes in use of energy, reflecting sluggish adjustment in energy consumption habits, and an error correction term.

$$\Delta \ln ce \quad = \quad - \underset{(3.5)}{0.42} \ + \ \underset{(4.9)}{0.43} \ * \ \Delta \ln ce_{-2} \ - \ \underset{(3.5)}{0.15} * ECM_{-1} \tag{17}$$

$\bar{R}^2 = 0.21$; $S.E. = 0.03$; $p(LM_4) = 0.01$; $p(JB) = 0.62$
Estimation period: 1978Q2 - 2008Q4

Firms not only invest in fixed capital, but they also hold stocks. As firms want to reduce stock out risk, the **volume of changes in inventories** (ds) depends positively on expected future final demand. Final demand ($yfin$) is the sum of private consumption, investment, exports, other government consumption. We assume backward looking expectations. Furthermore, current demand and labour costs affect changes in inventories negatively. The impact of the real interest rate is marginal. The real interest rate is defined as the average of the short and the long term interest rate less the annual growth rate of the deflator of final demand.

$$\begin{aligned} \frac{ds}{\sum_{i=1}^{4} y^{pr}_{va,-i}} &= \underset{(6.9)}{0.52} * \frac{ds_{-1}}{\sum_{i=1}^{4} y^{pr}_{va,-i}} - \underset{(4.6)}{0.20} * \frac{\Delta yfin}{\sum_{i=1}^{4} y^{pr}_{va,-i}} \\ &+ \underset{(4.4)}{0.24} * \frac{\frac{1}{4}\sum_{i=1}^{4} \Delta yfin_{-i}}{\sum_{i=1}^{4} y^{pr}_{va,-i}} - \underset{(3.6)}{0.05} * \Delta \ln \frac{W^{pr} + W^{s}}{pyfin * y^{pr}_{va}} \\ &- \underset{(1.3)}{0.0003} * \frac{1}{4}\sum_{i=2}^{5} \left(\frac{rs_{-i} + rl_{-i}}{2} - \dot{pyfin}_{-i} \right) \end{aligned} \tag{18}$$

$\bar{R}^2 = 0.46$; $S.E. = 0.002$; $p(LM_4) = 0.34$; $p(JB) = 0.05$
Estimation period: 1980Q3 - 2008Q4

The **volume of changes in inventories including statistical discrepancies** ($dels$) is equal to the change in inventories plus a residual. The **volume of stock of inventories** (s) accumulates as follows:

$$s = s_{-1} + ds \tag{19}$$

The **volume of private sector value added at basic prices** (y^{pr}_{va}) is calculated as the volume of gross domestic product (y) less volume of government value added at basic prices (y^{gov}_{va}) and net taxes on products in constant prices, plus a residual.

$$y^{pr}_{va} = y - y^{gov}_{va} - (taxprodr - subsprodr) \tag{20}$$

The **volume of gross domestic product** (y) is the sum of private consumption (c), government consumption (cg), government investment (ig), housing invest-

ment (ih), other private investment (io) and exports, less imports.

$$y = c + cg + ig + ih + io + x - m + dels \tag{21}$$

Private sector labour productivity ($prod$) is defined as private sector value added over private sector employment.

$$prod = y_{va}^{pr}/ep \tag{22}$$

We assume part of the private capital stock less dwellings is financed by (bank) loans. Hence, in the long term, **loans to firms** ($loansf$) depend positively on the capital stock (ko). Loans are negatively affected by the price of credit, which is approximated by the risk free long term interest rate plus the time-varying credit spread. Following the pecking-order theory of corporate finance, the demand for loans decreases as internal funds become more abundant. A rise in the short term interest rate makes maintaining a financial buffer less costly, which increases the demand for external funding.

$$\begin{aligned} \ln \frac{loansf}{py_{va}^{pr}} = & \underset{(6.0)}{-13.58} + \underset{(10.7)}{1.67} * \ln ko - \underset{(8.8)}{13.41} * \frac{1}{16}\sum_{i=0}^{15}(rl_{-i} + spread_{-i}) \\ & + \underset{(5.9)}{6.16} * \frac{1}{16}\sum_{i=0}^{15} rs_{-i} - \underset{(0.3)}{0.38} * \frac{1}{16}\sum_{i=0}^{15} profq_{-i} \end{aligned} \tag{23}$$

$S.E. = 0.03$; $p(ADF) = 0.09$

Estimation period: 1990Q4 - 2008Q4

In the short term, loans to firms are negatively affected by profitability and positively affected by changes in private sector value added, as a rise in production requires more working capital.

$$\begin{aligned} \Delta \ln \frac{loansf}{py_{va}^{pr}} = & \underset{(4.4)}{-0.24} * ECM_{-1} + \underset{(3.3)}{0.60} * \Delta \ln y_{va}^{pr} \\ & \underset{(2.1)}{-0.64} * \Delta profq + \underset{(4.1)}{0.52} * \Delta \ln \frac{loansf_{-1}}{py_{va,-1}^{pr}} \end{aligned} \tag{24}$$

$\bar{R}^2 = 0.30$; $S.E. = 0.01$; $p(LM_4) = 0.23$; $p(JB) = 0.00$

Estimation period: 1991Q2 - 2008Q4

Potential volume of private sector value added at basic prices ($ypot_{va}^{pr}$) is calculated by plugging potential private sector employment (ep^{struc}), structural hours worked per fte (hp^{struc}), the actual capital stock, structural labour-augmenting technical progress (ν_L^{struc}) and structural capital-augmenting technical progress (ν_K^{struc}) into the production function in equation (1). We define **potential private sector employment** as potential employment less actual government sector employment.

$$ep^{struc} = n_{1575} * part/\psi^{tot,struc} * (1 - u^{eq}) - eg \tag{25}$$

where potential total employment is defined as the population between 15 and 75 times the long term participation rate (equation (55)) times one minus the equilibrium unemployment rate divided by the **structural persons per fte ratio for the total economy** ($\psi^{tot,struc}$). The latter variable is obtained by applying the HP filter to a weighted average of persons to fte ratios for the private sector (ψ^{pr}), for the government sector (ψ^{gov}) and for the self-employed (ψ^{s}).

Structural labour-augmenting technical progress (ν_L^{struc}) and **structural capital-augmenting technical progress** (ν_K^{struc}) are obtained by applying the HP filter to the residuals of equation (3) and (4), respectively, after removing the linear trend.

The **equilibrium unemployment rate** (u^{eq}) is the unemployment rate that equalizes the labour income share obtained from the wage equation (59) to the labour income share obtained from the labour demand equation (3). Under this condition, the wage rate that results from the wage bargain does not elicit adjustment in factor demand, and vice versa, the demand for labour and capital does not give rise to a different outcome from the wage bargain. The equilibrium unemployment rate is increasing in the wedge, which is a mix of the value added tax rate τ^{vat}, the rate of employers' social contributions (τ_r) and the rate of employees' social contributions and income taxes (τ_n), the replacement rate (rpr),

the markup (py^{pr}_{va}/cy), and the real user cost of capital (pke/cy).

$$\begin{aligned} u^{eq} &= \frac{1}{0.012}\Bigg[-0.146 + 0.70 * \frac{1}{8}\sum_{i=0}^{7}\frac{py^{pr}_{va,-i}}{cy_{-i}} + 0.183 * \frac{1}{8}\sum_{i=0}^{7}\big(\ln(1+\tau^{vat}_{-i}) \\ &\quad - \ln(1-\tau_{r,-i}) - \ln(1-\tau_{n,-i})\big)\Bigg] + 0.313 * \frac{1}{8}\sum_{i=0}^{7}\ln rpr_{-i} \\ &\quad - \ln\left(1-(1-\theta)\left(\frac{1}{8}\sum_{i=0}^{7}\frac{pke_{-i}}{cy_{-i}}\right)^{1-\sigma}\right) \end{aligned} \tag{26}$$

The **replacement rate** (rpr) is defined as the average benefit from unemployment insurance ($transh_{ww}$), social assistance ($transh_{bw}$) and disability insurance ($transh_{wao}$) as a percentage of private sector contractual wages.

$$rpr = \frac{transh_{ww} + transh_{bw} + transh_{wao}}{(n_{ww} + n_{bw} + n_{wao}) * w^{pr}_{cnt}} \tag{27}$$

Potential output ($ypot$) is the sum of the potential private sector value added at basic prices, government sector value added at basis prices and net taxes on products in constant prices.

$$ypot = ypot^{pr}_{va} + y^{gov}_{va} + (taxprodr - subsprodr) \tag{28}$$

The **output gap** ($ygap$) is the difference between GDP and potential output as a percentage of potential output.

$$ygap = (y - ypot)/ypot \tag{29}$$

During times of financial stress, credit rationing may happen. For such situations, the model provides alternative equations for **loans to firms** ($loansf$) and **other private investment** (io). In the long term, other private investment in current prices and loans to firms are then jointly determined. In the short term, loans to firms are affected by producer confidence ($pconf$) and MFI's TIER one ratio ($tier1$). Other private investment is in the short term also affected by banks' lending standards, reported in the Bank Lending Survey (bls), where in increase in the variable indicates tighter lending standards.

$$\begin{aligned} \Delta \ln loansf &= \underset{(4.9)}{0.01} - \underset{(1.3)}{0.01} * (loansf_{-1} - 17.89 + \underset{(4.2)}{3.20} * pio_{-1} * io_{-1}) \\ &\quad + \underset{(1.3)}{0.16} * \Delta \ln loansf_{-1} + \underset{(0.8)}{0.03} * \Delta \ln(pio_{-1} io_{-1}) \\ &\quad + \underset{(0.7)}{0.01} * \Delta tier1_{-1} + \underset{(1.7)}{0.001} * pconf_{-1} \end{aligned} \tag{30}$$

$$
\begin{aligned}
\Delta \ln pio * io \quad = \quad & \underset{(0.5)}{0.00} + \underset{(2.0)}{0.03} * (loansf_{-1} - 17.89 + \underset{(4.2)}{3.20} * pio_{-1} * io_{-1}) \\
& + \underset{(1.6)}{0.51} * \Delta \ln loansf_{-1} - \underset{(3.6)}{0.38} * \Delta \ln(pio_{-1} io_{-1}) \qquad (31) \\
& + \underset{(1.6)}{0.04} * \Delta tier1_{-1} + \underset{(2.4)}{0.003} * pconf_{-1} - \underset{(1.5)}{0.0003} * bls_{-1}
\end{aligned}
$$

A.2 Households

The long term **consumption function** (32) distinguishes optimizing households and rule-of-thumb (RoT) households. RoT households receive 80 percent of net disposable household income excluding dividends and net interest payments ($YDIS^* = YDIS - divh - r^{hh}_{received} + r^{hh}_{paid}$). Optimizing households own the stock of net household wealth ($wealth$), with the exception of part (31 percent) of net housing wealth ($hwealthn^{hh} = hwealth$ - $loanshmor$), which is owned by the RoT households (including 31 percent of interest paid (r^{hh}_{paid})). The marginal propensity to consume out of wealth of the optimizing households depends on the real long term interest rate ($rrl = (rl$ - $\dot{p}c)/100$).

$$
\begin{aligned}
C \quad = \quad & \left(1 - (1 + rrl)^{\left(\underset{(18.3)}{0.99} - 1\right)} * (1 - \underset{(5.2)}{0.04})^{\left(\underset{(18.3)}{0.99}\right)}\right) \qquad (32) \\
& * \left(\frac{1}{4}(wealth_{-1} - 0.31 * hwealthn_{-1}) + divh - (1 - 0.31) * r^{hh}_{paid}\right. \\
& \left. + r^{hh}_{received} + (1 - 0.80) * \frac{1}{4}\sum_{i=0}^{3} YDIS^*_{-i} \,/(\underset{(1.2)}{0.01} * rl + 0.09)\right) \\
& + 0.80 * \frac{1}{4}\sum_{i=0}^{3} YDIS^*_{-i} - 0.31 * r^{hh}_{paid} + \underset{(3.6)}{0.09} * 0.31 * hwealthn_{-1}/4
\end{aligned}
$$

$\bar{R}^2 = 0.59$; $S.E. = 0.02$; $p(ADF) = 0.01$

Estimation period: 1971 - 2008

In the short term, private consumption (33) is driven by changes in real disposable income ($ydis^{hh}$), real stock prices (ps/pc), real house prices (ph/pc), the unemployment rate (u) and an error-correction term (ECM), which is obtained

by dividing both sides of equation (32) by pc and taking logs.

$$\begin{aligned}\Delta \ln c &= \underset{(5.3)}{0.01} + \underset{(1.8)}{0.15} * \Delta \ln ydis^{hh} - \underset{(3.0)}{0.01} * \frac{1}{4}\sum_{i=1}^{4} \Delta u_{-i} \\ &+ \underset{(2.2)}{0.02} * \frac{1}{2}\sum_{i=0}^{1} \Delta \ln(ps_{-i}/pc_{-i}) + \underset{(1.9)}{0.11} * \frac{1}{2}\sum_{i=0}^{1} \Delta \ln(ph_{-i}/pc_{-i}) \\ &- \underset{(4.0)}{0.20} * ECM_{-1}\end{aligned} \tag{33}$$

$\bar{R}^2 = 0.44$; $S.E. = 0.01$; $p(LM_4) = 0.26$; $p(JB) = 0.35$

Estimation period: 1984Q2 - 2008Q4

Sources of **household net disposable income** ($YDIS$) in equation (34) are compensation of employees (W, see equation (69)), mixed income (Z^{hh}), property income ($divh + r^{hh}_{received} - r^{hh}_{paid} + bf$) and social benefits in cash ($trans$), less taxes (tax^{hh}) and social contributions ($scr + scn$).

$$\begin{aligned}YDIS &= W + Z^{hh} + divh + r^{hh}_{received} - r^{hh}_{paid} + bf + transh - tax^{hh} \\ &\quad - scr - scn\end{aligned} \tag{34}$$

Social benefits in cash ($trans$) distinguishes between benefits from disability insurance ($transh_{wao}$), old age pensions ($transh_{aow}$), benefits from surviving relatives act ($transh_{anw}$), general family allowances ($transh_{akw}$), unemployment insurance ($transh_{ww}$), social assistance benefits ($transh_{bw}$), health care allowances ($transh_{zt}$), benefits from youth disability insurance ($transh_{wj}$), pension benefits ($transh_{pen}$), imputed employers' social contributions (scr_{imp}), and other social benefits ($transh_{oth}$).

$$\begin{aligned}transh &= transh_{wao} + transh_{aow} + transh_{anw} + transh_{akw} + transh_{ww} \\ &+ transh_{bw} + transh_{zt} + transh_{wj} + transh_{pen} + scr_{imp} + transh_{oth}\end{aligned} \tag{35}$$

Transfers, taxes and social contribution are discussed in 'Government and social security'.

Mixed income of households (Zhh) consists of imputed wages of self-employed (W^s), calculated as self-employment (es) times compensation per employee ($W/(e-$

es)), and a residual part, which is related to nominal GDP ($Y = py * y$) and the output gap.

$$W^s = es \frac{W}{e - es} \tag{36}$$

$$Z^{hh} = W^s + Y * \left(\underset{(6.6)}{-0.03} + \underset{(7.5)}{0.23} * \frac{1}{2} \sum_{i=0}^{1} ygap_{-i} + \underset{(8.9)}{0.50} * \frac{Z^{hh}_{-1}}{Y_{-1}} \right) \tag{37}$$

$\bar{R}^2 = 0.84$; $S.E. = 0.003$; $p(LM_4) = 0.00$; $p(JB) = 0.32$

Estimation period: 1984Q2 - 2008Q4

Households pay interest (r^{hh}_{paid}) on their mortgage debt ($loanshmor$) and other debt ($loansho$), notably consumer credit. The relevant interest rate is a weighted average of the short term interest rate (rs) and the mortgage interest rate (rm).

$$r^{hh}_{paid} = \underset{(4.8)}{-0.003} + 0.95 * \frac{1}{32} \sum_{i=0}^{31} \frac{rm_{-i}}{400} + \frac{0.05}{4} \sum_{i=0}^{3} \frac{rs_{-i}}{400} * \frac{loanshmor + loansho + loanshmor_{-1} + loansho_{-1}}{2} \tag{38}$$

$\bar{R}^2 = 0.83$; $S.E. = 708.3.9$; $p(LM_4) = 0.00$; $p(JB) = 0.02$

Estimation period: 1984Q4 - 2008Q4

Households receive interest ($r^{hh}_{received}$) on their financial assets excluding equities (b^{hh}). The relevant interest rate is a weighted average of the long term interest rate and the short term interest rate, but it also depends on the cyclical stance of the economy (gauged by the annual growth rate of GDP, $\dot{y}$) and the supply of these financial assets (measured by the assets as a percentage of nominal GDP ($Y = py * y$)).

$$r^{hh}_{received} = \underset{(10.3)}{-1176.65} + \left(\underset{(11.4)}{0.71} * \frac{1}{12} \sum_{i=0}^{11} \frac{rl_{-i}}{400} + (1 - \underset{(11.4)}{0.71}) * \frac{1}{4} \sum_{i=0}^{3} \frac{rs_{-i}}{400} + \underset{(2.7)}{0.01} + \underset{(7.9)}{0.001} * \frac{1}{4} \sum_{i=0}^{3} \dot{y}_{-i} - \underset{(2.6)}{0.005} * \frac{1}{4} \sum_{i=4}^{7} \left(\frac{b^{hh}_{-i}}{Y_{-i}} \right) \right) * \frac{b^{hh} + b^{hh}_{-1}}{2} \tag{39}$$

$\bar{R}^2 = 0.92$; $S.E. = 217.9$; $p(LM_4) = 0.00$; $p(JB) = 0.27$

Estimation period: 1979Q4 - 2008Q4

Dividends received by households ($divh$) is defined by an annualized dividend return applied to households' stock of equities.

$$divh = divhr * v^{hh}/4 \tag{40}$$

Net household wealth ($wealth$) balances equities (v^{hh}), other financial assets (b^{hh}), housing wealth ($hwealth$), mortgage debt ($loanshmor$) and other debt ($loansho$).

$$wealth = v^{hh} + b^{hh} + hwealth - loanshmor - loansho \tag{41}$$

Households allocated their financial wealth between equities (v^{hh}) and other asset (b^{hh}). Changes in the **nominal share allocated to equities** (sv^{hh}) depends on changes in the stock price (ps) and on the equity premium, measured by the gap between stock price inflation ($\dot{ps}$) and the long term interest rate.

$$\ln sv^{hh} = \ln sv^{hh}_{-1} + \underset{(14.4)}{0.29} * \Delta \ln ps + \underset{(2.3)}{0.0002} * \Delta_7(\dot{ps} - rl) \tag{42}$$

$\bar{R}^2 = 0.99$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.36$
Estimation period: 1979Q4 - 2008Q4

The **amount available to households for investment in either equities** (v^{hh}) or **other financial assets** (b^{hh}) is equal to the amount invested in the previous period corrected for capital gains ($v^{hh}_{-1} * ps/ps_{-1} + b^{hh}_{-1}$) plus savings ($YDIS - pc * c$) plus the change in debt not spent on housing investment ($\Delta loanshmor + loansho - pih * ih * \chi^{ih} * (1 - \delta^h)$)

$$\begin{aligned} v^{hh} = {} & sv^{hh} \left(v^{hh}_{-1} * ps/ps_{-1} + b^{hh}_{-1} + YDIS - pc * c \right. \\ & \left. + \Delta loanshmor + \Delta loansho - pih * ih * \chi^{ih} * (1 - \delta^h) \right) \end{aligned} \tag{43}$$

$$\begin{aligned} b^{hh} = {} & (1 - sv^{hh}) \left(v^{hh}_{-1} * ps/ps_{-1} + b^{hh}_{-1} + YDIS - pc * c \right. \\ & \left. + \Delta loanshmor + \Delta loansho - pih * ih * \chi^{ih} * (1 - \delta^h) \right) \end{aligned} \tag{44}$$

Households' housing wealth ($hwealth$) is equal to housing wealth in the previous period corrected for capital gains plus the share of net housing investment

$(pih * ih * (1 - \delta^h))$ carried out by households (χ^{ih}).

$$hwealth = hwealth_{-1} * \frac{ph}{ph_{-1}} + \chi^{ih} * pih * ih * (1 - \delta^h) \quad (45)$$

In the long term, **households mortgage debt** ($loanshmor$) is consistent with households allocating a fixed share of disposable income before taxes and interest payments ($YDIS + r^{hh}_{paid} + taxh$) to mortgage interest payments. The substantially autonomous increase in this share of disposable income over the past decades is captured by an upward sloping logistic trend, which has its inflection point around 1998.

$$\begin{aligned} \ln \frac{loanshmor}{4} = & \underset{(241.6)}{-1.69} * (1 - \text{logit}(tr; 1998)) - \underset{(49.8)}{0.34} * \text{logit}(tr; 1998) \quad (46) \\ & - \underset{(14.2)}{0.24} * \left(\ln rm - \ln(1 - \tau^{top})\right) + \ln(YDIS + r^{hh}_{paid} + taxh) \end{aligned}$$

$S.E. = 0.03$; $p(LM_4) = 0.00$; $p(JB) = 0.01$

Estimation period: 1980Q1 - 2008Q4

In the short term, household mortgage debt is affected by the unemployment rate (u), housing investment (ih) and an error-correction term.

$$\begin{aligned} \Delta \ln loanshmor = & \underset{(2.2)}{-0.08} - \underset{(4.4)}{0.11} * ECM_{-1} - \underset{(2.1)}{0.03} * \Delta \ln u \quad (47) \\ & + \underset{(2.4)}{0.01} * \ln ih_{-1} + \underset{(5.1)}{0.50} * \Delta \ln loanshmor_{-1} \end{aligned}$$

$\bar{R}^2 = 0.49$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1983Q2 - 2008Q4

Other debt ($loansho$), including consumer loans, is in the long term negatively related to interest rates and the unemployment rate and positively related to households' net disposable income.

$$\begin{aligned} \ln loansho = & \underset{(3.9)}{-5.05} - \underset{(1.8)}{0.56} * \ln \frac{1}{32} \sum_{i=0}^{31} \frac{0.75 * rl_{-i} + 0.25 * rs_{-i}}{100} \quad (48) \\ & + \underset{(6.5)}{1.23} * \ln \frac{1}{16} \sum_{i=0}^{15} YDIS_{-i} - \underset{(2.8)}{0.10} * \frac{1}{16} \sum_{i=0}^{15} u_{-i} \end{aligned}$$

$S.E. = 0.13$; $p(ADF) = 0.09$;
Estimation period: 1976 - 2008

In the short term, the change in other debt is affected by an error-correction term, the change in the unemployment rate and the change in domestic stock prices (ps^{nl}). The latter variable can be motivated by the fact that part of the other debt are loans contracted by self-employed, and the willingness of banks to grant loans to businesses being related to the valuation of firms in general.

$$\begin{aligned} \Delta \ln loansho &= \underset{(2.2)}{-0.08} * ECM_{-1} + \underset{(5.4)}{0.43} * \Delta \ln loansho_{-1} \\ &\quad + \underset{(1.3)}{0.002} * \Delta ps^{nl} - \underset{(3.45)}{0.05} * \Delta u_{-1} \end{aligned} \tag{49}$$

$\bar{R}^2 = 0.32$; $S.E. = 0.03$; $p(LM_4) = 0.00$; $p(JB) = 0.16$
Estimation period: 1985Q1 - 2008Q4

In the long term, households aim for fixed ratio of **housing investment** (ih) to private consumption, taking into account the ratio between the deflator of private consumption (pc) and user cost of housing (pkh). Housing investment is increasing in the number of building permits issued ($permits$)

$$\begin{aligned} \ln ih &= \ln c - \underset{(11.2)}{4.90} + \underset{(2.6)}{0.06} * (\ln pc - \ln pkh) \\ &\quad + \underset{(6.4)}{0.28} * \frac{1}{4} \sum_{i=1}^{4} \ln permits_{-i} \end{aligned} \tag{50}$$

$S.E. = 0.04$; $p(ADF) = 0.00$;
Estimation period: 1983Q1 - 2008Q4

In the short term, the change in housing investment is impacted by an error-correction term, the change in the number of productive hours worked per employee in the construction sector (hc) and the change in housing wealth ($hwealth$). The latter variable can be motivated by the fact that part of (surplus) housing

wealth is used for home improvement.

$$\Delta \ln ih = \underset{(0.1)}{0.001} - \underset{(4.7)}{0.31} ECM_{-1} + \underset{(2.8)}{0.16} * \Delta \ln hc + \underset{(1.3)}{0.33} * \frac{1}{4} \sum_{i=0}^{3} \Delta \ln hwealth_{-i} \quad (51)$$

$\bar{R}^2 = 0.86$; $S.E. = 0.03$; $p(LM_4) = 0.51$; $p(JB) = 0.98$

Estimation period: 1983Q2 - 2008Q4

The **user cost of housing capital** (pkh) is a conventional function of the long term interest rate ($rl - 1.2$), depreciation ($\delta^h = 0.02$) and capital gains from (backward looking) expectations of price changes. The long term interest rate is taken in deviation from the (fictional) tax on savings.

$$pkh = pih * \left((rl - 1.2)/400 + \delta^h - \frac{1}{4} \sum_{i=0}^{3} \Delta \ln pih_{-i} \right) \quad (52)$$

The **stock of dwellings** (kh) cumulates according to a perpetual inventory condition, with depreciation rate δ^h.

$$kh = (1 - \delta^h) kh_{-1} + ih \quad (53)$$

Labour supply (ls) is calculated as **working age population** (n_{1575}) times the **labour paticipation rate** ($part$).

$$ls = n_{1575} * part \quad (54)$$

In the 90s, the labour particpation rate increased substantially due to the inflow of women in the labour market. This is captured by a linear spline, with nodes at 1986Q2 and 2001Q1. Furthermore, an increase in the equilibrium rate of unemployment (u^{eq}) lowers the long term labour participation rate (long term discouraged worker effect).

$$part = \underset{(208.0)}{60.07} + \text{spline}(1986Q2; 2001Q1) - \underset{(3.4)}{0.16} * u^{eq} \quad (55)$$

$\bar{R}^2 = 0.995$; $S.E. = 0.34$; $p(ADF) = 0.00$;

Estimation period: 1979Q4 - 2008Q4

In the short term, changes in the labour participation rate are affected by an error-correction term, the change in the unemployment rate (short term discouraged worker effect) and the annual growth rate in the real gross wage rate in the private sector.

$$\begin{aligned}\Delta part &= \underset{(2.1)}{0.04} - \underset{(4.3)}{0.16} * ECM_{-1} + \underset{(1.9)}{0.24} * \Delta part_{-1} + \underset{(2.5)}{0.24} * \Delta part_{-3} \\ &\quad - \underset{(2.4)}{0.13} * \Delta(u_{-1}) + \underset{(2.1)}{1.59} * \Delta_4 \ln\left(\frac{w^{pr}_{gross,-1}}{pc_{-1}}\right) \end{aligned} \tag{56}$$

$\bar{R}^2 = 0.28$; $S.E. = 0.14$; $p(LM_4) = 0.00$; $p(JB) = 0.00$
Estimation period: 1980Q1 - 2008Q4

The **household savings ratio** ($savh$) is savings, including pension savings, divided by available household resources.

$$savh = \frac{YDIS - pc * c + savhp}{YDIS + savhp} \tag{57}$$

Pension savings ($savhp$) is given by contributions to pension schemes ($scr_{pen} + sce_{pen}$) less pension benefits ($transh_{pen}$), plus a residual to account for differences between National Accounts data and model variables.

$$savhp = scr_{pen} + sce_{pen} - transh_{pen} \tag{58}$$

A.3 Wages and labour market

Compensation per employee in the private sector (w^{pr}) is the outcome of a bargaining process in which trade unions and firms negotiate the wage. In the long, run the wage rate depends on the producer price (py^{pr}_{va}), productivity ($prod$), the unemployment rate (u), the replacement rate (rpr) and the wedge, which is a mix of the value added tax rate (τ^{vat}), the rate of employers' social contributions (τ_r), and the rate of employees' social contributions and income taxes (τ_n).

$$\begin{aligned}\ln w^{pr} &= \frac{1}{4}\sum_{i=0}^{3}(\ln py^{pr}_{va,-i} + \ln prod_{-i}) + \underset{(2.1)}{0.18} * \left(\frac{1}{4}\sum_{i=0}^{3}\ln(1+\tau^{vat}_{-i}) + \ln\tau_r \right. \\ &\quad \left. + \frac{1}{4}\sum_{i=1}^{4}\ln\tau_{n,-i}\right) + \underset{(6.8)}{0.31} * \frac{1}{4}\sum_{i=1}^{4}\ln rpr_{-i} - \underset{(3.0)}{0.01} * \frac{1}{4}\sum_{i=3}^{6}u_{-i}\end{aligned}$$

$S.E. = 0.02$; $p(ADF) = 0.01$;
Estimation period: 1971 - 2008

In the short run, we distinguish between **contractual wages** (w^{pr}_{cnt}) and the **wage drift** (w^{pr}_{drift}). Contractual wage growth responds to the gap between the actual compensation per employee and its long term level (ECM). The equation for the wage drift does not feature such error-correction mechanism. Since employees care about consumer prices, in the short term contractual wage growth is also affected by the private consumption deflator (pc).

$$\begin{aligned}\Delta \ln w^{pr}_{cnt} \quad = \quad & \underset{(7.9)}{+0.49} * \Delta \ln w^{pr}_{cnt,-2} - \underset{(2.7)}{0.07} * (ECM_{-4} - \underset{(502.7)}{1.87}) \\ & + (1 - \underset{(7.9)}{0.49} - \underset{(1.8)}{0.20}) * \frac{1}{4}\sum_{i=1}^{4} \Delta \ln py^{pr}_{va,-i} \\ & + \underset{(4.4)}{0.23} * \frac{1}{4}\sum_{i=1}^{4} \Delta \ln rpr_{-i} - \underset{(4.1)}{0.01} * \frac{1}{4}\sum_{i=1}^{4} \Delta u_{-i} \\ & - \underset{(2.3)}{0.26} * \left(\frac{1}{4}\sum_{i=0}^{3} \Delta \ln \tau_{r,-i} - \underset{(7.9)}{0.49} * \frac{1}{4}\sum_{i=2}^{5} \Delta \ln \tau_{r,-i} \right) \\ & + \underset{(3.4)}{0.14} * \frac{1}{2}\sum_{i=2}^{3} \Delta \ln prod_{-i} + \underset{(1.8)}{0.20} * \frac{1}{4}\sum_{i=1}^{4} \Delta \ln pc_{-i}\end{aligned} \tag{59}$$

$\bar{R}^2 = 0.67$; $S.E. = 0.003$; $p(LM_4) = 0.52$; $p(JB) = 0.08$
Estimation period: 1980Q1 - 2008Q4

The wage drift is measured as the contribution to compensation per employee. This contribution increases as productivity accelerates. When employees are on sick leave the wage drift is negatively affected.

$$\begin{aligned}w^{pr}_{drift} \quad = \quad & \underset{(2.9)}{0.20} * \frac{1}{4}\sum_{i=0}^{3} (\Delta \ln prod_{-i} - \Delta \ln prod_{-i-1}) - \underset{(4.0)}{0.006} * \frac{1}{4}\sum_{i=0}^{3} \Delta u_{-i} \\ & - \underset{(1.9)}{0.59} * \frac{1}{4}\sum_{i=0}^{3} \frac{n_{zw,-i}}{e_{-i}}\end{aligned} \tag{60}$$

$\bar{R}^2 = 0.08$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.00$
Estimation period: 1979Q2 - 2008Q4

The **gross wage in the private sector** (w^{pr}_{gross}) is the sum of contractual wage growth and the wage drift.

$$w^{pr}_{gross}/w^{pr}_{gross,-1} = w^{pr}_{cnt}/w^{pr}_{cnt,-1} + w^{pr}_{drift} \quad (61)$$

Compensation of employees in the private sector (W^{pr}) is defined as the gross wage multiplied by the number of employees in the private sector (emp) increased by the share of the private sector ($1-\chi^o$) in total employers' social contributions. Employers' social contributions consists of social security contributions (scr_{sec}), contributions to pension schemes (scr_{pp}), other social insurance contributions (scr_{oth}) and imputed social contributions (scr_{imp}).

$$W^{pr} = w^{pr}_{gross} * emp + (1-\chi^o) * (scr_{sec} + scr_{pp} + scr_{oth} + scr_{imp}) \quad (62)$$

Compensation per employee in the private sector is then calculated as compensation of employees divided by the number of employees.

$$w^{pr} = W^{pr}/emp \quad (63)$$

We assume that both **contractual wage growth in the government sector** (w^{gov}_{cnt}) and the **wage drift in the government sector** (w^{gov}_{drift}) moves in line with the private sector.

$$w^{gov}_{cnt}/w^{gov}_{cnt,-1} = w^{pr}_{cnt}/w^{pr}_{cnt,-1} \quad (64)$$

$$w^{gov}_{drift} = w^{pr}_{drift} \quad (65)$$

The **gross wage in the government sector** (w^{gov}_{gross}) is the sum of contractual wage growth and the wage drift.

$$w^{gov}_{gross}/w^{gov}_{gross,-1} = w^{gov}_{cnt}/w^{gov}_{cnt,-1} + w^{gov}_{drift} \quad (66)$$

Compensation of employees in the government sector (W^{gov}) is defined as the gross wage multiplied by the number of employees in the government sector (eg) increased by the share of the government sector (χ^o) in total employers' social contributions.

$$W^{gov} = w^{gov}_{gross} * eg + \chi^o * (scr_{sec} + scr_{pp} + scr_{oth} + scr_{imp}) \quad (67)$$

Compensation per employee in the government sector (w^{gov}) is then calculated as compensation of employees divided by the number of employees.

$$w^{gov} = W^{gov}/eg \tag{68}$$

Compensation of employees in the total economy (W) is the sum of compensation of employees in the private sector and in the government sector.

$$W = W^{pr} + W^{gov} \tag{69}$$

The **gross wage in the total economy** (w_{gross}) is a weighted average of the gross wage in the private sector and of the gross wage in the government sector.

$$w_{gross} = (ep * w^{pr}_{gross} + eg * w^{gov}_{gross})/(ep + eg) \tag{70}$$

Employment (e) is the sum of employment in the private sector (equation (15)) and employment in the government sector (equation (171)).

$$e = ep + eg \tag{71}$$

We assume that **self-employment** (es) is an exogenous fraction of private sector employment.

$$es = ep * \chi^{es} \tag{72}$$

The number of **employees in the total economy** (em) is defined by substracting self-employment from total employment

$$em = e - es \tag{73}$$

The number of **employees in the private sector in persons** (emp_n) is related to the number of employees in the private sector in fte by the factor ψ^{pr}. The number of **employees in the government sector in persons** (eg_n) is related to the number of employees in the government sector in fte by the factor ψ^{gov}. The number of **self-employed in persons** (es_n) is related to the number of self-employed in fte by the factor ψ^{s}.

$$emp_n = emp * \psi^{pr} \tag{74}$$

$$eg_n = eg * \psi^{gov} \tag{75}$$

$$es_n = es * \psi^{s} \tag{76}$$

The number of **employees in the total economy (persons)** (em_n) is the sum of employees in the private sector (persons) and the government sector (persons).

$$em_n = emp_n + eg_n \tag{77}$$

The number of **employed persons in the total economy** (e_n) is sum of the number of employees and the number of self-employed (persons).

$$e_n = em_n + es_n \tag{78}$$

The **unemployment rate** (u) measures the proportion of the labour supply not employed in private sector or in the government sector or self-employed. **Unemployment** (n_u) is defined by substracting total employment (persons) from the labour supply.

$$u = 100 * (ls - e_n) \; / \; ls \tag{79}$$

$$n_u = ls - e_n \tag{80}$$

A.4 Prices

In the long run, prices charged by firms depend both on the cost price (including energy, *cye*, see equation (7)) and on (foreign) competitors' prices. The cost price *cye* is derived assuming the private sector produces a single good, or bundle of goods and services. However, in the model we distinguish a variety of deflators. We therefore (implicitly) presume the presence of multiple (private) sectors, which differ in terms of their respective levels of productivity. Consequently, the cost price enters the long run price equations with a multiplicative correction for differences in productivity (*prode*), defined as:

$$prode = (y_{va}^{pr} + ce)/ep \tag{81}$$

In the same way that the cost price is defined including the price of energy, productivity is measure including the consumption of energy (ce).

In the long term, **HICP excluding energy** ($hicp\_e$) is a weighted average of the (productivity adjusted) cost price and the deflator of imported consumer goods

(pm^c). Also indirect taxes affect the HICP excluding energy, where $\frac{taxind-subs}{pc*c+pih*ih-(taxind-subs)}$ is the implied indirect tax rate on consumption and housing investment.

$$\ln hicp_{-e} = \underset{(2.1)}{-0.53} + \underset{(8.9)}{0.59} * \left(\ln cye + \underset{(1.1)}{0.22} * \frac{1}{12} \sum_{i=0}^{11} \ln prode_{-i} \right) \quad (82)$$
$$+ \underset{(8.9)}{(1-0.59)} \ln pm^c + \ln \left(1 + \frac{taxind - subs}{pc * c + pih * ih - (taxind - subs)} \right)$$

$S.E. = 0.02$; $p(ADF) = 0.12$;

Estimation period: 1980Q4 - 2008Q4

In the short term, $hicp_{-e}$ is determined by unit labour costs in the private sector ($\frac{w^{pr}}{prod}$), the output gap, the value added tax rate (τ^{vat}), rents ($hicp_{rents}$) and an error-correction term. Seasonal dummies are added to the equation because the HICP and its component series are not seasonally adjusted.

$$\begin{aligned} \Delta \ln hicp_{-e} = {} & (1 - \underset{(4.9)}{0.38} - 0.0825 * (1 - \underset{(4.9)}{0.39})) * \frac{1}{8} \sum_{i=6}^{13} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} \quad (83) \\ & + \underset{(4.9)}{0.39} * \Delta \ln hicp_{-e,-1} + \underset{(2.3)}{0.08} * \frac{1}{2} \sum_{i=0}^{1} ygap_{-i} \\ & + \underset{(5.1)}{0.60} * \Delta \ln(1 + \tau^{vat}) - \underset{(4.6)}{0.01} * (s1 - 0.25) \\ & + \underset{(3.8)}{0.002} * (s2 - 0.25) - \underset{(9.4)}{0.01} * (s3 - 0.25) \\ & + 0.0825 * \left(1 - \underset{(4.9)}{0.38} \right) * \Delta \ln hicp_{rents} - \underset{(5.4)}{0.08} * ECM_{-1} \end{aligned}$$

$\bar{R}^2 = 0.67$; $S.E. = 0.003$; $p(LM_4) = 0.01$; $p(JB) = 0.04$

Estimation period: 1988Q2 - 2008Q4

HICP energy ($hicp_e$) includes both fuels, gas and electricity. We assume prices of fuels are immediately affected by the oil price (in euro, per liter, $p_{oil}/(159*exr)$) and the tax rate on petrol (τ^{oil}). The latter variable enters the equation in an additive way. In contrast, we assume prices of gas and electricity to change only twice a year. The dummy variable $dum_{Q1,Q3}$ takes on the value one in the first and the third quarter, and zero otherwise. When gas and electricity prices change, they react to changes in oil prices with a lag.

$$\begin{aligned}\ln hicp_e &= 0.47 * \left(\Delta \ln(\frac{p_{oil}}{159 * exr} + \tau^{oil})\right) \\ &+ (1 - 0.47) * \underset{(5.7)}{0.17} * dum_{Q1,Q3} * \ln \Delta_4 \left(\frac{p_{oil}}{exr} + \frac{p_{oil,-1}}{exr_{-1}}\right) \\ &+ \underset{(3.1)}{0.02} * (s1 - 0.25) + \underset{(5.1)}{0.02} * (s2 - 0.25) + \underset{(2.5)}{0.01} * (s3 - 0.25)\end{aligned} \tag{84}$$

$\bar{R}^2 = 0.59$; $S.E. = 0.02$; $p(LM_4) = 0.48$; $p(JB) = 0.00$

Estimation period: 1988Q1 - 2008Q4

HICP is defined by the identity:

$$hicp = \chi^{hicpe} * hicp_e + (1 - \chi^{hicpe}) * hicp_{-e} \tag{85}$$

The **private consumption deflator** (pc) moves broadly in line with the HICP. Rents ($hicp_{rents}$) are added to the equation since rents receive a higher weight in the private consumption deflator compared to the HICP. The import deflator (pm^{dom}) is an approximation for residents' consumption abroad. Since the private consumption deflator is seasonally adjusted whereas the HICP is not, seasonal dummies are added to the equation.

$$\begin{aligned}\ln \frac{pc}{pc_{-1}} &= \underset{(1.6)}{0.002} * s1 - \underset{(3.1)}{0.002} * s2 + \underset{(0.0)}{0.000} * s3 + \underset{(0.7)}{0.001} * s4 \\ &+ 0.84 * \ln \frac{hicp}{hicp_{-1}} + 0.10 * \ln \frac{hicp_{rents}}{hicp_{rents,-1}} + 0.06 * \ln \frac{pm^{dom}}{pm^{dom}_{-1}}\end{aligned} \tag{86}$$

$\bar{R}^2 = 0.52$; $S.E. = 0.004$; $p(LM_4) = 0.00$; $p(JB) = 0.02$

Estimation period: 1978Q2 - 2008Q4

In the long term, the **government consumption deflator** (pcg) is affected by the (productivity adjusted) cost price, the deflator of imported consumer goods and compensation per employee in the government sector. The latter variable reflects the substantial weight of wages in government consumption.

$$\begin{aligned}\ln pcg &= -\underset{(59.6)}{3.40} + \underset{(9.5)}{0.23} * \left(\ln cye + \underset{(7.5)}{0.94} * \frac{1}{12} \sum_{i=0}^{11} \ln prode_{-i}\right) \\ &\left(1 - \underset{(9.5)}{0.23} - \underset{(27.4)}{0.62}\right) * \ln pm_c + \underset{(27.4)}{0.62} * \ln w^{gov}\end{aligned} \tag{87}$$

$S.E. = 0.01$; $p(ADF) = 0.03$;
Estimation period: 1980Q4 - 2008Q4

In the short term, the government consumption deflator is mostly affected by changes in compensation per employee. In addition, import prices (pm^{dom}) play a minor role.

$$\begin{aligned}\Delta \ln pcg \quad = \quad & + \underset{(9.0)}{1.03} * \frac{1}{4}\sum_{i=0}^{3} \Delta \ln w_{-i}^{gov} + \underset{(2.6)}{0.15} * \frac{1}{4}\sum_{i=4}^{7} \Delta \ln pm_{-i}^{dom} \\ & + \left(1 - \underset{(9.0)}{1.03} - \underset{(2.6)}{0.15}\right) * \Delta \ln pcg_{-1} - \underset{(1.9)}{0.11} * ECM_{-1}\end{aligned} \tag{88}$$

$\bar{R}^2 = 0.22$; $S.E. = 0.006$; $p(LM_4) = 0.01$; $p(JB) = 0.22$
Estimation period: 1981Q4 - 2008Q4

In the long term, the **housing investment deflator** (pih) is a weighted average of the (productivity adjusted) cost price, the house price (ph) and the deflator of imported investment goods (pm^i). In addition, the housing investment deflator is affected by indirect taxes (τ_h^{vat}). The house price enters the equation because some households may weigh buying a newly build house against buying an existing dwelling. The deflator of imported investment goods proxies for import of part of the building materials.

$$\begin{aligned}\ln pih \quad = \quad & - \underset{(8.2)}{1.07} + \underset{(14.7)}{0.24} \ln ph + \left(1 - \underset{(20.8)}{0.69} - \underset{(14.7)}{0.24}\right) * \ln pm^i \\ & + \underset{(20.8)}{0.69} * \left(\ln cye + \underset{(5.8)}{0.46} * \frac{1}{12}\sum_{i=0}^{11} \ln prode_{-i}\right) + \ln\left(1 + \tau_h^{vat}\right)\end{aligned} \tag{89}$$

$S.E. = 0.02$; $p(ADF) = 0.00$;
Estimation period: 1980Q4 - 2008Q4

In the short term, the housing investment deflator is affected by unit labour costs in the private sector, lagged changes in the house price, the output gap and

changes in taxation.

$$\begin{aligned}\Delta \ln pih \;=\; & \underset{(9.1)}{1.14} \;*\; \frac{1}{8}\sum_{i=6}^{13} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} \;+\; \underset{(3.0)}{0.22} \;*\; \Delta \ln ph_{-1} \\ & \left(1 - \underset{(9.1)}{1.14} - \underset{(3.0)}{0.22}\right) \;*\; \Delta \ln pih_{-1} \;+\; \underset{(1.8)}{0.20} \;*\; \frac{1}{2}\sum_{i=0}^{1} ygap_{-i} \\ & + \underset{(0.6)}{0.24} \;*\; \Delta \ln\left(1+\tau^{vat}_{h}\right) \;-\; \underset{(3.0)}{0.21} \;*\; ECM_{-1}\end{aligned} \tag{90}$$

$\bar{R}^2 = 0.51$; $S.E. = 0.01$; $p(LM_4) = 0.02$; $p(JB) = 0.02$

Estimation period: 1984Q2 - 2008Q4

In the long term, the **deflator of other private investment** (pio) is a weighted average of the (productivity adjusted) cost price and the deflator of imported investment goods.

$$\begin{aligned}\ln pio \;=\; & \underset{(1.7)}{-0.28} \;+\left(1 - \underset{(26.1)}{0.59}\right) \;*\ln pm^{i} \\ & +\underset{(26.1)}{0.59} \;*\; \left(\ln cye + \underset{(1.7)}{0.19} \;*\; \frac{1}{12}\sum_{i=0}^{11} \ln prode_{-i}\right)\end{aligned} \tag{91}$$

$S.E. = 0.03$; $p(ADF) = 0.01$;

Estimation period: 1980Q4 - 2008Q4

In the short term, the deflator of other private investment is affected by unit labour costs in the private sector, changes in the deflator of imported investment goods and the output gap.

$$\begin{aligned}\Delta \ln pio \;=\; & \left(1 - \underset{(11.9)}{0.89} - \underset{(7.7)}{0.44}\right) \;*\; \Delta \ln pio_{-1} \;+\; \underset{(11.9)}{0.89} \;*\; \frac{1}{8}\sum_{i=6}^{13} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} \\ & + \underset{(7.7)}{0.44} \;*\; \frac{1}{4}\sum_{i=0}^{3} \Delta \ln pm^{i}_{-i} \;+\; \underset{(3.7)}{0.21} \;*\; \frac{1}{2}\sum_{i=0}^{1} ygap_{-i} \\ & - \underset{(4.2)}{0.32} \;*\; ECM_{-1}\end{aligned} \tag{92}$$

$\bar{R}^2 = 0.38$; $S.E. = 0.01$; $p(LM_4) = 0.01$; $p(JB) = 0.00$

Estimation period: 1988Q1 - 2008Q4

In the long term, the **government investment deflator** (pig) is a weighted average of the (productivity adjusted) cost price and the deflator of imported investment goods.

$$\begin{aligned}\ln pig \quad = \quad & -\underset{(13.2)}{1.74} + \left(1 - \underset{(33.8)}{0.62}\right) * \ln pm^{i} \\ & + \underset{(33.8)}{0.62} * \left(\ln cye + \underset{(9.7)}{1.09} * \frac{1}{12}\sum_{i=0}^{11} \ln prode_{-i}\right)\end{aligned} \tag{93}$$

$S.E. = 0.02$; $p(ADF) = 0.00$;
Estimation period: 1980Q4 - 2008Q4

In the short term, the government investment deflator is affected by the unit labour costs in the private sector, the output gap and changes in the deflator of imported investment goods.

$$\begin{aligned}\Delta \ln pig \quad = \quad & \left(1 - \underset{(13.9)}{1.15} - \underset{(2.2)}{0.13}\right) * \Delta \ln pig_{-1} + \underset{(2.8)}{0.15} * \frac{1}{2}\sum_{i=0}^{1} \ln ygap_{-i} \\ & + \underset{(13.9)}{1.15} * \frac{1}{10}\sum_{i=6}^{15} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} + \underset{(2.2)}{0.13} * \frac{1}{2}\sum_{i=0}^{1} \Delta \ln pm^{i}_{-i} \\ & - \underset{(2.9)}{0.16} * ECM_{-1}\end{aligned} \tag{94}$$

$\bar{R}^2 = 0.65$; $S.E. = 0.01$; $p(LM_4) = 0.01$; $p(JB) = 0.76$
Estimation period: 1984Q4 - 2008Q4

In the long term, the **deflator of re-exports of goods and services** (px^{re}) is a weighted average of the (productivity adjusted) cost price, the deflator of imports for the purpose of re-exports (pm^{re}) and the ratio of foreign demand (x^{wo}) over GDP in OECD countries (y^{oecd}). The latter variable is added to proxy for downward trend in px^{re}, possibly related to globalisation. The large weight on pm^{re} reflects that re-exports leave the country without substantial manufacturing.

$$\begin{aligned}\ln px^{re} \quad = \quad & \underset{(285.5)}{0.15} + 0.05 * \left(\ln cye + 1.1 * \frac{1}{12}\sum_{i=0}^{11} \ln prode_{-i}\right) \\ & + (1 - 0.05) * \ln pm^{re} - \underset{(48.4)}{0.11} * \ln \frac{x^{wo}}{y^{oecd}}\end{aligned} \tag{95}$$

$S.E. = 0.00$; $p(ADF) = 0.00$;
Estimation period: 1980Q4 - 2008Q4

In the short term, the deflator of re-exports moves more or less in line with changes in the deflator of imports for the purpose of re-exports.

$$\begin{aligned}\Delta \ln px^{re} &= \underset{(72.7)}{(1 - 0.99)} * \Delta \left(\ln cye + 1.1 * \frac{1}{12} \sum_{i=0}^{11} \ln prode_{-i} \right) \\ &+ \underset{(72.7)}{0.99} * \Delta \ln pm^{re} - \underset{(1.5)}{0.11} * ECM_{-1}\end{aligned} \tag{96}$$

$\bar{R}^2 = 0.98$; $S.E. = 0.002$; $p(LM_4) = 0.00$; $p(JB) = 0.10$
Estimation period: 1987Q2 - 2008Q4

In the long term, the **deflator domestically produced exports of goods and services, excluding energy** ($px^{dom,-e}$) is a weighted average of the (productivity adjusted) cost price and competitors' export prices (px^{wo}).

$$\begin{aligned}\ln px^{dom,-e} &= \underset{(7.7)}{0.87} + \underset{(9.4)}{0.51} * \left(\ln cye - \underset{(11.9)}{0.61} * \frac{1}{12} \sum_{i=0}^{11} \ln prode_{-i} \right) \\ &+ \left(1 - \underset{(9.4)}{0.51} \right) * \ln px^{wo}\end{aligned} \tag{97}$$

$S.E. = 0.03$; $p(ADF) = 0.57$;
Estimation period: 1980Q4 - 2008Q4

In the short term, $px^{dom,-e}$ is affected by the unit labour costs in the private sector, the change in competitors' export prices and the euro-dollar exchange rate. The latter variable reflects the assumption that part of the exporting firms may set their prices in foreign currency.

$$\begin{aligned}\Delta \ln px^{dom,-e} &= \underset{(3.2)}{0.39} * \frac{1}{8} \sum_{i=4}^{11} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} + \underset{(2.7)}{0.25} * \Delta \ln px^{wo} \\ &\left(1 - \underset{(3.2)}{0.39} - \underset{(2.7)}{0.25} \right) * \Delta \ln px^{wo}_{-1} + \underset{(3.5)}{0.21} * \frac{1}{4} \sum_{i=0}^{3} \Delta \ln exr_{-i} \\ &- \underset{(3.0)}{0.14} * ECM_{-1}\end{aligned} \tag{98}$$

$\bar{R}^2 = 0.35$; $S.E. = 0.013$; $p(LM_4) = 0.02$; $p(JB) = 0.01$
Estimation period: 1987Q2 - 2008Q4

In the long term, we assume the **deflator exports of energy** (px^e) moves in line with the deflator of imports of energy (pm^e)

$$\ln px^e = \underset{(5.8)}{0.06} + \ln pm^e_{-1} \tag{99}$$

$S.E. = 0.08$; $p(ADF) = 0.00$;
Estimation period: 1977Q2 - 2008Q4

In the short term, the deflator of exports of energy is affected by changes in the deflator of imports of energy and the price of oil (in euro). The latter variable captures the different weight of fuels in exports of energy compared to imports of energy.

$$\begin{aligned} \Delta \ln px^e = & \underset{(3.7)}{0.26} * \Delta \ln \frac{p_{oil}}{exr} + \underset{(4.6)}{0.37} * \Delta \ln pm^e \\ & + (1 - \underset{(3.7)}{0.26} - \underset{(4.6)}{0.37}) * \Delta \ln pm^e_{-1} - \underset{(5.9)}{0.27} * ECM_{-1} \end{aligned} \tag{100}$$

$\bar{R}^2 = 0.91$; $S.E. = 0.03$; $p(LM_4) = 0.57$; $p(JB) = 0.28$
Estimation period: 1996Q1 - 2008Q4

In the long term, the **deflator imports of goods and services for the purpose of re-exports** (pm^{re}) is a weighted average of competitors' import prices (pm^{wo}), the deflator of imported investment goods, and the US export deflator of ICT products (in euro, px^{it}/exr). The latter variable is added to capture the relatively large share of ICT products in re-exports compared to world trade.

$$\begin{aligned} \ln pm^{re} = & \underset{(4.4)}{0.01} + \underset{(41.8)}{0.58} * \ln pm^{wo} + \underset{(18.2)}{0.32} * \ln pm^{i} \\ & + \left(1 - \underset{(41.8)}{0.58} - \underset{(18.2)}{0.32}\right) * \ln \frac{px^{it}}{exr} \end{aligned} \tag{101}$$

$S.E. = 0.02$; $p(ADF) = 0.00$;
Estimation period: 1980Q4 - 2008Q4

In the short term, pm^{re} is affected by lagged changes in pm^{re} and changes in competitors' import prices.

$$\Delta \ln pm^{re} = \underset{(9.6)}{0.61} * \Delta \ln pm^{re}_{-1} + \left(1 - \underset{(9.6)}{0.61}\right) * \Delta \ln pm^{wo} - \underset{(3.3)}{0.13} * ECM_{-1} \quad (102)$$

$\bar{R}^2 = 0.69$; $S.E. = 0.01$; $p(LM_4) = 0.07$; $p(JB) = 0.01$

Estimation period: 1981Q1 - 2008Q4

In the long term, the **deflator imports excluding imports for the purpose of re-exports, excluding energy** ($pm^{dom,-e}$) is a weighted average of the cost price and competitors' import prices. The ratio of foreign demand to GDP in OECD countries captures downward pressure that globalisation puts on import prices. The cost price reflects the assumption that importing firms take into account local production costs when setting their import prices (pricing-to-market).

$$\ln pm^{dom,-e} = \underset{(5.9)}{0.05} + \underset{(6.7)}{0.47} * \ln cye + \left(1 - \underset{(6.7)}{0.47}\right) * \ln pm^{wo} - \underset{(8.4)}{0.26} * \ln \frac{x^{wo}}{y^{oecd}} \quad (103)$$

$S.E. = 0.04$; $p(ADF) = 0.36$;

Estimation period: 1980Q4 - 2008Q4

In the short term, $pm^{dom,-e}$ is affected by unit labour costs in the private sector, changes in competitors' import prices and the euro-dollar exchange rate.

$$\Delta \ln pm^{dom,-e} = \left(1 - \underset{(5.6)}{0.60}\right) * \frac{1}{8} \sum_{i=6}^{13} \Delta \ln \frac{w^{pr}_{-i}}{prod_{-i}} + \underset{(5.6)}{0.60} * \Delta \ln pm^{wo} + \underset{(2.9)}{0.15} * \Delta \ln exr - \underset{(2.9)}{0.10} * ECM_{-1} \quad (104)$$

$\bar{R}^2 = 0.19$; $S.E. = 0.015$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1984Q4 - 2008Q4

In the long term, the ratio of the **deflator of imports of energy** (pm^e) to the oil price (in euro) displays a downward trend.

$$\ln pm^e = \ln \frac{p_{oil}}{exr} - \frac{1}{4}\underset{(6.5)}{0.02} * t \quad (105)$$

$S.E. = 0.08$; $p(ADF) = 0.00$;
Estimation period: 1976 - 2008

In the short term, there is partial pass-through of changes in the oil price into the deflator of imports of energy.

$$\Delta \ln pm^e = \underset{(21.7)}{0.75} * \Delta \ln \frac{p_{oil}}{exr} - \underset{(2.7)}{0.43} * (ECM_{-1} - \underset{(138.8)}{1.70}) \quad (106)$$

$\bar{R}^2 = 0.89$; $S.E. = 0.04$; $p(LM_4) = 0.24$; $p(JB) = 0.00$
Estimation period: 1996Q1 - 2008Q4

The **deflator of imports excluding imports for the purpose of re-exports** (pm^{dom}) is a weighted average of the deflators of its component series.

$$pm^{dom} = (m^{dom,-e} * pm^{dom,-e} + m^e * pm^e)/(m^{dom,-e} + m^e) \quad (107)$$

We assume the **deflator of use of energy** (pce) moves in line with the deflator of imports of energy.

$$\Delta \ln pce = \Delta \ln pm^e \quad (108)$$

In the long term, we assume that the **house price** (ph) is fully determined by the financing restrictions of households. As a results, the amount of mortgage credit determines the house price.

$$\ln ph = -3.05 + \underset{(21.3)}{0.65} * \ln loanshmor \quad (109)$$

Estimation period: 1978Q1 - 2008Q4

In the short term, the house price is affected by lagged changes in the house prices and in mortgage credit, and in the mortgage interest rate (to proxy for financing costs) and the unemployment rate (u, to proxy for future income flows).

$$\begin{aligned} \Delta \ln ph = {} & \underset{(0.5)}{0.003} + \underset{(0.2)}{0.02} * \Delta \ln ph_{-1} + \underset{(2.7)}{0.20} * \Delta \ln ph_{-2} \\ & + \underset{(4.8)}{0.34} * \Delta \ln ph_{-3} + \underset{(1.3)}{0.20} * \Delta \ln loanshmor_{-1} \\ & + \underset{(2.3)}{0.36} * \Delta \ln loanshmor_{-2} - \underset{(.1)}{0.02} * \Delta \ln loanshmor_{-3} \\ & - \underset{(2.8)}{0.01} * \Delta rm_{-1} - \underset{(1.6)}{0.001} * u_{-1} \end{aligned} \quad (110)$$

$\bar{R}^2 = 0.59$; $S.E. = 0.01$
Estimation period: 1978Q1 - 2008Q4

The **deflator value added of mining and quarrying** ($py_{va,min}$) is determined by the oil price (in euro), both in the short term and in the long term.

$$\begin{aligned}\Delta \ln py_{va,min} &= \underset{(5.4)}{0.56} + \underset{(2.2)}{0.05} * \Delta \ln \frac{p_{oil}}{exr} - \underset{(5.9)}{0.24} * (\ln py_{va,min,-1} \\ &\quad - \underset{(21.0)}{0.74} * \Delta \ln \frac{p_{oil,-1}}{exr_{,-1}}) + \underset{(3.3)}{0.26} * \Delta \ln py_{va,min,-1}\end{aligned} \tag{111}$$

$\bar{R}^2 = 0.65$; $S.E. = 0.04$; $p(LM_4) = 0.68$; $p(JB) = 0.00$
Estimation period: 1977Q2 - 2008Q4

The **deflator of private sector value added at basic prices** (py_{va}^{pr}) is defined as private sector value added at basic prices in current prices over the volume of private sector value added at basis prices.

$$py_{va}^{pr} = \frac{py * y - py_{va}^{gov} * y_{va}^{gov} - (taxprod - subsprod)}{y - y_{va}^{gov} - (taxprodr - subsprodr)} \tag{112}$$

The **deflator of gross domestic product** (py) is defined as gross domestic product in current prices over the volume of gross domestic product.

$$py = \frac{pc * c + pcg * cg + pit * it + px * x - pm * m + pds * ds}{c + cg + it + x - m + dels} \tag{113}$$

$$it = ig + ih + io \tag{114}$$

$$pit = \frac{pig * ig + pih * ih + pio * io}{ig + ih + io} \tag{115}$$

$$pds = \frac{psv * s - psv_{-1} * s_{-1}}{ds} \tag{116}$$

The **spread between the interest rate on mortgages and the long term interest rate** ($rm - rl$) has decreased over time, possibly reflecting increased competition in the market for mortgages. The spread is positively affected by the output gap, indicating that when the economy is booming banks are able to charge (relatively) high interest rates. On the other hand, when the economy is

in a cyclical lull, demand for new mortgages will be weak and banks are inclined to lower their interest rates.

$$rm - rl = \underset{(3.6)}{0.36} - \underset{(1.9)}{0.001} * t + \underset{(3.1)}{0.04} * ygap_{-1} + \underset{(7.9)}{0.56} * (rm_{-1} - rl_{-1}) + \underset{(1.9)}{0.14} * (rm_{-3} - rl_{-3}) \quad (117)$$

$\bar{R}^2 = 0.55$; $S.E. = 0.23$; $p(LM_4) = 0.65$; $p(JB) = 0.00$

Estimation period: 1980Q1 - 2008Q4

A.5 Rest of the world

Transactions of the Netherlands with the rest of world are summarized in the **current account** ($xmca$), which is the trade balance ($px * x - pm * m$) plus net factor income ($fir - fip$) and net transfer income received from abroad ($transfr - transfp$). Each of these components is discussed below.

$$xmca = px * x - pm * m + fir - fip + transfr - transfp \quad (118)$$

Exports (x) distinguishes between re-exports (x^{re}), energy (x^{e}), and domestically produced goods and services, excluding energy ($x^{dom,-e}$).

$$x = x^{re} + x^{e} + x^{dom,-e} \quad (119)$$

Similarly, **imports** (m) is broken down into imports for the purpose of re-exports (m^{re}), energy (m^{e}), and imports of goods and services for domestic use, excluding energy ($m^{dom,-e}$).

$$m = m^{re} + m^{e} + m^{dom,-e} \quad (120)$$

In the long term, exports are to a large extent driven by foreign demand (x^{wo}) and price competitiveness. Since a large share of **re-exports** (x^{re}) consists of ICT-related products, the world demand indicator in this case is a weighted average of foreign demand and the world volume of semiconductors sales. The latter is obtained by deflating the value of semiconductors sales ($semcon$) by the US export deflator of ICT products (px^{it}). The gap between the investment to GDP

ratio in the Netherlands and the investment to GDP in the euro area ($iodif$) reflects changes in non-price competitiveness, such as improved logistics. Finally, the deterministic trend captures the surge in re-exports relative to foreign demand over the past decades.

$$\begin{aligned}\ln x^{re} &= \underset{(114.1)}{3.56} + \underset{(44.3)}{0.93} * \ln x^{wo} + (1 - \underset{(44.3)}{0.93}) * \ln \frac{semcon}{px^{it}} \\ &\quad + \underset{(1.8)}{2.76} * \ln \frac{pm^{re}}{px^{re}} + \underset{(41.1)}{0.01} * t + \underset{(5.6)}{5.17} * \frac{1}{8}\sum_{i=1}^{8} iodif_{-i} \quad (121)\end{aligned}$$

$S.E. = 0.03$; $p(ADF) = 0.29$;
Estimation period: 1987 - 2008

In the short term, the elasticity of re-exports to changes in foreign demand slightly exceeds one. Re-exports fall when competitiveness of the Dutch re-exports sector, measured by the ratio of the deflator of 're-imports' (pm^{re}) to the deflator of re-exports (px^{re}), deteriorates.

$$\begin{aligned}\Delta \ln x^{re} &= \underset{(2.9)}{0.01} + \underset{(6.4)}{1.08} * \Delta \ln x^{wo} + \underset{(1.2)}{0.06} * \Delta \ln \frac{semcon}{px^{it}} \quad (122) \\ &\quad + \underset{(1.7)}{2.05} * \Delta \ln \frac{pm^{re}}{px^{re}} - \underset{(3.0)}{0.28} * ECM_{-1}\end{aligned}$$

$\bar{R}^2 = 0.59$; $S.E. = 0.02$; $p(LM_4) = 0.12$; $p(JB) = 0.88$
Estimation period: 1980Q1 - 2008Q4

Both in the long term and in the short term, **exports of energy** (x^e) are driven by demand and supply factors, gauged by GDP growth in OECD countries (y^{oecd}) and real value added in mining and quarrying ($y_{va,min}$), respectively. Changes in the (real) price of energy exports ($px^e/px^{dom,-e}$) measure changes in price competitiveness of Dutch energy exports in world energy markets.

$$\begin{aligned}\Delta \ln x^e &= \underset{(0.3)}{0.12} - \underset{(3.8)}{0.31} * \left(\ln x^e_{-1} - \underset{(14.7)}{1.16} * \ln y^{oecd}_{-1} - \underset{(2.8)}{0.36} * \ln y_{va,min,-1} \right) \\ &\quad \underset{(1.5)}{1.98} * \Delta \ln y^{oecd}_{-1} + \underset{(3.9)}{0.19} * \Delta \ln y_{va,min} \\ &\quad - \underset{(1.4)}{0.13} * \Delta \ln \frac{px^e}{px^{dom,-e}} \quad (123)\end{aligned}$$

$\bar{R}^2 = 0.23$; $S.E. = 0.04$; $p(LM_4) = 0.96$; $p(JB) = 0.32$
Estimation period: 1980Q2 - 2008Q4

Exports of domestically produced goods and services, excluding energy ($x^{dom,-e}$) are primarily driven by foreign demand, both in the short term and in the long term. In addition, a rise in price competitiveness ($px^{wo}/px^{dom,-e}$) supports exports; px^{wo} denotes competitors' export prices. Losses in market share ($x^{dom,-e}/x^{wo}$), beyond those that can be attributed to changes in price competitiveness, are assumed to be negatively related to the ratio of foreign demand over GDP in OECD countries. This ratio is increasing over time, and can be considered a measure of globalization.

$$\begin{aligned}\Delta \ln x^{dom,-e} \quad = \quad & \underset{(1.6)}{-0.07} * \left(\ln x_{-1}^{dom,-e} - \underset{(68.1)}{5.98} - \ln x_{-1}^{wo} - \underset{(2.4)}{1.58} * \ln \frac{px_{-1}^{wo}}{px_{-1}^{dom,-e}} \right. \\ & \left. + \underset{(2.8)}{0.85} * \ln \frac{x_{-1}^{wo}}{y_{-1}^{oecd}} \right) + \underset{(9.2)}{0.96} * (\Delta \ln x^{wo} + \underset{(2.0)}{0.40} * \Delta \ln x_{-1}^{wo}) \\ & + \underset{(2.7)}{0.44} * \Delta \ln \frac{px^{wo}}{px^{dom,-e}} - \underset{(2.0)}{0.40} * \Delta \ln x_{-1}^{dom,-e} \end{aligned} \tag{124}$$

$\bar{R}^2 = 0.59$; $S.E. = 0.02$; $p(LM_4) = 0.02$; $p(JB) = 0.38$
Estimation period: 1978Q3 - 2008Q4

We assume that changes in **imports of goods and services for the purpose of re-exports** (m^{re}) are closely related to fluctuations in re-exports.

$$\Delta \ln m^{re} \quad = \quad \underset{(7.4)}{0.75} * \Delta \ln m_{-1}^{re} + (\Delta \ln x^{re} - \underset{(7.4)}{0.75} * \Delta \ln x_{-1}^{re}) \tag{125}$$

$\bar{R}^2 = 0.999$; $S.E. = 0.00$; $p(LM_4) = 0.24$; $p(JB) = 0.58$
Estimation period: 1996Q1 - 2008Q4

The change in **imports of energy** (m^e) is assumed to be equal to the change in firms' consumption of energy (ce) (see 'Firms'). The exogenous ratio χ^e converts consumption of energy measured in Petajoule into the volume of imports of energy measured in million euros.

$$\Delta \ln m^e \quad = \quad \Delta \ln ce + \chi^e \tag{126}$$

In the long term, **imports of goods and services for domestic use, excluding energy** ($m^{dom,-e}$) change in line with a scale variable (fdm), which is defined as the weighted sum of the different components of final demand, the weights capturing their import content. In short term, the elasticity of imports with respect to the scale variable exceeds one, as domestic suppliers may not be able to immediately meet changes in domestic demand fully. The change in stock building (excluding statistical discrepancies, Δds) is added separately to the equation. Furthermore, a fall in the amount of slack in the domestic economy, measured by the output gap ($ygap$), supports imports in the short term. An increase in import prices relative to prices of domestic final demand ($pm^{dom,-e}/py^{-x+m}$) depresses imports. The deflator of domestic final demand (py^{-x+m}) is defined as the weighted average of the different consumption and investment deflators.

$$\begin{aligned}\Delta \ln m^{dom,-e} &= \underset{(4.8)}{-0.27} * \left(\ln m^{dom,-e}_{-1} + \underset{(19.5)}{0.15} - \ln fdm_{-1} \right. \\ &\quad \left. + \underset{(12.7)}{0.54} * \ln \frac{pm^{dom,-e}_{-1}}{py^{-x+m}_{-1}} \right) + \underset{(12.6)}{1.75} * \Delta \ln fdm \\ &\quad - \underset{(2.3)}{0.24} * \Delta \ln \frac{pm^{dom,-e}_{-1}}{py^{-x+m}} \\ &\quad + \underset{(3.4)}{0.53} * ygap_{-1} + \underset{(4.1)}{0.30} * \frac{\Delta ds}{\frac{1}{4}\sum_{i=1}^{4} m^{dom,-e}_{-i}}\end{aligned} \tag{127}$$

$\bar{R}^2 = 0.58$; $S.E. = 0.02$; $p(LM_4) = 0.03$; $p(JB) = 0.11$

Estimation period: 1980Q2 - 2008Q4

Factor income received from the rest of the world (fir) is defined as total foreign assets (tfa) in the previous period times the yield on foreign investment. The yield depends positively on the German (rs^{ge}) and US (rs^{us}) short term interest rates, the German long term interest rate (rl^{ge}), and GDP growth in OECD countries, but negatively on the euro-dollar exchange rate. The latter variable reflects the fact that exchange rate risk is generally not fully hedged.

$$\begin{aligned}fir &= 0.01 * tfa_{-1} * (\underset{(2.2)}{0.35} + \underset{(3.6)}{0.05} * rs^{ge} + \underset{(4.7)}{0.07} * rs^{us} \\ &\quad + \underset{(10.6)}{0.26} * \frac{1}{24}\sum_{i=0}^{23} rl^{ge}_{-i} + \underset{(2.3)}{0.07} * 100 * \Delta_4 \ln y^{oecd}_{-1} - \underset{(1.0)}{0.25} * \ln exr)\end{aligned} \tag{128}$$

$\bar{R}^2 = 0.82$; $S.E. = 0.23$; $p(LM_4) = 0.06$; $p(JB) = 0.00$
Estimation period: 1987Q1 - 2008Q4

We assume that exports (excluding re-exports) in current prices and factor income received from the rest of the world are fully added to **total foreign assets** (tfa). Furthermore, the value of foreign assets changes as a result of capital gains or losses, approximated by the change in world stock prices (ps^{wo}) and the German long term interest rate.

$$\begin{aligned} tfa &= tfa_{-1} + px^{dom,-e} * x^{dom,-e} + px^{e} * x^{e} + fir \\ &\quad + tfa_{-1} * \left(\underset{(3.9)}{0.06} * \Delta \ln \frac{ps^{wo}}{exr} - \underset{(3.4)}{0.01} * \Delta_4 rl^{ge} \right) - \underset{(47.1)}{623.2} * t \end{aligned} \tag{129}$$

$\bar{R}^2 = 0.30$; $S.E. = 0.02$
Estimation period: 1987Q1 - 2008Q4

Similarly to factor income received, **factor income paid to the rest of the world** (fip) is defined as total foreign liabilities (tfl) in the previous period times an appropriate return. The return is a function of the Dutch short and long term interest rates and the annual GDP growth rate.

$$\begin{aligned} fip &= 0.01 * tfl_{-1} * (\underset{(1.5)}{0.84} + \underset{(8.2)}{0.12} * rs + \underset{(5.2)}{0.24} * \frac{1}{24} \sum_{i=0}^{23} rl_{-i} \\ &\quad + \underset{(4.3)}{0.12} * 100 * \Delta_4 \ln y_{-1} - \underset{(2.2)}{0.01} * t_{-1}) \end{aligned} \tag{130}$$

$\bar{R}^2 = 0.90$; $S.E. = 0.23$; $p(LM_4) = 0.19$; $p(JB) = 0.00$
Estimation period: 1987Q1 - 2008Q4

Imports (excluding imports for the purpose of re-exports) in current prices and factor income paid to the rest of the world are fully added to **total foreign liabilities** (tfl). Capital gains or losses are captured by the change in Dutch stock prices (ps^{nl}) and the long term interest rate.

$$\begin{aligned} tfl &= tfl_{-1} + pm^{dom,-e} * m^{dom,-e} + pm^{e} * m^{e} + fip \\ &\quad + tfl_{-1} * \left(\underset{(3.8)}{0.06} * \Delta \ln ps^{nl} - \underset{(4.2)}{0.01} * \Delta_4 rl \right) - \underset{(47.1)}{623.2} * t \end{aligned} \tag{131}$$

$\bar{R}^2 = 0.25$; $S.E. = 0.02$
Estimation period: 1987Q1 - 2008Q4

Current transfers received from the rest of the world ($transfr$) consist of (exogenous) transfers received by the general government ($transgrf$) and transfers received by the private sector. The latter is modeled as a share of nominal GDP in OECD countries ($pm^{wo} * y^{oecd}$). Due to ongoing globalization, which we approximate by the ratio of foreign demand over GDP in OECD countries (see equation (124)), this share is increasing over time.

$$transfr = transgrf + pm^{wo} * y^{oecd} * (\underset{(5.9)}{-0.05} + \underset{(16.6)}{0.18} * \frac{x^{wo}_{-1}}{y^{oecd}_{-1}}) \quad (132)$$

$\bar{R}^2 = 0.83$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.16$
Estimation period: 1980Q1 - 2008Q4

Current transfers paid to the rest of the world ($transfp$) is the sum of transfers paid by the general government ($transgpf$) and transfers paid by the private sector, which are modeled as a share of nominal GDP ($py * y$).

$$transfp = transgpf + py * y * (\underset{(1.5)}{-0.001} + \underset{(16.6)}{0.01} * \frac{x^{wo}_{-1}}{y^{oecd}_{-1}}) \quad (133)$$

$\bar{R}^2 = 0.77$; $S.E. = 0.00$; $p(LM_4) = 0.37$; $p(JB) = 0.47$
Estimation period: 1980Q1 - 2008Q4

Current transfers paid to the rest of the world by the general government ($transgpf$) consists of GNP payments of the general government to the EU Budget ($transgpf_{eu}$) and other transfers ($transgpfo$). GNP payments to the EU Budget are partly related to the UK rebate and partly to changes in domestic nominal GDP. The other transfers paid to the rest of the world by the general government are also assumed to be related to changes in domestic nominal GDP.

$$transgpf = transgpf_{eu} + transgpfo \quad (134)$$

$$transgpf_{eu} = ukrebate + transgpf_{eu,-1} * (py * y)/(py_{-1} * y_{-1}) \quad (135)$$

$$transgpfo = transgpfo_{-1} * (py\ y)/(py_{-1}\ y_{-1}) \quad (136)$$

Complementary to the breakdown of exports into re-exports and exports of domestically produced goods and services, the model provides a breakdown of exports into **exports to euro area countries** (x^{intra}) and to countries outside the euro area (x^{extra}). Exports to euro area countries are defined by a share applied to total exports.

$$x^{intra} = \chi^{x,intra} * x \tag{137}$$

The share exports to euro area countries is increasing in both the ratio of competitors' exports prices in the euro area ($px^{wo,intra}$) to competitors' export prices outside the euro area ($px^{wo,extra}$) and the ratio of foreign demand from inside the euro area ($x^{wo,intra}$) to foreign demand from outside the euro area ($x^{wo,extra}$).

$$\ln \chi^{x,intra} = \underset{(1274.8)}{4.14} + \underset{(3.5)}{0.25} * \ln \frac{px^{wo,intra}}{px^{wo,extra}} + \underset{(8.9)}{0.67} * \ln \frac{x^{wo,intra}}{x^{wo,extra}} \tag{138}$$

$\bar{R}^2 = 0.86$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.35$

Estimation period: 1996Q1 - 2009Q2

Similarly, **imports to euro area countries** are defined by a share applied to total imports.

$$m^{intra} = \chi^{m,intra} * m \tag{139}$$

$$\ln \chi^{m,intra} = \underset{(213.4)}{3.76} + \underset{(5.1)}{0.82} * \ln \frac{pm^{wo,intra}}{pm^{wo,extra}} + \underset{(5.6)}{0.78} * \ln \frac{x^{wo,intra}}{x^{wo,extra}} \tag{140}$$

$\bar{R}^2 = 0.67$; $S.E. = 0.03$; $p(LM_4) = 0.00$; $p(JB) = 0.27$

Estimation period: 1996Q1 - 2009Q2

A.6 Pension funds

Pension benefits ($transh_{pen}$) depend on the number of people aged 65 or older, on the level of indexation that pension funds offer and on an autonomous factor that incorporates the gradual improvement of pensions with the different cohorts.

$$\Delta \ln transh_{pen} = \underset{(7.8)}{0.01} + \Delta \ln n_{65+} + indexpen/4 \tag{141}$$

$\bar{R}^2 = 0.005$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.08$
Estimation period: 1980Q2 - 2008Q4

We assume **premiums paid to pension funds** ($sce_{pen,paid}$) move in line with gross wages. Alternatively, the model contains an optional equation allowing the user to link pension premiums to developments in the pension funds' funding ratio.

$$\Delta \ln sce_{pen,paid} = \Delta \ln w_{gross} \tag{142}$$

As a rule of thumb, we assume **employers' contributions to pension schemes** (scr_{pen}) amount a constant fraction of about 2/3 of premiums paid to pension funds. Therefore, employers' contributions move in line with premiums paid.

$$\Delta \ln scr_{pen} = \Delta \ln sce_{pen,paid} \tag{143}$$

We assume employees pay the remaining 1/3 of premium paid to pension funds. In addition, in the National Accounts **employees' contributions to pension schemes** (sce_{pen}) include investment income of pension funds, like dividend and interest, as well. Investment income of pension funds is estimated at 70 percent of investment income from life insurance technical reserves ($icpf$, which includes pension funds).

$$sce_{pen} = sce_{pen,paid} - scr_{pen} + 0.70 * icpf \tag{144}$$

Pension funds and life insurers earn **investment income from life insurance technical reserves** ($icpf$) in the form of interest from bonds (b^{pf}) and loans ($loanspf$) and dividends from shares (v^{pf}). Investment income is defined as an weighted average return on investment (rpf) applied to total financial assets ($assetpf$). We use the long term interest rate (rl), averaged over the past ten years, to approximate interest income from bonds. This ten-year period reflects the composition of pension funds' portfolio. In the case of the - more risky - loans, we increase the long term interest rate with the credit spread on new loans to firms ($spread$). Dividends from shares are defined as a dividend return ($divpf$)

applied to the value of shares.

$$\begin{aligned}\Delta \ln icpf &= \Delta \ln(rpf * assetpf) \qquad (145)\\ rpf &= \left[\left(\frac{1}{40}\sum_{i=0}^{39} rl_{-i}\right) b^{pf}_{-1} + \left(\frac{1}{40}\sum_{i=0}^{39}(rl_{-i} + spread_{-i})\right) loanspf_{-1}\right.\\ &\quad \left. + divpf_{-1} v^{pf}_{-1}\right] / \left[b^{pf}_{-1} + loanspf_{-1} + v^{pf}_{-1}\right]\end{aligned}$$

Total financial assets of insurance corporations and pension funds ($assetpf$) consists of bonds, loans and shares. About 70 percent of these assets are held by pension funds. The market value of the assets develops according to the weighted average return on government bonds, corporate loans and stocks, taking into account the duration of the assets. Bonds and loans have a duration of 4.5 years and shares yield dividends and follow a world stock index (ps^{wo}) stated in dollar terms. We assume that 80 percent of the exchange risk for shares is hedged. The final term in the equation represents the difference between contributions and benefits, on which we assume pension funds initially earn the short term interest rate. Afterwards, we assume pension funds invest 45 percent of net premiums received in shares, 45 percent in bonds and 10 percent in loans.

$$\begin{aligned}assetpf &= b^{pf}_{-1}\,\frac{(1+rl_{-1})^{4.75}}{(1+rl)^{4.5}} + loanspf_{-1}\frac{(1+rl_{-1}+spread_{-1})^{4.75}}{(1+rl+spread)^{4.5}}\\ &+ share^{pf}_{-1}\left(\frac{ps^{wo}}{ps^{wo}_{-1}} * (\frac{exr_{-1}}{exr})^{0.8} + divpf_{-1}\right)\\ &\quad +(sce_{pen,paid} - transh_{pen}) * \frac{1}{2} * (1+rs)^{0.25} \qquad (146)\end{aligned}$$

The present value of **pension funds' liabilities** ($liabpf$) depends mainly on the long term interest rate. The duration of pension funds' liabilities is about 14 years. Furthermore, liabilities increase with indexation of existing pension rights ($indexpen$) and with new pension rights building up at a rate of 10 percent of compensation of employees (W^{pr}). Liabilities fall with pension benefits paid out ($transh_{pen}$). Pension funds' liabilities form about 60 percent of **households' net equity in life insurance and pension funds reserves** (v^{hh}_{pen}) in the National Accounts. We assume that the latter variable moves in line with pension funds'

liabilities.

$$\begin{aligned} liabpf &= liabpf_{-4} * \frac{1}{4}\sum_{i=1}^{4}(1 + indexpen_{-i}) * \frac{(\frac{1}{4}\sum_{i=1}^{4}(1 + rl_{-i-4}))^{15}}{(\frac{1}{4}\sum_{i=1}^{4}(1 + rl_{-i}))^{14}} \\ &+ \sum_{i=1}^{4}(0.10 * W^{pr}_{-i} - trans_{pen,-i}) \end{aligned} \tag{147}$$

$$\Delta \ln v^{hh}_{pen} = \Delta \ln liabpf \tag{148}$$

Pension funds' funding ratio ($frpf$) is defined as the present value of pension funds' assets over pension funds' liabilities.

$$frpf = 100 \ * \ \frac{assetpf}{liabpf} \tag{149}$$

The level of **indexation** ($indexpf$) offered by pension funds depends on the funding ratio. Full indexation to a weighted average of wage inflation ($\Delta \ln w^{pr}_{cnt}$) and consumer price inflation ($\Delta \ln pc_{-i}$) is offered if the funding ratio is at least 140 (indicated 'C'). At levels below 100, no indexation is offered (indicated 'A') and for values between 100 and 140 (indicated 'B'), pension funds offer partial indexation.

$$indexpen = \begin{cases} 0 & \text{if} \quad A \\ \sum_{i=1}^{4}(0.8\Delta \ln w^{pr}_{cnt,-i} + 0.2\Delta \ln pc_{-i})\frac{frpf_{-4}-100}{40} & \text{if} \quad B \\ \sum_{i=1}^{4}(0.8\Delta \ln w^{pr}_{cnt,-i} + 0.2\Delta \ln pc_{-i}) & \text{if} \quad C \end{cases} \tag{150}$$

A.7 Government and social security

Current period **government debt** ($gdebt$) is the sum of previous period's government debt, the government balance and any (exogenous) deficit debt adjustments (dda).

$$gdebt = gdebt_{-1} + gbal + dda \tag{151}$$

The **general government's balance** ($gbal$) is defined as total expenditures minus total revenues. Total expenditures consists of current transfers ($transgp$), interest paid (r^{gov}_{paid}), compensation of employees of the government sector (W^{gov}), government intermediate consumption (CGI), government investment ($pig * ig$), net acquisitions of non-financial assets ($gacq$) and capital transfers paid by the

government ($transcapgp$). Total government revenues is the sum of taxes on income and wealth (tax), indirect taxes ($taxind$), taxes on capital ($taxcap$), social security contributions (sc_{sec}), imputed social contribution of the government (scg_{imp}), dividends received related to gas production ($divggas$), other dividends received ($divgo$), interest received ($r^{gov}_{received}$), other transfers received ($transgro$), sales ($sales$), and other capital transfers received ($transcapgr$). Each of these components is discussed below.

$$\begin{aligned} gbal &= transgp + r^{gov}_{paid} + W^{gov} + CGI + pig * ig + gacq + transcapgp - tax \\ &\quad -taxind - taxcap - sc_{sec} - scg_{imp} - divggas - divgo - transgro \\ &\quad -sales - transcapgr \end{aligned} \tag{152}$$

Current transfers ($transgp$) consist of social security benefits in cash ($transh_{ss}$), social assistance benefits ($transh_{bw}$), general family allowances ($transh_{akw}$), health care allowances ($transh_{zt}$), youth disability insurance ($transh_{wj}$), social benefits in kind via market production (sb), subsidies on products ($subsp$), other subsidies ($subso$) and other transfers paid ($transgpo$).

$$\begin{aligned} transgp &= transh_{ss} + transh_{bw} + transh_{akw} + transh_{zt} + transh_{wj} + sb \\ &\quad +subsp + subso + transgpo \end{aligned} \tag{153}$$

Social security benefits in cash ($transh_{ss}$) is the sum of benefits from disability insurance ($transh_{wao}$), old age pensions ($transh_{aow}$), benefits from surviving relatives act ($transh_{anw}$), general family allowances ($transh_{akw}$) and benefits from unemployment insurance ($transh_{ww}$).

$$\begin{aligned} transh_{ss} &= transh_{wao} + transh_{aow} + transh_{anw} + transh_{akw} \\ &\quad +transh_{ww} \end{aligned} \tag{154}$$

We assume changes in per capita benefits from **disability insurance** ($transh_{wao}$) are indexed by a weighted average of the minimum wage and gross wage in the private sector.

$$\Delta \ln transh_{wao} = \Delta \ln n_{wao} + 0.95 * \Delta \ln w_{min} + 0.05 * \Delta \ln w^{pr}_{gross} \tag{155}$$

We assume changes in per capita **old age pensions** ($transh_{aow}$) are (partially) indexed by the minimum wage.

$$\Delta \ln transh_{aow} = \Delta \ln n_{65+} + 0.85 * \Delta \ln w_{min} \tag{156}$$

We assume changes in per capita benefits from **surviving relatives act** ($transh_{anw}$) are (partially) indexed by the minimum wage.

$$\Delta \ln transh_{anw} = \Delta \ln n_{anw} + 0.76 * \Delta \ln w_{min} \tag{157}$$

We assume changes in per capita **general family allowances** ($transh_{akw}$) are indexed by a moving average of HICP inflation.

$$\Delta \ln transh_{akw} = \Delta \ln n_{18-} + \frac{1}{8}\sum_{i=0}^{7} \Delta \ln hicp_{-i} \tag{158}$$

We assume changes in per capita benefits from **unemployment insurance** ($transh_{ww}$) are indexed by a weighted average of the minimum wage and gross wage in the private sector.

$$\Delta \ln transh_{ww} = \Delta \ln n_{ww} + 0.72 * \Delta \ln w_{min} + 0.28 * \Delta \ln w^{pr}_{gross} \tag{159}$$

Unemployed receive either benefits from unemployment insurance or from social assistance. Since the number of persons receiving benefits changes sluggishly, we assume the identity only applies after some lags, by imposing appropriate cross-equation restrictions. Hence, both the **number of persons receiving benefits from unemployment insurance** (n_{ww}) and the **number of persons receiving benefits from social assistance** (n_{bw}) is affected by the change in unemployment, and lagged changes in unemployment.

$$\begin{aligned} \Delta n_{ww} = {} & \underset{(5.7)}{0.24} * \Delta n_u + \underset{(8.5)}{0.57} * \frac{1}{4}\sum_{i=1}^{4} \Delta n_{u,-i} \\ & + (1 - \underset{(5.7)}{0.24} - \underset{(8.5)}{0.57} - \underset{(2.9)}{0.05} - \underset{(6.6)}{0.18} - \underset{(4.9)}{0.12}) * \frac{1}{4}\sum_{i=5}^{8} \Delta n_{u,-i} \end{aligned} \tag{160}$$

$$\begin{aligned} \Delta n_{bw} = {} & - \underset{(12.2)}{2.90} + \underset{(2.9)}{0.05} * \Delta n_u + \underset{(6.6)}{0.18} * \frac{1}{4}\sum_{i=1}^{4} \Delta n_{u,-i} \\ & + (1 - \underset{(5.7)}{0.24} - \underset{(8.5)}{0.57} - \underset{(2.9)}{0.05} - \underset{(6.6)}{0.18} - \underset{(4.9)}{0.12}) * \frac{1}{4}\sum_{i=5}^{8} \Delta n_{u,-i} \end{aligned} \tag{161}$$

We assume changes in per capita benefits from **social assistance** ($transh_{bw}$) are (partially) indexed by the minimum wage.

$$\Delta \ln transh_{bw} \quad = \quad \Delta \ln n_{bw} + 0.79 * \Delta \ln w_{min} \tag{162}$$

We assume changes in per capita benefits from **youth disability insurance** ($transh_{wj}$) are fully indexed by the minimum wage.

$$\Delta \ln transh_{wj} \quad = \quad \Delta \ln n_{wj} + \Delta \ln w_{min} \tag{163}$$

We assume changes in **health care allowance** ($trans_{zt}$) move in line with changes in health care expenses, cf. equation (166).

$$\Delta \ln transh_{zt} \quad = \quad \Delta \ln sb_{ss} \tag{164}$$

Social benefits in kind via market production (sb) consists of social security benefits in kind via market production (sb_{ss}) and social assistance benefits in kind via market producers (sb_{sa}). The latter includes for example rent rebates.

$$sb \quad = \quad sb_{ss} + sb_{sa} \tag{165}$$

Social security benefits in kind via market production (sb_{ss}) mainly consists of health care expenses. In the long term, we assume that the elasticity of real health care expenses with respect to potential output is one. Nonetheless, health care expenses grow faster than potential output in the long term because of ageing population, measured by the ratio of elderly (n_{65+}) to teen-agers (n_{15-}) as well as the average life expectancy of men ($life_m$) and women ($life_w$).

$$\begin{aligned} \Delta \ln sb_{ss} \quad = \quad & \Delta \ln pcg + \Delta \ln n - \underset{(2.9)}{1.59} \; - \underset{(3.5)}{0.10} \; * (\ln(sb_{ss,-1}/(pcg_{-1} * n_{-1})) \\ & - \ln(ypot_{-1}/n_{-1}) - \underset{(3.0)}{0.95} \; * n_{65+}/n_{15-} \\ & - \underset{(1.7)}{0.04} \; * (life_m + life_w)/2 \Big) + \underset{(1.7)}{0.18} \; * \Delta \ln(sb_{ss,-1}/(pcg_{-1} * n_{-1})) \end{aligned} \tag{166}$$

$\bar{R}^2 = 0.52$; $S.E. = 0.01$; $p(LM_4) = 0.01$; $p(JB) = 0.98$

Estimation period: 1980Q1 - 2008Q4

Subsidies ($subs$) is the sum of subsidies on products and other subsidies on production.

$$subs \quad = \quad subsp + subso \tag{167}$$

We assume **subsidies on products** ($subsp$) move in line with private consumption in current prices.

$$\Delta \ln subsp \quad = \quad \Delta \ln(pc * c) \tag{168}$$

Other subsidies on production ($subso$) include wage subsidies. Hence, we assume other subsidies move in line with the minimum wage.

$$\Delta \ln subso \quad = \quad \Delta \ln w_{min} \tag{169}$$

The change in **interest paid by the general government** (r^{gov}_{paid}) is given by a weighted average of long term (rl) and short term (rs) interest rates applied to the government balance. Since interest paid is measured at a quarterly frequency, the (annual) interest rates are divided by four.

$$r^{gov}_{paid} = r^{gov}_{paid,-1} + gbal * (0.91 * rl + 0.09 * rs)/4 \tag{170}$$

Compensation of employees of the government sector is given in equation (67). In forecasting exercises **government employment** (eg) is usually exogenous. In simulations we assume government aims at spending a fixed share of potential output on government consumption. If government consumption is too high, government employment is reduced, and vice versa.

$$\begin{aligned} \Delta \ln eg \quad = \quad & \underset{(2.1)}{-0.01} * (\ln(pcg_{-1} * cg_{-1}) - \ln(py_{-1} * ypot_{-1}) + \underset{(237.4)}{6.01}) \\ & \underset{(8.3)}{+0.62} * \Delta \ln eg_{-1} \end{aligned} \tag{171}$$

$\bar{R}^2 = 0.43$; $S.E. = 0.00$; $p(LM_4) = 0.13$; $p(JB) = 0.00$

Estimation period: 1980Q1 - 2008Q4

We assume that government aims at spending a fixed share of potential output on **government investment** (ig).

$$\Delta \ln ig = \underset{(4.1)}{-1.99} - \underset{(4.2)}{0.24} * (\ln(pig_{-1} * ig_{-1}) - \ln(py_{-1} * ypot_{-1})) - \underset{(1.4)}{0.12} * \Delta \ln ig_{-1}$$

(172)

$\bar{R}^2 = 0.19$; $S.E. = 0.04$; $p(LM_4) = 0.00$; $p(JB) = 0.00$
Estimation period: 1980Q1 - 2008Q4

The **stock of government capital** (kg) cumulates according to a perpetual inventory condition, with depreciation rate δ^g.

$$kg = (1 - \delta^g) * kg_{-1} + ig \tag{173}$$

We assume the **deflator of depreciation of government capital** (pdg) moves in line with the deflator of government investment.

$$\Delta \ln pgd = \Delta \ln pig \tag{174}$$

Government intermediate consumption (CGI) is the sum of other government consumption in current prices ($pcgo * cgo$) and sales less depreciation of government capital and net taxes paid on products ($ntaxprod$).

$$CGI = pcgo * cgo + sales - pdg * \delta^g * kg_{-1} - ntaxprod \tag{175}$$

Like in the cases of government employment and government investment, we assume government targets **other government consumption** (cgo) to be a fixed share of potential output in the long term. Furthermore, changes in government employment directly affect other government consumption.

$$\begin{aligned} \Delta \ln cgo = & \underset{(1.8)}{-0.16} - \underset{(1.8)}{0.06} * (\ln(pcgo_{-1} * cgo_{-1}) - \ln(py_{-1} * ypot_{-1})) \\ & \underset{(2.7)}{+1.20} * \Delta \ln eg \end{aligned} \tag{176}$$

Current taxes on income and wealth (tax) is the sum of taxes paid by firms ($taxf$), taxes paid by households ($taxh$) and other direct taxes collected by the general government ($taxo$)

$$tax = taxf + taxh + taxo \tag{177}$$

Taxes paid by firms distinguishes between **corporate taxes on gas revenues** ($taxfgas$), corporate taxes on non-gas revenues ($taxfngas$) and other direct taxes

paid by firms ($taxfo$).

$$taxf = taxfgas + taxfngas + taxfo \tag{178}$$

$$\tag{179}$$

The change in **corporate taxes on gas revenues** ($taxfngas$) is defined by a rate applied to a moving average in the change in the value added in mining and quarrying ($py_{va,min} * y_{va,min}$). The moving average accounts for lags in tax collection.

$$taxf = taxfgas + taxfngas + taxfo \tag{180}$$

$$\Delta taxfgas = \underset{(6.2)}{0.38} * \tau^{firms} * \sum_{i=0}^{5} \Delta(py_{va,min,-i} * y_{va,min,-i}) \tag{181}$$

Both the annual growth rate in **corporate taxes on non-gas revenues** ($\dot{taxfngas}$) and the annual growth rate in **other direct taxes paid by firms** ($\dot{taxfo}$) are assumed to move in line with the annual growth rate in gross operating surplus (Z), excluding imputed wages of self-employed (W^s) and value added in mining and quarrying, $Z^* = Z - W^s - py_{va,min} * y_{va,min}$. Again, moving averages account for lags in tax collection.

$$\dot{taxfngas} = \underset{(0.4)}{0.06} * \frac{1}{4}\sum_{i=0}^{3} \dot{Z^*_{-i}} + \underset{(0.4)}{(1 - 0.06)} * \frac{1}{4}\sum_{i=4}^{7} \dot{Z^*_{-i}} \tag{182}$$

$$\dot{taxfo} = \frac{1}{4}\sum_{i=0}^{3} \dot{Z\hat{2}_{-i}} \tag{183}$$

Taxes paid by households ($taxh$) is the sum of taxes on wages and income ($taxhw$), taxes on dividends ($taxhd$) and other direct taxes paid by households ($taxho$).

$$taxh = taxhw + taxhd + taxho \tag{184}$$

Taxes on wages and income ($taxhw$) distinguishes between taxes on labour income, taxes on old age pensions and taxes on social benefits, with shares $\chi^{tax,w}$, $\chi^{tax,pen}$ and $\chi^{tax,ss}$, respectively. $\hat{}$ denotes quarterly growth rate. Wage income

per worker W^* includes total compensation of employees, imputed wages of self-employed, and excludes employers' social security contributions. We allow for tax deductability of pension premium paid by employees ($sce_{pen,paid}$) and mortgage interest payments. We assume 88 percent of mortgage interest payments are paid for by workers, and the remaining 12 percent are due by pensioners. Taxes on labour income move in line with the number of employed persons (e_n). The elasticity of taxes on labour with respect to the wage rate exceeds one, indicating some degree of progressiveness in labour taxation.

$$\begin{aligned} \widehat{taxhw} &= \chi^{tax,w} * \underset{(2.7)}{(1.22} * \widehat{W^*} + \widehat{e}_n) + \chi^{tax,pen} * \widehat{transh^*_{pen}} \\ &\quad + \chi^{tax,ss} * \widehat{transh^*_{ss}} \end{aligned} \tag{185}$$

$$\begin{aligned} W^* &= (W + W^s - scr_{sec} - sce_{pen,paid} \\ &\quad -0.88 * \frac{1}{32} \sum_{i=0}^{31} (0.95rm_{-i} + 0.05rs_{-i}) * loanshmor)/e_n \end{aligned} \tag{186}$$

$$\begin{aligned} transh^*_{pen} &= transh_{pen} + transh_{aow} \\ &\quad -0.12 * \frac{1}{32} \sum_{i=0}^{31} (0.95rm_{-i} + 0.05rs_{-i}) * loanshmor \end{aligned}$$

$$transh^*_{ss} = transh_{ss} - transh_{aow} \tag{187}$$

Taxes on dividends paid by households ($taxhd$) are defined by a rate applied to the value of dividends received by households.

$$\Delta taxhd = \underset{(2.4)}{0.29} * \Delta divh \tag{188}$$

Other direct taxes paid by households ($taxho$) are defined by a rate applied to gross compensation of employees, which is equal to compensation of employees excluding employers' social security contribution, pension contributions, other social insurance contributions and imputed social contributions.

$$\Delta taxho = \underset{(5.0)}{0.02} \Delta(W - scr_{sec} - scr_{pen} - scr_{oth} - scr_{imp}) \tag{189}$$

Other direct taxes ($taxo$) are mainly taxes on dividends received from abroad, and are defined by a rate applied to taxes on dividends paid by domestic households.

$$\Delta taxo = \underset{(3.3)}{0.24} * \Delta taxhd \tag{190}$$

$\bar{R}^2 = 0.39$; $S.E. = 13.11$; $p(LM_4) = 0.00$; $p(JB) = 0.00$
Estimation period: 1979Q2 - 2008Q4

Indirect taxes ($taxind$) consists of value added tax ($taxvat$), energy levies ($taxe$), transfer tax on dwellings ($taxd$), and other indirect taxes ($taxindo$).

$$taxind \quad = \quad taxvat + taxe + taxd + taxindo \tag{191}$$

We assume the **value added tax** ($taxvat$) is charged on private consumption ($pc * \ c$) and on housing investment ($pih * \ ih$). In both cases, fixed rates apply.

$$\begin{aligned} \Delta taxvat \quad = \quad & \left(0.77 \ * \ \left(\frac{\tau_h^{vat}}{1 + vat_{high}^{vat}} \right) + 0.23 \ * \ \left(\frac{\tau_l^{vat}}{1 + \tau_l^{vat}} \right) \right) \ * \ \Delta(pc * \ c) \\ & + \frac{\tau_h^{vat}}{1 + \tau_h^{vat}} \ * \ \Delta(pih * \ ih) \end{aligned} \tag{192}$$

Energy levies ($taxe$) are defined by a rate applied to the value of private consumption.

$$\Delta taxe = \underset{(2.7)}{0.03} \ * \ \frac{1}{4} \sum_{i=0}^{3} \Delta(pc_{-i} * \ c_{-i}) \tag{193}$$

Transfer tax on dwellings ($taxd$) is defined by a rate applied to households' gross housing wealth.

$$\Delta taxd = \underset{(3.3)}{0.003} \ * \ \frac{1}{4} \sum_{i=0}^{3} \Delta hwealth_{-i}/4 \tag{194}$$

Capital taxes ($taxcap$), which are mainly inheritance taxes, are increasing in the share of elderly (n_{75+}) in total population (n) and in net household wealth.

$$\Delta taxcap = \left(- \underset{(1.8)}{0.01} \ + \ \underset{(1.8)}{0.16} * \frac{n_{75+}}{n} \right) \ * \ \Delta wealth \tag{195}$$

Social security contributions (sc_{sec}) consists of employers' contributions (scr_{sec}), employees' contributions (sce_{sec}) and contributions paid by self-employed (scs_{sec}). Social security contributions are assumed to move in line with gross

wages.

$$sc_{sec} = scr_{sec} + sce_{sec} + scs_{sec} \quad (196)$$

$$scr_{sec} = scr_{sec,-1} * w_{gross}/w_{gross,-1} \quad (197)$$

$$sce_{sec} = sce_{sec,-1} * w_{gross}/w_{gross,-1} \quad (198)$$

$$scs_{sec} = scs_{sec,-1} * w_{gross}/w_{gross,-1} \quad (199)$$

Employers' social contribution paid by the government (scg) is the sum of implied social contributions paid by the government (scg_{imp}) and social security contributions paid by the government (scg_{sec}). The latter are assumed to move in line with gross wages in the government sector.

$$scg = scg_{sec} + scg_{imp} \quad (200)$$

$$scg_{sec} = scg_{sec,-1} * w^{gov}_{gross}/w^{gov}_{gross,-1} \quad (201)$$

Government's share in employers' social contribution (χ^o) is defined as employers' social contributions paid by the government (scg) over total employers' social contributions.

$$\chi^o = scg/(scr_{sec} + scr_{pp} + scr_{oth} + scr_{imp}) \quad (202)$$

The **rate of employers' social contributions** (τ_r) is defined as social contributions paid by private sector employers as a percentage of private sector compensation of employees.

$$\tau_r = (1 - \chi^o) * (scr_{sec} + scr_{pp} + scr_{oth} + scr_{imp})/W^{pr} \quad (203)$$

The **rate of employees' social contributions and income taxes** (τ_n) is defined the sum of employees' social contribution and taxes on wage and income as a percentage of total economy gross wages. We assume that employees pay only a portion (sce_{sec}/scn_{sec}) of total wage and income taxes, the remainder of which is paid by self-employed.

$$\tau_n = \frac{sce_{sec} + taxhw * sce_{sec}/scn_{sec}}{w_{gross}} \quad (204)$$

Since the government is a stakeholder in gas production, the government not only collects corporate taxes on gas revenues but also receives **dividends related**

to gas production ($divggas$), which are defined by a rate applied to the value added in mining and quarrying in current prices.

$$\Delta \ln divggas = \underset{(34.1)}{0.63} * \Delta py_{va,min} * y_{va,min} \tag{205}$$

Other dividends received ($divgo$) is defined by a rate applied to gross operating surplus (Z), excluding imputed wages of self-employed (W^s) and value added in mining and quarrying, $Z^* = Z - W^s - py_{va,min} * y_{va,min}$.

$$\Delta divgo = \underset{(1.6)}{0.05} * \Delta(Z - W^s - py_{va,min} * y_{va,min}) \tag{206}$$

We assume **interest received by general government** ($r^{gov}_{received}$) is related to nominal GDP. The relevant return is a weighted average of long term and short term interest rates.

$$\Delta r^{gov}_{received} = \underset{(7.3)}{0.09} * \Delta(0.6 * \frac{1}{40}\sum_{i=0}^{39} rl_{-i} + (1-0.6) * rs) * py * y \tag{207}$$

Sales of the general government ($sales$) is defined by a rate applied to nominal GDP.

$$\Delta sales = \underset{(10.3)}{0.03} * \frac{1}{16}\sum_{i=0}^{15} \Delta(py_{-i} * y_{-i}) \tag{208}$$

The **net receipts from the EU budget** ($gbaleu$) consist of subsidies received ($subs_{eu}$), current transfers received ($transgrf_{eu}$) and capital transfers received ($transcapgr_{eu}$), less value added tax ($taxvat_{eu}$), other indirect taxes paid ($taxindo_{eu}$), GNP payment of government to EU budget ($transgpf_{eu}$), international co-operation paid by government to EU budget ($transgpf_{int}$) and capital transfers paid ($transcapgp_{eu}$). Many of the transactions with the EU budget are exogenous in the model, with the exception of value added tax, other indirect taxes paid and GDP payment of government to EU budget (see equation (135)).

We assume **value added tax paid to EU Budget** ($taxvat_{eu}$) is an exogenous ratio to private consumption and housing investment in current prices. Hence, changes in VAT paid move in line with this tax base.

$$\Delta \ln taxvat_{eu} = \Delta \ln(pc * c + pih * ih) \tag{209}$$

Since **other indirect taxes paid to EU Budget** ($taxindo_{eu}$) is mostly related to trade transactions, we assume it is an exogenous ratio to imports excluding energy in current prices. Therefore, other indirect taxes paid move in line with this tax base.

$$\Delta \ln taxindo_{eu} \quad = \quad \Delta \ln(pm * m - pm^{e} * m^{e}) \tag{210}$$

The **volume of government value added at basic prices** (y_{va}^{gov}) is the sum of compensation of employees in the government sector in constant prices (W_{real}^{gov}), depreciation of the government capital stock (dg), and the net taxes on production in constant prices ($ntaxprodr$). Real compensation of employees in the government sector equals government employment adjusted for changes in labour productivity in the government sector. In a similar way, **government value added at basic prices in current prices** is the sum of compensation of employees in the government sector, deprecation of the government capital stock in current prices and net taxes on production.

$$y_{va}^{gov} \quad = \quad W_{real}^{gov} + \delta^{g} * \ kg_{-1} + ntaxprodr \tag{211}$$

$$py_{va}^{gov} y_{va}^{gov} \quad = \quad W^{gov} + pdg * \ \delta^{g} * \ kg_{-1} + ntaxprod \tag{212}$$

Taxes on products in constant prices ($taxprodr$) is defined by a rate applied to the sum of private consumption and housing investment.

$$\Delta taxprodr = \underset{(4.3)}{0.29} \ * \ \frac{1}{4} \sum_{i=0}^{3} \Delta(c_{-i} + ih_{-i}) \tag{213}$$

$\bar{R}^2 = 0.05$; $S.E. = 310$; $p(LM_4) = 0.00$; $p(JB) = 0.00$
Estimation period: 1987Q2 - 2008Q4

Taxes on products ($taxprod$) is the sum of value added tax ($taxvat$), energy levies ($taxe$), transfer tax on dwellings ($taxd$) and a statistical discrepancy.

$$taxprod \quad = \quad taxvat + taxe + taxd \tag{214}$$

The **number of persons receiving sickness benefits** (n_{zw}) is decreasing in the unemployment rate, as in a weak labour market fewer employees dare to report

sick.

$$n_{zw}/e = \underset{(1.1)}{0.002} + \underset{(35.3)}{0.97} * n_{zw,-1}/e_{-1} - \underset{(2.9)}{0.002} * \frac{1}{4}\sum_{i=0}^{3}\Delta u_{-i} \tag{215}$$

$\bar{R}^2 = 0.95$; $S.E. = 0.00$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1977Q1 - 2008Q4

B The model variables

Name	Description
α	elasticity of private sector value added with respect to rate of capacity utilisation in manufacturing industry
γ	elasticity of substitution between energy and capital-labour composite
δ	depreciation rate capital stock
δ^g	depreciation rate government capital stock
δ^h	depreciation rate stock of dwellings
δ^o	depreciation rate private capital stock less dwellings
ζ	sample average share of energy costs in total factor income
η	economies of scale
θ	sample average share of labour income in sum of capital income and labour income
ν_E^1	energy-augmenting technical progress, linear part
ν_E^2	energy-augmenting technical progress, quadratic part
ν_K	capital-augmenting technical progress
ν_K^{struc}	structural capital-augmenting technical progress
ν_L	labour-augmenting technical progress
ν_L^{struc}	structural labour-augmenting technical progress
σ	elasticity of substitution between capital and labour
τ^{firms}	corporate tax rate
τ_n	private sector ratio of employees' social contributions and taxes on income to gross wages
τ^{oil}	tax rate on petrol
τ_r	private sector ratio of employers' social contributions to compensation of employees

Name	Description
τ^{subs}	investment premium (WIR)
τ^{top}	top income tax rate
τ^{vat}	weighted average of standard VAT rate and reduced VAT rate
τ_h^{vat}	standard VAT rate
τ_l^{vat}	reduced VAT rate
χ^{e}	ratio of volume of imports of energy (National Accounts) to Petajoule
χ^{es}	share of self-employment in private sector employment
χ^{hicpe}	weight of energy in HICP
χ^{ih}	share of housing investment carried out by households in total housing investment
$\chi^{m,intra}$	share of euro area countries in volume of imports of goods and services
χ^{o}	government's share in employers' social contribution
$\chi^{tax,pen}$	share of taxes on old age pensions in households' taxes on wages and income
$\chi^{tax,ss}$	share of taxes on social benefits in households' taxes on wages and income
$\chi^{tax,w}$	share of taxes on labour income in households' taxes on wages and income
$\chi^{x,intra}$	share of euro area countries in volume of exports of goods and services
ψ^{gov}	persons per fte, government sector
ψ^{pr}	persons per fte, private sector excluding self-employment
ψ^{s}	persons per fte, self-employed
$\psi^{tot,struc}$	structural persons per fte, total economy

Name	Description
$assetpf$	total financial assets of insurance corporations and pension funds
b^{hh}	long terms bonds and other financial assets of households
b^{pf}	long terms bonds of insurance corporations and pension funds
bls	MFI lending standards for loans to non-financial corporations
c	volume of private consumption
ce	volume of use of energy
cg	volume of government consumption
CGI	intermediate government consumption, current prices
cgo	volume of other government consumption
cu	capacity utilisation rate in manufacturing industry
cy	cost price
cye	cost price including energy
d	depreciation capital stock
dda	deficit debt adjustment
$dels$	volume of changes in inventories, including statistical discrepancies
dg	deprecation government capital stock
dh	depreciation stock of dwellings
$divggas$	dividends related to gas production received by the government
$divgo$	other dividends received by the government
$divhr$	households' dividend return
$divh$	dividend received by households
$divpf$	dividend return by pension funds
do	deprecation private capital stock less dwellings

Name	Description
ds	volume of changes in inventories
$dum_{Q1,Q3}$	dummy variable (Q1,Q3=1, Q2,Q4=0)
e	employment, fte
eg	government sector employees, fte
eg_n	government sector employees, persons
em	employees, fte
em_n	employees, persons
emp	private sector employees, fte
emp_n	private sector employees, persons
ep	private sector employment, fte
ep^{struc}	potential private sector employment, fte
e_n	employment, persons
es	self-employment, fte
es_n	self-employment, persons
exr	exchange rate ($ per €)
fdm	volume of import content of final domestic demand
fip	factor income paid to the rest of the world
fir	factor income received from the rest of the world
$frpf$	funding ratio pension funds
$gacq$	government's net acquisitions
$gbal$	general government's balance
$gbaleu$	net receipts from EU budget
$gdebt$	government debt
hc	productive hours worked per employee in construction sector
$hicp$	HICP total
$hicp_e$	HICP energy
$hicp_{-e}$	HICP excluding energy
$hicp_{rents}$	HICP rents
hp	number of hours per fte in private sector

Name	Description
hp^{struc}	structural number of hours per fte in private sector
$hwealth$	households' gross housing wealth
$icpf$	investment income from life insurance technical reserves, including pension funds
ict	share of ICT investment in total investment
ig	volume of government investment
ih	volume of housing investment
$indexpen$	annualized actual indexation of pension benefits
io	volume of other private investment
$iodif$	difference between investment to GDP ratio in the Netherlands and investment to GDP in euro area
it	volume of total investment
k	capital stock
kg	government capital stock
kh	stock of dwellings
ko	private sector capital stock less dwellings
$life_m$	life expectancy men
$life_w$	life expectancy women
$loanshmor$	households' mortgage loans
$loansho$	households' other loans
$loansf$	loans to (non-financial) firms
$loanspf$	long term loans issued by insurance corporations and pension funds
ls	labour supply, persons
m	volume of imports of goods and services
$m^{dom,-e}$	volume of imports for domestic use, excluding energy
m^e	volume of imports of energy
m^{intra}	volume of imports of goods and services from euro area countries
m^{re}	volume of imports for the purpose of re-exports

Name	Description
n	population
n_{1575}	population aged between 15 and 75
n_{15-}	population aged 15^-
n_{18-}	population aged 18^-
n_{65+}	population aged 65^+
n_{75+}	population aged 75^+
n_{anw}	surviving relatives act, fte
n_{aow}	old age pensions act, fte
n_{bw}	social assistance, fte
n_u	unemployment
n_{wao}	disability insurance act, fte
n_{ww}	unemployment insurance act, fte
n_{zw}	sickness benefits act, fte
$ntaxprod$	taxes on production minus subsidies
$ntaxprodr$	taxes on production minus subsidies, constant prices
p_{oil}	crude oil price (Brent, level in $ per barrel)
$part$	labour participation rate
pc	deflator of private consumption
pce	deflator of use of energy
$pcee$	price of use of energy in efficiency units
pcg	deflator of government consumption
$pconf$	producer confidence
pds	deflator of changes in inventories
$permits$	number of building permits issued
pgd	deflator of depreciation of government capital
ph	house price
pig	deflator of government investment
pih	deflator housing investment
pio	deflator of other private investment

Name	Description
pio^e	expected rate of change in deflator other private investment
pit	deflator of total investment
pk	user cost of capital
pke	user cost of capital in efficiency units
pkh	user cost of housing capital
ple	price of labour in efficiency units
pm	deflator of imports of goods and services
pm^c	deflator of imported consumer goods
pm^{dom}	deflator of imports of goods and services for domestic use
$pm^{dom,-e}$	deflator of imports of goods and services for domestic use excluding energy
pm^e	deflator of imports of energy
pm^{-e}	deflator of imports of goods and services excluding energy
pm^i	deflator of imports of investment goods
pm^{re}	deflator of imports of goods and services for the purpose of re-exports
pm^{wo}	competitors' import prices
$pm^{wo,extra}$	extra euro area competitors' import prices
$pm^{wo,intra}$	intra euro area competitors' import prices
$prod$	private sector labour productivity
$profq$	gross operating surplus less mixed income of households, % of GDP
ps	weighted average of MSCI-world share index (in €) and Amsterdam all share index
ps^{nl}	Amsterdam all share index
ps^{wo}	MSCI-world share index ($)
psv	deflator of stock of inventories

Name	Description
px	deflator of exports of goods and services
px^{dom}	deflator of exports of domestically produced goods and services
px^{e}	deflator of exports of energy
px^{-e}	deflator of exports of goods and services excluding energy
px^{it}	deflator of US exports of computers, peripherals and parts
px^{re}	deflator of re-exports of goods and services
px^{wo}	competitors' export prices
$px^{wo,extra}$	extra euro area competitors' export prices
$px^{wo,intra}$	intra euro area competitors' export prices
$px^{dom,-e}$	deflator of exports of domestically produced goods and services excluding energy
py	deflator of gross domestic product
py_{va}^{gov}	deflator of government value added at basic prices
py_{va}^{pr}	deflator of private sector value added at basic prices
$py_{va,min}$	deflator of value added of mining and quarrying at basic prices
py^{-x+m}	deflator of final domestic demand (private consumption, investment and government consumption)
$pyfin$	deflator of private consumption, investment, exports and other government consumption
r_{paid}^{hh}	interest paid by households
$r_{received}^{hh}$	interest received by households
r_{paid}^{gov}	interest paid by government
$r_{received}^{gov}$	interest received by government
rl	long term interest rate
rl^{ge}	German long term interest rate
rl^{us}	US long term interest rate

Name	Description
rm	mortgage interest rate
rpf	return on investment of pension funds
rpr	replacement rate
rs	short term interest rate
rs^{ge}	German short term interest rate
rs^{us}	US short term interest rate
s	volume of stock of inventories
$sales$	sales of government
sb	social benefits in kind via market production
sb_{sa}	social assistance benefits in kind via market producers
sb_{ss}	social security benefits in kind via market production
$savh$	households' saving ratio
$savhp$	adjustment for net equity in pension funds reserves by households
sc_{sec}	social security contributions
sce_{oth}	employees' other private social insurance contributions
sce_{pen}	employees' contributions to pension schemes
$sce_{pen,paid}$	charged contributions to pension schemes
sce_{sec}	employees' social security contributions
scg	employers' social contributions of government
scg_{imp}	imputed social contributions of government
scg_{sec}	social security contributions paid by the government
scn_{sec}	social security contribution less employers' social security contributions
scr_{imp}	employers' imputed social contributions
scr_{oth}	employers' other private social insurance contributions
scr_{pen}	employers' contributions to pension schemes

Name	Description
scr_{sec}	employers' social security contributions
scs_{sec}	self-employed social security contributions
$semcon$	value of worldwide semiconductors sales
$spread$	credit spread on new loans to firms
$spreadus$	US BAA intermediate corporate bond spread
sv^{hh}	share of shares and other equities in households' portfolio
$subs$	subsidies
$subs_{eu}$	subsidies received from EU Budget
$subso$	other subsidies on production
$subsp$	subsidies on products
$subspr$	subsidies on products in constant prices
t	time trend
tax	current taxes on income and wealth received by government
$taxcap$	capital taxes received by government
$taxd$	transfer tax on dwellings
$taxe$	energy levies
$taxf$	current taxes on income and wealth paid by firms
$taxfgas$	corporate taxes on gas revenues
$taxfngas$	corporate taxes less corporate taxes on gas revenues
$taxfo$	other direct taxes paid by firms
$taxh$	current taxes on income and wealth paid by households
$taxhd$	dividend tax paid by households
$taxho$	other direct taxes paid by households
$taxhw$	wage and income tax paid by households
$taxind$	indirect taxes
$taxindo$	other indirect taxes
$taxindo_{eu}$	other indirect taxes paid to EU Budget

Name	Description
$taxo$	other direct taxes received by government
$taxprod$	taxes on products
$taxprodr$	taxes on products, constant prices
$taxvat$	value added tax
$taxvat_{eu}$	value added tax paid to EU Budget
tfa	total foreign assets
tfl	total foreign liabilities
$tier1$	capital and reserves ratio of MFIs
$transh$	social benefits in cash
$transh_{akw}$	general family allowance act
$transh_{anw}$	surviving relatives act
$transh_{aow}$	old age pensions act
$transh_{bw}$	social assistance
$transgp$	current transfers paid by the general government
$transh_{oth}$	other social benefits received by households
$transh_{pen}$	pension benefits
$transh_{ss}$	social security benefits in cash
$transh_{wao}$	disability insurance act
$transh_{wj}$	youth disability insurance act
$transh_{ww}$	unemployment insurance act
$transh_{zt}$	health care allowances
$transcapgp$	capital transfers paid by general government
$transgpo$	other current transfers paid by general government
$transcapgp_{eu}$	capital transfers paid by government to EU Budget
$transcapgr$	capital transfers received by general government
$transcapgr_{eu}$	capital transfers (investments grants) received from EU Budget
$transfp$	current transfers paid to the rest of the world
$transgpf$	current transfers paid by government to the rest of the world

Name	Description
$transgpf_{eu}$	GNP payment of government to EU Budget
$transgpfo$	other transfers paid by the government to the rest of the world
$transgpf_{int}$	international co-operation paid by government to EU Budget
$transfr$	current transfers received from the rest of the world
$transgrf_{eu}$	current transfers received by government from EU Budget
$transgrf$	current transfers received by government from the rest of the world
$transgro$	other transfers received by general government
u	unemployment rate
u^{eq}	equilibrium rate of unemployment
$ukrebate$	UK rebate
v^{hh}	shares and other equities of households
v^{hh}_{pen}	households' net equity in life insurance and pension funds reserves
v^{pf}	shares and other equities of insurance corporations and pension funds
W	compensation of employees
W^{gov}	compensation of employees government sector
W^{gov}_{real}	compensation of employees government sector, constant prices
W^{pr}	compensation of employees private sector
W^{s}	imputed wages of self-employed
w_{min}	minimum wage
w^{gov}	compensation per employee government sector
w^{gov}_{cnt}	contractual wage government sector
w^{gov}_{drift}	wage drift government sector
w^{gov}_{gross}	gross wage government sector

Name	Description
w^{pr}	compensation per employee private sector
w^{pr}_{cnt}	contractual wage private sector
w^{pr}_{drift}	wage drift private sector
w^{pr}_{gross}	gross wage private sector
$wealth$	net wealth of households, including housing wealth
x	volume of exports of goods and services
x^{dom}	volume of domestically produced exports of goods and services
$x^{dom,-e}$	volume of domestically produced exports of goods and services excluding energy
x^{e}	volume of exports of energy
x^{-e}	volume of exports of goods and services excluding energy
x^{intra}	volume of exports of goods and services to euro area countries
x^{re}	volume of re-exports of goods and services
x^{wo}	volume of foreign demand
$x^{wo,extra}$	volume of foreign demand originating from outside the euro area
$x^{wo,intra}$	volume of foreign demand originating from euro area countries
$xmca$	current account
$YDIS$	disposable income of households
y	volume of gross domestic product
y^{oecd}	volume of gross domestic product in OECD countries
y^{gov}_{va}	volume of government value added at basic prices
$y_{va,min}$	volume of value added of mining and quarrying at basic prices
y^{pr}_{va}	volume of private sector value added at basic prices
y_{ea15}	euro area gross domestic product

Name	Description
$ydis$	disposable income of households, deflated by private consumption deflator
$yfin$	volume of private consumption, investment, exports and other government consumption
$ygap$	output gap
$ypot$	potential output
$ypot_{va}^{pr}$	potential volume of private sector value added at basic prices
Z	gross operating surplus
Z^{hh}	mixed income of households

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