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DELFI 2.0, DNB's Macroeconomic Policy Model of the Netherlands

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Abstract

This paper presents DELFI 2.0 - DNB's new macroeconomic policy model of the Netherlands. DELFI 2.0 is a medium-sized 'semi structural' macro-econometric model, which tries to strike a balance between theoretical rigour and statistical fit to the data. The model differs from its predecessor by incorporating a banking sector, an improved modelling of the pension sector and an explicit role for consumer confidence. A general overview of the structure of the model is given, including its steady state properties. The model's properties are explored in detail using various simulations, which also illustrate the interactions between the real and the financial side of the economy in model.

Keywords: Macro-econometric models, the Netherlands, banking sector, policy simulation.

JEL classification: C30, E10, E17.

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Foreword

This study presents the newest version of De Nederlandsche Bank's macroeconomic model DELFI. The first version of the model was published in 2011. The new version, coined DELFI 2.0, includes new elements, adjustments and extensions implemented in the model since the first publication. Changes in the economic environment and new (regulatory) policy requirements, stemming largely but not exclusively from the financial crisis and its aftermath, call for a richer and deeper description of the linkages between the financial and real economic sphere. This led to the inclusion in the model of a banking sector and a new framework for the pension system. This publication highlights these as well as other changes. Moreover, DELFI 2.0 fits into the rich tradition of macroeconomic modelling at the bank that dates back to the early 1970s.

This work is very much the result of a collective effort by the modellers and statisticians at the Economics and Research Division, who gratefully acknowledge the support and comments provided by colleagues from Statistics, Financial Stability and Supervision Policy. It is good to see this collaborative spirit among professionals bearing fruit. I am confident that, like its predecessors, the model will be an important vehicle for generating macroeconomic projections, scenario analyses and policy simulations.

Job Swank

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1 Introduction

This study presents a new, extended version of DELFI, the macroeconomic policy model of the Netherlands developed by De Nederlandsche Bank (DNB)[1]. The new version is coined DELFI 2.0. The model is used for generating forecasts, which are published in DNB's Economic Developments and Outlook, as well as for scenario analyses. DELFI has undergone various changes over time and has been regularly re-estimated, as new pieces of information on the working and evolution of the Dutch economy became available. Most notably, compared to its precursor, DELFI 2.0 includes a much richer sub-model of both the banking and pension sectors and therefore offers a more elaborate framework for analyzing the linkages between the financial sector and the real economy. This is a follow-up to the recommendations of the parliamentary committee on the financial system of the Dutch House of Representatives[2]. DELFI 2.0 differs from the original model version in the following aspects.

First and foremost, as a follow-up to the challenges posed by the financial crisis, the new version has been extended to include an aggregate sub-model of the Dutch banking sector. This block models the development of banks' assets and liabilities (loans and deposits of households and businesses in particular), lending rates, banks' profit and loss account, and the accumulation of bank capital. DELFI 2.0 provides a much more elaborated tool for studying the macroeconomic implications and real economy effects of shocks originating in the banking sector. Moreover, it captures important elements of the role of the banking sector in the propagation of other (financial or real) shocks on the Dutch economy. For instance, the impact of a stricter regulatory framework and more stringent capital requirements on the banking sector and the wider economy can be traced.

Second, the new pension block of the model tracks the changes over time in the funding ratio of the pension sector much better. The new block explicitly distinguishes six drivers of the movements in the funding ratio: 1) pension contributions, 2) pension benefits, 3) the indexation allowance, 4) the impact of changes in the term structure of interest rates on pension liabilities, 5) the impact of changes in interest rates, dividends, equity prices and real estate prices on pension returns, and 6) other factors, which include the impact of changes in life expectancy. The level of the funding ratio vis-à-vis a certain benchmark feeds back into the setting of pension contributions or indexation allowances. These mechanic feed-back rules can be switched on and off or tailored to the specific circumstances one wants to study.

Third, in DELFI 2.0 consumer confidence is explicitly modelled and found to have a significant impact on the dynamics of private consumption, residential investment and house prices. While the impact of normal

[1] DELFI stands for *Dutch Economic Linkages: a Forecasting Instrument*. See DNB (2011) for an overview of the first version of the model.

[2] Tweede Kamer de Staten-Generaal, 2010, Parlementair onderzoek financieel stelsel (Verloren Krediet), report 31980 (in Dutch).

fluctuations in consumer confidence is typically limited and temporary, large movements in confidence such as those witnessed in the early 1990s, 2002-2003 and 2008-2009 can materially contribute to the dynamics of household spending.

A fourth difference relates to price setting. The theoretical basis remains unchanged, i.e. firms operate in a monopolistically competitive market and set prices as a mark-up over cost price. But the model now provides for more data-coherence by allowing the pass-through of the cost of capital on prices to deviate from that of the aggregate unit cost of production. This leads to a smaller impact of capital costs on the deflators of domestic spending categories compared to the previous version of DELFI. Furthermore, pricing-to-market has become markedly stronger for exporters, reflecting that for Dutch producers it has become more difficult to pass on higher production costs to their foreign customers. Also importers' prices are found to be more tightly linked to world prices than before. These changes have implications for the pass-through of monetary policy and exchange rate shocks on domestic prices.

Chapter 2 provides a bird's eye view of DELFI 2.0, notably the modelling approach and estimation methodology followed, a schematic presentation of the model and its main channels of interaction, and the various uses of the model in practice. This is followed, in Chapter 3, by a more detailed description of the different model blocks, with particular emphasis on the new banking block and the interaction between the financial and real sphere. This chapter also discusses the dynamic in-sample fit of the model and the long-run properties of the model. Chapter 4 focuses on the simulation properties of DELFI 2.0. The responses of the Dutch economy to a large variety of real and financial shocks and policy measures are investigated. Chapter 5 looks at scenarios with shocks originating in or affecting the banking sector. References to the literature are in Chapter 6. The Annexes A and B offer a full description of the model's equations and model variables, respectively.

2 A bird's eye view on DELFI 2.0

DELFI 2.0 is DNB's quarterly econometric model of the Dutch economy. It belongs to the class of large-scale semi-structural models. Since DELFI is used for conditional forecasting and exploring actual policy measures, it should closely fit recent patterns in macroeconomic data. The model's structure furthermore has to reflect the breadth of macroeconomic detail that the policy process requires. Policy issues addressed with the model are many: they include, among other things, the transmission of monetary policy and financial shocks to the wider economy; the role of the housing market, banking sector and pension system in propagating prudential policy measures and financial shocks; the macroeconomic impact of fiscal policy; wage and price formation; labour market developments; aggregate demand; trade; potential growth. Theory-coherence is important in DELFI. But it is not tightly imposed in an internally consistent way as it is in DSGE-models.[3]

Compared to the previous model version the framework of demand and supply in DELFI 2.0 has been kept broadly unchanged. It combines the neoclassical approach to economics - with optimizing agents and clearing markets - with new-Keynesian elements, in which imperfections and frictions affect the short-run dynamics of product, labour and financial markets. The market of goods and services is characterized by monopolistic competition, where producers set a markup on the cost price and earn a profit. In the short run, output is determined by demand. Deviations of aggregate demand from the long-run equilibrium level of output trigger wage and price adjustments, moving the economy towards equilibrium again.

As mentioned in the introduction a richer modelling of the interaction of the real economy and the financial sector is an important new element in DELFI 2.0. A variety of real-financial linkages is accounted for. In the Netherlands the housing market is a crucial financial transmission channel. A change in the supply of mortgage credit to households - triggered by interest rate changes, financial shocks or regulatory measures affecting the financial sector - determines the development of house prices. This reflects the practice that for many potential house buyers the maximum mortgage that they can afford given their income determines the price they want to pay for a house. House prices, interest rates and equity prices together determine the wealth effects on private consumption and residential investment by households. The relative cost of capital (a combination of the cost of borrowing and cost of equity) affects capital formation by firms. The short-run dynamics of business investment also depends on the development of international equity prices, the dividend yield and firms' profitability. Furthermore, the acceleration of the supply of credit to non-financial corporations - the so-called credit impulse - has a temporary and small direct effect on investment. The standard model version does not take into account a regime of credit rationing[4]. The mandatory participation in occupational pension schemes is another potentially important channel of financial transmission to the real economy. Changes in market interest rates and changes in equity and real estate prices affect pension liabilities and returns. If their funding ratios drop below the regulatory minimum, pension funds may need to raise pension premiums, reduce indexation allowances, or even resort to outright pension benefit cuts. This will affect economy activity, by increasing production costs or by lowering households' disposable income, or a combination of both.

As before, expectations are adaptive or backward-looking and represented by lagged values of variables.

[3]While the debate on the pros and cons of different types of macroeconomic models is of all times, it was revived and became more intense in the aftermath of the financial crisis. See Blanchard (2018) and Hendry and Muellbauer (2018) for a recent discussion on the roles and merits of different types of macroeconomic models. In the Netherlands Lafourcade and de Wind (2012) and Elbourne, Luginbuhl and de Wind (2015) describe recent work on specifying and estimating a DSGE-model for the Dutch economy.

[4]Quantity rationing in credit markets is likely to be important during times of financial stress. This could be captured by replacing the standard equation for business investment by an alternative equation in which the amount of investment directly depends on credit supply conditions and outstanding loans. See DNB (2011) and van der Veer and Hoeberichts (2016).

Therefore expectation formation and delayed responses to shocks (for instance because of adjustment costs) are intertwined and cannot be separated[5]. The use of backward looking expectations in large semi-structural models is quite common (see for instance the Banca d'Italia econometric model in Bulligan et al. (2017)). Elements of forward looking expectations can be captured indirectly by conditioning on specific profiles of exogenous variables which are consistent with forward looking expectations. For instance in generating short-term forecasts the assumptions on international interest rates and asset prices reflect market expectations. However for simulation exercises, in particular those involving policy changes, the use of backward looking expectations may be less appropriate if agents indeed base their expectations on sophisticated forecasting tools rather than simple rules of thumb.

Data requirements and estimation methodology

DELFI 2.0 is fully compatible with ESA-2010 National Accounts standards. Equations for key macroeconomic variables are estimated using quarterly data from the National Accounts over the period 1977:Q1 to 2016:Q4. Depending on the availability of coherent data the estimation period may start later. In the banking block, for instance, the sample period for equations on items of the profit and loss account starts in the early 1990s, while data on retail rates and balance sheet data on private sector loans and deposits are available from the early 1980s. The model has to fulfil information requirements of policymakers inside and outside DNB. For instance, DELFI forecasts are input to the Broad Macroeconomic Projection Exercises in the Eurosystem, which requires that country data must have the same content and level of detail.

The econometric methodology that is used is the co-integration framework. This methodology explicitly distinguishes short-term dynamics from long-term equilibrium relationships. Deviations from equilibrium trigger a process of adjustment that moves the economy back towards its equilibrium path, the so-called error correction mechanism. The methodology provides an estimate of the mean reverting speed. The long-run relationships are derived from 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. In principle equations are estimated by ordinary least squares. To the extent that variables are expected to strongly interact across equations or if parameter restrictions across equations need to be imposed, a simultaneous estimation approach is adopted. Model building also requires judgement. Where estimation produced implausible parameter values and simulation outcomes, parameters have been calibrated based on insights from the literature or on estimation over a more recent, shorter sample period. In the pension block estimates of key parameters have been obtained from panel estimation based on microdata for individual pension funds.

[5] For a different approach in which expectations and delayed responses are separated, see the Federal Reserve Board's FRB/US model (Brayton et al. (1997) and Brayton et al. (2014)).

Figure 1: Labour income ratio

Percentages

3 A closer look at the model

3.1 Firms

The production sector of DELFI consists of cost-minimizing 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) observed in the Dutch economy over the past 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 in the case of a Cobb Douglas technology[6]. The model allows for labour-, capital- and energy-saving technological progress. The long-run relationships for the demand for labour,

[6]For 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).

capital and energy follow from the first-order conditions for the cost minimizing producers. These factor demand equations, together with the production function, are estimated using a normalized supply-side system approach, cf. Klump et al. (2007). The estimation results demonstrate that in the long run the demand for capital goods increases with output and decreases with the real user cost of capital. Labour demand (measured in full-time equivalent workers) in the longer term adjusts to a level implied by the inversion of the production function[7].

The elasticity of substitution between the production factors labour and capital is estimated at 0.50, 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 5.0 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 0.19. This elasticity is low compared to the elasticity of 0.50 that is 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 1.9 percent less energy and more capital and labour per unit of output. On average the structural rates of progress in labour-saving and capital-saving technologies are estimated at 1.3 percent per annum and 0.6 percent per annum, respectively. Quadratic technological progress for energy saving is used to reflect the empirical finding that progress in energy saving started to level off in the early 2000s.

The short-run dynamics show that the elasticity of the demand for investment goods with respect to output exceeds 1 by a considerable margin, in line with the well-known accelerator effect. The change in the dividend yield, which acts as a proxy for the equity premium (Rozeff (1984), Barkai (2016)), negatively affects investment growth. In contrast, the demand for labour responds less than one-for-one to changes in output, exemplifying labour hoarding behaviour. Labour demand is also affected by labour supply increases and nominal wage growth. Furthermore, the short-run dynamics of both the demand for investment goods and the demand for labour are shaped by various sources of firms' funding. There is a large literature that finds evidence of financial conditions impacting on the demand for investment goods (see Hubbard (1998) for an overview and Lewellen and Lewellen (2016) for recent evidence), while there are few studies that allow for such a role for financial variables in the context of labour demand models (Nickell and Wadhwani (1991), Benito and Hernando (2008), Chodorow-Reich (2014)). In DELFI profits, equity prices (scaled by private sector value added) and the change in the growth rate in bank loans to the non-financial corporate sector (the so-called credit impulse, see Biggs et al. 2009) all support the demand for investment goods. Financial variables also play a role in explaining short-run fluctuations in labour demand, although quantitatively their contribution is less important than in the case of investment goods. By including loans to non-financial corporations in the equations for demand for investment goods and for labour demand

[7]This formulation leads in the long run to the same level of employment as in alternative specifications based on profit maximization or cost minimization, but improves the simulation properties of the model (Fagan et al., 2005).

novel connections between firms' behaviour and the banking sector are established. These connections help to flesh out the linkages between the real economy and the financial sector in the model.

Potential output in the private sector is explicitly modelled in DELFI and is determined by substituting 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 minus imports. The difference between actual output and potential output defines the output gap[8]. The output gap is a measure of tension or slack 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 and services 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 interest rates, the equity premium, corporate taxes and amortizations. Dutch firms finance investment with 49 percent equity and 51 percent debt. The required return on equity is equal to the long-term interest rate plus the dividend yield, which serves as a proxy for the equity premium. The return on debt is equal to the (after tax) interest rate on bank lending to non-financial corporations. This interest rate not only depends on the composition of the banks' balance sheet, but also on the health of the corporate sector, proxied by the output gap, as well. These feedback loops from the output gap and the banks' balance sheet to the user cost of capital, and from the user cost of capital to investment, the output gap and banks' profits are examples of linkages between the real economy and the financial sector 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. Current demand has a negative impact on the level of inventories. Neither capital costs nor labour costs affect inventory investment.

3.2 Households

Households maximize utility from current and future private consumption. Two types of households are distinguished: 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

[8]Regarding the government sector, the assumption is made that potential output always equals actual output.

Table 1: Dutch household sector balance sheet 2016

Billions of euros; year end[1]

Housing property	1333.9	Mortgages	650.5
Deposits	395.9	Other loans	110.4
Shares and other assets	293.0	Net wealth	1261.9
Total assets	2022.8	Total liabilities	2022.8

[1] Excluding pension wealth.

RoT-households simply consume their entire disposable income every period. The share of optimizers in the household sector is calibrated, based on data on the wealth distribution provided by Statistics Netherlands: 20 percent of all households are assumed to be optimizers, 80 percent are RoT consumers.

Optimizers invest in houses, accumulate financial wealth in deposits and shares and other assets 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 consisting of deposits that yield interest-income and shares and other assets on which they earn dividend income. The increase in total household financial wealth is determined by new savings and (net) new borrowings. The demand for household deposits is a function of the real rate of return on deposits, household income and life expectancy (Bloom et al., 2007), see Section 3.5. Given the change in total wealth, the optimizers' holdings of shares and other assets are computed as a residual. The change in total wealth includes capital gains on financial assets and housing property. The net-income from interest and dividends received is part of their disposable income. RoT-households 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 accumulate no financial assets, they are allowed to own a house. In the model, the RoT-households own about 23 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. The displacement effect, i.e. the change in private savings following a change in pension wealth, is assumed to be zero. Empirical studies that try to measure the displacement effect using micro-data show mixed results. Some studies indicate that the impact of pension wealth on consumption is difficult to identify (Alessie et al. (1997), Euwals (2000)), while others conclude that if uncertainty regarding pension wealth is properly accounted for the displacement effect can be substantial (Van Santen, 2016).

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 difference between the actual level of the unemployment rate and the equilibrium level of the unemployment rate (unemployment gap). In the short-run, a drop in the actual unemployment rate raises the participation rate, reflecting the so-called encouraged worker effect.

The estimation results suggest that optimizers adopt a planning horizon of approximately seven years. Moreover, the marginal propensity to consume (mpc) out of housing wealth (4.3 percent both for optimizers and RoT) is slightly larger than for financial wealth (4.1 percent only for optimizers). The mpc for total wealth is about 4.2 percent. Both changes in the level of unemployment - which acts as proxy for income expectations - and changes in consumer confidence - which represents a general feeling of well-being - 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, with the former being more important quantitatively. The finding that changes in consumer confidence affect the dynamics of private consumption is a new feature of the model. The idea behind introducing consumer confidence is that consumer expenditures are a combination of objective financial resources ("ability") and subjective perception of the world ("willingness"). This implies that even if negative shocks do not directly affect consumers' ability to buy, it might affect their willingness to buy. While in the literature evidence on the relevance of consumer confidence as a driver of consumer spending in addition to the information contained in other economic indicators is mixed (Ludvigson, 2004), many influential economists - led by Keynes - are convinced that confidence and animal spirits are important in understanding consumer behaviour (see Barsky and Sims, 2012).

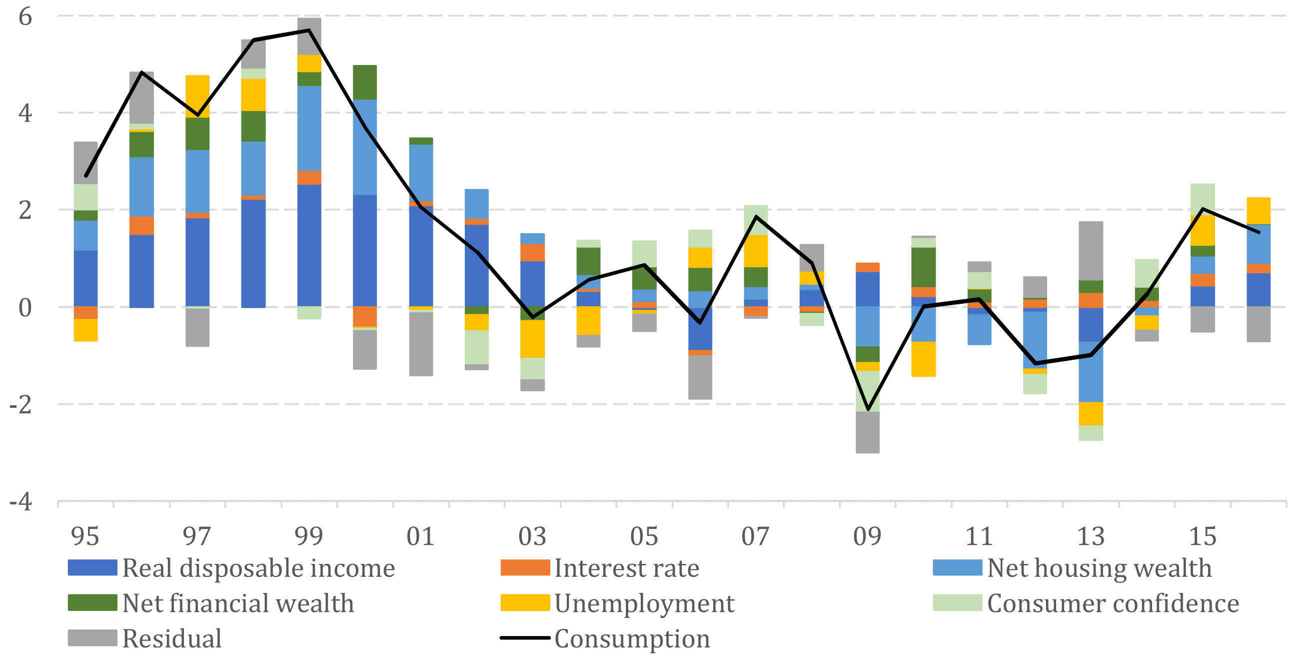
The short run impact of household income on consumer spending is estimated to be rather small, implying a fair degree of consumption smoothing. Formal tests indicate that this parameter, as well as the other parameters of the short run consumption equation, do not suffer from instability. Figure 2, which presents the annual growth rate of consumption along with the model-based contributions of its key determinants, shows that the model equation can track consumption reasonably well. While the impact of normal fluctuations in consumer confidence is typically limited and temporary, large movements in confidence such as witnessed in the early 1990s, 2002-2003 and 2008-2009 do materially contribute to the dynamics of household spending.

Consumer confidence is endogenously determined in DELFI. Following up on earlier research by Neisingh and Stokman (2013) for the Netherlands, consumer confidence is determined by an array of financial variables (house prices, equity prices, funding ratio of pension funds, interest rates, financial stability index) and real variables (unemployment, income, oil prices). The residuals of this model equation can be viewed as shocks to confidence.

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

Figure 2: Private consumption

Percentages



investment. A rise in households' housing wealth will give rise to a temporary shift from consumption towards housing investment. Also a pick-up in consumer confidence will boost housing investment.

3.3 Wages and prices

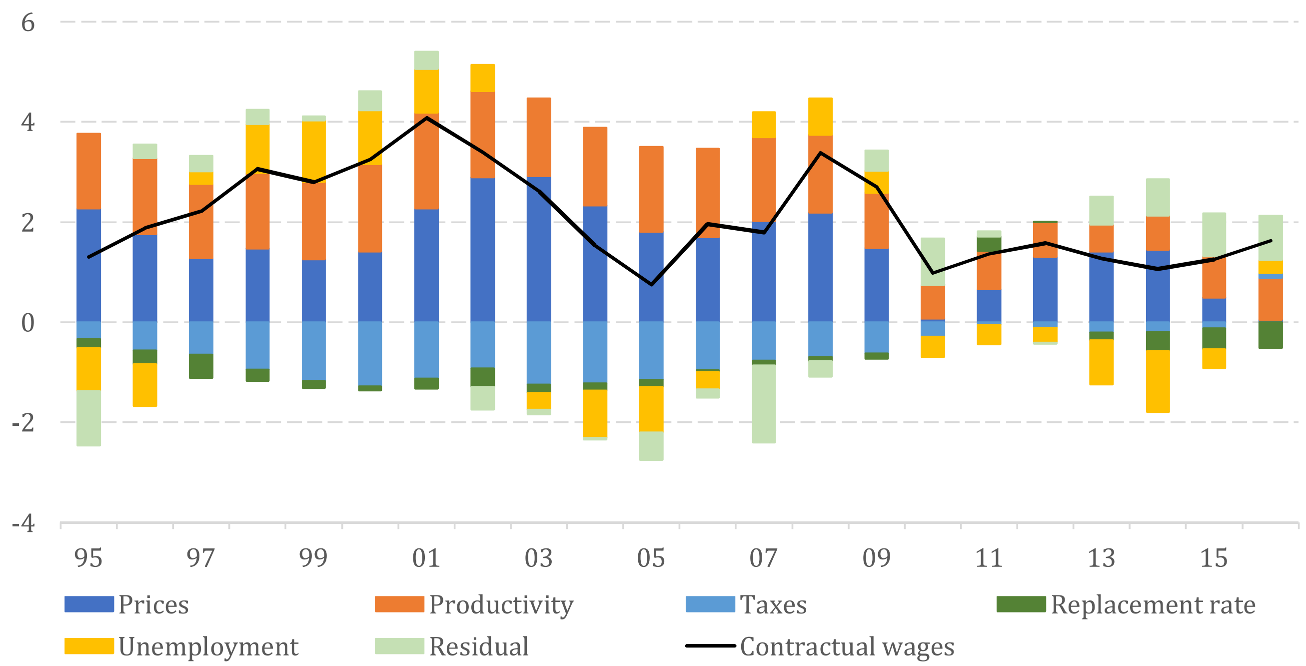
Wage formation

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. Although the assumption of a wage bargaining process may make sense intuitively, from a theoretical perspective it is actually not clear whether a wage equation can be properly identified in this way. But given that the estimated wage equation by-and-large confirms prior expectations, it is assumed that the wage equation indeed reflects the underlying wage-setting mechanism, cf. Bean (1994).

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

Figure 3: Contractual wages

Percentages



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 1.1 percent; a 10 percent decline in the replacement rate weakens the position of the workers in the wage negotiations and will result in a 2.5 percent wage decline; a 10 percent smaller wedge leads to a 5.1 percent wage decline.

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. Both changes in consumer prices and changes in labour productivity are relevant in explaining the short-term dynamics in contractual wages. In both cases, the elasticity is significantly below one. This implies that changes in prices and labour productivity are reflected in contractual wages only gradually and wages may under- or overshoot their equilibrium level for a considerable amount of time. Figure 3, which presents the annual growth rate of contractual wages along with the model-based contributions its key determinants, shows that the model equation can track contractual wage growth reasonably well.

The incidental wage component is the (residual) item that measures the gap between contractual wages and gross wages. It reflects, among other things, the impact of bonuses, promotions and composition effects. Composition effects are changes in average wage costs caused by changes in for instance the age or education structure of the employed population. Composition effects could also relate to changes in the type of labour contract (fixed versus flex) or to changes in the relative wage levels of entrants and exiters in the labour market, cf. Daly and Hobijn (2017). The incidental wage component is a fairly noisy variable. It is found to react to short-term movements in the unemployment rate (-), labour productivity (+), and the rate of workers on sickness leave (-). In addition, the incidental wage component is negatively related to the share of workers aged 45 and older in the total working age population. This is a new feature of the model. As workers grow older their prospects for getting promotion tend to diminish, as a result of which there is less support for a positive incidental wage component.

Contractual and incidental wages in the public sector are linked to developments in the private sector, and not the other way around, cf. Zeilstra and Elbourne (2014).

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. As outline in Section 3.1, the cost price of firms depends on three input prices: capital costs, cost of energy and labour costs. This implies that when interest rates are raised, capital costs increase and prices will go up mechanically. This is the so-called capital cost channel of monetary policy. Whether the capital cost channel is quantitatively important is ultimately an empirical question. To allow for more flexibility in estimating the strength of the capital cost channel, capital costs have been added as a separate explanatory variable to the long run price equations. It turns out that by doing so the capital cost channel is estimated to be more muted. The full-model impact of interest rates on prices is always negative, whereas in the previous version of the model it took a couple of years for the impact of interest rates on prices to become negative.

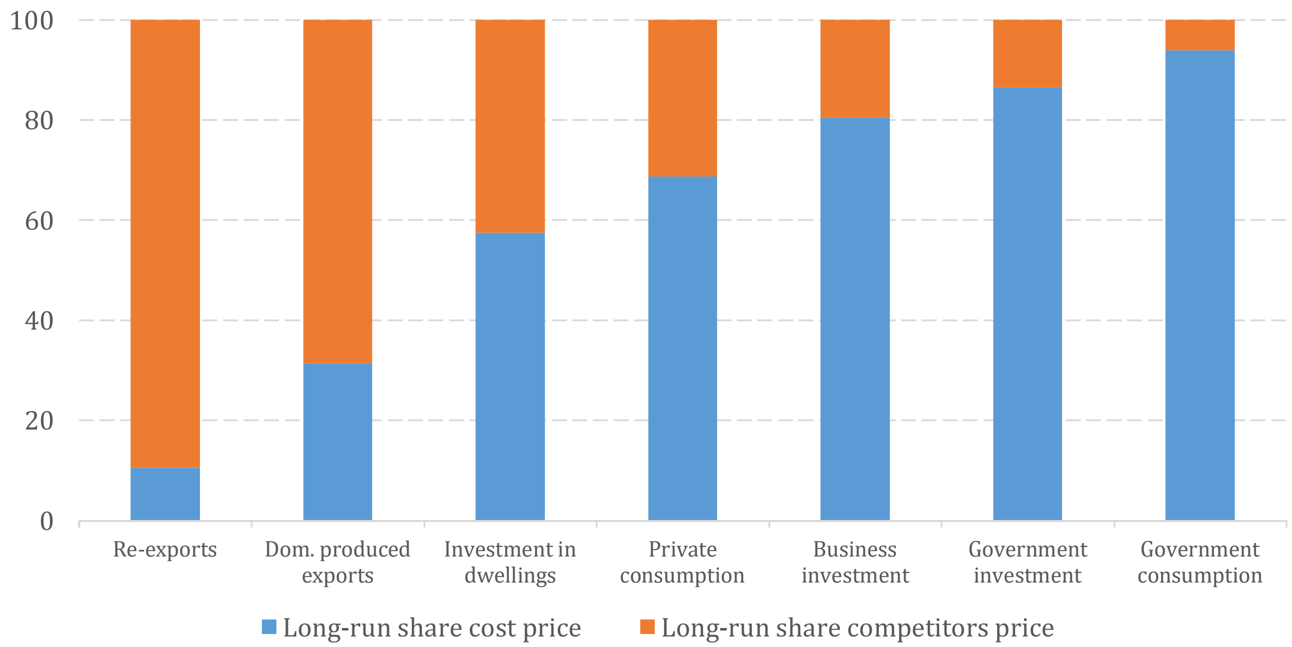
In the short run, the markup also depends on the output gap. When aggregate demand falls short of potential output, the output gap is negative and there will be downward pressure on prices through shrinking markups. With positive output gaps, firms have an opportunity to raise prices. As prices are sticky in the short run, it takes time for prices to adjust to their underlying equilibrium levels. In addition, the markup is affected by changes in unit labour costs, as changes in unit labour costs are translated into changes in prices with a delay.

The short-term price equations are homogeneous in prices and unit labour costs. This helps the model to converge to a proper steady state, see also Section 3.10. The hypothesis of (dynamic) homogeneity is supported by the data.

The 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

Figure 4: Weight of competitors' prices in long term price setting

Percentages



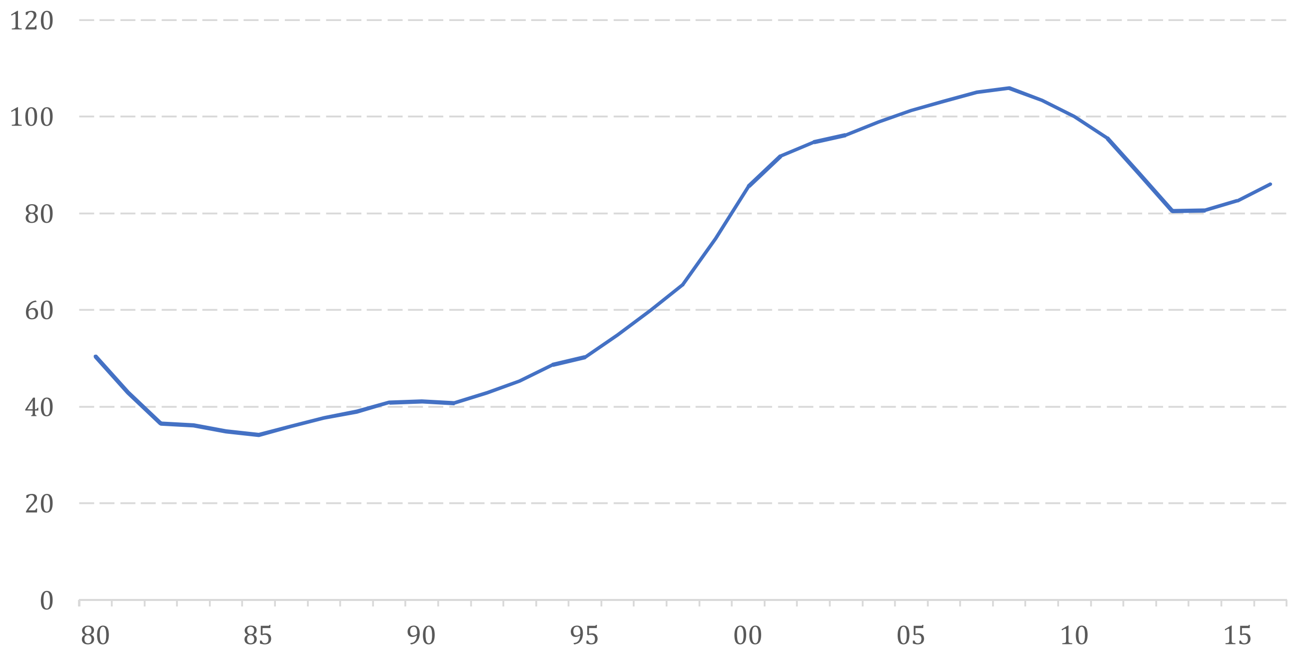
of domestic prices with respect to foreign competitors' prices varies from 0.06 to 0.90 (see Figure 4). Foreign competitors' prices are particularly important in the price setting of exports, both re-exports and domestically produced exports ("Made in Holland"). For goods and services in less competitive markets - like government consumption and government 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 products 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 investment goods converge relatively quickly to their long run levels. The speed of price adjustment is slower for prices of private consumption goods and of goods purchased by the government.

3.4 Housing market

The housing market is an important source of business cycle fluctuations, cf. Leamer (2007) and Leamer (2015). For example, estimates based on DELFI 2.0 suggest a little over one quarter of the cyclical upswing of GDP realized between 2013Q2 and 2017Q3 can be contributed to the housing market recovery; its influence on private consumption growth is even considerably bigger (60%) (DNB, 2017).

Figure 5: Real house prices

2010=100, deflated by consumer prices



Net nominal ownership of houses represents over 50 percent of Dutch households' total net wealth (see Table 1 in Section 3.2). For the optimizing households, the development of housing wealth or house prices is an important determinant of their consumption pattern. Housing wealth also affects housing investment and consumer confidence (see Section 3.2). House prices in the Netherlands have risen sharply, especially during the late 1990s (see Figure 5). In 2008 they reached a peak after which they plunged. In 2013, house prices started to recover. In the Netherlands, house prices are primarily driven by fluctuations in demand or, more specifically, by the amount of mortgage credit (see Section 3.5 for more details on the modelling of mortgage credit). The price responsiveness of housing supply is rather low in the Netherlands (Caldera and Johansson, 2013). Reflecting this situation, mortgages and house prices are modelled 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 reasonable well. The speed at which house prices revert to equilibrium is not very high, though. Put differently, the short-term dynamics of house prices are fairly persistent. One interpretation is that agents have heterogeneous expectations and that due to the presence of trend-followers in the housing market episodes of optimism are followed by spells of pessimism (Bolt et al., 2014). In addition, the short-run dynamics of house prices depend on mortgage interest rates and consumer confidence.

3.5 Banking sector

The banking sector model is included in order to provide a more detailed elaboration of real-financial linkages between the financial sector and the domestic economy. Changes in the composition of the banking sector's balance sheet, and in particular changes in bank leverage, directly affect the price of credit for households and firms and the adjustment process of bank loans and other assets. Consequent changes in the cost of finance and the demand for credit will in turn affect the level of domestic economic activity. These transmission mechanisms are fully endogenized within DELFI through the interaction of the banking sector with the rest of the model.

The Dutch banking sector: stylized facts and data

The Dutch banking sector is large relative to the size of the domestic economy. Banks have significant business interests and subsidiaries abroad, both within the euro area, but also further afield, in particular before the financial crisis. Conditions in foreign markets will therefore feed into the profits and losses of Dutch banks. In modelling the income and cost flows (interest income, interest costs, other income, operating costs, impairments, taxes paid) and the accumulation of total regulatory capital in the banking sector, consolidated data covering world-wide activities of banks are used (see Table 2). These data come from aggregated reports collected for banking supervision purposes. Note that total regulatory capital includes Tier 1, Tier 2 and Tier 3 capital[9].

The consolidated balance sheet data do not provide a sectoral breakdown of assets and liabilities. This is problematic since it would not allow for the inclusion of separate equations for credit and deposits of households and firms. For this reason the balance sheet variables in the banking model are sourced from the monetary statistics which cover a full breakdown of total assets and liabilities of Dutch MFIs by sector (see Table 3).

The coverage of the supervision data and the monetary statistics is not identical. As a result equations determining income and cost flows have dependent variables based on consolidated profit and loss data while explanatory variables are based on monetary balance sheet data. These two are reconciled simply by assuming that the (unobserved) composition of the consolidated balance sheet is identical to that of the monetary balance sheet. A further breakdown of bank loan data is needed because the demand for credit within DELFI relates to bank credit within the domestic economy rather than within the euro area. The relevant variables within DELFI are loans to domestic firms and households, including securitized loans. These variables are explicitly linked to the balance sheet variables of the banking sector using a series of bridging equations.

[9]Tier 3 is small relative to the other two classes of capital and only applies in the years 1998-2007 after which it was eliminated from the BIS definition of regulatory capital (see Basel Committee on Banking Supervision, 2011).

Table 2: Banking sector profit & loss account and regulatory capital in 2016

Billions of euros, unless stated otherwise[1]

Interest income	93.8	
Interest costs	-60.8	
Net interest income	33.1	33.1
Net other income		8.2
Operating costs		-25.2
Net impairments for bad loans		-2.0
Profit before taxes		14.0
Taxes		-3.7
Profit after taxes		10.3
Dividends		-4.4
Other changes in regulatory bank capital		3.7
Total change in regulatory bank capital		9.6
End of period level of total regulatory bank capital		*168.8*
Capital as % of risk-weighted assets		*22.4*

[1] Source: Consolidated banking sector.

The basic theoretical framework

The theoretical framework on which the banking sector model is based is an extension of the well-known Monti-Klein model (see Klein (1971) and Monti (1972)). The Monti-Klein model considers a monopolistic bank (or set of oligopolistic banks that play a symmetric Cournot equilibrium) that is facing a downward-sloping demand for loans and an upward-sloping supply of deposits. In this framework the bank is assumed to be able to access any amount of market funding against a fixed interest rate. The approach deviates from the standard Monti-Klein model by introducing (i) bank equity, and (ii) a class of assets other than loans. The market for other assets and liabilities is assumed to be competitive, hence the bank is a price-taker. In the standard version of the model the interest rate on market funding is determined by the rate on government bonds plus a constant spread. While in practice the spread will also depend on the health of the bank, especially in periods of financial distress, such a link could not be modelled empirically due to a lack of data.

In the long-run, the bank aims at a stable ratio of capital to total assets, also termed the leverage ratio.

Table 3: Banking sector balance sheet in 2016

Billions of euros, unless stated otherwise; end of period[1]

Loans to households[2]	502.0	Deposits of households	405.1
Loans to non-financial corporations[2]	392.6	Deposits of non-financial corporations	319.3
Loans to MFIs	281.5	Deposits of MFIs	178.5
Loans to government	56.4	Deposits of government	8.1
Other loans[2]	200.4	Other deposits	264.9
Total loans	1432.9	Total deposits	1175.8
Shares and other equity	322.4	Debt securities	451.4
Fixed income and other assets	271.2	Other liabilities	261.7
External assets	477.3	External liabilities	466.0
		Capital and reserves	148.7
Total assets	2503.7	Total liabilities	2503.7
Total assets as % of GDP	*365.4*		
Capital and reserves as % of total assets	*5.9*		

[1] Monetary statistics.

[2] Not adjusted for securitizations and notional cash pooling.

[3] Includes other financial institutions and insurance and pension funds.

The level of the leverage ratio may for instance be set by the regulator or by equity or debt holders. The bank maximizes profit with respect to loans, deposits and other assets to determine the optimal lending and deposit rates. These rates are - in principle - functions of the composition of the balance sheet. It is assumed that the bank, for a given composition of the balance sheet, minimizes its operating costs with respect to labour and overheads. These minimum costs are a function of loans and other assets only.

The theoretical framework guides the specification of the long run equations for loans, deposits, lending rates and deposit rates. As usual in DELFI, the specification of the short run dynamics is (mostly) based on empirical fit.

Related literature

The theoretical framework deviates from the frictionless Modigliani-Miller world, in which changes in the composition of the balance sheet or changes in the capital ratio have no impact on the price and quantity of bank lending, and hence do not affect the real economy. In practice, the banking sector is far from frictionless and changes in the balance sheet composition and banking regulation do matter. A recent study by Bahaj and Malherbe (2016) provides an insightful elaboration of the theory of bank behaviour under capital regulation. The response of lending to a change in capital requirements is ambiguous due to the interplay between risk taking incentives and debt overhang considerations, which arise due to limited liability and government guarantees[10]. Risk-taking incentives are distorted as government guarantees induce banks to not fully internalize the downside risks from lending. Following Myers (1977) debt overhang considerations mean that a bank may not be able to repay its debt in full due to a poor quality of its assets. In that case banks are hesitant to fund projects with positive net present value because part of the returns are in fact transferred to (senior) debtholders. Bahaj and Malherbe show that the relationship between lending and the capital requirement is U-shaped. When capital requirements are low, an increase in the requirement generates a lending cut, but at higher levels, it generates an increase. Moreover, both the lending and the capital response are affected by the expected returns on loans. Banks mainly adjust to a higher capital requirement through cutting lending when expected returns are low, and by raising capital when they are high.

Most of the empirical literature indicates that banks respond to a strengthening of capital requirements by reducing lending and shrinking balance sheets. The US recession in the early 1990s triggered a number of empirical studies exploring the hypothesis that the economic downturn was at least in part - driven by a reduction in credit supply, i.e. the so-called credit crunch hypothesis. Bernanke and Lown (1991) argue that a shortage of equity capital has indeed limited banks' ability to make loans, although the size of the impact on bank lending was modest and the consequent impact on employment was found to be small. Based on data for banks in the region of New England, Peek and Rosengren (1995) show that poorly capitalized institutions downsized their balance sheets to satisfy capital requirements. More recently Berrospide and Edge (2010), using balance sheet data for large US bank holding companies, find that the effects of capital shortfalls on loan growth are relatively modest, while other factors such as economic activity and an increased perception of riskiness are found to be more important determinants.

For the UK several empirical studies suggest that more stringent capital requirements seem to induce banks to cut lending and reduce risk-weighted assets. Aiyar et al. (2012) show that regulated banks reduce lending in response to tighter capital requirements, while unregulated banks (resident foreign branches) increase lending. This "leakage" amounts to about one-third of the initial impulse from the regulatory change. According to Bridges et al. (2014) in the year following an increase in capital requirements banks reduce loan growth for commercial real estate, for other corporates and for household secured lending. Loan growth mostly recovers within three years.

In a study for the euro area Mésonnier and Monks (2015) used the EBA recapitalization exercise of 2011-12 as a quasi-natural experiment to test the impact of stricter bank capital requirements on lending to

[10]The interplay of debt overhang and risk shifting is also a key feature in a recent study by Jakucionyte and Van Wijnbergen (2018) exploring the macroeconomic impact of banking frictions.

the real economy. Controlling for individual bank characteristics and demand at the level of country of residence, their study documents a contractionary effect of an unexpected tightening of capital requirements on bank lending. The authors argue that the magnitude of the effects is at the lower range of the effects of regulatory capital shocks on credit supply found in the empirical literature. Kanngiesser et al. (2017), using a Bayesian VAR with sign restrictions, find that an increase in bank capital is attended by a decrease in corporate and mortgage loans and an increase in bank lending spreads for mortgages and corporate loans.

Other studies highlight the role of bank capital as a channel of monetary policy transmission or as a macroeconomic propagation channel. An early example of the former is Van den Heuvel (2002). In his model bank lending depends on the capital adequacy of the banking sector. Shocks to profitability and loan defaults have persistent effects on loan supply. A key finding is that lending by banks with low capital has a delayed and then amplified reaction to interest rate shocks, relative to well-capitalized banks. Jordà et al. (2017), in an empirical study of bank balance sheets for 17 countries based on historical data going back to 1870, argue that higher capital buffers lead to quicker recovery in the aftermath of a financial crisis. This finding is consistent with the evidence presented by Homar and Van Wijnbergen (2017), showing that timely bank recapitalizations significantly reduce the duration of recessions after financial crises.

Structural empirical macroeconomic models used in central banks and policy circles for forecasting and policy analysis have been adjusted to include the crucial role of the banking sector in the propagation of shocks. Miani et al. (2012) develop a model of the banking sector which is fully integrated into the Bank of Italy Quarterly Model, emphasizing the role of the bank capital channel and the default channel in modelling real-financial linkages. The changes introduced in the model result in an amplification of the responses of macroeconomic variables to monetary policy and world demand shocks, although, in normal times, the effect is not large. Barrell et al. (2010) outline a model of the UK banking sector which is nested within NiGEM (NIESR, 2018), a large-scale structural global multi-country model. This model can be used to trace the effects of raising (risk-weighted) capital adequacy ratios. In a more recent example, Burgess et al. (2016) develop a model for the UK linking real variables to a detailed financial sector using a stock-flow coherent database.

The empirical model of the Dutch banking sector

In the empirical model the interest rate equations are considered supply equations while the equations for loans to non-financial firms (NFCs) and loans to households are considered demand equations. In the loan equations, in the long run, the (own) interest rates are on the right hand side of the equation, consistent with downward-sloping demand curves in the theoretical Monti-Klein model. While variables related to the composition of the banks balance sheet are present in the long-run interest rate equations, they are absent from the long-run loan equations. In the short run, when guidance from economic theory is less strict, the banks' balance sheet composition may play a role in both the loan and the interest rate equations. For example, it may be easier for banks to adjust loan volumes rather than interest rates in the short run, see for example O'Brien and Whelan (2014), Bridges et al. (2014) and Aiyar et al. (2016).

Non-equity funding in the model is determined by the supply of deposits from households and firms, and the supply of market funding. Deposits equations are derived and estimated with reference to household and firm financial balances. Market funding is not very explicitly modelled in the standard empirical model, it is assumed to grow with the size of the economy. However, this assumption can be replaced in order to explore the likely effects of a wholesale funding shock on the bank balance sheet. An example of such a simulation exercise reflecting heightened tensions in wholesale funding markets is presented in Chapter 5.

Bank profits are modelled as the sum of 1) net interest income (interest earned on loans and other assets minus interest paid on deposits and other liabilities) plus 2) net other income (income earned on brokerage and other banking services and activities) less 3) operating costs and less 4) net impairments for bad loans. The banking sector model is completed through an equation for bank capital accumulation. Capital accumulates after-tax bank profits minus dividends in each period. It also allows for new capital issuance or recapitalizations and other changes in equity, captured by an exogenous add-factor in the equation.

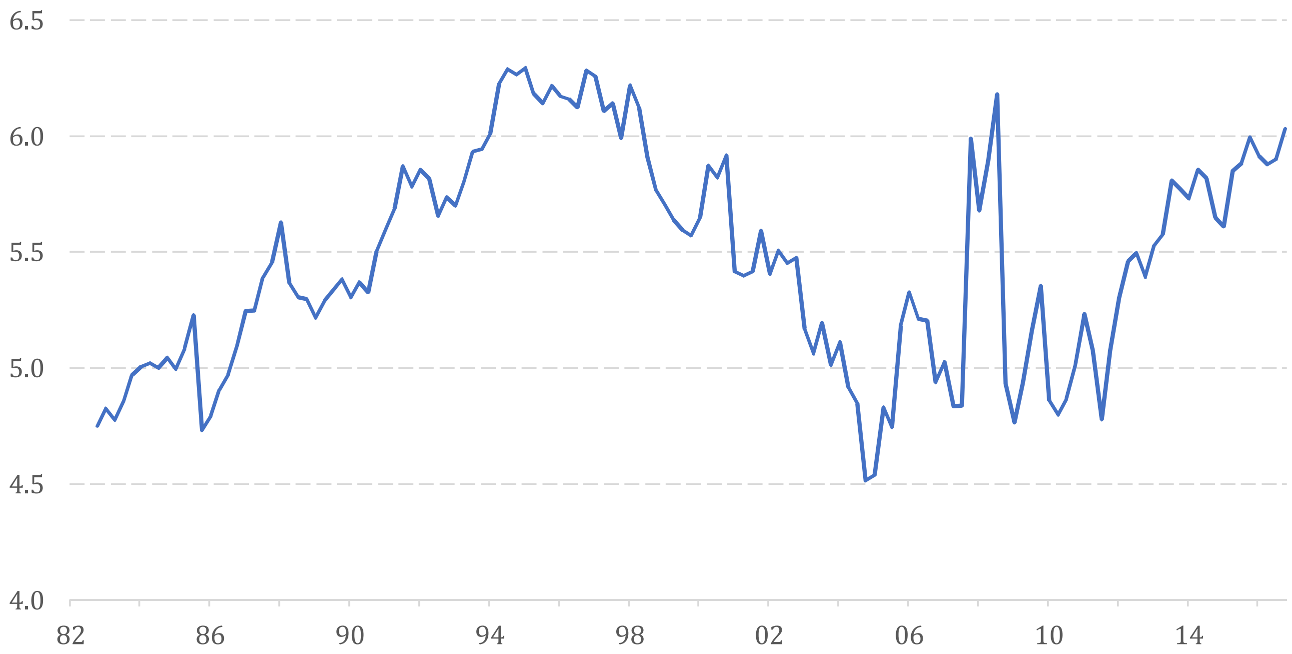
Changes in the composition of banks' balance sheets - reflecting solvency and liquidity - have direct effects on the behaviour of banks. In the empirical model a key role is played by the leverage ratio in deviation from target. The leverage ratio is defined as the banking sector's capital and reserves as a percentage of total assets[11], see Figure 6. The leverage ratio is computed using the monetary statistics. The sample mean is used as a proxy for the target leverage ratio, as it was not possible to construct a time series for the actual level of required capital for the banking sector as a whole. To illustrate its role imagine a negative shock to bank profits, reducing bank capital and leading to a decrease in the leverage ratio compared to its target. This will induce the banks to raise interest rates on loans, curbing the demand for credit, and also to reduce total assets, curbing the supply of credit, in the short-run. Furthermore, banks will cut dividend payments in order to limit the erosion of capital. The choice to use the leverage ratio rather than the risk-weighted capital ratio as the key transmission variable is empirically based. For simulation purposes the two ratios can be linked in order to explore the effects of changes in risk-weighted capital on loans and asset classes. See Chapter 5 for a simulation exercise highlighting the use of a risk-weighted capital ratio in the model.

Other key indicators of the banking sectors' balance sheet composition in the empirical model are the funding mix, measured as the share of total deposits in total bank debt, and the loan-to-deposit ratio,

[11]The leverage ratio is the inverse of that normally associated with measures of a firm's debt gearing. The erratic behaviour of the leverage ratio around 2007-2008 is due to the goodwill from Fortis' acquisition of ABN AMRO, which was written off when Fortis/ABN had to be nationalized.

Figure 6: Leverage ratio banking sector

Percentage



defined as total loans to households and firms divided by total deposits held by households and firms. Below the various parts of the empirical banking sector model are discussed in more detail.

Interest rates and the cost of market funding. Banks set four interest rates: the mortgage interest rate, the lending rate for firms, the interest rate on household savings and the interest rate on the savings of firms. The exogenous short-term EURIBOR rate and the 10-year government bond rate are important determinants of retail rates. Full pass-through from these market interest rates is not rejected for lending rates, however the empirical results firmly reject the hypothesis of full pass-through for savings rates. The estimated coefficients of the short-term and long-term market rates can be interpreted as capturing the maturity of the funding sources for the respective loans.

The deposit rates for households and firms also depend on the loan-to-deposit ratio. An increase in this ratio ceteris paribus induces banks to increase deposit rates in order to attract deposits. The deposit rate for firms is inherently more volatile than that for households. As firms deposits are not covered by the deposit guarantee system and thus face higher risk, there would be a good argument for making the rate conditional on the health of the banking sector. A plausible empirical representation of such a link over the sample period has not been found.

The lending rates to households and NFCs depend on various other determinants apart from market rates. A higher CDS spread for the Dutch banking sector, which captures banks' difficulties in obtaining market

Table 4: Effect of 1 percentage point increase in capital ratio on lending rate

	lending rate	lending rate firms	lending rate households
Elliott (2009)	[4.5,19.0]		
Macroeconomic Assessment Group (2010)	[15,17]		
Basel Committee on Banking Supervision (2010)	13		
Berben et al. (2010)	22	11	19
Institute of International Finance (2011)	[30,80]		
Slovik and Cournède (2011)	[8,20]		
Elliott et al. (2012)	[5,15]		
Ishikawa et al. (2012)	3		
Miles et al. (2013)	5.5		
Oxford Economics (2013)	15		
Akram (2014)	14		
Meeks (2017)		10	28
Burgess et al. (2016)		15	

funding, feeds through into higher lending rates for both households and firms. Not surprisingly, the lending rate to firms is affected by cyclical conditions: more slack and an increased bankruptcy probability come with a higher risk premium in lending rates to NFCs. The funding mix also has an impact on the long-run determination of lending rates to firms, albeit small. This captures the fact that deposit funding is typically more expensive than other non-equity funding. Last but not least, the leverage ratio affects the long-run lending rates to households and NFCs. A decrease in the leverage ratio compared to target (i.e. lower excess capital) results in higher lending rates.

It turned out to be difficult to estimate the impact of the leverage ratio on the lending rates based on the available data for the aggregate Dutch banking sector. However, without a meaningful feedback of excess capital on lending rates the adjustment of the banking sectors' balance sheet after a shock to the banking system would become implausibly slow. Therefore, the coefficient for the deviation of the leverage ratio from target in the long-run equation for lending rates is calibrated. The calibrated coefficient is set equal to -0.15. This means that a 1 percentage point increase in the target leverage ratio will lead to an increase in lending rates of 15 basis points. This is in line with results from Macroeconomic Assessment Group (2010), Burgess et al. (2016) for the UK and Akram (2014) for Norway among others, see Table 4.

The cost of banks' market funding (other than deposits and equity) and the yield on banks non-loan assets are both taken to depend on the short-term market interest rate plus a fixed margin. The assumption of a fixed margin can be replaced to allow for the fact that investors demand a higher return for a given amount of funding if a banks balance sheet is in bad shape (see Chapter 5).

Loans and other financial assets. The banking sector's balance sheet includes various assets and liabilities. In terms of real-financial linkages, the equations for loans and deposits of households and firms are crucial and most elaborate. In the long-run the demand for loans by Dutch firms is driven by business investment, measured in current prices. The equation includes the ratio of international stock prices to GDP as a proxy for equity markets as an alternative source of funding for Dutch firms. Higher levels of investment will increase the demand for loans while an improvement in the stock markets will ceteris paribus reduce the demand for bank lending as a source of funding. The lending rate in real terms is included as a measure of the price of bank credit to firms. The dynamics of the growth of loans to firms depend on the deviation of the leverage ratio from target reflecting short-run credit supply effects. The estimation results indicate that a higher (lower) level of excess capital ceteris paribus enhances (reduces) bank lending.

The demand for loans by households in DELFI is disaggregated into three separate categories: mortgage loans, credit for consumption purposes and other credit. Mortgage debt is modelled from the perspective of the household, not the bank. This means that the dependent variable includes non-bank lending; this is mainly from SPVs but also mortgages issued by pension funds, life insurance funds and investment funds. In the long-run equation, household mortgage debt is consistent with households allocating a fixed share of disposable income before taxes and interest payments to mortgage interest payments. An autonomous s-shaped term captures the secular increase in household mortgage debt in the 1990s, driven by changes in legislation and a de facto softening of credit standards by banks. In the short run the estimation results indicate that credit supply effects also affect mortgage lending to households: a higher leverage ratio compared to target is attended by a higher growth rate of mortgage loans. Mortgage lending dominates total bank lending to households. In 1996 over 80% of total loans to households were for residential mortgages; that share has increased steadily since then to 94% by 2016.

The other assets on the balance sheet of the banking sector are modelled using simple rules-of-thumb. Loans to MFIs, government, and other loans are assumed to grow at the same rate as nominal GDP (capturing the influence of economic activity) and further depend on the deviation of the leverage ratio from target (capturing the impact of excess capital). The feedback coefficient for the latter is set equal to the estimated coefficient in the equation for loans to NFCs. External assets, securities and other assets are each assumed to grow at the same rate as total loans.

Deposits and other financial liabilities. Domestic firms' holdings of deposits are driven by economic considerations. Bates et al. (2009) identify four reasons to hold deposits. First, firms hold cash to conduct transactions. Second, for precautionary reasons. Third, for tax motives and fourth, for agency reasons.

The firm will equate the marginal cost of holding an extra euro on deposit to the marginal benefit of having liquidity when needed. Opler et al. (1999) suggests that increases in cash flow, which is correlated to profits, increases firms cash holdings. Furthermore, a firm's cash flow seems to become riskier when the size of operations increases, which may induce firms to bring their deposit holdings in line with sales and costs. In the empirical model the long-run demand for deposits of domestic firms depends on nominal value added generated by the business sector to proxy for changes in firms' turnover and profitability. Moreover, the marginal benefit of holding deposits increases when the real interest rate on these deposits increases.

The demand for household deposits is a function of household income and the real rate of return on deposits. There has been a noticeable acceleration in holdings of deposits relative to income since around 2000. This change in behaviour cannot be explained by changes in the equity premium or the real interest rate. In the model it is related to the life expectancy for men, the rationale being that higher life expectancy will increase the need for savings[12].

Deposits held by government, MFIs and other sectors, as well as external and other liabilities, are linked to the growth rate in the overall economy. This is a technical assumption designed to ensure that the bank balance sheet grows with the size of the economy. The equation for debt securities on the balance sheet is defined as a residual item which ensures that total assets equal total liabilities on the balance sheet.

The empirical banking model: discussion

The empirical banking model offers an approximate description of how the banking sector in the Netherlands responds to shocks in bank capital by changing retail rates and (short-term) credit supply volumes. As far as possible the behaviour of the banking sector reflects patterns found in the data. In the standard model version banks raise lending rates, and reduce lending volumes, other assets and dividend payments in response to an increase in capital requirements, with a downside impact on economic activity. This leads to a gradual recovery of the capital position.

Where needed the standard model can be adjusted to capture and simulate alternative mechanisms and scenarios. For instance, if banks have to comply immediately with stricter capital requirements, the model allows for building in a speedier adjustment process by issuing new equity or raising loan rates and reducing lending even further. Higher capital buffers may also come with positive effects when they lower the probability of a bank default and thereby decrease its cost of capital. This mechanism is absent in the standard version of the model, but could be included or taken on board in the design of relevant simulation

[12]Two recent empirical studies investigating savings behaviour use life expectancy as an explanatory variable. Bloom et al. (2007) in a cross-country panel study of the savings rate for 57 countries find that life expectancy is only significant in the presence of a social security system where there are incentives to retire at a particular age (as is the case in the Netherlands). In this case higher life expectancy leads to increase savings for a longer retirement. More recently El Mekkaoui de Freitas and Martins (2014), in a panel study of national savings rates for 22 OECD countries, find a positive link between longevity and savings.

exercises. Although wholesale funding costs are tied with a fixed margin to short-term interest rates, the model offers the flexibility to deviate from this assumption and to simulate the effects of a shock to market funding costs. See Section 5.1 for an example. There it is shown that higher capital buffers - by means of recapitalizations or issuance of new equity - help to mitigate the impact of severe market stress on economic activity.

3.6 Pension funds

A large majority of Dutch employees saves for retirement by compulsory participation in occupational pension schemes. In 2016 total assets managed by pension funds amount to about EUR 1270 billion, which is 180 percent of GDP. It goes without saying that the pension sector is a potentially important link through which developments in the financial sphere affect the real economy. The representative pension fund receives pension contributions from employers and employees. It invests these contributions in fixed-income securities (bonds), equities and other financial assets, and real estate, amounting to approximately 50%, 40% and 10% of total assets, respectively. The pension fund's liabilities consist of (future) claims of current and future pensioners. In the regulatory framework pension funds assets and liabilities are based on market valuation. The market value of the assets depends on the development of factors affecting the return on pension savings such as (long-term) interest rates, the duration of bonds, international equity and real estate prices and exchange rates. The market value of pension liabilities is the present 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 16 years, which is much longer than the 7-year duration of the pension fund's portfolio of fixed-income securities. This duration gap makes pension funds sensitive to changes in the long-term interest rate.

The pension funds' funding ratio, i.e. the ratio of the market value of pension assets to the present value of pension liabilities, is the key information variable around which decisions on the rate of pension contributions and indexation allowances are centered. In the new model version DELFI 2.0 six main drivers of the annual change in the funding ratio - termed $frpfr_1$ to $frpfr_6$ - are distinguished (for technical details see Annex A):

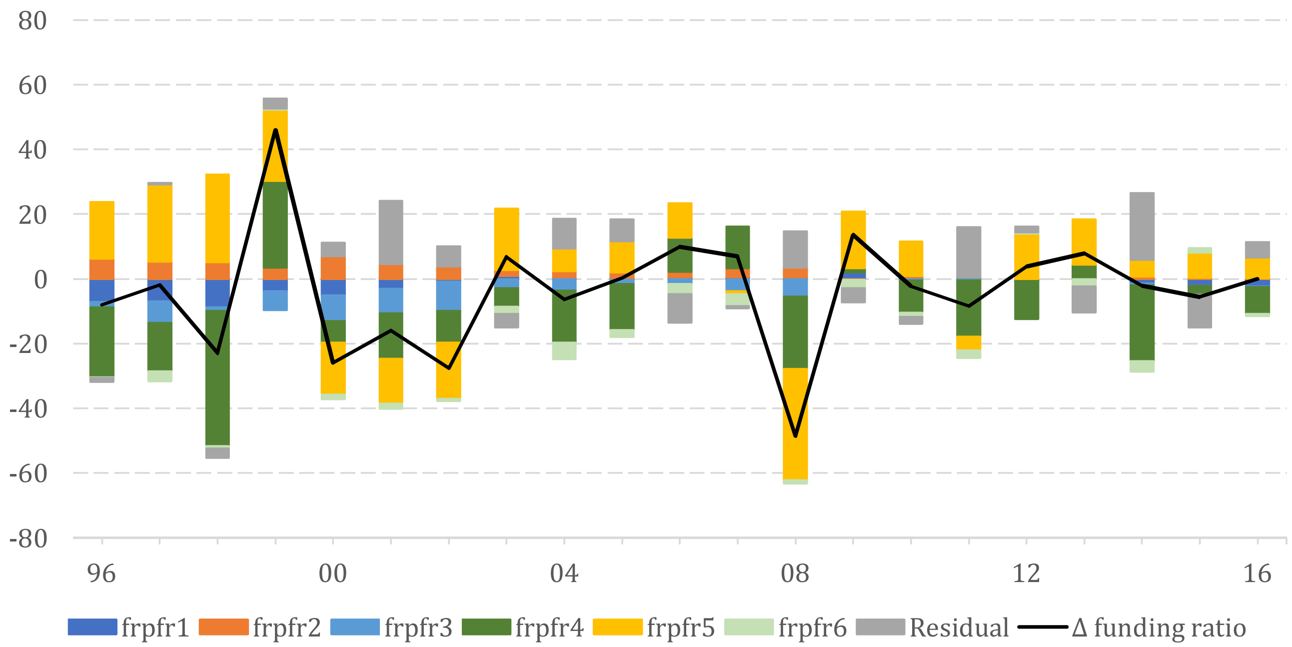
- $frpfr_1$: pension contributions. If the actual pension contribution exceeds the actuarially fair contribution, the funding ratio increases.

- $frpfr_2$: pension benefits. Pension benefits lead to an increase in the funding ratio where the funding ratio at the outset is above 100%. The funding ratio will decrease if the funding ratio at the outset is below 100%.

- $frpfr_3$: indexation allowances. A higher indexation allowance results in a lower funding ratio. A

Figure 7: Funding ratio pension funds

Percentage points



negative indexation allowance or an outright cut in pension benefits leads to a higher funding ratio.

- $frpfr_4$: impact of the term structure of interest rates on liabilities. Higher interest rates lower the present value of pension liabilities and result in a higher funding ratio.
- $frpfr_5$: impact of the returns on pension savings. If the return on pension savings increases and lies above the return required to maintain the level of technical pension provisions, the funding ratio increases.
- $frpfr_6$: life expectancy. An increase in life expectancy lowers the funding ratio.

To calibrate the six drivers microdata on Dutch pension funds have been used. A one percentage point shift in the yield curve leads to a 16 percentage points increase in the funding ratio ($frpfr_4$), while a one year increase in life expectancy leads to a 9 percentage points lower funding ratio ($frpfr_6$). Apart from these six drivers there is a residual term that is left unexplained. The direct impact of each of the six drivers as described above holds under the *ceteris paribus* clause. The residual term could therefore include the interaction of the six main drivers as well as other factors affecting the funding ratio. Figure 7 shows that $frpfr_4$ and $frpfr_5$ are the most important factors in explaining the change in the funding ratio. Unexplained residuals are relatively large in 2001, 2011 and 2014.

If the funding ratio falls below a critical level pension funds have to present a plan to restore it. They can cut indexation or increase the rate of pension contributions to reach the required funding ratio over a specific recovery period. If pension funds decide to apply only partial indexation of pension obligations, pensioners will experience a drop in their disposable income. The standard version of the model explicitly includes a decision rule for indexation allowances. When the funding ratio is above 140 percent pension funds provide 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 (20%) and wage inflation (80%). If the funding ratio is below 100 percent, there is no indexation allowance. If the funding ratio is lower than 140 percent but higher than 100 percent, there will be partial indexation that linearly moves from full indexation at a funding ratio of 140 to no indexation at a funding ratio of 100. The discretionary decision to change the rate of pension contributions is not part of the standard model, but DELFI 2.0 allows for the option to include such a rule. Pension contributions are paid partly by employers and partly by employees. Employers' pension contributions are part of their labour costs, so that changes in contributions affect firms' profitability, labour demand, investment and the cost price of output. For the employees, changes in pension contributions impact their disposable income.

3.7 Current account transactions

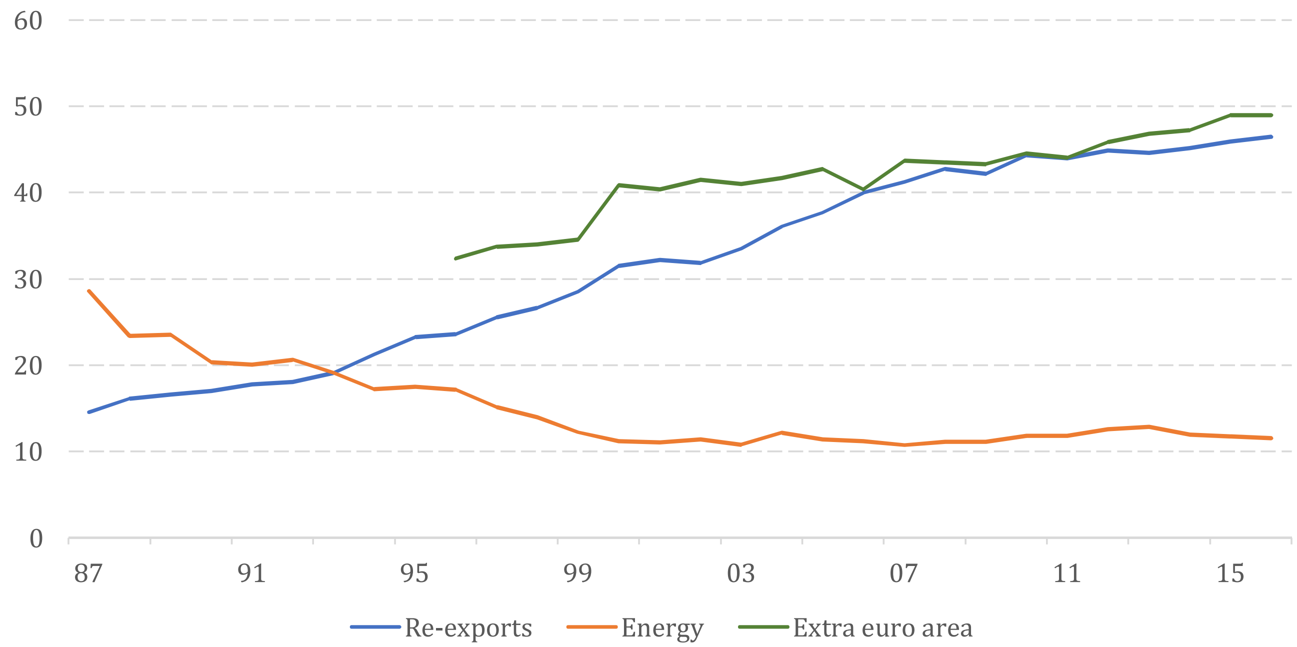
Exports and imports of goods and services

The volume of home-made exports excluding energy, re-exports and energy are modelled separately; no distinction is made between goods and services. The long-run determinants of home-made exports excluding energy include foreign demand (with an elasticity of one) and price competitiveness (elasticity of -1.8). Estimation of the price elasticity has always been difficult, generally delivering implausibly low and insignificant parameter values. If, however, account is taken of the simultaneity of exports and export prices, exports' sensitivity to price competitiveness rises. The 1.8 is close to the 'Tinbergen's two' (Tinbergen, 1952), but is smaller than estimates usually found utilizing micro data (see for example Imbs and Mejean, 2015). In practice, the dynamics in foreign demand and price competitiveness fall short in explaining the persistent drop in the market share of Dutch home-made exports in world markets. The growth rate of international trade, for example due to the entrance of China in the world market, has outpaced that of Dutch exports by a considerable margin in past decades. Therefore, the ratio of foreign demand over GDP in OECD countries is included, which acts as a proxy for "globalization", as an additional explanatory variable. The variable has the expected negative sign. In the short run, exports growth is also significantly affected by foreign demand and price competitiveness.

Making a distinction between home-made exports and re-exports is important because re-exports make up a large share of total exports and have a different composition. Also, since the import content of re-exports is very high, one additional euro of re-exports has a much smaller impact on GDP compared to a one euro increase in home-made exports. Close to half of total exports of goods and services are re-exported goods and services that are bought and imported by Dutch companies and exported again, see Figure 8.

Figure 8: Re-exports, exports of energy and extra euro area exports

% total volume of exports



These goods cross the Dutch mainland because of the attractive location (harbours, rivers, airport-hub), its well-developed expertise and infrastructure as regards logistics and distribution, and to some extent the relatively high international ranking in terms of overall 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. 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. According to a formal stability test, the impact of both world demand for semiconductors and the above-mentioned investment ratio have become somewhat weaker in recent years. In contrast to home-made exports, re-exports have significantly gained market share in past decades. Again, this is captured by the ratio of foreign demand over GDP in OECD countries, which now enters with a positive sign. The volume of re-imports directly follows from the volume of re-exports. Re-exports excluding energy is calculated as a residual assuming a fixed share of energy products is re-exported.

The long-run determinants of energy exports are GDP in OECD countries and the value added of the mining and quarrying sector in the Netherlands. The former variable serves as a proxy for the demand for energy products from abroad. The latter variable is closely related to the production of natural gas, which is in part exported and in part consumed domestically.

Table 5: Current account transactions in 2016

Billions of euros

	receipts	payments	balance
1. Goods and services	579.3	502.0	77.3
o.w. re-exports	268.1	233.1	35.0
2. Income account	208.6	217.0	-8.4
3. Current transfers account	11.1	18.3	-7.3
4. Adj. for equity in pension funds reserves			-0.4
5. Current account (5=1+2+3+4)	799.0	737.3	61.2

The model also provides a breakdown of total exports into exports to euro area countries ("intra euro area exports") and exports to non-euro area countries ("extra euro area exports"). The share of extra euro area exports in total exports is explained by the ratio of the demand from euro area countries to total foreign demand. Intra euro area exports equal total exports minus extra euro area exports.

Imports (excluding energy and import for re-exports) depend on weighted final demand. Weighted final demand is calculated as the sum of the demand components weighted by their import shares. The import shares are taken to be fixed numbers, and are equal to the averages calculated over 2007-2016. These imports are modelled along the same lines as home-made exports, with final 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 react stronger to changes in domestic demand. In the previous model version imports were also positively related to the output gap. With the newly available data, this mechanism turned out to be no longer significant.

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 20 percent of all current account transactions, current transfers about 1 percent (see Table 5). By definition, adding up the net values of these three balances gives 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.

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). A stylized model is adopted to describe the income flows arising from these cross-border investment holdings. Investment income receipts are explained by GDP in OECD countries, whereas investment income payments are determined by GDP growth in the Netherlands. Both investment income receipts and payments are positively related to globalization, again approximated by the ratio of foreign demand to GDP in OECD countries.

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 2.0, the size of income transfers is related to GDP abroad (measured by GDP in OECD countries) and Dutch GDP, respectively.

3.8 Government and social security

The government sector in DELFI consists of the government sector in a narrow sense and social security funds. Table 6 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. Because the model singles out the banking sector from other firms, direct taxes paid by corporations are broken down into taxes paid by the banking sector and taxes paid by other corporations. Consequently, the profitability of the banking sector directly affects the governments' balance, which provides another example of the interaction between the financial sector and the real economy in the model. Non-tax receipts like government revenues from gas exploitation are also modelled.

On the expenditure side, modelling depends on the intended use of the model. When the model is to be used to produce projections, the latest stance of policy measures is taken into account, which implies that many expenditure items are exogenised. In simulations, however, expenditures may behave endogenously. For example, the default is that contractual civil service wages follow directly from contractual wages in the private sector. A stylized version of the 'real expenditure framework' is incorporated. 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. Social security and assistance benefits depend on contractual wages or 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, the age composition of the population and life expectancy.

The model provides an account of the transactions with the EU budget. Many items are exogenous, with

Table 6: General government revenue and expenditure in 2016

Billions of euros

Revenue		Expenditure	
Current taxes on income and wealth	82.0	Compensation of employees	61.0
Taxes on production and imports	81.8	Intermediate consumption	40.9
		Interest payable	7.6
Sales	23.4	Subsidies	8.4
Net social contributons	107.4	Social security benefits	112.0
		in cash	55.3
		in kind	56.8
		Social assistance benefits	39.3
		in cash	23.9
		in kind	15.4
Other current revenue	10.8	Other current transfers	9.5
Capital revenue	2.4	Capital expenditures	26.6
Total revenues	307.8	Total expenditures	305.2

the exception of taxes paid and GNP payments of the general government to the EU budget (included in other current transfers).

The government balance is the difference between total revenues and total expenditures. The current period government debt is the sum of previous period's government debt, the government balance and any (exogenous) deficit debt adjustment. The latter includes among other things transactions related to the bail out of financial institutions.

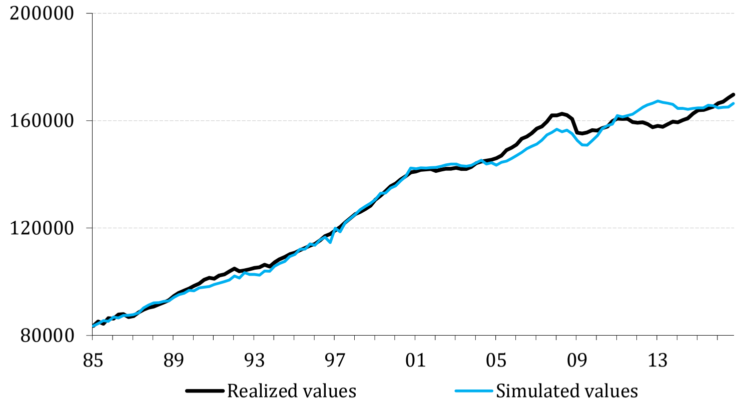
3.9 Dynamic simulations

As a measure of the overall fit of the model to the data, this section presents the results of a historical tracking exercise. The historical data record is compared to the solution of the model based on a full-model in-sample dynamic simulation. In a dynamic simulation, starting from given initial conditions, one period's solution for the endogenous variables in the model provides values for the lagged endogenous variables in the calculation of the next period's solution, while exogenous variables take their known values. The dynamic simulation starts in 1985Q1 and ends in 2016Q4. This period of 32 years broadly coincides with the sample over which the model equations have been estimated. In the simulation the residuals of each equation are set equal to their sample average, which is usually close to zero. However, when residuals reflect (non-modelled) changes in policy, they retain their known values. This applies particularly, but not exclusively, to various equations in the fiscal block of the model, such as equations for employers and employees social contributions, taxes on wages and income, old age pensions, unemployment insurance, but also the number of persons receiving benefits of various kinds. Furthermore, a number of extremely large residuals are kept, including residuals in equations for business investment, house prices and some of the trade deflators. These large residuals reflect extreme outlying observations, which normally are captured by dummy variables, but not in these instances. This dynamic simulation constitutes a severe test of the model.

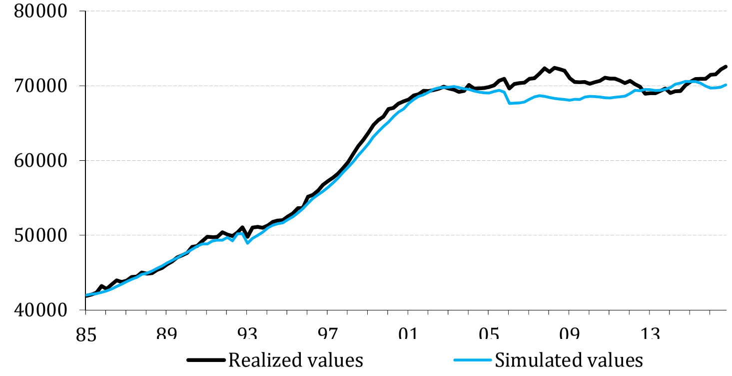
Figures 9 to 11 present the full-model dynamic in-sample fit for a selected number of endogenous variables; black lines are historical data and blue lines depict simulated values. The quality of the fit varies across variables. Since the results mostly speak for themselves, they are only briefly described here. Regarding the demand side of the economy, DELFI is able to track GDP and private consumption reasonably well. But the large swings in both residential and business investment observed since the mid 2000s remain for a greater part unexplained. Also the fit of the labour market is satisfactory. Although the gap between the simulated unemployment rate and the historical data is substantial every now and then, the two series remain reasonably aligned. More detailed analyses show that the discrepancies between the actual and simulated unemployment rate are not caused by a lack of fit of the employment equation *per se*, but are brought about by the simultaneity of model. In particular, errors in private sector value added, which is a key determinant of employment, are important. DELFI explains negotiated wages of the private sector fairly well, except for recent years. The latter is related to the under-prediction of the unemployment rate. Concerning prices, the fit of HICP inflation - which is typical of the fit of domestic prices in the model - is adequate, save for the final part of the sample, where errors in negotiated wages and inflation seem to be mutually reinforcing. Turning to the housing market, DELFI is able to track the upswing in house prices and mortgage credit until the mid 2000s well, but thereafter - like in the case of residential investment - is less successful in explaining the episode in which house prices went through a severe cyclical lull. This lack of fit of house prices is related to that of mortgage credit, but other factors, such as the unemployment rate, play a role as well. Loans to non-financial corporations ranks high among the variables that are difficult to explain: fundamental drivers, such as investment, value added, equity prices and interest rates, can only account for a limited share of its fluctuations. Looking at the banking sector's balance sheet more broadly, the model can track the leverage ratio fairly well, except for the last few years. In these years, the growth rate of the banking sector's total assets slowed markedly, in part by unexplained factors such as banks disposing of part of the international operations. Finally, the model accounts for most of the dynamics of the government balance as a percentage GDP; the errors mainly reflect errors in government revenues.

Figure 9: In-sample simulations

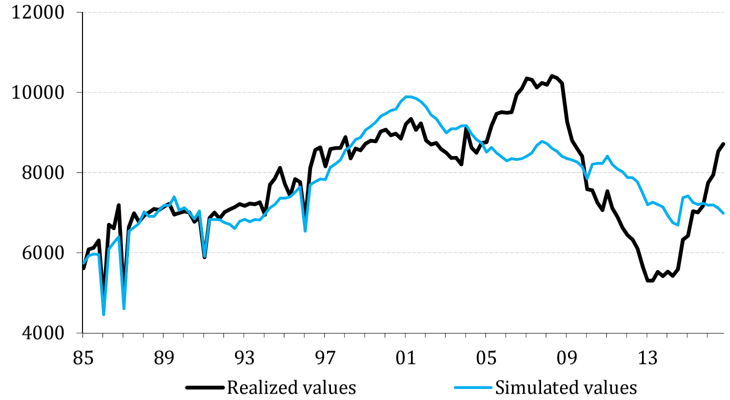
Million of euros



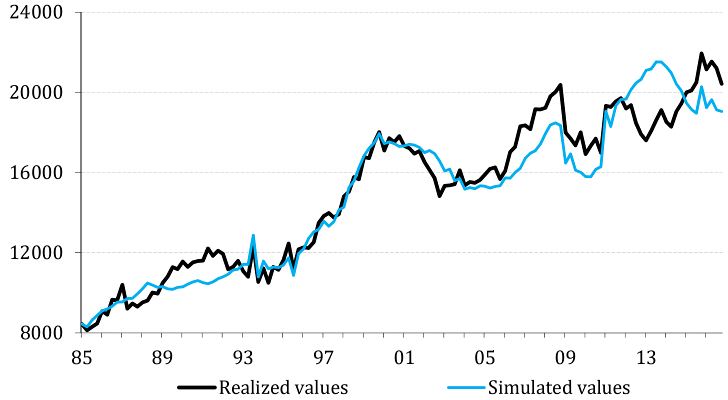
(a) GDP



(b) Private consumption



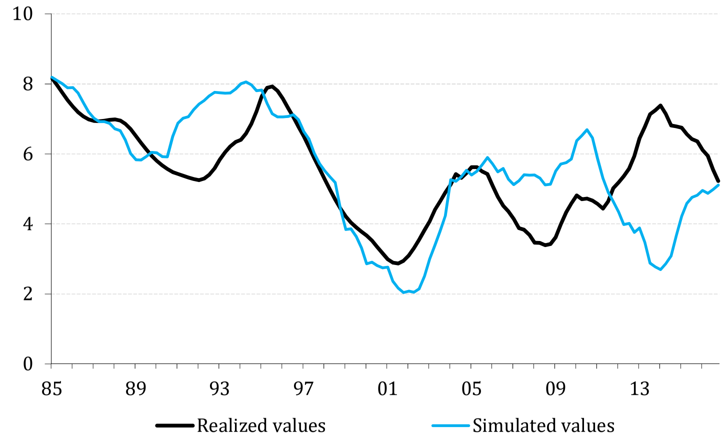
(c) Residential Investment



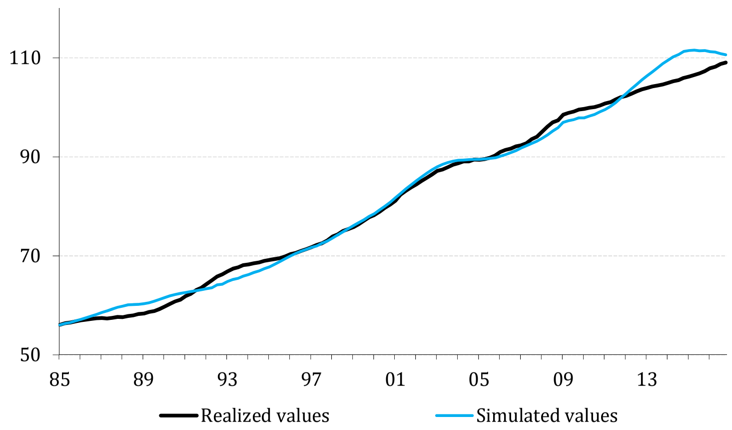
(d) Business Investment

Figure 10: In-sample simulations (2)

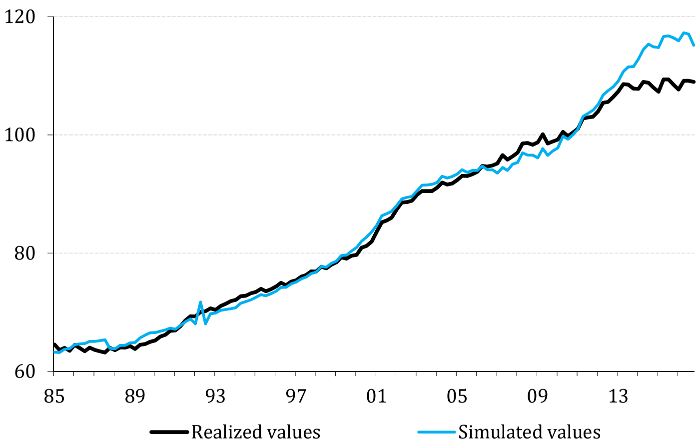
Million of euros, unless stated otherwise



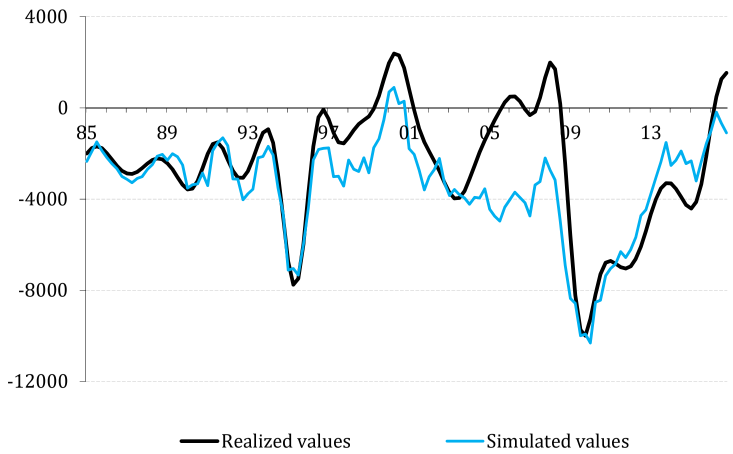
(a) Unemployment rate[1]



(b) Negotiated wages[2]



(c) HICP[2]



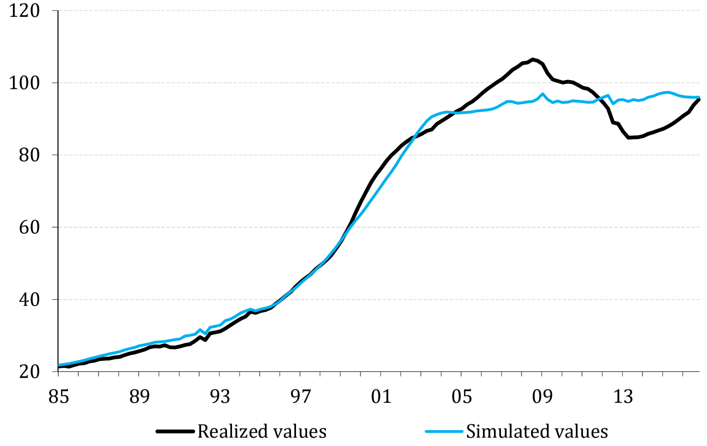
(d) Government balance

[1] Percentage points.

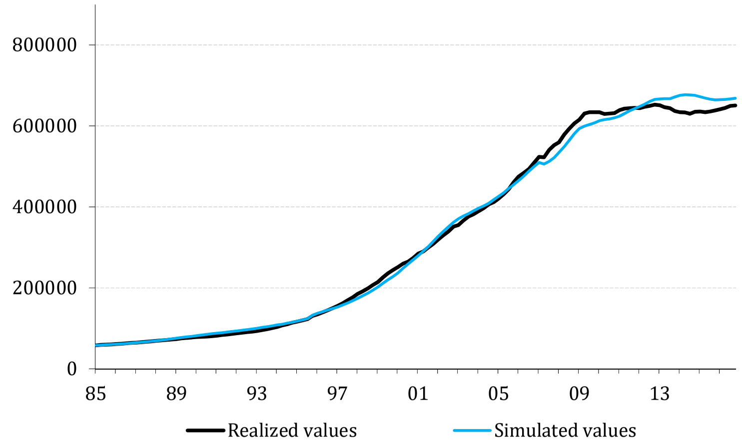
[2] Index 2010=100.

Figure 11: In-sample simulations (3)

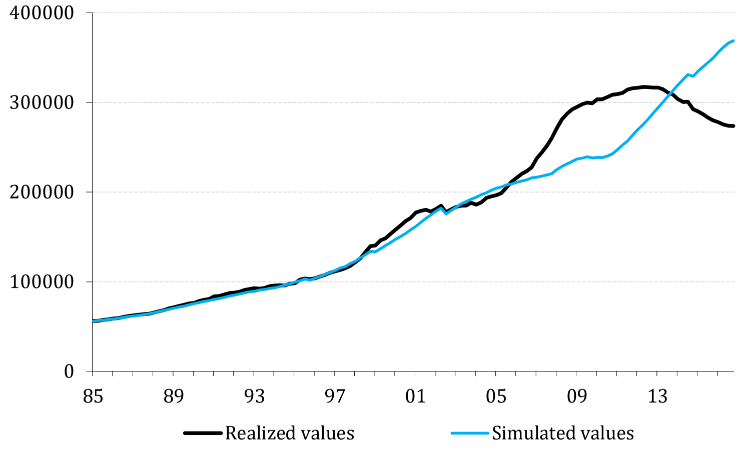
Million of euros, unless stated otherwise



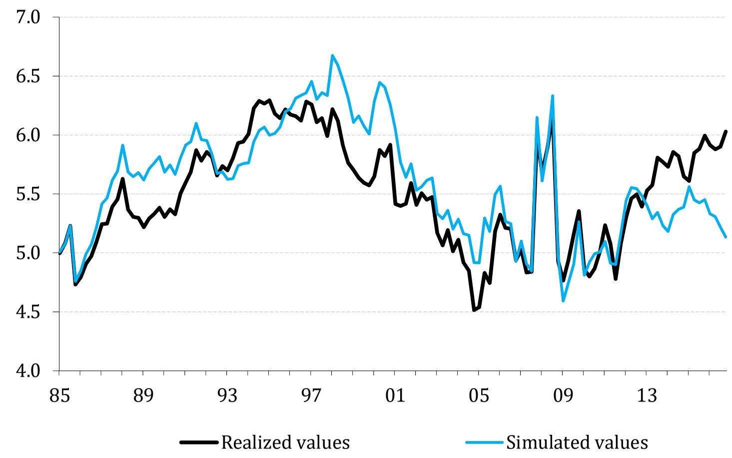
(a) House prices[2]



(b) Mortgages



(c) Loans to non-financial corporations



(d) Banks' leverage ratio[1]

[1] Percentage points.

[2] Index 2010=100.

3.10 Long-run version of DELFI and convergence to steady state

As outlined before, the specification of DELFI tries to balance long-term theoretical rigour and short-term dynamics that describe the data well. In particular, the use of error-correction mechanisms in many behavioural equations is expected to support convergence to the theoretically founded steady state. Having a steady state is not only a technical necessity but in policy scenarios it is also often important to have a gauge of the long-term consequences. Despite the presence of error-correction mechanisms, it is however not clear *a priori* whether the model converges to a proper steady state. One approach to study the long-run properties of the model and to assess its steady state is to carry out long run simulations with the model, for a given path of the exogenous variables (foreign prices, foreign demand, trend productivity, interest rates, population). This method not only gives information on the steady state of the model, but on the speed of convergence towards equilibrium as well.

When carrying out such a long run simulation with DELFI, it becomes evident that the model does not mechanically converge to a steady state. This should not come as a surprise. Over the past decades, the Dutch economy has experienced numerous structural changes. For example, the share of re-exports in total exports has surged, the unemployment rate is nowadays much lower than in the early 1980s and the price of investment goods has dropped considerably relatively to that of consumer goods. The specification of DELFI reflects these, and various other, structural changes. Hence, for DELFI to converge to a steady state or balanced growth path, along which all volumes grow at the same rate and all prices grow at the same rate, its specification has to be adjusted in a number of places. In this so-called long-run version of DELFI, market shares in trade, relative prices and wages, and other big macroeconomic ratios are constant in the steady state, while the output and unemployment gaps close and inflation is on target. To achieve this, trends in export equations that capture structural changes in market shares are dropped, house prices are linked to consumer prices (price homogeneity), household benefits are related to changes in negotiated wages so that both employed and unemployed and old age pensioners share the same increase in income and wealth, a fiscal solvency rule is introduced that stabilizes the government balance (and debt) as a percentage of GDP, and the long run price elasticity in the export equation is increased to speed up convergence. Finally, the delay by which prices respond to changes in unit labour costs, which varies between two and thirteen quarters, is shortened to one quarter.

Figures 12 and 13 report the transition to the steady state for a number of variables. Since the out-of-sample simulation is fully model based and many exogenous variables jump to their steady state values immediately, the transition path should not be interpreted as a meaningful projection. The figures do show that the model converges to a proper steady state in which the output gap and unemployment gap are close, and GDP and HICP attain the imposed steady state growth rates of two percent.

In practice, the speed at which the model returns to the steady state depends on the starting point of the

Figure 12: Convergence of output gap and unemployment gap

Percentages

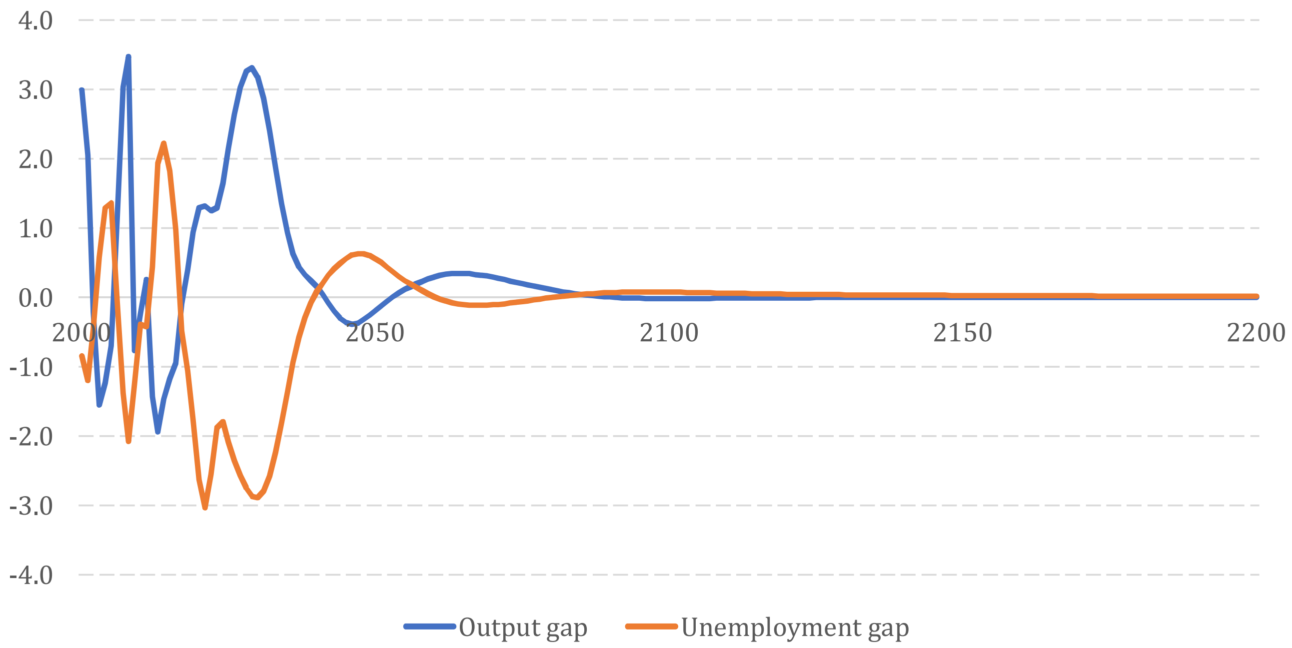
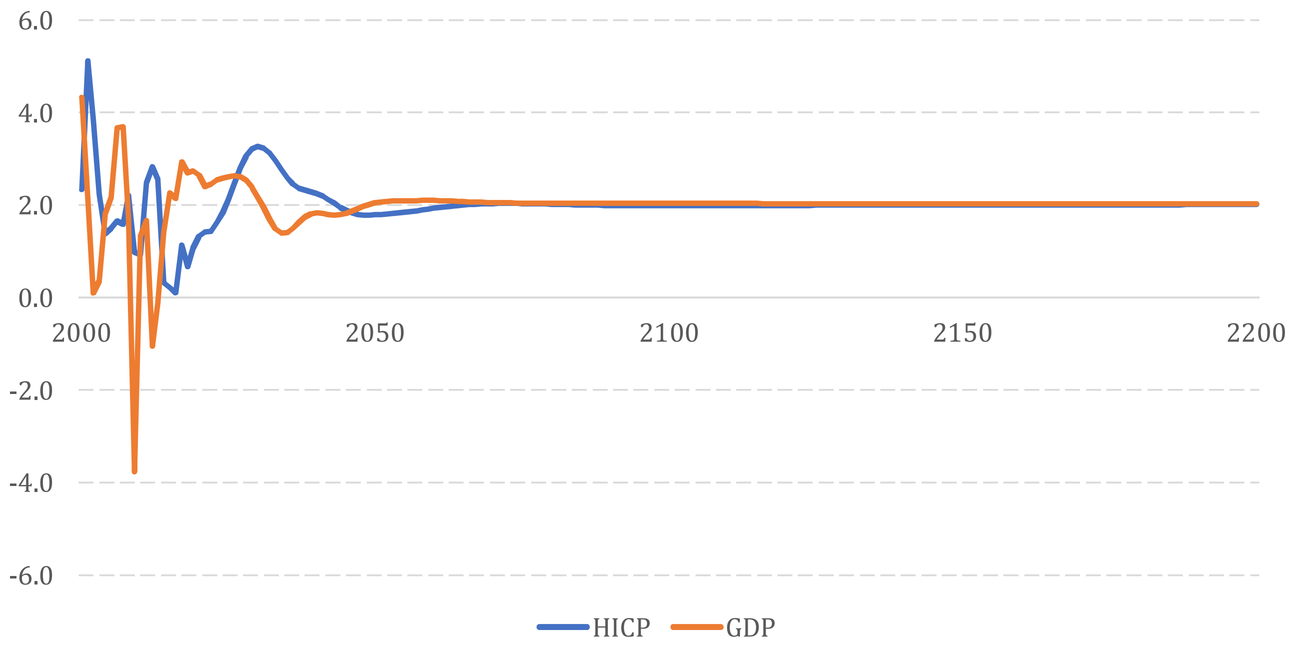


Figure 13: Convergence of GDP and HICP

Percentages



simulation, or the mix of shocks that hit the economy. To have a better idea of the speed of adjustment to equilibrium, stochastic simulations of the model around the steady state are conducted. The model is

Figure 14: Stochastic simulations output gap

Percentages

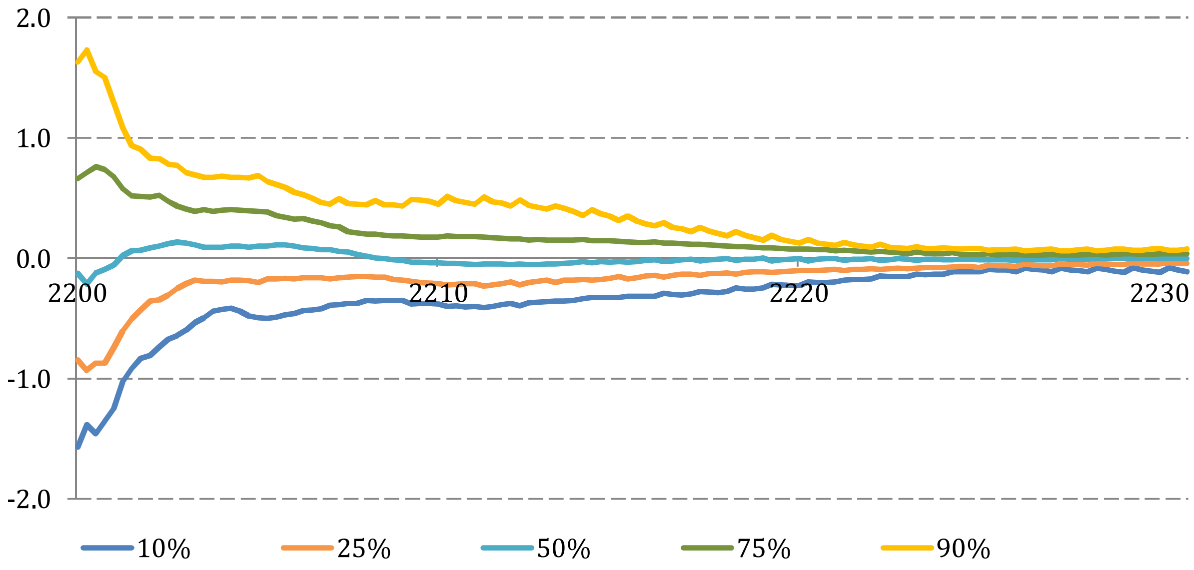
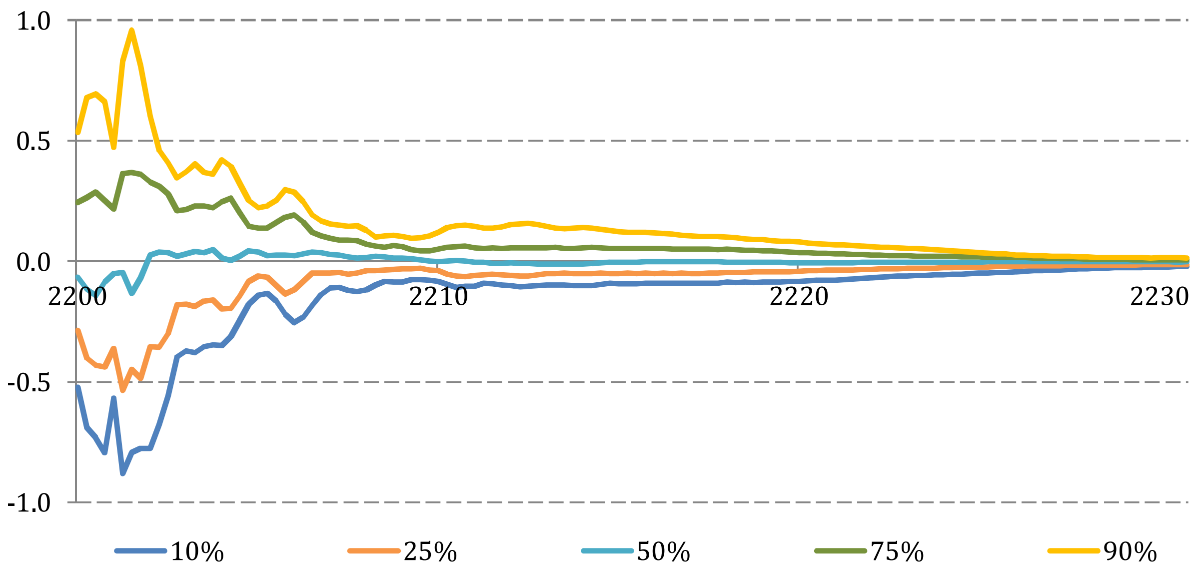


Figure 15: Stochastic simulations HICP

Percentages



simulated 500 times around the steady state in 2200Q1. The residuals of all model equations are shocked for one quarter. Shocks are drawn from a normal distribution, with the standard deviation equal to the ones observed historically (1980Q1-2016Q4). The shocks are assumed uncorrelated across model equations. Figures 14 and 15 present the 10%, 25%, 50%, 75% and 90% percentiles of the responses for each period, in the form of percentage point deviations from baseline. The figures indicate that after approximately 20 to 25 years, the steady state is reached. This speed of convergence is similar to that of the ECBs area-wide model (Fagan et al., 2005).

4 Scenario analysis using DELFI

The scenarios 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. An obvious example is to analyse how the Dutch economy responds to changes in the volume of world trade or how it is affected by shocks to global stock markets and exchange rates and commodity prices. A second type of scenario concerns changes in policy instruments. Here one could think of monetary or fiscal policy instruments (changes in policy interest rates, public sector spending and tax policies, changes in social security or pension contributions) and regulatory policies. Finally, there is a large heterogeneous set of hypothetical questions which can be addressed. For instance, one could analyze how restrictions in credit supply, changes in house prices or changes to price and wage mark-ups would affect the Dutch economy.

Each of the scenarios presented in this chapter focuses on the effects of changes in just one particular variable. Of course, in practice this is not always realistic. In the oil price scenario the international repercussions of higher oil prices are taken on board by implementing accompanying shocks to world trade and prices based on simulations with the NiGEM model (see NIESR, 2018). In principle results from the individual scenarios can be combined to answer more complicated 'what if' questions. However, one should be careful in using standard simulation results for scenarios involving a complex combination of multiple shocks at the same time or for very large impulses over a protracted period. Such "exotic" or very severe scenarios may fall outside the limits of the model and could therefore display implausible or unrealistic outcomes.

The scenario results are based on the standard version of the model, and hence on the estimation results for the model's equations obtained over the sample period. They are presented in the form of tables. The baseline projection is the development of the Dutch economy without a shock to a specific variable. The baseline projection is taken to be the realised data for the period 2009-2016; hence, the simulations are performed 'in-sample'. For a number of key variables these tables show the deviation of the economy as a result of the shock from its so-called 'baseline projection'. The table presents the difference in percentages (for volumes, prices, employment and loans) or percentage points (for the unemployment rate, the labour income share, government balance, interest rates and the leverage ratio) between the level of a variable in the scenario and the baseline projection in a given year. The impact on the growth rate of a variable in that year can be assessed by taking first differences of the level effects. The government balance is measured as a percentage of GDP. The scenario results are computed over a horizon of eight years, thus focusing on the short-run effects as well as on the medium to long-run effects.

4.1 World trade +1 %

In this scenario the volume of world trade is raised by 1%. Foreign demand for Dutch products increases accordingly. This means that exporters can sell more goods and services to foreign countries. To meet the increased demand, companies invest more, and imports rise as well. Initially GDP rises by 0.2%. Later on the positive spillovers to domestic demand increase and by year four GDP is 0.4% above base level. Firms start taking on more staff and unemployment decreases. Households have more to spend thanks to higher wages and growing employment, resulting in a rise in consumption. The pressure on wages and costs per unit of production gradually increases. These developments lead to higher consumption and export prices. The latter will slow down exports and hence investment and GDP in the longer term. In line with nominal activity loans to firms and households rise and banks' profits increase. This translates into an improved capital position, which is reflected in a small rise of the leverage ratio. The favourable economic developments in turn lead to more tax revenues and less unemployment benefits, which has a positive effect on the general government balance.

Table 7: World trade +1 %

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.21	0.32	0.39	0.40	0.35	0.27	0.21	0.20
Private consumption	0.02	0.18	0.43	0.60	0.68	0.68	0.65	0.62
Housing investment	0.02	0.13	0.39	0.67	0.81	0.72	0.55	0.49
Other private investment	0.15	0.60	0.71	0.53	0.17	-0.13	-0.23	-0.11
Exports	0.90	0.99	0.98	0.94	0.88	0.84	0.79	0.77
Domestically produced exports	0.58	0.54	0.51	0.42	0.32	0.22	0.12	0.06
Imports	0.70	0.88	0.98	1.02	1.02	1.01	0.98	0.98
Prices and wages								
HICP	0.01	0.02	0.07	0.16	0.29	0.40	0.45	0.45
Domestically produced exports	0.00	-0.03	-0.06	0.02	0.14	0.23	0.32	0.34
Cost price (including energy)	0.03	0.09	0.20	0.31	0.43	0.49	0.53	0.52
Wages (contractual) private sector	0.01	0.09	0.21	0.33	0.44	0.53	0.57	0.58
House prices	0.00	0.12	0.42	0.73	0.92	0.99	1.04	1.08
Other items								
Government balance (%GDP)	0.06	0.13	0.19	0.22	0.22	0.20	0.19	0.16
Total employment	0.03	0.18	0.32	0.41	0.43	0.38	0.32	0.26
Unemployment rate (%-points)	-0.02	-0.15	-0.23	-0.27	-0.28	-0.25	-0.22	-0.19
Labour share of income (%-points)	-0.18	-0.15	-0.04	0.03	0.07	0.07	0.04	0.01
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to firms (%-points)	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
Loans to firms	0.02	0.16	0.36	0.59	0.81	1.00	1.11	1.18
Loans to households	0.02	0.20	0.50	0.71	0.88	1.02	1.17	1.28
Leverage ratio (%-points)	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03

[1] Percent deviation from central projection.

4.2 Oil price +20 %

This scenario shows the impact of a sustained 20% rise in the price of oil. This is implemented as a pure supply-side shock: the higher oil price is assumed to be a direct result of a reduction in the supply of oil. A global increase in the price of oil leads directly to higher consumer prices. In addition, production costs for firms - both domestically and internationally - increase, so that the price of goods and services increases worldwide. The higher consumer prices have a negative effect on purchasing power, driving down private consumption both domestically and internationally. This reduction in consumer demand reduces world trade and pushes down exports. Together lower consumption and reduced exports lead to a decline in the volume of GDP. Lower production in turn leads to a reduction in business investment and employment. Higher unemployment will further suppress real wages and thus private consumption. Initially higher oil prices lead to a slight improvement in the government balance, because of an increase in revenues from gas production. This is because higher oil prices feed through into higher gas prices.

Table 8: Oil price +20 %

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.16	-0.49	-0.81	-0.98	-0.99	-0.85	-0.69	-0.55
Private consumption	-0.15	-0.52	-1.03	-1.63	-2.03	-2.14	-2.00	-1.75
Housing investment	-0.11	-0.45	-0.65	-1.16	-1.69	-1.72	-1.42	-1.21
Other private investment	-0.08	-0.68	-1.36	-1.47	-0.88	0.17	0.71	0.58
Exports	-0.52	-1.67	-2.26	-2.37	-2.16	-1.99	-1.90	-1.64
Domestically produced exports	-0.44	-1.07	-1.30	-1.31	-1.20	-1.12	-1.06	-0.94
Imports	-0.43	-1.61	-2.37	-2.70	-2.63	-2.47	-2.34	-2.12
Prices and wages								
HICP	0.32	0.57	0.81	0.96	0.97	0.84	0.63	0.49
Domestically produced exports	1.15	2.53	3.78	4.75	4.55	3.61	2.10	1.19
Cost price (including energy)	0.45	0.90	1.23	1.30	1.20	1.09	0.85	0.69
Wages (contractual) private sector	0.04	0.23	0.31	0.31	0.29	0.28	0.27	0.21
House prices	-0.05	-0.20	-0.51	-1.01	-1.34	-1.38	-1.29	-1.18
Other items								
Government balance (%GDP)	0.02	0.05	-0.07	-0.18	-0.24	-0.35	-0.42	-0.43
Total employment	-0.02	-0.18	-0.53	-0.89	-1.10	-1.13	-1.04	-0.90
Unemployment rate (%-points)	0.01	0.16	0.41	0.63	0.74	0.76	0.72	0.64
Labour share of income (%-points)	0.17	0.24	0.09	-0.24	-0.54	-0.44	-0.19	0.02
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to firms (%-points)	0.00	0.01	0.03	0.04	0.05	0.04	0.04	0.04
Loans to firms	-0.01	-0.04	-0.05	-0.10	-0.12	-0.16	-0.24	-0.35
Loans to households	0.00	-0.14	-0.55	-0.95	-1.19	-1.35	-1.53	-1.60
Leverage ratio (%-points)	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	-0.01	-0.02

[1] Percent deviation from central projection.

In the medium term, however, lower levels of production and employment induce lower levels of tax revenue and higher unemployment benefits, causing the government balance to decline. In year four the volume of GDP bottoms out at 1% below base. By then business investment starts recovering as the negative accelerator effects subside and turn positive and because business profitability starts to rise.

4.3 Short and long-term interest rates +1%-point

The simulation of a 1%-point rise in market interest rates is of the *ceteris paribus* type. Serving mainly to illustrate the transmission of changes in interest rates to the domestic economy, it abstracts from accompanying effects on foreign interest rates, other financial market prices such as exchange rates and stock prices, and global activity. A higher level of interest rates will have an adverse effect on the corporate sector, households as well as the central government. The corporate sector is confronted with higher capital and borrowing costs. This causes business investment to fall. The impact on exports is small, as pricing to market is important, so that higher capital costs only moderately affect export prices. Lower demand for capital goods results in lower production, and lower production means that fewer staff are needed. Falling employment and slightly lower real wages depress real disposable income, resulting in lower consumer spending. Higher (mostly long-term) interest rates translate into higher mortgage rates, which reduces the amount of mortgage credit for house purchases. This in turn puts downward pressure on house prices, reinforcing the reduction in private consumption and residential investment. These adverse economic developments in turn lead to lower tax revenues and higher unemployment benefits, which reduce the general government balance. Moreover, the government will have to pay more interest on its debt. Real GDP bottoms out at -0.6%. After a small reduction in the first year, the leverage ratio of banks improves. This is mainly driven by the fact that, once lending and deposit rates have fully adjusted to the higher market rates, interest payments received by banks exceed interest costs paid by banks, because the pass-through in lending rates is stronger than in deposit rates. Higher profits bolster the banks' capital position. The higher leverage ratio (compared to its target level) somewhat mitigates the negative impact of higher lending rates on business and mortgage credit. Therefore, in the second half of the simulation period the negative responses of house prices, consumption and residential investment gradually become smaller. Improved acceleration effects and recovering profitability support business investment over time.

Table 9: Short and long-term interest rates +1%-point

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.16	-0.35	-0.53	-0.59	-0.50	-0.30	-0.06	0.09
Private consumption	-0.33	-0.65	-1.05	-1.32	-1.37	-1.09	-0.64	-0.15
Housing investment	-0.53	-1.40	-2.26	-2.75	-2.67	-1.57	-0.41	0.29
Other private investment	-0.32	-1.30	-1.85	-1.95	-1.55	-0.98	-0.62	-0.72
Exports	-0.02	-0.08	-0.13	-0.15	-0.13	-0.08	-0.04	-0.02
Domestically produced exports	-0.04	-0.13	-0.24	-0.28	-0.24	-0.15	-0.07	-0.04
Imports	-0.16	-0.35	-0.58	-0.68	-0.68	-0.56	-0.42	-0.31
Prices and wages								
HICP	-0.02	-0.12	-0.24	-0.41	-0.60	-0.80	-0.92	-0.92
Domestically produced exports	0.06	0.18	0.28	0.26	0.14	0.01	-0.07	-0.06
Cost price (including energy)	1.54	1.38	1.28	0.99	0.83	0.74	0.83	0.95
Wages (contractual) private sector	0.00	-0.09	-0.27	-0.49	-0.68	-0.80	-0.82	-0.73
House prices	-0.76	-1.82	-2.67	-3.15	-3.12	-2.51	-1.62	-0.68
Other items								
Government balance (%GDP)	-0.02	-0.11	-0.24	-0.32	-0.31	-0.24	-0.14	-0.01
Total employment	-0.01	-0.15	-0.35	-0.51	-0.57	-0.47	-0.27	-0.04
Unemployment rate (%-points)	0.01	0.13	0.25	0.34	0.35	0.28	0.16	0.01
Labour share of income (%-points)	0.12	0.13	0.00	-0.17	-0.32	-0.34	-0.29	-0.19
Financial variables								
Mortgage rate (%-points)	0.85	0.91	0.96	0.97	0.98	0.97	0.97	0.96
Lending rate to firms (%-points)	1.02	1.03	1.03	1.03	1.02	1.01	0.99	0.97
Loans to firms	-0.09	-0.68	-1.34	-1.85	-2.15	-2.21	-2.05	-1.74
Loans to households	-0.15	-0.72	-1.39	-1.79	-1.95	-1.85	-1.57	-1.12
Leverage ratio (%-points)	-0.03	0.00	0.07	0.15	0.24	0.28	0.32	0.36

[1] Percent deviation from central projection.

4.4 Appreciation of the effective euro exchange rate by 5%

An appreciation of the euro, i.e. a rising exchange rate, makes Dutch export products more expensive to consumers and companies outside the euro area. This causes exports to decline, resulting in lower GDP. Companies react to declining demand by investing less and taking on fewer staff, so that unemployment rises. Falling employment depresses real disposable income of households, which has a negative impact on private consumption. The stronger euro makes imported products cheaper for households and companies, which dampens inflation. These adverse economic developments lead to lower tax revenues and higher unemployment benefits, which have a negative effect on the general government balance. Lower nominal income and business investment translate into lower nominal credit to firms and households. Because of the appreciation of the euro and the decline of nominal GDP, banks' net other income in euro decrease. Hence banks' profits and capital are lower, as reflected in the lower leverage ratio. In response to the latter, banks raise lending rsates charged to firms and households and further reduce lending volumes. Lower mortgage credit volumes reduce house prices, which adds to the downward pressure on consumption and residential investment. After four years real GDP bottoms out at -1.2% compared to baseline. Over time the phasing out of negative acceleration effects and recovering profitability support business investment.

Table 10: Appreciation of the effective euro exchange rate by 5%

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.53	-0.84	-1.11	-1.17	-1.06	-0.88	-0.75	-0.71
Private consumption	-0.03	-0.38	-0.93	-1.38	-1.69	-1.80	-1.89	-1.98
Housing investment	-0.05	-0.35	-1.08	-1.73	-2.17	-2.14	-1.97	-1.99
Other private investment	-0.55	-1.63	-2.12	-1.76	-0.77	0.10	0.49	0.26
Exports	-0.87	-0.87	-0.92	-0.81	-0.64	-0.42	-0.22	-0.08
Domestically produced exports	-1.51	-1.57	-1.65	-1.47	-1.15	-0.77	-0.41	-0.14
Imports	-0.35	-0.36	-0.51	-0.54	-0.50	-0.41	-0.35	-0.35
Prices and wages								
HICP	-0.15	-0.39	-0.74	-1.19	-1.69	-2.13	-2.41	-2.52
Domestically produced exports	-1.17	-1.62	-2.01	-2.54	-2.99	-3.30	-3.43	-3.43
Cost price (including energy)	-0.30	-0.66	-1.19	-1.73	-2.22	-2.55	-2.76	-2.85
Wages (contractual) private sector	-0.05	-0.40	-0.93	-1.49	-2.03	-2.46	-2.75	-2.92
House prices	-0.02	-0.37	-1.20	-2.12	-2.89	-3.46	-4.02	-4.53
Other items								
Government balance (%GDP)	-0.23	-0.44	-0.62	-0.71	-0.69	-0.63	-0.61	-0.51
Total employment	-0.10	-0.50	-0.86	-1.11	-1.17	-1.06	-0.92	-0.81
Unemployment rate (%-points)	0.09	0.40	0.60	0.74	0.75	0.69	0.63	0.58
Labour share of income (%-points)	0.57	0.51	0.29	0.06	-0.06	-0.05	-0.02	0.00
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
Lending rate to firms (%-points)	0.01	0.04	0.06	0.07	0.08	0.08	0.08	0.08
Loans to firms	-0.01	-0.45	-1.13	-1.95	-2.80	-3.61	-4.19	-4.61
Loans to households	-0.07	-0.64	-1.44	-2.21	-2.92	-3.65	-4.41	-5.04
Leverage ratio (%-points)	-0.04	-0.07	-0.09	-0.12	-0.18	-0.16	-0.16	-0.15

[1] Percent deviation from central projection.

4.5 Government spending +1% GDP

This scenario presents the impact of a sustained increase in government spending on material goods and investment by 1% GDP, funded by issuing government debt. Tax rates remain constant over the simulation horizon. Implicitly, it is assumed that government finances remain solid so that households do not factor in higher future taxes and that interest rates on government bonds are not affected. Higher public sector consumption and investment immediately raise GDP. Through the accelerator-effect business investment is boosted, while private consumption benefits from higher employment and wages. Later on, rising real house prices reinforce the stimulus to private consumption and housing investment. The positive impact on the level of real GDP peaks at 1.4% in year 3. Due to the increase in economic activity the reduction in the government balance remains contained to -0.6% GDP. In response to higher aggregate demand and the tightening of the labour market, wages and production costs start to rise, resulting in higher consumer prices and - with some lag - also export prices. Higher export prices relative to foreign competitors reduce the level of exports. Lower exports and the fading away of the initial acceleration effect in business investment mitigate the initial strong rise in GDP. After eight years GDP is 0.6% above its baseline level. Bank lending to households and firms increase with economic activity. Banks' profitability improves, which results in a slightly higher leverage ratio.

Table 11: Government spending +1% GDP

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.96	1.21	1.41	1.33	1.07	0.81	0.62	0.59
Private consumption	0.10	0.77	1.52	1.87	1.92	1.68	1.40	1.18
Housing investment	0.07	0.52	1.48	2.30	2.48	1.84	1.10	0.73
Other private investment	0.89	2.21	2.04	0.92	-0.50	-1.27	-1.18	-0.45
Exports	-0.02	0.02	0.02	-0.12	-0.30	-0.46	-0.56	-0.60
Domestically produced exports	-0.03	0.04	0.03	-0.22	-0.54	-0.84	-1.04	-1.12
Imports	0.55	0.80	1.04	1.03	0.90	0.72	0.60	0.55
Prices and wages								
HICP	0.15	0.21	0.47	0.86	1.29	1.56	1.61	1.46
Domestically produced exports	0.04	-0.07	-0.03	0.35	0.71	0.93	1.00	0.89
Cost prices (including energy)	0.16	0.38	0.82	1.18	1.45	1.54	1.51	1.34
Wages (contractual) private sector	0.08	0.45	0.89	1.24	1.55	1.70	1.69	1.55
House prices	0.03	0.58	1.73	2.65	3.10	3.08	2.97	2.86
Other items								
Government balance (%GDP)	-0.61	-0.46	-0.33	-0.31	-0.38	-0.49	-0.53	-0.59
Total employment	0.15	0.76	1.12	1.28	1.17	0.89	0.62	0.42
Unemployment rate (%-points)	-0.14	-0.61	-0.76	-0.84	-0.75	-0.59	-0.45	-0.33
Labour share of income (%-points)	-0.75	-0.22	0.21	0.38	0.41	0.25	0.13	-0.01
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Lending rate to firms (%-points)	-0.02	-0.05	-0.07	-0.07	-0.06	-0.05	-0.04	-0.04
Loans to firms	0.34	0.90	1.56	2.25	2.83	3.19	3.32	3.32
Loans to households	0.27	1.40	2.21	2.73	3.01	3.30	3.51	3.52
Leverage ratio (%-points)	0.03	0.06	0.07	0.08	0.11	0.10	0.09	0.07

[1] Percent deviation from central projection.

4.6 Government spending +1% GDP (balanced budget)

In this scenario the 1% of GDP additional government spending is funded by increasing wage and income taxes such that the general government balance does not change. This is the so-called "balanced budget" rule. When the public sector consumes or invests more, this will have an immediate positive effect on GDP. In the first years rising government demand also stimulates the corporate sector to invest more and to take on more staff. The positive impact on the level of real GDP in the short run peaks at almost 1% in year three. Higher taxes weigh down on disposable household income and hence on private consumption. In response to higher aggregate demand and the tightening of the labour market wages and cost prices start to rise. In the first years the negative impact of higher taxes on private consumption is mitigated or even compensated by the rise in employment and higher wages. After some time, however, higher costs of production adversely affect exports, making them more expensive relative to foreign competitors. Lower exports, the fading away of the initial acceleration effect in business investment, and the eventually dominant impact of lower disposable income on consumption depress GDP. After seven years GDP is back to its baseline level. Over the long run, higher public spending is fully offset by lower private domestic spending and lower exports. Mainly due to higher non-interest income the profitability and capital position of the banking sector improves, especially in the first half of the simulation period.

Table 12: Government spending +1% GDP (balanced budget)

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.85	0.92	0.97	0.78	0.45	0.13	-0.15	-0.28
Private consumption	-0.21	0.00	0.34	0.33	0.03	-0.54	-1.22	-1.79
Housing investment	-0.03	0.11	0.77	1.12	0.80	-0.12	-1.01	-1.64
Other private investment	0.84	1.79	1.35	0.21	-1.04	-1.66	-1.59	-1.03
Exports	-0.01	0.02	0.01	-0.13	-0.29	-0.42	-0.50	-0.52
Domestically produced exports	-0.02	0.04	0.02	-0.23	-0.52	-0.76	-0.92	-0.96
Imports	0.46	0.57	0.68	0.58	0.39	0.16	-0.04	-0.18
Prices and wages								
HICP	0.16	0.24	0.48	0.81	1.18	1.38	1.37	1.20
Domestically produced exports	0.03	-0.07	-0.01	0.36	0.67	0.83	0.85	0.74
Cost price (including energy)	0.14	0.32	0.72	1.04	1.27	1.35	1.31	1.17
Wages (contractual) private sector	0.07	0.43	0.86	1.21	1.50	1.67	1.70	1.61
House prices	0.00	0.46	1.36	1.91	2.02	1.79	1.46	1.08
Other items								
Government balance (%GDP)	0.03	-0.02	0.04	-0.04	0.01	0.01	0.00	0.03
Total employment	0.14	0.64	0.83	0.81	0.57	0.18	-0.18	-0.51
Unemployment rate (%-points)	-0.13	-0.51	-0.54	-0.51	-0.35	-0.11	0.10	0.31
Labour share of income (%-points)	-0.67	-0.08	0.30	0.42	0.42	0.32	0.26	0.19
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Lending rate to firms (%-points)	-0.02	-0.04	-0.05	-0.04	-0.03	-0.02	0.00	0.01
Loans to firms	0.10	0.59	1.06	1.55	1.95	2.14	2.10	1.89
Loans to households	0.08	0.80	1.42	1.72	1.85	1.86	1.75	1.43
Leverage ratio (%-points)	0.03	0.04	0.05	0.06	0.07	0.06	0.05	0.03

[1] Percent deviation from central projection.

4.7 Labour income taxes +1% GDP

Higher labour income taxes equivalent to 1% of GDP depress households' disposable income, causing private consumption to fall. As a result of lower domestic demand companies will invest less and take on fewer staff, putting even more downward pressure on households' income and consumption, while unemployment increases. The negative impact on domestic demand at the same time mitigates the increase in tax revenues and leads to higher unemployment benefits, so that the initial improvement of the general government balance fades away over time. While the increase in unemployment has a negative impact on wages, the shifting by employees of higher income taxes on wage demands on balance keeps private sector wage costs relatively unaffected. Over time consumer prices do decline modestly in response to a higher level of slack. Loans to households gradually decrease in line with lower household income and residential investment, while the increase in the unemployment rate also adds downward pressure on loan demands. House prices move lower in tandem with mortgage credit. The decrease in loans to firms is mainly due to lower nominal business investment spending and lower nominal value added in the business sector.

Table 13: Labour income taxes +1% GDP

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.16	-0.42	-0.62	-0.74	-0.73	-0.63	-0.54	-0.51
Private consumption	-0.45	-1.14	-1.71	-2.14	-2.32	-2.26	-2.16	-2.05
Housing investment	-0.14	-0.62	-1.05	-1.64	-2.15	-2.25	-2.10	-1.97
Other private investment	-0.08	-0.61	-0.99	-1.00	-0.62	-0.12	0.18	0.11
Exports	0.00	0.00	-0.01	-0.01	0.02	0.06	0.10	0.12
Domestically produced exports	0.00	0.00	-0.02	-0.02	0.03	0.11	0.19	0.23
Imports	-0.14	-0.34	-0.52	-0.62	-0.62	-0.54	-0.48	-0.46
Prices and wages								
HICP	0.02	0.03	0.00	-0.07	-0.17	-0.28	-0.36	-0.35
Domestically produced exports	-0.01	0.00	0.03	0.02	-0.06	-0.16	-0.22	-0.22
Cost price (including energy)	-0.03	-0.09	-0.13	-0.19	-0.23	-0.22	-0.16	-0.08
Wages (contractual) private sector	0.00	-0.04	-0.05	-0.06	-0.06	-0.03	0.04	0.13
House prices	-0.04	-0.17	-0.49	-0.97	-1.37	-1.59	-1.73	-1.80
Other items								
Government balance (%GDP)	0.96	0.69	0.51	0.31	0.10	0.03	0.07	0.19
Total employment	-0.01	-0.16	-0.42	-0.66	-0.82	-0.85	-0.81	-0.74
Unemployment rate (%-points)	0.01	0.14	0.32	0.46	0.54	0.56	0.54	0.51
Labour share of income (%-points)	0.13	0.20	0.13	0.03	-0.05	-0.04	0.04	0.13
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Lending rate to firms (%-points)	0.00	0.01	0.03	0.04	0.04	0.04	0.04	0.04
Loans to firms	-0.01	-0.13	-0.37	-0.66	-0.96	-1.24	-1.41	-1.49
Loans to households	-0.03	-0.23	-0.66	-1.08	-1.40	-1.66	-1.92	-2.07
Leverage ratio (%-points)	-0.01	-0.02	-0.03	-0.03	-0.05	-0.04	-0.04	-0.04

[1] Percent deviation from central projection.

4.8 Labour supply +1%

A permanent 1% increase in labour supply initially leads to a surge in unemployment, as not all entrants in the labour market will find a job immediately. The rise in unemployment induces households to raise precautionary savings, leading to an initial reduction in private consumption and residential investment. Higher unemployment rates also put downward pressure on wages, production costs and prices. Lower export prices stimulate exports, and higher profitability supports business investment. Gradually GDP increases, prompting companies to take on more staff. The rise in GDP and the decrease in real product wages supports growing demand for labour over time and a gradual decrease in unemployment. After eight years almost 80% of the additional labour supply has been absorbed in employment. If the simulation horizon is extended even further unemployment eventually returns to its base level. Initially, the government's budget balance deteriorates as a result of the increase in unemployment benefits. Over time, however, the government's balance recovers due to the rise in economic activity, which comes with higher tax revenues and less unemployment benefits.

Table 14: Labour supply +1%

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.09	-0.11	0.12	0.29	0.47	0.60	0.65	0.60
Private consumption	-0.29	-0.41	0.00	0.15	0.40	0.59	0.70	0.69
Housing investment	-0.21	-1.35	-0.98	-0.38	0.20	0.81	1.13	1.10
Other private investment	-0.02	-0.24	0.17	0.72	1.19	1.44	1.35	1.04
Exports	0.00	0.03	0.08	0.15	0.24	0.31	0.34	0.33
Domestically produced exports	0.01	0.06	0.14	0.27	0.44	0.56	0.62	0.62
Imports	-0.11	-0.21	-0.09	-0.01	0.10	0.18	0.23	0.22
Prices and wages								
HICP	-0.04	-0.30	-0.55	-0.77	-0.92	-0.98	-0.93	-0.79
Domestically produced exports	-0.01	-0.09	-0.18	-0.32	-0.47	-0.53	-0.50	-0.41
Cost price (including energy)	-0.30	-0.63	-0.76	-0.97	-1.08	-1.08	-1.02	-0.92
Wages (contractual) private sector	-0.16	-0.53	-0.74	-0.99	-1.13	-1.17	-1.11	-1.00
House prices	-0.38	-1.17	-1.03	-0.87	-0.49	-0.10	0.15	0.23
Other items								
Government balance (%GDP)	-0.24	-0.28	-0.23	-0.16	-0.07	0.01	0.06	0.07
Total employment	0.04	0.21	0.21	0.37	0.55	0.71	0.81	0.82
Unemployment rate (%-points)	0.83	0.55	0.64	0.56	0.45	0.34	0.26	0.23
Labour share of income (%-points)	-0.08	-0.06	-0.27	-0.33	-0.31	-0.24	-0.20	-0.16
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to firms (%-points)	0.01	0.04	0.05	0.05	0.04	0.03	0.02	0.02
Loans to firms	-0.01	-0.17	-0.43	-0.59	-0.67	-0.66	-0.55	-0.36
Loans to households	-0.78	-0.83	-0.84	-0.82	-0.63	-0.48	-0.39	-0.31
Leverage ratio (%-points)	0.02	-0.01	-0.01	0.00	0.00	0.00	0.01	0.01

[1] Percent deviation from central projection.

4.9 Private sector wages +1%

In this scenario the shock is calibrated to deliver an *ex ante* permanent 1% increase in the level of private sector contractual wages *at each and every point in time over the simulation period*[13]. Due to second order effects, such as the interaction between wages and prices, *ex post* the wage profile will deviate from the *ex ante* shock. The wage increase generates a higher disposable household income, which will gradually feed into private consumption and residential investment (consumption smoothing). Production costs will rise, causing firms to take on fewer staff and reduce investment in capital goods. Firms will also pass on the higher cost of production to consumers by raising their prices. Higher prices in turn drive up wages, triggering a modest wage-price spiral. Exporting companies raise their prices only partially (due to the prevalence of pricing to market to protect market share). This dampens exports. On balance, business investment decreases, also due to lower profitability. In the first two years GDP is broadly unchanged.

[13] The calibration is corrected for any autonomous build-up of wages due to the presence of lagged dependent variables in the wage equation.

Thereafter, GDP falls slightly (bottoming out at -0.1%), as the negative effect of declining exports and business investment outweighs the positive impact of household spending. Towards the end of the simulation period real GDP recovers and hovers around its baseline level. Public spending increases as a result of higher unemployment benefits and higher wages for public servants.

Table 15: Private sector wages +1%

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.02	-0.03	-0.12	-0.14	-0.10	-0.03	0.03	0.08
Private consumption	0.17	0.32	0.38	0.43	0.54	0.73	0.94	1.13
Housing investment	0.04	0.20	0.49	0.51	0.65	0.90	1.12	1.24
Other private investment	0.04	-0.36	-0.74	-0.72	-0.43	-0.13	0.10	0.07
Exports	-0.01	-0.09	-0.19	-0.24	-0.28	-0.29	-0.30	-0.31
Domestically produced exports	-0.02	-0.17	-0.35	-0.44	-0.50	-0.54	-0.56	-0.59
Imports	0.09	0.11	0.09	0.10	0.14	0.19	0.24	0.27
Prices and wages								
HICP	0.06	0.32	0.49	0.61	0.58	0.55	0.54	0.55
Domestically produced exports	0.03	0.24	0.43	0.45	0.42	0.40	0.38	0.39
Cost price (including energy)	0.72	0.83	0.91	0.94	0.99	1.02	1.09	1.16
Wages (contractual) private sector	1.01	1.05	1.14	1.22	1.28	1.32	1.38	1.44
House prices	0.02	0.08	0.17	0.42	0.74	1.11	1.44	1.69
Other items								
Government balance (%GDP)	-0.13	-0.15	-0.16	-0.18	-0.19	-0.16	-0.11	-0.09
Total employment	-0.02	-0.14	-0.18	-0.24	-0.24	-0.18	-0.10	-0.02
Unemployment rate (%-points)	0.02	0.12	0.12	0.16	0.15	0.11	0.06	0.02
Labour share of income (%-points)	0.53	0.30	0.24	0.23	0.26	0.29	0.36	0.39
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to firms (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01
Loans to firms	0.02	0.21	0.43	0.57	0.64	0.73	0.86	1.01
Loans to households	0.06	0.13	0.35	0.57	0.81	1.09	1.36	1.63
Leverage ratio (%-points)	0.01	0.02	0.02	0.03	0.04	0.03	0.03	0.03

[1] Percent deviation from central projection.

4.10 Second-pillar pension contributions +10%

In this scenario employers and employees each pay half of the 10% increase in pension contributions. For the corporate sector a rise in pension contributions means higher overall wage costs, and thus higher costs of production and lower profitability. To some extent they will pass on the costs to prices. The peak effect on consumer prices is close to 0.5%; on export prices it is 0.4%. Exports and business investment decrease. For households the rise in pension contributions depresses real disposable income and hence private consumption and residential investment, reinforcing the drop in business investment through the accelerator effect. The fall in real GDP, coupled with higher overall real wage costs, translates into a decrease in employment. Higher unemployment puts household spending under further pressure. Note that contractual private sector wages decrease relative to baseline. This is due to the rise in unemployment and to the shifting by employers of a small part of the burden of higher pension costs to employees. The general government balance deteriorates due to lower tax revenues, higher unemployment benefits and higher pension contributions.

Table 16: Second-pillar pension contributions +10%

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.02	-0.23	-0.44	-0.55	-0.58	-0.56	-0.50	-0.43
Private consumption	-0.03	-0.30	-0.67	-1.01	-1.27	-1.37	-1.39	-1.34
Housing investment	0.00	-0.05	-0.14	-0.57	-0.97	-1.11	-1.10	-1.15
Other private investment	0.04	-0.64	-1.20	-1.14	-0.74	-0.36	-0.05	0.11
Exports	-0.01	-0.10	-0.19	-0.22	-0.23	-0.21	-0.18	-0.12
Domestically produced exports	-0.02	-0.17	-0.35	-0.40	-0.41	-0.38	-0.32	-0.23
Imports	0.00	-0.13	-0.28	-0.36	-0.40	-0.41	-0.40	-0.38
Prices and wages								
HICP	0.08	0.34	0.44	0.47	0.36	0.25	0.12	-0.02
Domestically produced exports	0.03	0.25	0.42	0.38	0.31	0.23	0.13	0.02
Cost price (including energy)	0.73	0.67	0.65	0.61	0.60	0.52	0.34	0.27
Wages (contractual) private sector	-0.06	-0.17	-0.21	-0.24	-0.33	-0.43	-0.50	-0.54
House prices	0.00	-0.11	-0.34	-0.55	-0.77	-0.88	-0.97	-1.06
Other items								
Government balance (%GDP)	-0.11	-0.16	-0.25	-0.36	-0.42	-0.44	-0.43	-0.40
Total employment	-0.03	-0.20	-0.35	-0.54	-0.66	-0.70	-0.67	-0.59
Unemployment rate (%-points)	0.02	0.15	0.22	0.34	0.41	0.44	0.42	0.37
Labour share of income (%-points)	0.64	0.33	0.27	0.24	0.26	0.24	0.16	0.23
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to firms (%-points)	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03
Loans to firms	0.01	0.11	0.16	0.07	-0.10	-0.26	-0.37	-0.49
Loans to households	0.00	-0.17	-0.33	-0.55	-0.76	-0.93	-1.15	-1.32
Leverage ratio (%-points)	0.00	0.01	0.00	0.00	0.00	0.00	-0.01	-0.02

[1] Percent deviation from central projection.

4.11 Equity prices +20%

This simulation abstracts from accompanying effects on global activity and focusses on the direct impact of higher equity prices in the domestic economy. A permanent 20% rise in equity prices causes households' financial wealth to grow, while at the same time disposable income increases as a result of higher dividend payments. This results in an increase in private consumption and residential investment. Higher equity prices reduce the cost of capital for companies. These lower costs and increasing consumer demand encourage companies to invest more and take on more staff in the first few years. Over time the stimulus to business investment fades away when the acceleration effects subside. As the labour market tightens, wages start to rise. Production costs and export prices also increase, making Dutch exports less competitive. Nevertheless, the rise in real GDP by around 0.6% is pretty persistent. The banking sector contributes to this sustained development. Higher equity prices boost banks' profits and capital position, which is reflected in a higher leverage ratio. This stimulates loans to households, mortgages in particular, and thereby house prices. Higher house prices substantially reinforce the positive financial wealth effect on consumption and residential investment. The negative response of loans to firms is largely due to higher equity prices, which supports the role of the stock market as an alternative source of funding. The government budget balance improves due to higher tax revenues and lower unemployment benefits.

Table 17: Equity prices +20%

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.15	0.46	0.61	0.63	0.61	0.62	0.66	0.76
Private consumption	0.32	1.09	1.64	2.01	2.33	2.62	2.94	3.26
Housing investment	0.14	0.88	1.55	1.78	2.13	2.34	2.47	2.74
Other private investment	0.51	1.25	1.31	0.88	0.28	-0.06	0.04	0.38
Exports	0.00	-0.01	-0.02	-0.05	-0.11	-0.18	-0.23	-0.26
Domestically produced exports	0.00	-0.01	-0.03	-0.09	-0.20	-0.33	-0.43	-0.49
Imports	0.14	0.39	0.54	0.59	0.61	0.63	0.71	0.80
Prices and wages								
HICP	-0.01	0.00	0.10	0.24	0.38	0.50	0.58	0.61
Domestically produced exports	0.01	0.02	0.04	0.12	0.25	0.36	0.42	0.41
Cost price (including energy)	0.02	0.14	0.30	0.47	0.63	0.73	0.80	0.87
Wages (contractual) private sector	0.00	0.11	0.27	0.44	0.59	0.70	0.78	0.86
House prices	0.06	0.59	1.35	2.11	2.71	3.16	3.61	4.08
Other items								
Government balance (%GDP)	0.13	0.47	0.62	0.67	0.71	0.74	0.83	0.86
Total employment	0.09	0.36	0.57	0.69	0.70	0.68	0.69	0.75
Unemployment rate (%-points)	-0.09	-0.28	-0.39	-0.46	-0.46	-0.46	-0.50	-0.55
Labour share of income (%-points)	-0.06	-0.04	0.09	0.22	0.24	0.15	0.10	0.07
Financial variables								
Mortgage rate (%-points)	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02
Lending rate to firms (%-points)	0.00	-0.01	-0.03	-0.04	-0.04	-0.05	-0.05	-0.06
Loans to firms	-0.25	-0.60	-0.70	-0.71	-0.71	-0.68	-0.70	-0.74
Loans to households	0.07	0.72	1.48	2.18	2.73	3.30	3.98	4.61
Leverage ratio (%-points)	0.05	0.08	0.10	0.12	0.15	0.13	0.12	0.11

[1] Percent deviation from central projection.

4.12 House prices +10%

This scenario shows the effects of an *ex ante* permanent 10% increase in the level of house prices. Due to second order effects, such as the interaction with mortgage loans, *ex post* the rise in house prices is a bit stronger than the 10% shock. Higher house prices have an immediate upward effect on household wealth. Households will spend part of this capital gain. Private consumption and in particular residential investment get a boost. The consequent growth in domestic demand will lead companies to increase their productive capacity by investing in capital and taking on more staff. Unemployment rates will fall as a result. The tighter labour market pushes up real wages, encouraging households to spend more. Production costs increase. Over time firms partially pass on the higher costs of production to their domestic and, albeit to a lesser extent, foreign customers. The deterioration of the exporters' price competitiveness results in lower export volumes. The overall rise in economic activity raises tax revenues and lowers unemployment benefits. The general government budget balance improves. Loans to firms and households increase because of higher nominal income and investment demand. Banks' profits increase mainly on the back of higher non-interest income, which translates into a higher leverage ratio. As a result of this banks ease their credit conditions, thereby moderately reinforcing the increase in loans to the private sector. Real GDP peaks at +1.3% compared to baseline. Over time, lower exports and the fading away and eventually reversal of positive cyclical accelerator effects on business investment reduces the stimulus to real GDP.

Table 18: House prices +10%

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.84	1.18	1.26	1.03	0.64	0.29	0.08	0.10
Private consumption	1.60	2.48	3.29	3.54	3.37	2.92	2.50	2.23
Housing investment	7.58	9.35	7.52	6.49	5.80	3.81	2.52	1.70
Other private investment	0.62	2.25	2.05	0.60	-1.17	-2.04	-1.78	-0.72
Exports	-0.02	0.00	0.01	-0.11	-0.31	-0.47	-0.56	-0.57
Domestically produced exports	-0.04	0.00	0.02	-0.20	-0.56	-0.86	-1.04	-1.06
Imports	0.81	1.08	1.23	1.10	0.87	0.63	0.50	0.48
Prices and wages								
HICP	0.04	0.14	0.36	0.72	1.13	1.39	1.39	1.17
Domestically produced exports	0.06	-0.02	-0.04	0.30	0.74	0.96	0.98	0.80
Cost price (including energy)	0.12	0.35	0.80	1.17	1.42	1.44	1.33	1.11
Wages (contractual) private sector	0.04	0.37	0.84	1.19	1.42	1.50	1.42	1.24
House prices	10.68	11.24	12.17	12.64	12.76	12.79	12.88	12.92
Other items								
Government balance (%GDP)	0.41	0.68	0.82	0.80	0.65	0.51	0.41	0.33
Total employment	0.11	0.71	1.16	1.29	1.10	0.74	0.44	0.27
Unemployment rate (%-points)	-0.10	-0.59	-0.81	-0.83	-0.69	-0.49	-0.34	-0.25
Labour share of income (%-points)	-0.63	-0.22	0.39	0.68	0.67	0.48	0.31	0.19
Financial variables								
Mortgage rate (%-points)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Lending rate to firms (%-points)	-0.01	-0.05	-0.07	-0.07	-0.05	-0.04	-0.03	-0.03
Loans to firms	0.06	0.59	1.21	1.81	2.31	2.61	2.62	2.49
Loans to households	0.45	1.75	3.25	4.00	4.33	4.49	4.56	4.46
Leverage ratio (%-points)	0.02	0.04	0.05	0.06	0.08	0.07	0.05	0.04

[1] Percent deviation from central projection.

5 The banking sector: illustrative scenarios

This chapter presents a number of scenarios in which the banking sector plays a key role. The scenario results are based on the standard version of the model as well as on a somewhat modified version of it, which illustrates the models flexibility in addressing particular policy questions. Each scenario starts off with a hypothetical what-if question. This what-if question is then re-formulated in terms of shocks to particular (exogenous) variables in the model, after which the model is used to trace out the responses of various key macroeconomic aggregates. The simulations are run over the period 2013-2020. This period excludes the Great Financial Crisis during which some banking sector variables were rather volatile. In order to calculate (very) long run effects, the baseline has been extended further to 2500, and from 2021 onwards the long-run version of the model (see Section 3.10) has then been used.

In the aftermath of the Great Financial Crisis various changes in the banking sector's regulatory framework have been implemented or they will be phased in in the years to come. Well-known examples are the Basel 3 and Basel 3.5 packages. Such packages comprise a lot of detailed requirements that banks need to fulfil. No attempt will be made here to exactly quantify the macroeconomic impact of such comprehensive policy packages. Instead, the focus is on examining specific policy measures, such as a rise in the level of leverage ratio or changes in the risk weights used to compute risk weighted assets.

5.1 Wholesale funding costs +2 %-points

As explained in Section 3.5, in the standard version of the model wholesale funding costs are tied with a fixed margin to short-term interest rates. This may be a reasonable assumption in normal times. But in times of stress in financial markets, or when there are growing concerns regarding the health of the banking sector, wholesale funding may become much dearer. In this scenario the interest rate banks pay on wholesale funding is raised by 2 percentage points for two consecutive years. In addition the CDS spread of the banking sector jumps by 2 percentage points, also for two years. It is assumed that after this two year period of turbulence trust in the banking sector is restored so that both the wholesale funding costs and the CDS spread return to base.

An increase in funding costs leads to a decline in the profits of the banking sector. When no new capital is issued this automatically translates into lower banking capital, and the leverage ratio drops below its target level, see Table 19. Banks then attempt to bring back the leverage ratio to its target level by raising lending rates, cutting back on lending and reducing dividends. Furthermore, there is a direct pass-through of the higher CDS spread into lending rates for households and firms. The model shows that these reactions from the banking sector have significant consequences for the real economy. Higher mortgage interest rates and lower mortgage lending impact negatively on house prices and private consumption. The higher lending rate to firms and lower lending to firms reduce firms' spending on investment projects. Due to lower consumption and investment, aggregate economic activity falls, with negative knock-on effects on the labour market. The unemployment rate rises, and wages and prices fall. Lower employment and wages in turn imply lower household disposable income, reducing households' demand for credit. Similarly, lower business investment leads firms to reduce their demand for new loans. Hence, both lower supply and lower demand for credit contribute to the overall decline in lending. After eight years, the leverage ratio is nearly back at its target level and lending rates have almost reverted to their respective baseline levels.

The recovery of the real economy follows that of the banks' leverage ratio with a lag. The impact on GDP peaks at -0.72 percent in year five. After eight years real GDP is 0.1% below baseline while the impact on private consumption is still more marked.

Table 19: Wholesale funding costs +2 %-points for two years

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.03	-0.22	-0.50	-0.69	-0.72	-0.59	-0.36	-0.10
Private consumption	-0.10	-0.66	-1.37	-1.81	-2.05	-2.03	-1.79	-1.42
Housing investment	-0.05	-0.91	-2.73	-4.26	-4.59	-4.22	-3.12	-1.33
Other private investment	-0.01	-0.22	-0.79	-1.22	-1.23	-0.79	-0.16	0.43
Exports	0.00	0.00	0.00	-0.01	0.03	0.10	0.19	0.27
Domestically produced exports	0.00	0.00	-0.01	-0.01	0.05	0.19	0.37	0.52
Imports	-0.03	-0.19	-0.44	-0.62	-0.67	-0.64	-0.52	-0.35
Prices and wages								
HICP	0.00	0.02	-0.02	-0.13	-0.32	-0.55	-0.76	-0.86
Domestically produced exports	0.00	0.00	0.01	0.01	-0.08	-0.26	-0.44	-0.55
Cost prices (including energy)	0.04	0.11	0.08	-0.12	-0.38	-0.62	-0.78	-0.85
Wages (contractual) private sector	0.00	-0.01	-0.09	-0.28	-0.52	-0.75	-0.93	-1.02
House prices	-0.26	-2.41	-6.13	-9.05	-10.39	-10.24	-8.87	-6.79
Other items								
Government balance (%GDP)	0.10	-0.02	-0.40	-0.54	-0.60	-0.58	-0.50	-0.37
Total employment	0.00	-0.05	-0.23	-0.46	-0.61	-0.63	-0.50	-0.27
Unemployment rate (%-points)	0.00	0.04	0.18	0.33	0.41	0.40	0.31	0.16
Labour share of income (%-points)	0.02	0.15	0.18	0.08	-0.06	-0.16	-0.21	-0.22
Financial variables								
Mortgage rate (%-points)	0.37	1.13	1.17	0.66	0.39	0.24	0.14	0.08
Lending rate to firms (%-points)	0.06	0.22	0.29	0.26	0.23	0.19	0.15	0.11
Loans to firms	-0.38	-2.49	-5.56	-7.74	-8.97	-9.50	-9.50	-9.07
Loans to households	-0.38	-2.62	-5.94	-8.20	-9.35	-9.65	-9.26	-8.42
Leverage ratio (%-points)	-0.80	-1.24	-0.92	-0.64	-0.39	-0.20	-0.09	-0.01
Interest income banking sector[2]	-0.04	-0.42	-1.16	-1.72	-2.48	-3.56	-4.79	-6.69
Interest costs banking sector[2]	25.33	22.18	-3.03	-5.06	-6.21	-7.56	-8.98	-11.29
Operating costs banking sector[2]	-0.04	-0.30	-0.69	-0.94	-1.08	-1.15	-1.13	-1.05
Net impairments for bad loans[2]	-0.01	-0.06	-0.14	-0.11	-0.10	-0.36	-0.53	-0.61
Net other income banking sector[2]	-0.03	-0.48	-1.58	-2.04	-2.69	-3.40	-3.82	-3.63
Profits banking sector[2]	-25.35	-22.73	1.12	2.36	2.23	2.10	2.02	2.64
Taxes banking sector[2]	-5.03	-4.51	0.22	0.47	0.44	0.42	0.40	0.52
Dividends banking sector[2]	-1.70	-2.81	-2.05	-1.54	-1.32	-0.76	-0.31	0.13
Other changes in capital[2]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIER capital[2]	-18.62	-34.04	-31.09	-27.66	-24.55	-22.11	-20.17	-18.18

[1] Percent deviation from central projection.
[2] Deviation from central projection in billions of euros.

To illustrate further the importance of bank capital for the transmission of shocks originating in the banking sector to the real economy, consider what occurs if the banking sector were able to restore part of its buffers by the issuance of new capital. Table 20 shows what happens if the banking sector issues (with a lag of two quarters) new capital to an amount equal to fifty percent of the initial loss of capital owing to the increase in the funding costs. This early re-capitalization of the banking sector means that the CDS spread which initially increases 2 percentage points drops back to 1 percentage point above its baseline level from the moment that the banking sector starts to issue capital. After two years, confidence in the banking sector has fully recovered, as in the previous scenario. Under these conditions, the decline in the leverage ratio is less steep. Consequently, lending to the private sector falls by less compared to the scenario in which no new capital is issued. Also, the hikes in lending rates are smaller. This means that consumption and investment are affected less. All in all, the impact on the real economy is more contained.

Table 20: Wholesale funding costs +2 %-points for two years; issuance of new capital

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.03	-0.16	-0.27	-0.31	-0.26	-0.16	-0.05	0.05
Private consumption	-0.10	-0.46	-0.72	-0.80	-0.79	-0.70	-0.54	-0.38
Housing investment	-0.05	-0.76	-1.61	-1.87	-1.64	-1.24	-0.60	0.19
Other private investment	-0.01	-0.19	-0.47	-0.60	-0.45	-0.14	0.15	0.34
Exports	0.00	0.00	0.00	0.00	0.02	0.06	0.10	0.12
Domestically produced exports	0.00	0.00	-0.01	-0.01	0.03	0.11	0.18	0.23
Imports	-0.03	-0.13	-0.24	-0.28	-0.26	-0.21	-0.14	-0.06
Prices and wages								
HICP	0.00	0.01	-0.02	-0.08	-0.17	-0.27	-0.33	-0.33
Domestically produced exports	0.00	0.00	0.01	0.01	-0.06	-0.15	-0.21	-0.23
Cost prices (including energy)	0.03	0.06	0.01	-0.10	-0.21	-0.29	-0.33	-0.32
Wages (contractual) private sector	0.00	-0.01	-0.07	-0.16	-0.27	-0.34	-0.39	-0.39
House prices	-0.26	-1.68	-3.05	-3.70	-3.71	-3.24	-2.45	-1.53
Other items								
Government balance (%GDP)	0.10	0.01	-0.27	-0.29	-0.28	-0.23	-0.18	-0.12
Total employment	0.00	-0.04	-0.14	-0.23	-0.26	-0.22	-0.13	-0.02
Unemployment rate (%-points)	0.00	0.03	0.11	0.16	0.17	0.13	0.07	0.01
Labour share of income (%-points)	0.02	0.10	0.08	0.00	-0.07	-0.09	-0.09	-0.08
Financial variables								
Mortgage rate (%-points)	0.34	0.71	0.64	0.34	0.19	0.10	0.05	0.03
Lending rate to firms (%-points)	0.06	0.13	0.14	0.11	0.08	0.06	0.04	0.02
Loans to firms	-0.33	-0.99	-1.71	-2.33	-2.63	-2.69	-2.56	-2.29
Loans to households	-0.34	-1.36	-2.42	-3.20	-3.50	-3.45	-3.12	-2.64
Leverage ratio (%-points)	-0.26	-0.36	-0.24	-0.13	-0.05	0.00	0.03	0.05
Interest income banking sector[2]	-0.04	0.08	0.49	0.38	0.07	-0.33	-0.72	-1.18
Interest costs banking sector[2]	25.24	22.21	-1.10	-1.71	-2.01	-2.34	-2.65	-3.11
Operating costs banking sector[2]	-0.04	-0.14	-0.25	-0.33	-0.36	-0.37	-0.34	-0.30
Net impairments for bad loans[2]	-0.01	-0.03	-0.04	-0.04	-0.04	-0.12	-0.17	-0.18
Net other income banking sector[2]	-0.03	-0.36	-0.78	-0.86	-0.97	-1.08	-1.03	-0.75
Profits banking sector[2]	-25.27	-22.32	1.10	1.59	1.51	1.43	1.41	1.67
Taxes banking sector[2]	-5.01	-4.43	0.22	0.32	0.30	0.28	0.28	0.33
Dividends banking sector[2]	-1.63	-2.03	-0.55	-0.27	-0.13	0.08	0.23	0.38
Other changes in capital[2]	12.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00
TIER capital[2]	-6.63	-10.49	-9.06	-7.51	-6.17	-5.11	-4.20	-3.25

[1] Percent deviation from central projection.
[2] Deviation from central projection in billions of euros.

5.2 Target leverage ratio + 1 %-point

It is often argued that a well capitalized banking sector is better able to absorb negative shocks, such as the hike in funding costs analyzed above. One way of achieving a better capitalized banking sector is by raising the required leverage ratio. In this scenario the target level of the leverage ratio is raised by 1 percentage point. Consequently, at the start of the scenario the banking sector is confronted with a gap between its observed leverage ratio and the target level. Since the banking sector in the standard version of the model features many error-correction type mechanisms, the gap between the actual leverage rate and its new target will be closed only gradually. One possible interpretation of the scenario is therefore a situation in which the regulator, after having set a higher level for the target leverage ratio, grants the banking sector some time to adjust its capital position. If it were the case that the new capital requirements had to be implemented at short notice then the relevant model equations can be modified in order to speed up the adjustment process.

In the model the banking sector can increase its leverage ratio both by shrinking the size of its balance sheet, by lowering dividend payments or by issuing new capital. In order to shrink the size of the balance sheet, the banks raise lending rates and lower the supply of credit. As before, higher mortgage interest rates and lower mortgage lending impact negatively on house prices and private consumption, and higher lending rate to firms and lower lending to firms reduce firms spending on investment projects, see Table 21. The impact on GDP reaches a peak at -0.33 percent in year five and is -0.1 percent in year 8. These estimates fall within the range observed in other studies, see Fidrmuc and Lind (2018)[14]. After eight years, the leverage ratio has increased 0.77 percentage points. A longer term simulation (not shown) reveals that it takes another four years for the leverage ratio to reach its new target level (equivalent to a one percentage

[14]Fidrmuc and Lind (2018) in a meta-analysis of 48 studies found that GDP on average fell by approximately 0.2 percentage points following a 1 percentage point increase in the capital ratio.

point increase). Ultimately, GDP reverts to base.

Table 21: Target leverage ratio +1 %-points

	1	2	3	4	5	6	7	8
Volumes								
GDP	-0.01	-0.10	-0.22	-0.32	-0.33	-0.28	-0.18	-0.07
Private consumption	-0.04	-0.30	-0.62	-0.87	-0.99	-0.97	-0.87	-0.74
Housing investment	0.02	-0.48	-1.41	-2.04	-2.11	-1.87	-1.34	-0.62
Other private investment	0.00	-0.14	-0.32	-0.48	-0.52	-0.36	-0.10	0.14
Exports	0.00	0.00	0.00	0.01	0.02	0.05	0.09	0.13
Domestically produced exports	0.00	0.00	0.00	0.01	0.04	0.10	0.17	0.24
Imports	-0.01	-0.09	-0.20	-0.29	-0.32	-0.30	-0.25	-0.19
Prices and wages								
HICP	0.00	0.00	-0.02	-0.07	-0.16	-0.26	-0.35	-0.40
Domestically produced exports	0.00	0.00	0.00	-0.01	-0.05	-0.12	-0.20	-0.25
Cost prices (including energy)	0.02	0.04	0.01	-0.07	-0.17	-0.27	-0.34	-0.37
Wages (contractual) private sector	0.00	-0.01	-0.05	-0.13	-0.24	-0.35	-0.43	-0.47
House prices	-0.30	-1.88	-3.77	-5.10	-5.61	-5.44	-4.82	-4.03
Other items								
Government balance (%GDP)	-0.01	-0.07	-0.16	-0.22	-0.25	-0.25	-0.22	-0.17
Total employment	0.00	-0.04	-0.12	-0.22	-0.28	-0.29	-0.24	-0.14
Unemployment rate (%-points)	0.00	0.04	0.09	0.15	0.19	0.19	0.15	0.09
Labour share of income (%-points)	0.01	0.05	0.06	0.04	-0.02	-0.07	-0.09	-0.09
Financial variables								
Mortgage rate (%-points)	0.01	0.07	0.09	0.09	0.07	0.06	0.05	0.05
Lending rate to firms (%-points)	0.03	0.08	0.11	0.12	0.12	0.11	0.10	0.09
Loans to firms	-1.47	-3.29	-4.57	-5.38	-5.88	-6.20	-6.39	-6.46
Loans to households	-1.04	-2.60	-3.68	-4.36	-4.77	-4.96	-4.96	-4.83
Leverage ratio (%-points)	0.15	0.32	0.48	0.61	0.69	0.72	0.75	0.77
Interest income banking sector[2]	-0.58	-1.99	-2.75	-2.89	-2.99	-3.44	-4.11	-5.46
Interest costs banking sector[2]	-0.56	-2.21	-3.45	-4.12	-4.53	-5.28	-6.34	-8.34
Operating costs banking sector[2]	-0.15	-0.35	-0.48	-0.56	-0.61	-0.64	-0.66	-0.65
Net impairments for bad loans[2]	-0.06	-0.12	-0.14	-0.08	-0.07	-0.21	-0.32	-0.39
Net other income banking sector[2]	-0.07	-0.34	-0.94	-1.13	-1.47	-1.88	-2.21	-2.33
Profits banking sector[2]	0.12	0.34	0.38	0.74	0.74	0.82	0.99	1.59
Taxes banking sector[2]	0.02	0.07	0.08	0.15	0.15	0.16	0.20	0.32
Dividends banking sector[2]	-0.60	-1.56	-1.42	-1.07	-0.76	-0.57	-0.49	-0.34
Other changes in capital[2]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIER capital[2]	0.69	2.52	4.25	5.91	7.26	8.49	9.77	11.40

[1] Percent deviation from central projection.
[2] Deviation from central projection in billions of euros.

5.3 Risk weight on lending to households +10 %-points

The leverage ratio is the key variable that links the banking sector, via lending rates and loans, to the real side of the economy. The selection of the leverage ratio over a risk-weighted capital ratio as the key transmission variable is empirically based, as explained in Section 3.5. Nevertheless, it may be of interest to investigate how the banking sector and the real economy would respond to changes in risk weights of particular asset classes, such as credit extended to households or firms. Risk weights are used to compute risk weighted assets (RWA), which are an ingredient of the (risk weighted) TIER capital ratio. In this scenario, the risk weight on lending to households is increased by 10 percentage points. For this shock to have any impact, the standard version of the model is modified by replacing the leverage ratio and its target level by the (risk weighted) TIER capital ratio and a matching target level, respectively. The target level of the TIER ratio is chosen to be its sample mean, as was done in the case of the leverage ratio. Replacing the leverage ratio by the TIER capital ratio requires re-calibration of the relevant regression parameters in the model. This is done by observing that the leverage ratio can be written as the product of the risk weighted capital ratio times the density ratio, i.e. the average risk weight per unit of assets, see Fender and Lewrick (2015) and Gambacorta and Karmakar (2016). Since in the model the leverage ratio is calculated using monetary statistics and the TIER capital ratio is based on supervisory data, this product is extended here by two more ratios: first, the ratio of total assets on the MFI balance sheet to total asset from the consolidated balance sheet, and second, the ratio of capital on the MFI balance sheet to TIER capital based on supervision data. These four ratios are approximated by their respective baseline averages. These numbers are then multiplied by the regression parameters that measure the impact of the leverage ratio to compute the regression parameters that quantify the effect of the TIER capital ratio (more details on linking the leverage ratio to the risk weighted capital ratio are provided in the appendix).

An increase in the risk weight on lending to households implies that - *ceteris paribus* - risk weighted assets increase and the TIER capital ratio falls. In order to return the TIER capital ratio to its target level, banks start to cut back on lending and to increase lending rates. This mechanism is similar to the scenarios discussed above. It is assumed that banks cut back on all lending activities and not on lending to households in particular. As before, higher mortgage interest rates and lower mortgage lending impact negatively on house prices and private consumption, and a higher lending rate to firms and lower lending to firms reduce firms spending on investment projects, see Table 22. The response of real GDP is hump-shaped, reaching a maximum after six years. After eight years, real GDP is still around 0.1 percentage points below its baseline level. A longer term simulation (not shown) reveals that in the long run real GDP reverts back to its baseline level, while the (unweighted) leverage ratio remains above its baseline level. This suggests that, after a transition period, a safer banking sector need not necessarily come at the cost of a permanently lower level of economic activity.

In this scenario, the risk weight on lending to households is raised in the Netherlands only. If this policy were to be simultaneously implemented in competitor countries, the macro impact of the move to higher capitalization requirements could last longer. An internationally coordinated increase in risk weights could lead to less lending and economic activity abroad, which lowers foreign demand for Dutch exporters.

Table 22: Risk weight on lending to households +10 %-points

	1	2	3	4	5	6	7	8
Volumes								
GDP	0.00	-0.02	-0.06	-0.10	-0.12	-0.12	-0.11	-0.08
Private consumption	-0.01	-0.06	-0.17	-0.28	-0.35	-0.40	-0.41	-0.39
Housing investment	0.01	-0.08	-0.37	-0.65	-0.79	-0.85	-0.82	-0.67
Other private investment	0.00	-0.03	-0.08	-0.14	-0.18	-0.17	-0.11	-0.04
Exports	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.04
Domestically produced exports	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.08
Imports	0.00	-0.02	-0.05	-0.09	-0.11	-0.13	-0.13	-0.12
Prices and wages								
HICP	0.00	0.00	0.00	-0.02	-0.04	-0.08	-0.12	-0.15
Domestically produced exports	0.00	0.00	0.00	0.00	-0.01	-0.04	-0.06	-0.09
Cost prices (including energy)	0.00	0.00	0.00	-0.02	-0.05	-0.09	-0.12	-0.15
Wages (contractual) private sector	0.00	0.00	-0.01	-0.03	-0.07	-0.11	-0.15	-0.18
House prices	-0.04	-0.43	-1.09	-1.69	-2.08	-2.27	-2.26	-2.13
Other items								
Government balance (%GDP)	0.00	-0.01	-0.04	-0.07	-0.09	-0.10	-0.10	-0.10
Total employment	0.00	-0.01	-0.03	-0.06	-0.09	-0.11	-0.11	-0.09
Unemployment rate (%-points)	0.00	0.01	0.02	0.05	0.07	0.08	0.07	0.06
Labour share of income (%-points)	0.00	0.01	0.02	0.02	0.01	-0.01	-0.02	-0.03
Financial variables								
Mortgage rate (%-points)	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Lending rate to firms (%-points)	0.00	0.01	0.02	0.03	0.03	0.04	0.04	0.04
Loans to firms	-0.27	-0.94	-1.50	-1.94	-2.30	-2.58	-2.81	-2.97
Loans to households	-0.18	-0.73	-1.20	-1.56	-1.85	-2.07	-2.21	-2.29
Leverage ratio (%-points)	0.03	0.08	0.13	0.18	0.22	0.24	0.26	0.27
Interest income banking sector[2]	-0.10	-0.59	-0.98	-1.14	-1.28	-1.55	-1.93	-2.65
Interest costs banking sector[2]	-0.10	-0.62	-1.12	-1.47	-1.74	-2.17	-2.75	-3.79
Operating costs banking sector[2]	-0.03	-0.10	-0.16	-0.20	-0.23	-0.27	-0.29	-0.30
Net impairments for bad loans[2]	-0.01	-0.03	-0.05	-0.03	-0.02	-0.08	-0.13	-0.17
Net other income banking sector[2]	-0.01	-0.08	-0.28	-0.38	-0.57	-0.81	-1.06	-1.24
Profits banking sector[2]	0.03	0.08	0.07	0.17	0.15	0.15	0.18	0.38
Taxes banking sector[2]	0.01	0.02	0.01	0.03	0.03	0.03	0.04	0.08
Dividends banking sector[2]	-0.09	-0.26	-0.30	-0.29	-0.28	-0.26	-0.23	-0.18
Other changes in capital[2]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIER capital[2]	0.11	0.43	0.79	1.21	1.62	2.00	2.37	2.86

[1] Percent deviation from central projection.
[2] Deviation from central projection in billions of euros.

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A The model equations

This appendix presents the model equations in detail. The appendix consists of eight sections: firms, households, wages and labour market, prices, rest of world, pension funds, government and social security and banks. Most behavioural equations have been estimated on data starting in the early 1980s and ending 2016Q4; further details are provided directly below each equation. In general the econometric methodology adopted is an ECM approach, where a long-run cointegrated equation describing equilibrium conditions is nested within a short-run dynamic equation. In all cases, close attention is given to the empirical performance of the estimated equations, it is important that all of the estimated equations are congruent with the underlying data. 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' production is modelled using a nested CES production function which combines inputs of labour, capital and energy. We allow for both labour-augmenting, capital-augmenting and energy-augmenting technical progress. This means that all inputs enter in efficiency units. Sample averages, indicated by bars, are used to normalize the production function.

We combine capital and labour first, cf. Van der Werf (2008). Labour is measured in hours worked. Capital is the private sector capital stock excluding dwellings. We include a measure of capacity utilisation to allow for the fact that production factors do not always operate at full capacity. Labour-augmenting technical progress is quantitatively more important than capital-augmenting technical progress.[15] The elasticity of substitution between capital and labour is estimated to be 0.50, which is at the lower end of the range found in the academic literature (Chirinko (2008)).

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

where

y^{pr}_{va}: 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

[15] Economies of scale are assumed constant, this is confirmed by free estimation of the elasticties of scale parameter η in (1).

$\nu_L = 0.275$ (0.004): labour-augmenting technical progress

$\nu_K = 0.185$ (0.009): capital-augmenting technical progress

$\alpha = 0.462$ (0.050): elasticity with respect to rate of capacity utilisation in manufacturing industry

$\eta = 1.000$: economies of scale

$\sigma = 0.50$ (0.000): elasticity of substitution between capital and labour

$\theta = 0.675$: 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. 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 in Van der Werf (2008). Energy-augmenting technical progress was increasing until around 2015, and has since diminished very slightly.

$$y^{pr}_{va,t} + ce_t = (\bar{y}^{pr}_{va,t} + \overline{ce}) \left[\zeta^{\frac{1}{\gamma}} \left(e^{\nu^1_E t/\bar{t} + \nu^2_E (t/\bar{t})^2} \frac{ce_t}{\overline{ce}} \right)^{\frac{\gamma-1}{\gamma}} + (1-\zeta)^{\frac{1}{\gamma}} \left(\frac{y^{pr}_{va,t}}{\bar{y}^{pr}_{va}} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \tag{2}$$

where

ce: volume of domestic use of energy

$\zeta = 0.039$: sample average share of energy costs in total factor income

$\gamma = 0.186$ (0.050): elasticity of substitution between energy and capital-labour composite

$\nu^1_E = 0.008$ (0.003): energy-augmenting technical progress, linear part

$\nu^2_E = -0.000029$ (0.00002): energy-augmenting technical progress, quadratic part.

Standard errors are in parentheses.

We assume cost-minimizing behaviour on the part of firms, and solve equations (1) and (2) to derive the long term demand equations for **private sector employment** (ep), **private sector capital excluding dwellings** (ko) and **use of energy** (ce). The long run demand for labour in equation (3) is derived as the inverse of the production function where $A^{ep} = \bar{y}^{pr}_{va} * \left[\theta^{\frac{1}{\sigma}} + (1-\theta)^{\frac{1}{\sigma}} \right]$ is a constant from the production function (1).

$$\ln(ep_t) = \ln \left[\left(\left(\frac{y^{pr}_{va,t}}{A^{ep} * \frac{cu_t}{\bar{cu}}^{\alpha}} \right)^{\frac{\sigma-1}{\sigma\eta}} - (1-\theta)^{\frac{1}{\sigma}} \left(\frac{K_t}{\bar{K}} e^{\nu^{struc}_{K,t}} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \theta^{\frac{1}{1-\sigma}} \left(\bar{L} \frac{\bar{hp}}{hp} e^{-v^{struc}_{L,t}} \right) \right] \tag{3}$$

$$\ln(ko_t) = \frac{1}{\eta} \left[\ln(y^{pr}_{va,t} + ce_t) - \gamma \ln \left(\frac{cy_t}{cye_t} \right) \right] - \sigma \ln \left(\frac{pke_t}{cy_t} \right) - \nu^{struc}_{K,t} - \alpha \ln(cu_t) \tag{4}$$

$$\ln(ce_t) = \ln(y^{pr}_{va,t} + ce_t) - \gamma \ln \left(\frac{pcee_t}{cye_t} \right) - \nu^1_E t - \nu^2_E t^2 \tag{5}$$

where

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:

$$cy_t = \left[\theta ple_t^{1-\sigma} + (1-\theta) pke_t^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \quad (6)$$

$$cye_t = \left[(1-\zeta) cy_t^{1-\gamma} + \zeta pcee_t^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \quad (7)$$

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

$$ple_t = \frac{W_t^{pr} + W_t^{s}}{ep_t * hp_t}\, e^{-\nu_{L,t}^{struc}} \quad (8)$$

The **user of cost of capital in efficiency units** (pke) is defined as the **user cost of capital** (pk) adjusted for structural capital-augmenting technical progress. The expression for pk contains the conventional Jorgensonian user-cost elements, namely the cost of financing investment, a depreciation rate and an expected inflation rate for capital goods, measured as the expected rate of change of the deflator of (other private) investment (pio^e). We assume 49 percent of the capital stock is financed using equity and 51 percent using (bank) loans. The cost of equity is proxied as the long rate plus the yield on dividends $rl + divf$, where $divf$ is included as a proxy for the equity premium. Firms pay the bank lending rate r^f on their (bank) loans. We do not disaggregate the capital stock 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 (ict) in the capital stock, we decompose the depreciation rate in equation (9) into the depreciation rate on non-ICT investments ($\delta^o * (1 - ict)$) and the depreciation rate on ICT investments ($\delta^{ict} * ict$). Finally we estimate the cost of capital in efficiency units pke based on production function estimates of structural capital-augmenting technical progress(ν_K^{struc}).

$$pk_t = pio_t * \frac{1 - \tau_t^{subs} - \tau_t^{firms} * 0.6}{1 - \tau_t^{firms}} * \left[0.49 * (rl_t + divf_t) + 0.51 * r_t^f * (1 - \tau_t^{firms}) + [\delta_t^o * (1 - ict_t) + \delta_t^{ict} * ict_t] - pio_t^e\right] \quad (9)$$

$$pke_t = pk_t\, e^{-\nu_{K,t}^{struc}} \quad (10)$$

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.

$$\ln(io_t) = \left[\ln(y^{pr}_{va,t} + ce_t) - \gamma \ln\left(\frac{cy_t}{cye_t}\right)\right] - \sigma \ln\left(\frac{pke_t}{cy_t}\right) - \nu^{struc}_{K,t} - \alpha \ln(cu_t) + \ln(\delta^o_t + \mu) \tag{11}$$

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

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

$$ko_t = (1 - \delta^o_t)ko_{t-1} + io_t \tag{12}$$

In the short term equation for **employment in the private sector** ep the ECM term is derived from the long run demand for labour in equation (3). Short term growth in employment is further affected by lagged changes in private sector value added, changes in the cost of labour in efficiency units, changes in labour supply (ls) and deviations in the profit rate $profq$ from a 5-year moving average. If firms increase their profits, part of the additional profit is used to increase employment. In periods when the labour market it doing well, we assume that some labour market inflow is sufficiently qualified to immediately find a job. This only applies 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. The equation also includes two financial variables, growth in stock market prices relative to value added and the growth in bank credit to domestic firms.

$$\begin{aligned}
\Delta \ln ep_t = & -\underset{(2.9)}{0.04} * ep_{ECM,t-1} + \underset{(4.9)}{0.45} * \Delta \ln ep_{t-1} + \underset{(3.4)}{0.24} * \frac{1}{4}\sum_{i=2}^{5} \Delta \ln y^{pr}_{va,t-i} \\
& - \underset{(-4.0)}{0.1} * \Delta \ln ple_{t-3} + \underset{(3.1)}{0.21} * \ I_A \Delta \ln ls_{t-3} + \underset{(0.7)}{0.0001}\left(profq_{t-3} - \frac{1}{20}\sum_{i=3}^{22} profq_{t-i}\right) \\
& + \underset{(4.3)}{0.009} * \Delta \ln \frac{ps^{wo}_{t-2}/exr_{t-2}}{y^{pr}_{va,t-2} * py^{pr}_{va,t-2}} + \underset{(1.6)}{0.01} * \Delta \ln \frac{loansf^{dom}_{t-2}}{pio_{t-2}} \qquad (13) \\
profq_t = & \ (Z_t - Z^{hh}_t)/(py_t * y_t)
\end{aligned}$$

$\bar{R}^2 = 0.77$; $S.E. = 0.002$; $p(LM_4) = 0.18$; $p(JB) = 0.00$

Estimation period: 1982Q3 - 2016Q4

In the short term, the equation for the growth in the **volume of other private investment** (io) includes an ECM term derived from equation (11). In the short term, the growth in investment is strongly affected by growth in private sector value added, this captures the classical accelerator mechanism. In addition deviations in profitability from a 5-year moving average, the growth in world stock prices relative to GDP (from 2000Q1 onwards) and the growth in the *flow* of bank credit positively affect the growth in investment.

There is a negative relationship with the dividend yield.

$$\Delta \ln io_t = -\underset{(3.5)}{0.14} * io_{ECM,t-1} - \underset{(4.1)}{0.36} * \Delta \ln io_{t-1} + \underset{(2.1)}{0.76} * \Delta \ln y^{pr}_{va,t-2} + \underset{(2.7)}{1.24} * \Delta \ln y^{pr}_{va,t-3}$$
$$+ \underset{(2.5)}{0.07} * I_{2000Q1,t} * \Delta \ln \frac{ps^{wo}_{t-2}/exr_{t-2}}{y^{pr}_{va,t-2} * py^{pr}_{va,t-2}} + \underset{(2.7)}{0.16} * \left(\Delta \ln \frac{loansf^{dom}_{t-4}}{pio_{t-4}} - \Delta \ln \frac{loansf^{dom}_{t-5}}{pio_{t-5}} \right)$$
$$+ \underset{(2.3)}{0.007} * \left(profq_{t-4} - \frac{1}{20} \sum_{i=4}^{23} profq_{t-i} \right) - \underset{(-3.1)}{0.005} * \frac{1}{4} \sum_{i=1}^{4} divf_{t-i} \tag{14}$$

$\bar{R}^2 = 0.42$; $S.E. = 0.03$; $p(LM_4) = 0.50$; $p(JB) = 0.00$

Estimation period: 1985Q1 - 2016Q4

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 based on equation (5).

$$\Delta \ln ce_t = -\underset{(3.8)}{0.34} + \underset{(3.8)}{0.36} * \Delta \ln ce_{t-2} - \underset{(3.8)}{0.13} * ce_{ECM,t-1} \tag{15}$$

$\bar{R}^2 = 0.17$; $S.E. = 0.04$; $p(LM_4) = 0.02$; $p(JB) = 0.00$

Estimation period: 1978Q2 - 2016Q4

Firms not only invest in fixed capital, they also hold stocks. Firms want to minimise stock out risk, this means that the **volume of changes in inventories** (ds) will depend positively on expected future final demand. In equation (16) final demand ($yfin$) equals the sum of private consumption, investment, exports and other government consumption and we assume backward looking expectations. In addition, current demand affects changes in inventories.

$$\frac{ds_t}{\sum_{i=1}^{4} y^{pr}_{va,t-i}} = \underset{(5.7)}{0.55} * \frac{ds_{t-1}}{\sum_{i=1}^{4} y^{pr}_{va,t-i}} - \underset{(4.3)}{0.26} * \frac{\Delta yfin_t}{\sum_{i=1}^{4} y^{pr}_{va,t-i}}$$
$$+ \underset{(2.1)}{0.08} * \frac{\frac{1}{4}\sum_{i=1}^{4} \Delta yfin_{t-i}}{\sum_{i=1}^{4} y^{pr}_{va,t-i}} + \underset{(5.9)}{0.13} * \Delta \ln y^{pr}_{va,t} \tag{16}$$

$\bar{R}^2 = 0.58$; $S.E. = 0.001$; $p(LM_4) = 0.17$; $p(JB) = 0.06$

Estimation period: 1980Q3 - 2016Q4

The **volume of stock of inventories** (s) accumulates as follows:

$$s_t = s_{t-1} + ds_t \tag{17}$$

The **volume of changes in inventories including statistical discrepancies** ($dels$) is equal to the change in inventories plus a residual.

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 which includes an adjustment for imputed banking services.

$$y^{pr}_{va,t} = y_t - y^{gov}_{va,t} - (taxprodr_t - subsprodr_t) \tag{18}$$

The **volume of gross domestic product** (y) is the sum of private consumption (c), government consumption (cg), total investment (it), exports less imports and the change in stocks ($dels$). Total investment is equal to the sum of government investment (ig), housing investment (ih) and other private investment (io).

$$y_t = c_t + cg_t + it_t + x_t - m_t + dels_t \tag{19}$$

$$it_t = ig_t + ih_t + io_t \tag{20}$$

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

$$prod_t = y^{pr}_{va,t}/ep_t \tag{21}$$

Potential volume of private sector value added at basic prices ($ypot^{pr}_{va}$) 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^{struc}_{L}) and structural capital-augmenting technical progress (ν^{struc}_{K}) into the CES production function in equation (1). Capacity utilisation drops out of the potential output equation.

$$ypot^{pr}_{va,t} = \bar{y}^{pr}_{va}\left[\theta^{\frac{1}{\sigma}}\left(e^{\nu^{struc}_{L,t}}\frac{ep^{struc}_t * hp^{struc}}{\bar{L}}\right)^{\frac{\sigma-1}{\sigma}} + (1-\theta)^{\frac{1}{\sigma}}\left(e^{\nu^{struc}_{K,t}}\frac{K_t}{\bar{K}}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\eta\sigma}{\sigma-1}} \tag{22}$$

We define **potential private sector employment** as potential employment less actual government sector employment.

$$ep^{struc}_t = n_{1575,t} * \frac{part^{struc}_t * (1-u^{eq}_t)}{\psi^{tot,struc}_t} - eg_t \tag{23}$$

where potential total employment is defined as the population between 15 and 75 times the long term participation rate (equation (46)) 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^{struc}_{L}) and **structural capital-augmenting technical progress** (ν^{struc}_{K}) 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 (50) 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).

$$\begin{aligned} u^{eq}_t &= +\frac{1}{0.011}\left[-0.51 + 0.63 * \frac{1}{8}\sum_{i=0}^{7}\frac{py^{pr}_{va,t-i}}{cy_{t-i}} + 0.25 * \frac{1}{8}\sum_{i=0}^{7}\ln rpr_{t-i}\right] \\ &\quad +\frac{1}{0.011}\left[+0.51 * \frac{1}{8}\sum_{i=0}^{7}\left(\ln(1+\tau^{vat}_{t-i}) - \ln(1-\tau_{r,t-i}) - \ln(1-\tau_{n,t-i})\right)\right] \\ &\quad +\frac{1}{0.011}\left[-\ln\left(1-(1-\theta)\left(\frac{1}{8}\sum_{i=0}^{7}\frac{pke_{t-i}}{cy_{t-i}}\right)^{1-\sigma}\right)\right] \end{aligned} \tag{24}$$

The **replacement rate** (rpr) variable is based on CPB data. This is linked to DELFI by relating it to an implicit replacement rate between unemployment benefits and private sector wages. Specifically rpr is estimated as a function of the ratio between benefits received from unemployment insurance ($transh_{ww}$) and social assistance ($transh_{bw}$) relative to private sector gross wages w^{pr}_{gross}. To track income tax effects this term is adjusted for changes in the top tax rate τ_{top}.

$$rpr_t = \underset{(24.1)}{54.5} + \underset{(10.7)}{61270} * (1-\tau^{top}_t) * \left(\frac{transh_{ww,t} + transh_{bw,t}}{n_{ww,t} + n_{bw,t}}\right)\Big/ w^{pr}_{gross,t} \tag{25}$$

$\bar{R}^2 = 0.83$; $S.E. = 3.11$; $p(LM_4) = 0.00$; $p(JB) = 0.18$
Estimation period: 1975 - 2016

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.

$$ypot_t = ypot^{pr}_{va,t} + y^{gov}_{va,t} + (taxprodr_t - subsprodr_t) \tag{26}$$

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

$$ygap_t = (y_t - ypot_t)/ypot_t \tag{27}$$

A.2 Households

The long term **consumption function** (28) distinguishes between 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 ($wealth$), apart from 23 percent of net housing wealth ($hwealthn$ = $hwealth$ - $loanshmor$) which is owned by the RoT households (including 23 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 ($rl * 0.01 - \frac{\Delta_4 pc_t}{pc_{t-4}}$).

$$C_t = \left(1 - \left(1 + rl_t * 0.01 - \frac{\Delta_4 pc_t}{pc_{t-4}}\right)^{\left(\underset{(15.7)}{0.98} - 1\right)} * (1 - \underset{(3.5)}{0.04})^{\left(\underset{(15.7)}{0.98}\right)}\right) \tag{28}$$
$$* \left(\frac{1}{4}(wealth_{t-1} - 0.23 * hwealthn_{t-1}) + divh_t - (1 - 0.23) * r^{hh}_{paid,t}\right.$$
$$\left. + r^{hh}_{received,t} + (1 - 0.80) * YDIS^*_t / (0.01 * rl_t + \underset{(1.6)}{0.11})\right)$$
$$+ 0.80 * YDIS^*_t - 0.23 * r^{hh}_{paid,t} + \underset{(0.7)}{0.05} * 0.23 * hwealthn_{t-1}/4$$

$\bar{R}^2 = 0.61$; $S.E. = 0.02$; $p(ADF) = 0.00$

Estimation period: 1981Q1 - 2016Q4

In the short term, private consumption (29) is driven by changes in real disposable income ($ydis$), real stock prices (ps/pc), real house prices (ph/pc), the unemployment rate (u), changes in consumer confidence ($cconf$), changes in the mortgage rate (r^m) and an error-correction term (c_{ECM}), which is obtained by dividing both sides of equation (28) by pc and taking logs.

$$\Delta \ln c_t = \underset{(5.0)}{0.002} - \underset{(4.2)}{0.11} * c_{ECM,t-1} + \underset{(2.0)}{0.05} * \Delta \ln ydis_t - \underset{(2.8)}{0.01} * \frac{1}{4}\sum_{i=1}^{4} \Delta u_{t-i} \tag{29}$$
$$+ \underset{(2.2)}{0.02} * \frac{1}{2}\sum_{i=1}^{2} \Delta \ln(ps_{t-i}/pc_{t-i}) + \underset{(5.8)}{0.15} * \Delta \ln(ph_t/pc_t)$$
$$- \underset{(1.7)}{0.003} * \Delta r^m_{t-1} + \underset{(2.5)}{0.00005} * \Delta_6 cconf_{t-1}$$

$\bar{R}^2 = 0.50$; $S.E. = 0.01$; $p(LM_4) = 0.39$; $p(JB) = 0.50$

Estimation period: 1984Q2 - 2016Q4

The **consumer confidence** equation includes the unemployment rate u, the interest rate spread $rl - rs$, the coverage ratio $frpf$, the VAT rate τ^{vat}_h and the financial stress indicator fsi specified in absolute differences while real disposable income $ydis$, stock market prices ps, real house prices ph/pc and the oil price p_{oil} are included in log differences.

$$cconf_t = -\underset{(-2.2)}{1.34} + \underset{(17.5)}{0.76} * cconf_{t-1} - \underset{(-3.3)}{13.8} * \Delta u_t + \underset{(2.3)}{0.66} * 100 * \ln\left(1 + \frac{\Delta_2 ydis_t}{ydis_{t-2}}\right) + \underset{(3.4)}{0.10} * \Delta_4 frpf_{t-1}$$
$$+ \underset{(1.6)}{0.11} * 100 * \ln\left(1 + \frac{\Delta ps_t}{ps_{t-1}}\right) + \underset{(2.3)}{1.28} * \Delta_4(rl_t - rs_t) + \underset{(3.0)}{0.95} * 100 * \ln\left(1 + \frac{\Delta(ph_t/pc_t)}{(ph_{t-1}/pc_{t-1})}\right)$$
$$- \underset{(-2.7)}{4.11} * \Delta_2 fsi_t - \underset{(-3.0)}{7.9} * \ln\left(1 + \frac{\Delta_2 p_{oil,t}}{p_{oil,t-2}}\right) - \underset{(-2.8)}{2.85} * \Delta\tau^{vat}_{h,t} \tag{30}$$

$\bar{R}^2 = 0.92$; $S.E. = 5.50$; $p(LM_4) = 0.04$; $p(JB) = 0.04$

Estimation period: 1989Q2 - 2016Q4

Sources of **household net disposable income** ($YDIS$) in equation (31) are compensation of employees (W, see equation (61)), mixed income (Z^{hh}), property income ($divh + r^{hh}_{received} - r^{hh}_{paid} + icpf$) and social benefits in cash ($transh$), less taxes paid by households ($taxh$) and social contributions ($scr + scn$).

$$YDIS_t = W_t + Z^{hh}_t + divh_t + r^{hh}_{received,t} - r^{hh}_{paid,t} + icpf_t + transh_t - taxh_t - scr_t - scn_t \tag{31}$$

Social benefits in cash ($transh$) 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 ($transh_{oth}$).

$$\begin{aligned} transh_t = {} & transh_{wao,t} + transh_{aow,t} + transh_{anw,t} + transh_{akw,t} + transh_{ww,t} \\ & + transh_{bw,t} + transh_{zt,t} + transh_{wj,t} + transh_{pen,t} + scr_{imp,t} + transh_{oth,t} \end{aligned} \tag{32}$$

Transfers, taxes and social contributions are discussed in the section 'Government and social security'.

Mixed income of households (Z^{hh}) is the sum of imputed wages of self-employed (W^s), calculated as self-employment (es) times compensation per employee ($W/(e - es)$), and a non-wage part, which is modelled as a function of nominal GDP ($py * y$) and the output gap.

$$W^s_t = es_t * \frac{W_t}{e_t - es_t} \tag{33}$$

$$Z^{hh}_t = W^s_t + Y_t * \left(\underset{(8.0)}{-0.05} + \underset{(9.0)}{0.29} * \frac{1}{2} \sum_{i=0}^{1} ygap_{t-i} + \underset{(7.0)}{0.53} * \frac{1}{3} \sum_{i=1}^{3} \frac{Z^{hh}_{t-i}}{Y_{t-i}} \right) \tag{34}$$

$\bar{R}^2 = 0.94$; $S.E. = 0.004$; $p(LM_4) = 0.00$; $p(JB) = 0.32$
Estimation period: 1981Q1 - 2016Q4

Households pay interest (r^{hh}_{paid}) on their mortgage debt ($loanshmor$) and other debt ($loansho$). The relevant interest rate is a weighted average of the mortgage interest rate (labelled A^{rm} for convenience in equation (35)), the short term interest rate (rs) and a constant term with two regimes. The constant term is negative before 1998Q4, thereafter it is positive. This equation also includes an adjustment ($fisim^{paid,hh}_t$) related to FISIM paid by households.

$$\begin{aligned} r^{hh}_{paid,t} = {} & fisim^{paid,hh}_t + \left[\frac{1}{2} \sum_{i=0}^{1} (loanshmor_{t-i} + loansho_{t-i}) \right] * \\ & \frac{1}{400} * \left(A^{rm}_t + 0.0375 * \frac{1}{4} \sum_{i=0}^{3} rs_{t-i} - \underset{(9.4)}{0.31} * (1 - I_{1998Q4,t}) + \underset{(6.5)}{0.19} * I_{1998Q4,t} \right) \end{aligned} \tag{35}$$

where

$$A_t^{rm} = 0.9625 * \left(0.5 * \frac{1}{8}\sum_{i=0}^{7} r_{t-i}^{m} + 0.25 * \frac{1}{8}\sum_{i=8}^{15} r_{t-i}^{m} + 0.25 * \frac{1}{16}\sum_{i=16}^{31} r_{t-i}^{m}\right)$$

$\bar{R}^2 = 0.50$; $S.E. = 0.24$; $p(LM_4) = 0.00$; $p(JB) = 0.58$

Estimation period: 1984Q4 - 2016Q4

Households receive interest ($r_{received}^{hh}$) on their deposits ($deph^{dom}$). The relevant interest rate is the deposit rate, modelled in equation (131). This equation also includes an adjustment ($fisim_t^{received,hh}$) related to FISIM received by households.

$$r_{received,t}^{hh} = fisim_t^{received,hh} - \underset{(10.9)}{382} + \frac{rdep_{t-i}^{h}}{400} * \left(\frac{1}{2}\sum_{i=0}^{1} deph_{t-i}^{dom}\right) \quad (36)$$

$\bar{R}^2 = 0.76$; $S.E. = 198.4$; $p(LM_4) = 0.00$; $p(JB) = 0.25$

Estimation period: 1982Q4 - 2016Q4

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

$$divh_t = divhr_t * v_t^{hh} * 0.25 \quad (37)$$

Net household wealth ($wealth$) is the sum of equities and bonds (v^{hh}), household deposits ($deph^{dom}$), housing wealth ($hwealth$), net of mortgage debt ($loanshmor$, equation (136)) and other debt ($loansho$, equation (142)).

$$wealth_t = v_t^{hh} + deph_t^{dom} + hwealth_t - loanshmor_t - loansho_t \quad (38)$$

The **amount available to households for investment in equities, long-term bonds and other financial assets other than deposits** (v^{hh}) is equal to the amount invested in the previous period corrected for capital gains ($v_{-1}^{hh} * ps/ps_{-1}$) plus savings out of disposable income plus new borrowings not spent on housing investment ($\Delta loanshmor + \Delta loansho - pih * ih * \chi^{ih} * (1 - \delta^{ih})$) minus the increase in bank deposits.

$$\begin{aligned} v_t^{hh} = & \Big(v_{t-1}^{hh} * ps_t/ps_{t-1} + YDIS_t - pc_t * c_t\Big) \\ & + \Delta loanshmor_t + \Delta loansho_t - pih_t * ih_t * \chi^{ih} * (1 - \delta^{ih}) - \Delta deph_t^{dom}\Big) \end{aligned} \quad (39)$$

Household **mortgage debt** ($loanshmor$) and **other debt** ($loansho$) are described later in the banking section.

Households' housing wealth ($hwealth$) is equal to housing wealth in the previous period corrected for capital gains plus the share of net housing investment ($pih * ih * (1 - \delta^{ih})$) carried out by households (χ^{ih}).

$$hwealth_t = hwealth_{t-1} * \frac{ph_t}{ph_{t-1}} + \chi^{ih} * pih_t * ih_t * (1 - \delta^{ih}) \quad (40)$$

In the long term, households target a 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 ($permits$).

$$\ln ih_t = \ln c_t - \underset{(-22.4)}{6.6} + \underset{(4.2)}{0.11} * (\ln pc_t - \ln pkh_t) + \underset{(15.6)}{0.45} * \frac{1}{4}\sum_{i=1}^{4} \ln permits_{t-i} \tag{41}$$

$\bar{R}^2 = 0.88$; $S.E. = 0.06$; $p(ADF) = 0.00$

Estimation period: 1980Q1 - 2016Q4

In the short term, the change in housing investment is driven by the long-run ECM term from equation (41), the change in the number of productive hours worked per employee in the construction sector (hc) and changes in consumer confidence ($cconf$). In addition it is driven by both the growth in housing wealth ($hwealth$), motivated by the fact that part of (surplus) housing wealth is used for home improvement, and by changes in the loan-to-value ratio (LTV) where an increase in the LTV serves to discourage housing investment.

$$\begin{aligned} \Delta \ln ih_t = & - \underset{(-2.1)}{0.11} * ih_{ECM,t-1} + \underset{(3.3)}{0.17} * \Delta \ln hc_t + \underset{(2.0)}{0.0002} * \Delta_6 cconf_{t-1} \\ & + \underset{(2.7)}{0.39} * \frac{1}{4}\sum_{i=0}^{3} \Delta \ln hwealth_{t-i} + \underset{(3.3)}{0.84} * \Delta \ln \left(\frac{hwealth_{t-1} - loanshmor_{t-1}}{hwealth_{t-1}} \right) \end{aligned} \tag{42}$$

$\bar{R}^2 = 0.79$; $S.E. = 0.03$; $p(LM_4) = 0.65$; $p(JB) = 0.49$

Estimation period: 1980Q1 - 2016Q4

The **user cost of housing capital** (pkh) is a conventional function of the mortgage interest rate, depreciation ($\delta^h = 0.02$) and capital gains from (backward looking) expectations of price changes. The mortgage interest rate is adjusted to allow for mortgage interest relief at the top rate τ^{top}.

$$pkh_t = pih_t * \left(0.01 * r_t^m \left(0.67(1 - \tau_t^{top}) + 0.33 \right) * 0.25 + \delta^h - \frac{1}{4}\sum_{i=0}^{3} \Delta \ln pih_{-i} \right) \tag{43}$$

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

$$kh_t = (1 - \delta^h) kh_{t-1} + ih_t \tag{44}$$

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

$$ls_t = n_{1575,t} * part_t \tag{45}$$

Between the mid 1980s and the mid-2000s, the **labour force participation rate** increased substantially due to the inflow of women into the labour market. This is captured in modelling the participation rate by a linear spline, with nodes at 1981Q1, 1986Q3, 1995Q1, 2003Q3, 2009Q1 and 2017Q1. Furthermore, an increase in the unemployment gap $(u - u^{eq})$ lowers the labour force participation rate (discouraged worker effect).

$$part_t \;=\; \underset{(197.0)}{60.11} + \text{spline}(1986Q2; 2017Q1) - \underset{(2.4)}{0.28} * (u_t - u_t^{eq}) \tag{46}$$

$\bar{R}^2 = 0.989$; $S.E. = 0.55$; $p(ADF) = 0.01$

Estimation period: 1981Q1 - 2016Q4

In the short term, changes in the labour participation rate are driven by the error-correction term from (46) and the change in the unemployment rate.

$$\begin{aligned} \Delta part_t \;=\; & \underset{(2.4)}{0.04} - \underset{(-2.8)}{0.09} * part_{ECM,t-1} + \underset{(2.4)}{0.32} * \Delta part_{t-1} + \underset{(3.6)}{0.30} * \Delta part_{t-3} \\ & - \underset{(-2.1)}{0.16} * \Delta u_{t-1} \end{aligned} \tag{47}$$

$\bar{R}^2 = 0.33$; $S.E. = 0.15$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1981Q1 - 2016Q4

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

$$savh_t \;=\; \frac{YDIS_t - pc_t * c_t + savhp_t}{YDIS_t + savhp_t} \tag{48}$$

Pension savings ($savhp$) is given by contributions to pension schemes ($scr_{pen} + sce_{pen}$) less pension benefits ($transh_{pen}$).

$$savhp_t \;=\; scr_{pen,t} + sce_{pen,t} - transh_{pen,t} \tag{49}$$

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_{va}^{pr}), 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).

$$\begin{aligned} \ln w_t^{pr} \;=\; & \frac{1}{4}\sum_{i=0}^{3}(\ln py_{va,t-i}^{pr} + \ln prod_{t-i}) + \underset{(4.3)}{0.25} * \frac{1}{4}\sum_{i=1}^{4}\ln rpr_{t-i} - \underset{(3.7)}{0.01} * \frac{1}{4}\sum_{i=3}^{6} u_{t-i} \\ & + \underset{(3.5)}{0.51} * \left(\frac{1}{4}\sum_{i=0}^{3}\ln(1+\tau_{t-i}^{vat}) + \frac{1}{4}\sum_{i=1}^{4}\ln\frac{1}{(1-\tau_{r,t-i})} + \frac{1}{4}\sum_{i=1}^{4}\ln\frac{1}{(1-\tau_{n,t-i})}\right) \end{aligned} \tag{50}$$

$\bar{R}^2 = 0.998$; $S.E. = 0.02$; $p(ADF) = 0.01$

Estimation period: 1971 - 2016

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 (w^{pr}_{ECM}) as determined in equation (50). Because employees care about consumer prices, contractual wage growth is also affected in the short term by the growth in the private consumption deflator (pc).

$$\begin{aligned}\Delta \ln w^{pr}_{cnt,t} \;=\;& \underset{(1.9)}{-0.02} * (w^{pr}_{ECM,t-4} - \underset{(118.8)}{1.65}) + \underset{(1.8)}{0.13} * \frac{1}{4}\sum_{i=1}^{4} \Delta \ln rpr_{t-i} \\ & - \underset{(4.5)}{0.005} * \frac{1}{4}\sum_{i=1}^{4} \Delta u_{t-i} + (1 - \underset{(6.4)}{0.41}) * \Delta \ln w^{pr}_{cnt,t-2} + \underset{(6.4)}{0.41} * \frac{1}{4}\sum_{i=1}^{4} \Delta \ln pc_{t-i} \\ & - \underset{(1.4)}{0.08} * \frac{1}{4}\sum_{i=0}^{3} \Delta \left(\ln \frac{1}{(1-\tau_{r,t-i})} \right) + \underset{(1.9)}{0.11} * \frac{1}{2}\sum_{i=2}^{3} \Delta \ln prod_{t-i}\end{aligned} \tag{51}$$

$\bar{R}^2 = 0.66$; $S.E. = 0.003$; $p(LM_4) = 0.07$; $p(JB) = 0.00$

Estimation period: 1981Q1 - 2016Q4

The wage drift measures the contribution of incidental factors to total compensation per employee. This contribution increases as productivity accelerates, while when employees are on sick leave, measured the share of those claiming sick leave benefits in total employment n_{zw}/e, the wage drift is negatively affected. Increases in the share of the working age population over 45 negatively affects the wage drift due to reduced chances of promotions etc.

$$\begin{aligned}w^{pr}_{drift,t} \;=\;& \underset{(2.6)}{0.09} * \frac{1}{4}\sum_{i=0}^{3} (\Delta \ln prod_{t-i} - \Delta \ln prod_{t-i-1}) - \underset{(2.2)}{0.004} * \frac{1}{4}\sum_{i=0}^{3} \Delta u_{t-i} \\ & - \underset{(2.1)}{0.59} * \frac{1}{4}\sum_{i=0}^{3} \frac{n_{zw,t-i}}{e_{t-i}} - \underset{(2.2)}{0.015} * \frac{n_{4575,t}}{n_{1575,t}}\end{aligned} \tag{52}$$

$\bar{R}^2 = 0.08$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1979Q2 - 2016Q4

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

$$w^{pr}_{gross,t}/w^{pr}_{gross,t-1} \;=\; w^{pr}_{cnt,t}/w^{pr}_{cnt,t-1} + w^{pr}_{drift,t} \tag{53}$$

Total 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) plus the share of the private sector ($1-\chi^o$) in total employers' social contributions. Employers' social contributions consist of social security contributions (scr_{sec}), contributions to pension schemes (scr_{pen}) and imputed social contributions (scr_{imp}).

$$W^{pr}_t \;=\; w^{pr}_{gross,t} * emp_t + (1-\chi^o_t) * (scr_{sec,t} + scr_{pen,t} + scr_{imp,t}) \tag{54}$$

Compensation per employee in the private sector is then:

$$w^{pr}_t \;=\; W^{pr}_t / emp_t \tag{55}$$

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}) move in line with the private sector.

$$w^{gov}_{cnt,t}/w^{gov}_{cnt,t-1} = w^{pr}_{cnt,t}/w^{pr}_{cnt,t-1} \quad (56)$$

$$w^{gov}_{drift,t} = w^{pr}_{drift,t} \quad (57)$$

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

$$w^{gov}_{gross,t}/w^{gov}_{gross,t-1} = w^{gov}_{cnt,t}/w^{gov}_{cnt,t-1} + w^{gov}_{drift,t} \quad (58)$$

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) plus the share of the government sector (χ^o) in total employers' social contributions.

$$W^{gov}_t = w^{gov}_{gross,t} * eg + \chi^o_t * (scr_{sec,t} + scr_{pen,t} + scr_{imp,t}) \quad (59)$$

Compensation per employee in the government sector (w^{gov}) is then:

$$w^{gov}_t = W^{gov}_t/eg_t \quad (60)$$

Compensation of employees in the total economy (W) is the sum of compensation of employees in the private sector and in the government sector; **gross wages in the total economy** (W_{gross}) is compensation of employees net of total employers' social contributions, and the gross wage rate in the total economy is w_{gross}.

$$W_t = W^{pr}_t + W^{gov}_t \quad (61)$$

$$W_{gross,t} = W_t - (scr_{sec,t} + scr_{pen,t} + scr_{imp,t}) \quad (62)$$

$$w_{gross,t} = \frac{W_{gross,t}}{em_t} \quad (63)$$

Employment (e) is the sum of employment in the private sector (equation (13)) and employment in the government sector (equation (283)).

$$e_t = ep_t + eg_t \quad (64)$$

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

$$es_t = ep_t * \chi^{es}_t \quad (65)$$

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

$$em_t = e_t - es_t \quad (66)$$

All of the labour market model is specified in ftes. To derive employment in persons we use sector-specific, time-varying conversion factors ψ. **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}.

$$emp_{n,t} = emp_t * \psi_t^{pr} \tag{67}$$

$$eg_{n,t} = eg_t * \psi_t^{gov} \tag{68}$$

$$es_{n,t} = es_t * \psi_t^{s} \tag{69}$$

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).

$$em_{n,t} = emp_{n,t} + eg_{n,t} \tag{70}$$

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).

$$e_{n,t} = em_{n,t} + es_{n,t} \tag{71}$$

The growth in e_n is used to derive **total hours worked** e_h, similarly the growth in em_n is used to derive **total hours worked by employees** em_h and the growth in emp_n is used to derive the growth in **total hours worked by employees in the private sector** emp_h. Hours worked by the self-employed es_h and hours worked by employees in the government sector eg_h can then be computed directly.

$$\Delta \ln e_{h,t} = \Delta \ln e_{n,t} \tag{72}$$

$$\Delta \ln em_{h,t} = \Delta \ln em_{n,t} \tag{73}$$

$$\Delta \ln emp_{h,t} = \Delta \ln emp_{n,t} \tag{74}$$

$$es_{h,t} = e_{h,t} - em_{h,t} \tag{75}$$

$$eg_{h,t} = em_{h,t} - emp_{h,t} \tag{76}$$

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 in persons** (n_u) is defined by subtracting total employment (persons) from the labour supply.

$$u_t = 100 * (ls_t - e_{n,t}) \;/\; ls_t \tag{77}$$

$$n_{u,t} = ls_t - e_{n,t} \tag{78}$$

The **labour share of income** ($lshare$) measures the share of wage income, including imputed wage income of the self-employed (W^s) from equation (33) in total income.

$$lshare_t = \frac{W_t + W_t^s}{W_t + Z_t} \tag{79}$$

An **alternative measure of the labour share** ($lshare^{alt}$) is based on recent work described in CBS(2017) which uses an observed measure of imputed self-employed wage income $W^{s,alt}$.

$$lshare_t^{alt} = \frac{W_t + W_t^{s,alt}}{W_t + Z_t} \tag{80}$$

$$W_t^{s,alt} = W_t^s + W_t^{s,resid} \tag{81}$$

A.4 Prices

In the long run, prices charged by firms depend both on the cost price (including energy) and on (foreign) competitors' prices. The cost price variable cye is derived assuming the private sector produces a single good, or bundle of goods and services, see equation (7). However, in the model we identify a range of deflators, this implicitly implies the presence of multiple (private) sectors with differing levels of productivity. To allow for such productivity differences across sectors, the cost price term that enters the long run price equations includes a multiplicative correction (a_{VL}) for structural labour augmenting technical progress ν_L^{struc}. Further, to allow for more flexibility in estimating the direct effect of capital costs on prices, pke is also separately included (coefficient a_{PKE}) in this adjusted cost price term: $\left(\ln cye_t + a_{VL} * \nu_{L,t}^{struc} + a_{PKE} * \ln pke_t\right)$.

There is a one-to-one transmission of indirect taxes and subsidies through to market prices. We identify four indirect tax rate variables, for private consumption τ^c, government consumption τ^{cg}, investment τ^{it} and domestically produced exports excluding energy $\tau^{xdom,-e}$. These are defined as implicit indirect tax rates where indirect taxes net of subsidies are expressed as a share of the relevant expenditure base excluding taxes and subsidies. Input-output weights are used to allocate indirect taxes and subsidies across the four expenditure categories.

$$\tau_t^c = \frac{0.578 * taxind_t - 0.2978 * subs_t}{0.01 * pc_t * c_t - (0.578 * taxind_t - 0.2978 * subs_t)} \tag{82}$$

$$\tau_t^{cg} = \frac{0.1147 * taxind_t - 0.2692 * subs_t}{0.01 * pcg_t * cg_t - (0.1147 * taxind_t - 0.2392 * subs_t)} \tag{83}$$

$$\tau_t^{it} = \frac{0.2002 * taxind_t - 0.1160 * subs_t}{0.01 * pit_t * it_t - (0.2002 * taxind_t - 0.1160 * subs_t)} \tag{84}$$

$$\tau_t^{xdom,-e} = \frac{0.1068 * taxind_t - 0.3160 * subs_t}{0.01 * px_t^{dom,-e} * x_t^{dom,-e} - (0.1068 * taxind_t - 0.3160 * subs_t)} \tag{85}$$

In the long term, **HICP excluding energy and food** ($hicp_{sa}^{-ef}$) is a weighted average of the (adjusted) cost price, rents ($hicp^{rents}$)[16] and the deflator of imported consumer goods (pm^c). The equation also includes the implicit indirect tax rate for consumption goods τ^c.

$$\ln hicp_{sa,t}^{-ef} = -\underset{(7.6)}{0.92} + \underset{(11.0)}{0.69} * \left(\ln cye_t + \underset{(3.2)}{0.63} * \nu_{L,t}^{struc} - \underset{(16.5)}{0.40} * \ln pke_t\right) \tag{86}$$
$$+0.12 * \ln hicp_t^{rents} + (1 - 0.69 - 0.12) * \ln pm_t^c + \ln(1 + \tau_t^c)$$

[16] The weight on rents is based on 2016 data.

$S.E. = 0.01$; $p(ADF) = 0.07$

Estimation period: 1980Q4 - 2016Q4

In the short term, growth in $hicp_{sa}^{-ef}$ is determined by the growth in unit labour costs in the private sector ($\frac{w^{pr}}{prod}$), the growth in import prices, rents ($hicp_{rents}$), the output gap and an error-correction term.

$$\begin{aligned}\Delta \ln \frac{hicp_{sa,t}^{-ef}}{1+\tau_t^c} \quad = \quad & -\underset{(2.4)}{0.07} * hicp_{sa,ECM,t-1}^{-ef} + \underset{(2.0)}{0.05} * \frac{1}{2}\sum_{i=1}^{2} \Delta \ln ygap_{t-i} + \underset{(3.1)}{0.28} * \Delta \ln \frac{hicp_{sa,t-2}^{-ef}}{1+\tau_{t-2}^c} \\ & + 0.12 * (1-0.28) * \Delta \ln hicp_t^{rents} + \underset{(2.4)}{0.10} * \frac{1}{4}\sum_{i=2}^{5} \Delta \ln pm_{t-i}^c \\ & + \underset{(2.5)}{0.20} * \frac{1}{4}\sum_{i=2}^{5} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} + \underset{(1.9)}{0.15} * \frac{1}{4}\sum_{i=6}^{9} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} \\ & + (1-0.28-0.12*(1-0.28)-0.20-0.15-0.10) * \frac{1}{4}\sum_{i=10}^{13} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} \end{aligned} \tag{87}$$

$\bar{R}^2 = 0.16$; $S.E. = 0.003$; $p(LM_4) = 0.50$; $p(JB) = 0.85$

Estimation period: 1988Q3 - 2016Q4

HICP energy ($hicp^e$) includes fuels, gas and electricity and is modelled as a function of the oil price. We assume the prices of fuels are contemporaneously determined by the oil price (defined in euro per litre, $p_{oil}/(159 * exr)$) plus the tax rate on petrol per litre (τ^{oil}). In contrast, we assume prices of gas and electricity 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. Gas and electricity prices react to changes in oil prices with a lag. Because $hicp^e$ is not seasonally adjusted the equation also includes seasonal dummies.

$$\begin{aligned}\ln \frac{hicp_t^e}{hicp_{t-1}^e} \quad = \quad & 0.47 * \Delta \ln \left(\frac{p_{oil,t}}{159 * exr_t} + \tau_t^{oil} \right) \\ & + (1-0.47) * \underset{(6.1)}{0.16} * dum_{Q1,Q3} * \left(\ln(\frac{p_{oil,t-1}}{exr_{t-1}} + \frac{p_{oil,t-2}}{exr_{t-2}}) - \ln(\frac{p_{oil,t-3}}{exr_{t-3}} + \frac{p_{oil,t-4}}{exr_{t-4}}) \right) \\ & + \underset{(3.5)}{0.02} * (s1-0.25) + \underset{(6.1)}{0.02} * (s2-0.25) + \underset{(1.9)}{0.01} * (s3-0.25) \end{aligned} \tag{88}$$

$\bar{R}^2 = 0.58$; $S.E. = 0.02$; $p(LM_4) = 0.68$; $p(JB) = 0.00$

Estimation period: 1988Q1 - 2016Q4

While the HICP data series are not seasonally adjusted, the variable $hicp_{sa}^{-ef}$ used in equation (86) has been seasonally adjusted prior to estimation. To ensure consistency this is converted to a non-seasonal basis $hicp^{-ef}$ prior to aggregation. **HICP food** $hicp^f$ is assumed to grow at the same rate as $hicp^{-ef}$:

$$\Delta \ln hicp_t^f \quad = \quad \Delta \ln \; hicp_t^{-ef} \tag{89}$$

The total **HICP** is defined by the identity:

$$hicp_t \quad = \quad \chi_t^{hicpe} * hicp_t^e + \chi_t^{hicpf} * hicp_t^f + (1 - \chi_t^{hicpe} - \chi_t^{hicpf}) * hicp_t^{-ef} \tag{90}$$

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.

$$\begin{aligned}\ln \frac{pc_t}{pc_{t-1}} \quad = \quad & \underset{(1.1)}{0.001} * s1 - \underset{(4.4)}{0.004} * s2 + \underset{(1.3)}{0.001} * s3 + \underset{(2.0)}{0.001} * s4 \\ & + 0.84 * \ln \frac{hicp_t}{hicp_{t-1}} + 0.10 * \ln \frac{hicp_t^{rents}}{hicp_{t-1}^{rents}} + 0.06 * \ln \frac{pm_t^{dom}}{pm_{t-1}^{dom}}\end{aligned} \tag{91}$$

$\bar{R}^2 = 0.02$; $S.E. = 0.005$; $p(LM_4) = 0.00$; $p(JB) = 0.15$

Estimation period: 1980Q4 - 2016Q4

In the long term, the **government consumption deflator** (pcg) is affected by the (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. The equation includes the implicit indirect tax rate for government consumption goods τ^{cg}.

$$\begin{aligned}\ln pcg_t \quad = \quad & - \underset{(4.4)}{0.83} + \underset{(15.4)}{0.63} * \left(\ln cye_t + \underset{(14.4)}{0.77} * \nu_{L,t}^{struc} - \underset{(24.7)}{0.34} * \ln pke_t \right) \\ & + \underset{(11.7)}{0.31} * \ln w_t^{gov} + (1 - 0.63 - 0.31) * \ln pm_t^c + \ln(1 + \tau_t^{cg})\end{aligned} \tag{92}$$

$S.E. = 0.01$; $p(ADF) = 0.00$

Estimation period: 1980Q4 - 2016Q4

In the short term, growth in the government consumption deflator is mostly affected by changes in compensation per employee and in the price of value added in basic prices py_{va}.

$$\begin{aligned}\Delta \ln \frac{pcg_t}{1 + \tau_t^{cg}} \quad = \quad & - \underset{(2.8)}{0.14} * pcg_{ECM,t-1} + \underset{(7.2)}{0.48} * \Delta \ln w_t^{gov} \\ & + \underset{(3.3)}{0.42} * \frac{1}{4} \sum_{i=1}^{4} \Delta \ln py_{va,t-i} - \underset{(1.0)}{0.08} * \Delta \ln \frac{pcg_{t-1}}{1 + \tau_{t-1}^{cg}}\end{aligned} \tag{93}$$

$\bar{R}^2 = 0.35$; $S.E. = 0.005$; $p(LM_4) = 0.63$; $p(JB) = 0.51$

Estimation period: 1981Q1 - 2016Q4

In the long term, the **housing investment deflator** (pih) is a weighted average of the (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 net indirect taxes. The house price enters the equation because some households may weigh buying a newly built house against buying an existing dwelling. The deflator of imported investment goods is included to account for imports of some building materials.

$$\begin{aligned}\ln pih_t \quad = \quad & \underset{(2.5)}{0.29} + \underset{(9.0)}{0.57} * \left(\ln cye_t + \underset{(1.2)}{0.22} * \nu_{L,t}^{struc} - \underset{(4.4)}{0.21} * \ln pke_t \right) \\ & + \underset{(22.0)}{0.35} * \ln ph_t + (1 - 0.57 - 0.35) * \ln pm_t^i + \ln(1 + \tau_t^{it})\end{aligned} \tag{94}$$

$S.E. = 0.04$; $p(ADF) = 0.30$

Estimation period: 1980Q4 - 2016Q4

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

$$\Delta \ln \frac{pih_t}{1+\tau_t^{it}} = -\underset{(4.2)}{0.19} * pih_{ECM,t-1} + \underset{(11.2)}{1.15} * \frac{1}{4}\sum_{i=5}^{8} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} + \underset{(1.2)}{0.12} * \frac{1}{2}\sum_{i=2}^{3} \Delta \ln ph_{t-i} + (1-1.15-0.12) * \Delta \ln \frac{pih_{t-1}}{1+\tau_{t-1}^{it}} + \underset{(2.7)}{0.31} * \frac{1}{2}\sum_{i=0}^{1} ygap_{t-i} \tag{95}$$

$\bar{R}^2 = 0.27$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1981Q2 - 2016Q4

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

$$\ln pio_t = \underset{(16.7)}{1.16} + \underset{(22.6)}{0.80} * \left(\ln cye_t + \underset{(0.71)}{0.07} * \nu_{L,t}^{struc} - \underset{(13.2)}{0.36} * \ln pke_t\right) + (1-0.80) * \ln pm_t^i + \ln(1+\tau_t^{it}) \tag{96}$$

$S.E. = 0.02$; $p(ADF) = 0.01$

Estimation period: 1980Q4 - 2016Q4

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.

$$\Delta \ln \frac{pio_t}{1+\tau_t^{it}} = -\underset{(3.4)}{0.46} * pio_{ECM,t-1} + \underset{(4.1)}{0.83} * \frac{1}{8}\sum_{i=4}^{11} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} + \underset{(4.1)}{0.55} * \frac{1}{4}\sum_{i=0}^{3} \Delta \ln pm_{t-i}^i + (1-0.83-0.55) * \Delta \ln \frac{pio_{t-1}}{1+\tau_{t-1}^{it}} + \underset{(2.4)}{0.28} * \frac{1}{2}\sum_{i=0}^{1} ygap_{t-i} \tag{97}$$

$\bar{R}^2 = 0.45$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1981Q2 - 2016Q4

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

$$\ln pig_t = \underset{(18.2)}{0.98} + \underset{(31.4)}{0.86} * \left(\ln cye_t + \underset{(6.1)}{0.49} * \nu_{L,t}^{struc} - \underset{(17.7)}{0.33} * \ln pke_t\right) + (1-0.86) * \ln pm_t^i + \ln(1+\tau_t^{it}) \tag{98}$$

$S.E. = 0.02$; $p(ADF) = 0.00$

Estimation period: 1980Q4 - 2016Q4

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

$$\Delta \ln \frac{pig_t}{1+\tau_t^{it}} = -\underset{(4.5)}{0.54} * pig_{ECM,t-1} + \underset{(7.5)}{0.93} * \frac{1}{8}\sum_{i=4}^{11} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} + \underset{(2.1)}{0.14} * \Delta \ln pm_t^i + (1-0.93-0.14) * \Delta \ln \frac{pig_{t-1}}{1+\tau_{t-1}^{it}} + \underset{(2.6)}{0.36} * \frac{1}{2}\sum_{i=0}^{1} ygap_{t-i} \tag{99}$$

$\bar{R}^2 = 0.41$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1981Q2 - 2016Q4

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

$$\ln px_t^{dom,-e} = \underset{(2.0)}{0.21} + \underset{(5.0)}{0.31} * \left(\ln cye_t - \underset{(6.6)}{1.53} * \nu_{L,t}^{struc} - \underset{(0.2)}{0.01} * \ln pke_t \right) + (1-0.31) * \ln px_t^{wo} + \ln(1+\tau_t^{xdom,-e}) \tag{100}$$

$S.E. = 0.05$; $p(ADF) = 0.00$

Estimation period: 1980Q4 - 2016Q4

In the short term, $px^{dom,-e}$ is affected by 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 some exporting firms may set their prices in foreign currency.

$$\Delta \ln \frac{px_t^{dom,-e}}{1+\tau_t^{xdom,-e}} = -\underset{(3.2)}{0.11} * px_{ECM,t-1}^{dom,-e} + \underset{(4.5)}{0.59} * \frac{1}{8}\sum_{i=4}^{11} \Delta \ln \frac{w_{t-i}^{pr}}{prod_{t-i}} + \underset{(1.9)}{0.21} * \Delta \ln px_t^{wo} \; (1-0.59-0.21) * \Delta \ln px_{t-1}^{wo} + \underset{(2.4)}{0.15} * \frac{1}{4}\sum_{i=0}^{3} \Delta \ln exr_{t-i} \tag{101}$$

$\bar{R}^2 = 0.17$; $S.E. = 0.02$; $p(LM_4) = 0.34$; $p(JB) = 0.05$

Estimation period: 1981Q1 - 2016Q4

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

$$\ln px_t^{re,e} = \underset{(8.7)}{0.06} + \underset{(8.6)}{0.10} * \left(\ln cye_t - 1.1 * \nu_{L,t}^{struc}\right) + (1 - 0.10) * \ln pm_t^{re,-e} - \underset{(6.1)}{0.03} * \ln \frac{x_t^{wo}}{y_t^{oecd}} \quad (102)$$

$S.E. = 0.01$; $p(ADF) = 0.00$

Estimation period: 1980Q4 - 2016Q4

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.

$$\Delta \ln px_t^{re,-e} = -\underset{(0.8)}{0.03} * px_{ECM,t-1}^{re,-e} + (1 - 0.98) * \Delta\left(\ln cye_t - 1.1 * \nu_{L,t}^{struc}\right) + \underset{(166.5)}{0.98} * \Delta \ln pm_t^{re,-e} \quad (103)$$

$\bar{R}^2 = 0.97$; $S.E. = 0.002$; $p(LM_4) = 0.00$; $p(JB) = 0.07$

Estimation period: 1981Q1 - 2016Q4

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

$$\ln px_t^e = \underset{(0.15)}{0.002} + \ln pm_{t-1}^e \quad (104)$$

$\bar{R}^2 = 0.96$; $S.E. = 0.10$; $p(ADF) = 0.00$

Estimation period: 1977Q2 - 2016Q4

In the short term, growth in the deflator of exports of energy is driven by changes in the deflator of imports of energy, where the latter variable is driven by the oil price in euro. The equation is split into two samples, with a faster implied pass-through from import to export prices of energy from 2009Q2 onwards.

$$\text{If} \quad t <= 2009\text{Q2} \quad \text{then} \quad (105)$$

$$\Delta \ln px_t^e = \underset{(5.1)}{0.03} - \underset{(4.6)}{0.46} * px_{ECM,t-1}^e + \underset{(21.7)}{0.70} * \Delta \ln pm_t^e + \underset{(5.9)}{0.44} * \Delta \ln pm_{t-1}^e$$

$$\text{else}$$

$$\Delta \ln px_t^e = \underset{(0.5)}{-0.002} - \underset{(5.8)}{0.58} * px_{ECM,t-1}^e + \underset{(17.0)}{0.87} * \Delta \ln pm_t^e + \underset{(7.1)}{0.55} * \Delta \ln pm_{t-1}^e$$

$\bar{R}^2 = 0.93$; $S.E. = 0.02$

Estimation period: 1996Q1 - 2016Q4

In the long term, the **deflator of imports for domestic use, 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 is included to capture potential pricing-to-market effects, where importing firms take into account local production costs when setting their import prices.

$$\ln pm_t^{dom,-e} \;=\; \underset{(0.4)}{-0.002} + \underset{(4.5)}{0.25} * \ln cye_t + (1-0.25) * \ln pm_t^{wo} - \underset{(20.9)}{0.35} * \ln \frac{x_t^{wo}}{y_t^{oecd}} \qquad (106)$$

$S.E. = 0.05$; $p(ADF) = 0.00$

Estimation period: 1980Q4 - 2016Q4

In the short term, $pm^{dom,-e}$ is affected by changes in competitors' import prices.

$$\Delta \ln pm^{dom,-e} \;=\; -\underset{(3.1)}{0.10} * pm_{ECM,t-1}^{dom,-e} + \underset{(3.0)}{0.26} * \Delta \ln pm_t^{wo} - \underset{(2.0)}{0.19} * \Delta \ln pm_{t-1}^{dom,-e} \qquad (107)$$

$\bar{R}^2 = 0.23$; $S.E. = 0.02$; $p(LM_4) = 0.03$; $p(JB) = 0.37$

Estimation period: 1984Q4 - 2016Q4

In the long term, the **deflator of imports for the purpose of re-exports, excluding energy** ($pm^{re,-e}$) 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 imports that are re-exported.

$$\ln pm_t^{re,-e} \;=\; \underset{(5.0)}{0.02} + \underset{(20.7)}{0.36} * \ln pm_t^{wo} + \underset{(27.9)}{0.59} * \ln pm_t^{i} + (1-0.36-0.59) * \ln \frac{px_t^{it}}{exr_t} \qquad (108)$$

$S.E. = 0.03$; $p(ADF) = 0.02$;

Estimation period: 1980Q4 - 2016Q4

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

$$\begin{aligned}\Delta \ln pm_t^{re,-e} \;=\; & -\underset{(2.8)}{0.11} * pm_{ECM,t-1}^{re,-e} + \underset{(5.2)}{0.31} * \Delta \ln pm_{t-1}^{re,-e} + \underset{(4.8)}{0.31} * \Delta \ln pm_{t-2}^{re,-e} \\ & + (1-0.31-0.31) * \Delta \ln pm_t^{wo}\end{aligned} \qquad (109)$$

$\bar{R}^2 = 0.31$; $S.E. = 0.01$; $p(LM_4) = 0.11$; $p(JB) = 0.00$

Estimation period: 1981Q1 - 2016Q4

In the long term, the ratio of the **deflator of imports of energy** (pm^e) to the oil price (in euro) is trending downwards.

$$\ln pm_t^{e} \;=\; \ln \frac{p_{oil,t}}{exr_t} - \frac{1}{4} * \underset{(7.3)}{0.013} * t_t \qquad (110)$$

$S.E. = 0.09$; $p(ADF) = 0.01$;

Estimation period: 1976 - 2016

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

$$\Delta \ln pm^e_t \;=\; \underset{(6.0)}{0.43} * \Delta \ln \frac{p_{oil,t}}{exr_t} + \underset{(4.2)}{0.27} * \Delta \ln pm^e_{t-1} - \underset{(3.3)}{0.13} * \left(pm^e_{ECM,t-1} - \underset{(36.2)}{0.98} \right) \tag{111}$$

$\bar{R}^2 = 0.72$; $S.E. = 0.05$; $p(LM_4) = 0.62$; $p(JB) = 0.00$

Estimation period: 1977Q3 - 2016Q4

We assume the **deflator of use of energy** (pce) moves with the deflator of imports of energy:

$$pce_t = pm^e_t \tag{112}$$

In the long term, we assume that **house prices** (ph) are fully determined by the financing restrictions of households. As a result, the stock of mortgage credit determines house prices.

$$\ln ph_t \;=\; -\,3.94 + \underset{(41.1)}{0.63} * \ln loanshmor_t \tag{113}$$

$\bar{R}^2 = 0.98$; $S.E. = 0.09$; $p(ADF) = 0.00$

Estimation period: 1978Q2 - 2016Q4

In the short term, house price changes are affected by lagged changes in house prices and in mortgage credit, together with changes in the mortgage interest rate (to proxy financing costs) and changes in consumer confidence.

$$\begin{aligned} \Delta \ln ph_t \;=\; & \underset{(4.3)}{-0.04} * ph_{ECM,t-1} + \underset{(4.2)}{0.28} * \Delta \ln\ ph_{t-2} + \underset{(8.1)}{0.40} * \Delta \ln\ ph_{t-3} \\ & + \underset{(3.1)}{0.25} * \Delta \ln loanshmor_{t-1} + \underset{(3.4)}{0.29} * \Delta \ln loanshmor_{t-2} \\ & - \underset{(3.5)}{0.01} * \Delta rm_{t-1} + \underset{(2.0)}{0.0001} * \Delta_3 cconf_{t-1} \end{aligned} \tag{114}$$

$\bar{R}^2 = 0.65$; $S.E. = 0.01$

Estimation period: 1979Q1 - 2016Q4

The price of **residential commercial property** pcp^h is modelled as a long run function of house prices and rents. In the short run equation these prices adapt slowly to the long run ECM.

$$\ln pcp^h_t \;=\; \underset{(4.4)}{0.83} + \underset{(19.3)}{0.67} * \ln ph_t + \underset{(3.3)}{0.17} * \ln hicp^{rents}_t \tag{115}$$

$\bar{R}^2 = 0.99$; $S.E. = 0.02$; $p(ADF) = 0.02$

Estimation period: 1995Q1 - 2016Q4

$$\Delta \ln pcp^h_t \;=\; \underset{(0.6)}{-0.0004} - \underset{(3.2)}{0.03} * pcp^h_{ECM,t-1} + \underset{(11.4)}{1.18} * \Delta \ln pcp^h_{t-1} - \underset{(2.6)}{0.28} * \Delta \ln pcp^h_{t-2} \tag{116}$$

$\bar{R}^2 = 0.95$; $S.E. = 0.003$; $p(LM_4) = 0.57$; $p(JB) = 0.01$

Estimation period: 1995Q4 - 2016Q4

The price of **retail commercial property** pcp^{ret} is modelled as a function of private consumption in nominal terms. The long run price equation includes a downward trend which triggers from 2013 onwards (I_{2013Q1}. This captures the dampening effect which the rise of e-commerce has had on retail commercial property prices in recent years.

$$\ln pcp_t^{ret} = \underset{(4.8)}{-3.4} + \underset{(11.4)}{0.71} * \frac{1}{12}\sum_{i=0}^{11}\ln(c_{t-i} * pc_{t-i}) - \underset{(1.3)}{0.008} * I_{2013Q1,t} * t_t \tag{117}$$

$\bar{R}^2 = 0.95$; $S.E. = 0.04$; $p(ADF) = 0.04$

Estimation period: 1995Q1 - 2016Q4

$$\begin{aligned}\Delta \ln pcp_t^{ret} = & \underset{(0.9)}{-0.0006} - \underset{(1.7)}{0.01} * pcp^{ret}_{ECM,t-1} + \underset{(15.2)}{1.02} * \Delta \ln pcp^{ret}_{t-1} - \underset{(2.6)}{0.17} * \Delta \ln pcp^{ret}_{t-2} \\ & + \underset{(2.1)}{0.11} * \frac{1}{2}\sum_{i=1}^{2}\Delta\ln(c_{t-i} * pc_{t-i} * 0.01)\end{aligned} \tag{118}$$

$\bar{R}^2 = 0.90$; $S.E. = 0.003$; $p(LM_4) = 0.00$; $p(JB) = 0.03$

Estimation period: 1995Q4 - 2016Q4

The **deflator of value added in mining and quarrying** (py_{va}^{min}) is driven by the oil price in the long term, and in the short term via a rapid adjustment to the ECM.

$$\ln py_{va,t}^{min} = \underset{(7.9)}{1.29} + \underset{(16.7)}{0.83} * \ln\frac{p_{oil,t}}{exr_t} \tag{119}$$

$$\Delta \ln py_{va,t}^{min} = \underset{(4.8)}{-0.20} * py^{min}_{va,ECM,t-1} + \underset{(1.5)}{0.14} * \Delta \ln py^{min}_{va,t-1} \tag{120}$$

$\bar{R}^2 = 0.35$; $S.E. = 0.07$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1977Q3 - 2016Q4

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.

$$py_{va,t}^{pr} = \frac{py_t * y_t - py_{va,t}^{gov} * y_{va,t}^{gov} - (taxprod_t - subsprod_t)}{y_t - y_{va,t}^{gov,t} - (taxprodr_t - subsprodr_t)} \tag{121}$$

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

$$py_t = \frac{pc_t * c_t + pcg_t * cg_t + pit_t * it_t + px_t * x_t - pm_t * m_t + pds_t * ds_t}{c_t + cg_t + it_t + x_t - m_t + dels_t} \tag{122}$$

$$pit_t = \frac{pig_t * ig_t + pih_t * ih_t + pio_t * io_t}{ig_t + ih_t + io_t} \tag{123}$$

$$pds_t = \frac{psv_t * s_t - psv_{t-1} * s_{t-1}}{ds_t} \tag{124}$$

A.5 Banking sector

In the **mortgage interest rate** equation (125), the long-run mortgage rate is predominantly determined by rl with a coefficient of 0.82. Full pass-through is not rejected, implying a coefficient 0.18 on rs. This captures the fact that Dutch households often fix their mortgage rate for 10 years or longer. CDS spreads increase the mortgage rate; 91% of the increase in CDS spreads is transmitted to r^m. In terms of balance sheet variables, the deviation of the (lagged) leverage ratio from target is included with a coefficient calibrated to -0.15.[17]

$$\begin{aligned} r_t^m &= \underset{(11.07)}{1.01} + \underset{(3.6)}{0.18} * rs_t + 0.82 * rl_t + \underset{(6.5)}{0.91} * cds_t \\ &\quad -0.15 * (lev_{b,t-1} - \overline{lev_b}) \end{aligned} \tag{125}$$

$\bar{R}^2 = 0.96$; $S.E. = 0.41$; $p(ADF) = 0.03$

Estimation period: 1983Q4 - 2016Q4

In the short run equation (126) lagged changes in r^m are significant as well as contemporaneous changes in rl and rs. Note that if rl increases by one percentage point in period t, r^m increases by 48 basis points in the same period so the contemporaneous effect is quite large.

$$\Delta r_t^m = -\underset{(-3.7)}{0.13} * r^m_{ECMt-1} + \underset{(8.1)}{0.34} * \Delta r^m_{t-1} - \underset{(-4.3)}{0.17} * \Delta r^m_{t-2} + \underset{(7.9)}{0.48} * \Delta rl_t + \underset{(6.9)}{0.18} * \Delta rs_t \tag{126}$$

$\bar{R}^2 = 0.75$; $S.E. = 0.14$; $p(LM_4) = 0.36$; $p(JB) = 0.84$

Estimation period: 1983Q2 - 2016Q4

In the long-run equation the **lending rate for firms** depends on both the short and long rate, with full pass-through not rejected in estimation. Short rates are more important with a coefficient of 0.79, this is in line with evidence that firms in general borrow for shorter maturities than households. The CDS spread also affects r^f: if the CDS spread increases by 1 percentage point, lending rates to firms increase by about 0.15 percentage points in the long run. The impact of cyclical developments on lending rates is captured by the output gap. The coefficient of -9.1 implies that on average a 1 percentage point increase in GDP relative to potential would reduce lending rates to firms by 0.09 percentage points. In terms of balance sheet variables the funding mix positively affects r^f, so that an increase in deposit funding will increase the lending rate, while the deviation of the (lagged) leverage ratio from target has been included with a coefficient calibrated at -0.15.

$$\begin{aligned} r_t^f &= \underset{(1.86)}{0.60} + \underset{(22.9)}{0.79} * rs_t + 0.21 * rl_t + \underset{(1.7)}{0.15} * cds_t + \underset{(2.2)}{0.01} * fundmix_t \\ &\quad - \underset{(-3.8)}{9.1} * ygap_t - 0.15 * (lev_{b,t-1} - \overline{lev_b}) \end{aligned} \tag{127}$$

$\bar{R}^2 = 0.99$; $S.E. = 0.22$; $p(ADF) = 0.00$

Estimation period: 1983Q1 - 2016Q4

[17] The target leverage ratio is defined empirically as the sample average of the leverage ratio.

In the short-term equation (128) the results show that changes in r^f depend on changes in the short and long rate, where once again changes in the short rate are more important. Changes in the bankruptcy rate (equation (129)) are significant, where *bkrupt* can be viewed as a proxy measure for the cyclical risk premium in corporate lending rates.

$$\Delta r_t^f = \underset{(-3.8)}{-0.13} * r^f_{ECM,t-1} + \underset{(7.1)}{0.29} * \Delta rl_t + \underset{(28.4)}{0.73} * \Delta rs_t + \underset{(2.0)}{0.33} * \Delta bkrupt_t \quad (128)$$

$\bar{R}^2 = 0.91$; $S.E. = 0.11$; $p(LM_4) = 0.04$; $p(JB) = 0.94$

Estimation period: 1983Q3 - 2016Q4

The **bankruptcy probability** *bkrupt* of firms increases when they face low demand, become less profitable and when entrepreneurs become discouraged. In this specification we use GDP growth to capture the state of the economic cycle, i.e. when the economy is in a boom, demand is high and the bankruptcy probability decreases. When a firm becomes less profitable, its resilience to adverse shocks decreases, so its distance to default becomes smaller. We capture the profitability of firms in the economy with the profit share of output $profq$. Finally, if entrepreneurs become less optimistic about the future they are less likely to invest and are more likely to file for bankruptcy. Entrepreneur confidence is captured with the producer confidence variable $pconf$.

$$bkrupt_t = \underset{(5.4)}{0.21} - \underset{(-4.4)}{3.5} * \frac{1}{4}\sum_{i=1}^{4}\Delta\ln(y_{t-i}) - \underset{(-4.7)}{0.008} * \frac{1}{4}\sum_{i=1}^{4}(profitq_{t-i}) - \underset{(-4.4)}{0.006} * \Delta pconf_{t-1} + \underset{(26.3)}{0.88} * bkrupt_{t-1} \quad (129)$$

$\bar{R}^2 = 0.90$; $S.E. = 0.04$; $p(LM_4) = 0.08$; $p(JB) = 0.11$

Estimation period: 1985Q3 - 2016Q4

In the long-run equation for the **household deposit interest rate** both the short and long rate are significant, with a coefficient of 0.23 on rs and 0.31 on rl. The coefficients on rs and rl sum to 0.54, which implies that there is no full pass-through from exogenous interest rates to $rdep^h$. The loan-to-deposit ratio has a significantly positive sign and the coefficient of 0.01 implies that a ten percentage point increase in the *ltd* ratio will increase the savings rate by 0.1%-point. This is consistent with a bank aiming to partly match loans with deposit financing. It is also consistent with treating (130) as a supply equation where the supply of deposits depends negatively on $rdep^h$.

$$rdep_t^h = \underset{(-1.3)}{-0.61} + \underset{(3.1)}{0.23} * rs_t + \underset{(4.7)}{0.31} * rl_t + \underset{(2.6)}{0.01} * ltd_t \quad (130)$$

$\bar{R}^2 = 0.92$; $S.E. = 0.33$; $p(ADF) = 0.05$

Estimation period: 1990Q4 - 2016Q4

In the short term equation (131) lagged changes in $rdep^h$ are important, with a coefficient of 0.65. This is because banks aim to stabilize deposit interest rates to ensure a dependable deposit financing base.

$$\Delta rdep_t^h = \underset{(-4.1)}{-0.08} * rdep^h_{ECMt-1} + \underset{(11.7)}{0.65} * \Delta rdep^h_{t-1} + \underset{(6.0)}{0.13} * \Delta rl_t \quad (131)$$

$\bar{R}^2 = 0.66$; $S.E. = 0.06$; $p(LM_4) = 0.71$; $p(JB) = 0.00$
Estimation period: 1991Q1 - 2016Q4

In the long-run equation for **the deposit rate for firms** $rdep^f$ both rl and rs are significant, but the sum of their coefficients is less than one. A Wald test rejects the hypothesis of full pass-through, similar to the household deposit rate. The loan-to-deposit ratio positively affects the deposit rate for firms, this is also true for the household deposit rate.

$$rdep^f_t = \underset{(-1.9)}{-0.67} + \underset{(6.5)}{0.28} * rs_t + \underset{(7.5)}{0.31} * rl_t + \underset{(2.4)}{0.007} * ltd_t \tag{132}$$

$\bar{R}^2 = 0.97$; $S.E. = 0.23$; $p(ADF) = 0.00$
Estimation period: 1990Q4 - 2016Q4

Changes in rs and rl are significant in the dynamics of equation (133) as are lagged changes in $rdep^f$. The coefficient of 0.44 on the $\Delta rdep^f_{t-1}$ is smaller than that for the household savings rate, suggesting that banks have a smaller smoothing motive for $rdep^f$ compared to $rdep^h$.

$$\begin{aligned} \Delta rdep^f_t = & \underset{(-2.5)}{-0.07} * rdep^f_{ECM,t-1} + \underset{(5.3)}{0.44} * \Delta rdep^f_{t-1} \\ & + \underset{(8.6)}{0.29} * \Delta rs_t - \underset{(-2.2)}{0.07} * \Delta rs_{t-1} + \underset{(2.7)}{0.06} * \Delta rl_t \end{aligned} \tag{133}$$

$\bar{R}^2 = 0.83$; $S.E. = 0.07$; $p(LM_4) = 0.04$; $p(JB) = 0.00$
Estimation period: 1991Q1 - 2016Q4

In the long-run, equation (134), **the demand for loans by Dutch firms** $loansf^{dom}$ is driven by business investment $io*pio$, measured in current prices and the ratio of international stock prices to GDP $\frac{ps^{wo} * exr}{py * y}$.

$$\begin{aligned} \ln loansf^{dom}_t = & \underset{(-10.6)}{-4.5} + \underset{(51.0)}{1.45} * \ln(io_t * pio_t) - \underset{(-8.8)}{0.04} * \frac{1}{4}\sum_{i=0}^{3}(r^f_{t-i} - \frac{\Delta py^{pr}_{va,t-i}}{py^{pr}_{va,t-4-i}} * 100) \\ & - \underset{(-14.7)}{0.38} * \ln(\frac{ps^{wo}_t * exr_t}{py_t * y_t}) \end{aligned} \tag{134}$$

$\bar{R}^2 = 0.98$; $S.E. = 0.09$; $p(ADF) = 0.00$
Estimation period: 1979Q4 - 2016Q4

In the short-run equation the growth in business sector value-added is significant; this variable can be viewed as capturing a firm's need for working capital. It has a lag of three quarters, which is consistent with other evidence that suggests that credit to firms lags economic growth by approximately one year (see for example Box 1 in ECB (2009)). The deviation of the lagged leverage ratio from target, in logs, is significant at the 10% level with a coefficient of 0.04. If the leverage ratio falls below target this will cause a reduction in credit, and vice versa. O'Brien and Whelan (2014) find similar behaviour for a panel of American banks. The estimated adjustment coefficient on the ECM term in equation (135) is small suggesting that the demand for credit adjusts slowly to changes in firm investment.

$$\Delta loansf^{dom}_t = \underset{(2.8)}{0.01} - \underset{(-1.7)}{0.03} * loansf^{dom}_{ECM,t-1} + \underset{(1.4)}{0.17} * \Delta \ln(y^{pr}_{va,t-3} * py^{pr}_{va,t-3}) + \underset{(1.68)}{0.038} * (\ln lev_{b,t-1} - \overline{\ln lev_b}) \quad (135)$$

$\bar{R}^2 = 0.58$; $S.E. = 0.01$; $p(JB) = 0.02$

Estimation period: 1983Q1 - 2016Q4

In the long run equation (136), **household 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. This share rose strongly in the 1990s, driven by changes in legislation and the lending behaviour of banks. This autonomous increase is modelled using an S-curve, with the inflexion point estimated to occur in mid-1999.

$$\ln \frac{loanshmor_t}{4} = -\underset{(-11.0)}{1.35} * \left(1 - \frac{1}{1 + e^{-\underset{(41.9)}{0.26}{}^2 * \left(t_t - \underset{(127.3)}{90.8}\right)}}\right) + \underset{(1.1)}{0.13} * \left(\frac{1}{1 + e^{-\underset{(41.9)}{0.26}{}^2 * \left(t_t - \underset{(127.3)}{90.8}\right)}}\right) - \underset{(-3.9)}{0.12} * \left(\ln r^m_t + \ln(1 - \tau^{top}_t)\right) + \ln(YDIS_t + r^{hh}_{t,paid} + taxh_t) \quad (136)$$

$\bar{R}^2 = 0.998$; $S.E. = 0.04$; $p(ADF) = 0.15$

Estimation period: 1981Q1 - 2016Q4

In the short run equation (137), household mortgage debt is affected by the unemployment rate u, housing investment in constant prices ih and the deviation of the leverage ratio from its target (in logs). An increase in the leverage ratio has a positive effect on mortgage credit. The equation also includes a Bank Lending Survey (bls^h) variable, defined as the deviation of cumulative changes in credit standards from its mean. This captures the impact of changes in credit conditions on mortgage lending, following Van de Veer and Hoeberichts (2016). Finally household mortgage debt gradually adjusts to its long-term equilibrium (ECM term in equation (137)).

$$\Delta \ln loanshmor_t = \underset{(-4.5)}{-0.07} - \underset{(-2.5)}{0.04} * loanshmor_{ECM,t-1} - \underset{(-3.4)}{0.05} * \frac{1}{2}\sum_{i=1}^{2} \Delta \ln u_{t-i} + \underset{(5.1)}{0.01} * \ln(ih_{t-1}) - \underset{(-6.4)}{0.00002} * (bls^h_t - \overline{bls^h}) + \underset{(3.2)}{0.32} * \Delta \ln loanshmor_{t-1} + \underset{(2.5)}{0.024} * (\ln lev_{b,t-1} - \overline{\ln lev_b}) \quad (137)$$

$\bar{R}^2 = 0.79$; $S.E. = 0.01$; $p(LM_4) = 0.06$; $p(JB) = 0.08$

Estimation period: 1983Q4 - 2016Q4

Equation (138) links **bank mortgages** to total mortgages by simply setting the growth in bank mortgages $loansh^{h,cor}$ equal to the growth in total mortgage credit $loanshmor$.

$$\Delta loansh^{h,cor}_t = \Delta loanshmor_t \quad (138)$$

Consumption credit to households, $loansh_t^{c,cor}$ includes loans for consumption purposes and is predominantly short-term credit, including credit card debt and overdrafts. Extensive testing of different interest rates to estimate a price effect was unsuccessful.[18] Consumer credit is modelled using a simple dynamic specification, where the stock of household consumer credit grows one-for-one with the value of personal consumption. The estimates are shown in equation (139). The stock of household consumer credit has fallen steadily since 2009. The equation includes a step dummy I_{2009Q1} (equal to zero before 2009Q1, 1 thereafter) to capture this switch from positive to negative growth.

$$\Delta \ln \frac{loansh_t^{c,cor}}{c_t * pc_t} = \underset{(2.2)}{+0.005} * (1 - I_{2009Q1,t}) - 0.014 * I_{2009Q1,t} + \underset{(2.2)}{0.19} * \Delta \ln \frac{loansh_{t-1}^{c,cor}}{c_{t-1} * pc_{t-1} * 0.01} \tag{139}$$

$\bar{R}^2 = 0.36$; $S.E. = 0.02$; $p(LM_4) = 0.10$; $p(JB) = 0.31$

Estimation period: 1991Q2 - 2016Q4

The growth in **other household credit** includes loans for purposes other than house purchase or consumption. An example would be a loan used to finance a study course or a collateralised loan for a sole trader or ZZPer.[19] This type of credit is typically long-term, it is modelled as a simple demand equation including price, income and wealth effects. The estimation results suggested the best specification for the long-run equation included the unemployment rate, short-term interest rates, house prices and CDS spreads as shown in equation (140). The unemployment rate captures the effect of the cycle on the demand for this type of credit. The significance of house prices indicates a wealth effect, where households borrow against an increase in the value of their housing wealth. It could also be capturing the role of house prices as a proxy for collateral for business loans.

$$\ln loansh_t^{o,cor} = \underset{(14.0)}{9.3} + \underset{(3.0)}{0.4} * \ln ph_t - \underset{(-2.2)}{0.05} * \ln rs_t - \underset{(-4.1)}{0.11} * u_t - \underset{(-4.4)}{0.33} * cds_t \tag{140}$$

$\bar{R}^2 = 0.79$; $S.E. = 0.15$; $p(ADF) = 0.19$

Estimation period: 1990Q4 - 2016Q4

In the short run, the growth in nominal house prices has a strong positive effect on the growth in $loansh^{o,cor}$, while a tightening of (mortgage) credit conditions adversely affects its growth.

$$\Delta \ln loansh_t^{o,cor} = \underset{(0.7)}{0.003} - \underset{(-1.5)}{0.03} * loansh_{ECMt-1}^{o,cor} + \underset{(4.0)}{0.44} * \Delta \ln ph_t - \underset{(-2.9)}{0.00002} * bls_t^h + \underset{(1.9)}{0.12} * \Delta \ln loansh_{t-1}^{o,cor} + \underset{(3.0)}{0.21} * \Delta \ln loansh_{t-2}^{o,cor} \tag{141}$$

$\bar{R}^2 = 0.34$; $S.E. = 0.03$; $p(LM_4) = 0.81$; $p(JB) = 0.00$

Estimation period: 1991Q3 - 2016Q4

[18] In MORKMON II, a predecessor to DELFI, the interest rate was also found to be insignificant in the short-term credit to the household sector (Fase et al. (1992)).

[19] Households in the MFI statistics includes individual households, freelancers (ZZPers) and non-profit institutions.

loansho measures the stock of **total (bank and non-bank) household non-mortgage debt**. The growth in this stock is estimated as a function of the growth in bank non-mortgage credit to households as shown in equation (142).

$$\begin{aligned}\Delta \ln loansho_t &= \frac{1}{4}\sum_{i=0}^{3}(\Delta \ln loansh_{t-i}^{c,cor} + \Delta \ln loansh_{t-i}^{o,cor}) \\ &+ \underset{(2.8)}{0.27} * \left(\Delta \ln loansho_{t-1} - \sum_{i=1}^{4}(\Delta \ln loansh_{t-i}^{c,cor} + \Delta \ln loansh_{t-i}^{o,cor})\right) \qquad (142)\end{aligned}$$

$\bar{R}^2 = 0.05$; $S.E. = 0.03$
Estimation period: 1992Q1 - 2016Q4

Bridging equations linking loans to domestic firms and households to bank balance sheet: The bank balance sheet includes *loansf* which is loans from Dutch MFIs to firms in the Euro Area excluding securitised loans. This is linked to $loansf^{dom}$ in equation (143) where the growth in *loansf* is set equal to the growth in $loansf^{dom}$. The bank balance sheet variable *loansh* excludes securitised loans while when modelling household behaviour household credit includes securitised loans, $loansh^{cor}$. These are linked by setting the growth in *loansh* equal to the growth in $loansh^{cor}$ as shown in equation (144).

$$\Delta loansf_t = \Delta \ln loansf_t^{dom} \qquad (143)$$

$$\Delta loansh_t = \Delta loansh_t^{cor} \qquad (144)$$

$$loansh_t^{cor} = loansh_t^{h,cor} + loansh_t^{c,cor} + loansh_t^{o,cor} \qquad (145)$$

Equation (146) shows the long term equation modelling **firm deposits** as a function of the value added generated by the business sector and the real interest rate on deposits.

$$\begin{aligned}\ln depf_t^{dom} &= -\underset{(-13.5)}{5.1} + \underset{(45.4)}{1.5} * \ln(y_{va,t}^{pr} * py_{va,t}^{pr}) \qquad (146) \\ &+ \underset{(2.5)}{0.018} * \left(\frac{1}{4}\sum_{i=0}^{3}(rdep_{t-i}^{f} - \Delta \ln py_{va,t-i}^{pr} * 400)\right)\end{aligned}$$

$\bar{R}^2 = 0.99$; $S.E. = 0.04$; $p(ADF) = 0.02$
Estimation period: 1990Q4 - 2016Q4

The error correction coefficient in the dynamic equation (147) is quite large with a point estimate of -0.15 so that deviations from the equilibrium are relatively short lived. We find that changes in stock prices have a positive effect on cash holdings. In general firms issue equity when equity prices are high. In addition, we also find lagged changes in value added generated by the business sector to be important.

$$\begin{aligned}\Delta \ln depf^{dom} &= \underset{(1.9)}{0.01} - \underset{(2.9)}{0.15} * depf_{ECM,t-1}^{dom} + \underset{(2.4)}{0.06} * \Delta \ln \frac{ps_t^{wo}}{exr_t} \qquad (147) \\ &+ \underset{(2.1)}{0.50} * \Delta \ln(y_{va,t-1}^{pr} * py_{va,t-1}^{pr})\end{aligned}$$

$\bar{R}^2 = 0.34$; $S.E. = 0.02$; $p(LM_4) = 0.45$; $p(JB) = 0.01$
Estimation period: 1991Q1 - 2016Q4

The **demand for household deposits** is a function of the real rate of return on deposits, household income and male life expectancy $life_m$. Equation (148) shows the estimation results. The long-run semi-elasticity with respect to the real interest rate is 0.02. Increases in the life expectancy of men increases holdings of deposits relative to disposable income.

$$\ln \frac{deph_t^{dom}}{YDIS_t} = \underset{(-38.0)}{-32.3} + \underset{(5.2)}{0.02} * \left(rdep_t^h - (\frac{pc_t}{pc_{t-4}} - 1) * 100 \right) + \underset{(39.7)}{7.7} \ln life_{m,t} \tag{148}$$

$\bar{R}^2 = 0.94$; $S.E. = 0.05$; $p(ADF) = 0.09$
Estimation period: 1982Q4 - 2016Q4

In the dynamic equation the ECM term is significant and correctly signed, with an adjustment coefficient of -0.054. Changes in the real deposit interest rate, both contemporaneous and lagged one period, are significant.

$$\begin{aligned} \Delta \ln deph_t^{dom} = {} & \underset{(16.0)}{0.01} - \underset{(-4.2)}{0.054} * deph_{ECMt-1}^{dom} + \underset{(2.3)}{0.09} * \Delta \ln YDIS_t \\ & + \underset{(2.7)}{0.003} * \Delta \left(rdep_t^h - (\frac{pc_t}{pc_{t-4}} - 1) * 100 \right) + \underset{(2.0)}{0.002} * \Delta \left(rdep_{t-1}^h - (\frac{pc_{t-1}}{pc_{t-5}} - 1) * 100 \right) \end{aligned} \tag{149}$$

$\bar{R}^2 = 0.18$; $S.E. = 0.01$; $p(LM_4) = 0.01$; $p(JB) = 0.00$
Estimation period: 1982Q4 - 2016Q4

The growth of **total deposits of firms in the Euro Area,** $depf$**,** is set equal to the growth rate in $depf^{dom}$, while the growth of **total deposits of households in the Euro Area,** $deph$**,** is set equal to the growth rate in $deph^{dom}$.

$$\Delta \ln depf_t = \Delta \ln depf_t^{dom} \tag{150}$$
$$\Delta \ln deph_t = \Delta \ln deph_t^{dom} \tag{151}$$

Other assets and liabilities on the balance sheet: Loans to households and firms only comprise a part of total assets. There are also loans to other sectors (MFIs $loans^{mfi}$, OFIs $loans^{ofi}$, government $loans^{gg}$, insurance corporations and pension funds $loans^{ipf}$) and there are assets other than loans (securities $assetb^{sec}$, external assets $assetb^{ext}$ and other assets $assetb^{oth}$). Equally deposits of households and firms only comprise a part of total liabilities. There are also deposits to other sectors (MFIs dep^{mfi}, OFIs dep^{ofi}, central government dep^{cg}, general government dep^{gg}, insurance corporations and pension funds dep^{ipf}). There are non-deposit liabilities, namely debt securities $liabb^{debt}$, external liabilities $liabb^{ext}$ and other liabilities $liabb^{oth}$. Bank capital Kb, measured at book value, is also another item on the liability side of the balance sheet. Each of these items on the balance sheet is modelled using a simple rule-of-thumb.

Loans to MFIs, to general government, to IPFs and to OFIs are assumed to grow at the same rate as nominal GDP, see equations (152) to (155). Each of these loan equations includes an adjustment coefficient which links to the deviation of the lagged (log) leverage ratio from target; the coefficient is set equal to the estimated coefficient on *loansf*. This means that total credit in the banking sector, defined as *loanstot* in (156), responds to changes in leverage in the short-run.

$$\Delta \ln loans_t^{mfi} = \Delta \ln y_t * py_t + \alpha_{mfi} * (\ln lev_{b,t-1} - \overline{\ln(lev_b)}) \quad (152)$$

$$\Delta \ln loans_t^{gg} = \Delta \ln y_t * py_t + \alpha_{gg} * (\ln lev_{b,t-1} - \overline{\ln(lev_b)}) \quad (153)$$

$$\Delta \ln loans_t^{ipf} = \Delta \ln y_t * py_t + \alpha_{ipf} * (\ln lev_{b,t-1} - \overline{\ln(lev_b)}) \quad (154)$$

$$\Delta \ln loans_t^{ofi} = \Delta \ln y_t * py_t + \alpha_{ofi} * (\ln lev_{b,t-1} - \overline{\ln(lev_b)}) \quad (155)$$

$$loanstot_t = loans_t^{mfi} + +loans_t^{gg} + loans_t^{ipf} + loans_t^{ofi} + loansf_t + loansh_t \quad (156)$$

External assets, securities and other assets are each assumed to grow at the same rate as *loanstot*, see equations (157) to (159).

$$\Delta \ln assetb_t^{sec} = \Delta \ln loanstot_t \quad (157)$$

$$\Delta \ln assetb_t^{ext} = \Delta \ln loanstot_t \quad (158)$$

$$\Delta \ln assetb_t^{oth} = \Delta \ln loanstot_t \quad (159)$$

Deposits held by Central and General Government, IFPs, MFIs and OFIs are assumed to grow at the same rate as nominal GDP, see equations (160) to (164).

$$\Delta \ln dep_t^{cg} = \Delta \ln(y_t * py_t) \quad (160)$$

$$\Delta \ln dep_t^{gg} = \Delta \ln(y_t * py_t) \quad (161)$$

$$\Delta \ln dep_t^{ipf} = \Delta \ln(y_t * py_t) \quad (162)$$

$$\Delta \ln dep_t^{mfi} = \Delta \ln(y_t * py_t) \quad (163)$$

$$\Delta \ln dep_t^{ofi} = \Delta \ln(y_t * py_t) \quad (164)$$

$$deptot_t = dep_t^{cg} + dep_t^{gg} + dep_t^{ipf} + dep_t^{mfi} + dep_t^{ofi} + depf_t + deph_t \quad (165)$$

External liabilities and other liabilities are assumed to grow at the same rate as nominal GDP, see equations (166) and (167).

$$\Delta \ln liabb_t^{ext} = \Delta \ln(y_t * py_t) \quad (166)$$

$$\Delta \ln liabb_t^{oth} = \Delta \ln(y_t * py_t) \quad (167)$$

Bank capital *Kb* is defined using a capital accumulation equation (168).

$$Kb_t = Kb_{t-1} + profitb_t - taxb_t - divb_t + \Delta Kb_t^{gg} \quad (168)$$

The equation for **debt securities** (169) on the balance sheet is defined as the residual which ensures that total assets equals total liabilities on the balance sheet.

$$liabb_t^{debt} = assetb_t^{tot} - (deptot_t + liabb_t^{ext} + liabb_t^{rest} + Kb_t) \tag{169}$$

Finally equation (170) defines **total assets** and equation (171) links this to **total assets from the consolidated accounts**.

$$assetb_t^{tot} = loanstot + asset_t^{ext} + asset_t^{sec} + asset_t^{oth} \tag{170}$$

$$\Delta \ln assetb_t^{tot,ww} = \Delta \ln assetb_t^{tot} \tag{171}$$

Profits in the banking sector are defined in equation (172). Bank profits are the sum of net interest income (interest earned minus interest paid) plus net other income less operating costs and less net impairments for bad loans. Each of these components is modelled as a separate equation.

$$profitb_t = r_{received,t}^b - r_{paid,t}^b + profitb_t^{oth} - ocb_t - imp_t^b \tag{172}$$

Interest income is computed as a simple accounting identity as total assets times the asset-specific interest rate. Assets are split between loans and non-loan assets. There are three categories of loan dinstinguished: 1) loans to households $loansh$, 2) loans to firms $loansf$ and 3) other loans ($loans^{tot} - loansh - loansf$). The respective interest rates are the mortgage interest rate r^m, the lending rate for firms r^f and the 10 year government bond rate rl for other loans. Mortgage loans in the Netherlands are often based on an interest rate that is fixed for ten years. To account for this the interest rate used to calculate mortgage income is an 8-year average rate. For loans to firms the interest rate used is a two-year average while for other loans it is simply the contemporaneous long rate rl. To compute interest income on non-loan assets an implicit interest rate on these assets is estimated as a fixed margin above the short interest rate $rs_{t-1} + r^{oa}$, see equation (173). The estimates suggest a margin of 0.04 on an annualised basis.

The interest income variable is from the consolidated banking sector, denoted ^{ww}, while the sectoral loan data are from the monetary balance sheet. To adjust for this discrepancy in sources, $r_{received}^b$ is multiplied by the ratio of total assets from the monetary balance sheet to total assets from the consolidated balance sheet $\frac{assetb^{tot}}{assetb^{tot,ww}}$. Assuming that the structure of the consolidated balance sheet is identical to the structure of the monetary balance sheet, this adjustment will proxy interest income based on monetary balance sheet items.

$$\begin{aligned} r_{received,t}^b * \frac{assetb_{t-1}^{tot}}{assetb_{t-1}^{tot,ww}} &= \left(0.5 * \frac{1}{8}\sum_{i=1}^{8}\frac{r_{t-i}^m}{400} + 0.25 * \frac{1}{8}\sum_{i=9}^{16}\frac{r_{t-i}^m}{400} + 0.25 * \frac{1}{16}\sum_{i=17}^{32}\frac{r_{t-i}^m}{400}\right) * loansh_{t-1} \\ &+ \frac{1}{8}\sum_{i=1}^{8}\frac{r_{t-i}^f}{400} * loansf_{t-1} + \frac{rl_{t-1}}{400} * (loans_{t-1}^{tot} - loansh_{t-1} - loansf_{t-1}) \\ &+ (\frac{rs_{t-1}}{400} + \underset{(12.6)}{0.01}) * (assetb_{t-1}^{tot} - loanstot_{t-1}) \end{aligned} \tag{173}$$

$\bar{R}^2 = 0.86$; $S.E. = 3686$; $p(LM_4) \;= 0.00$; $p(JB) \;= 0.32$
Estimation period: 1993Q1 - 2016Q4

Interest costs are modelled in a similar fashion to interest income. A simple accounting identity for deposit interest income multiplies deposits by the corresponding deposit interest rate, $rdep^f$ for firms and $rdep^h$ for households. For interest paid on liabilities other than deposits the implicit interest rate on these liabilities is estimated as a fixed margin above the short interest rate $rs_t + r^{ol}$. The estimate suggests a margin of 0.03 on an annualised basis. This is lower than the estimated margin on other assets r^{oa}, ensuring profitability on the net margin for other assets relative to other liabilities. Again, to adjust for the discrepancy in data sources equation (174) is scaled by $\frac{assetb^{tot}}{assetb^{tot,ww}}$.

$$\begin{aligned} r^b_{paid,t} * \frac{assetb^{tot}_{t-1}}{assetb^{tot,ww}_{t-1}} &= \frac{1}{2}(\frac{rdep^h_{t-1}}{400} + \frac{rdep^h_{t-2}}{400}) * deph_{t-1} + \frac{1}{2}(\frac{rdep^f_{t-1}}{400} + \frac{rdep^f_{t-2}}{400}) * depf_{t-1} \\ &+ \frac{rl_{t-1}}{400} * (deptot_{t-1} - deph_{t-1} - depf_{t-1}) \\ &+ (\frac{rs_{t-1}}{400} + \underset{(12.7)}{0.008}) * (liabb^{tot}_{t-1} - deptot_{t-1} - Kb_{t-1}) \end{aligned} \tag{174}$$

$\bar{R}^2 = 0.84$; $S.E. = 3382$; $p(LM_4) \;= 0.00$; $p(JB) \;= 0.26$
Estimation period: 1993Q1 - 2016Q4

Net other income is modelled as a function of assets other than loans, where it depends positively on growth in nominal GDP $y * py$ and stock prices (ps^{wo}, MSCI world index). $profitb^{oth}$ is a residual measure of other bank income. It excludes net interest income, operating costs and loan loss provisions. This item includes one-off payments to the government relating to fines (for example the Libor manipulation fine). Its interpretation comes closest to net income generated from non-traditional banking activities. However, it also contains losses on items such as goodwill during the financial crisis. For example in 2008Q4 after nationalizing ABN Amro-Fortis the goodwill on Fortis balance sheet booked following acquisition of ABN Amro in 2007 had to be written off[20].

$$\begin{aligned} \frac{profitb^{oth}_t}{assetb^{tot}_{t-1} - loanstot_{t-1}} &= \underset{(37.3)}{0.90} * \frac{profitb^{oth}_{t-1}}{assetb^{tot}_{t-2} - loanstot_{t-2}} \\ &+ \underset{(3.7)}{0.059} * \Delta \ln(y_{t-1} * py_{t-1}) + \underset{(1.8)}{0.002} * \Delta \ln \left(\frac{ps^{wo}_{t-1}}{exr_{t-1}} \right) \end{aligned} \tag{175}$$

$\bar{R}^2 = 0.94$; $S.E. = 0.00$; $p(LM_4) \;= 0.02$; $p(JB) \;= 0.15$
Estimation period: 1993Q2 - 2016Q4

We model **total operating costs for banks** *ocb* using a translog cost function specification with two inputs, labour and overheads, and two outputs, loans and other assets. In the estimated equation we include

[20] To take account of these events, a number of dummy variables are included in estimation during the quarters of the Fortis-ABN Amro takeover and nationalisation.

the unit prices of labour w^b and overheads p^b, and two outputs Q_1 and Q_2, where $Q_1 = loansh + loansf$ is loans to firms and households and $Q_2 = assetb^{tot} - (loansh + loansf)$ is other assets. This specification separates funding costs, modelled in equation (174), from other costs incurred by the banking sector. Assuming cost minimisation behaviour, the implied economic theory restrictions (price homogeneity and symmetry of the cost function) are imposed in equation (176). We include an addition term, $\frac{assetb^{tot,ww}}{assetb^{tot}}$, which is the ratio of total consolidated assets to total MFI assets. This variable is included to test for a possible differential cost elasticity for non-MFI assets relative to MFI assets[21]. The estimation results indicated that many of the scale (output) terms were insignificant. Where coefficients were not significantly different from zero we dropped them for estimation so that the final estimated coefficients are:

$$\begin{aligned} ln\frac{ocb_t}{w_t^b} = & -\underset{(-2.3)}{1.8} + \underset{(15.2)}{2.2} * \ln\frac{p_t^b}{w_t^b} - 0.5 * \underset{(-12.5)}{-0.14} * (\ln\frac{p_t^b}{w_t^b})^2 \\ & + \underset{(14.6)}{3.0} * \ln Q_{2,t} - \underset{(-7.4)}{0.02} * \ln Q_{1,t} * \ln\frac{p_t^b}{w_t^b} + \underset{(14.3)}{0.13} * \ln Q_{2,t} * \ln\frac{p_t^b}{w_t^b} \\ & + \underset{(34.1)}{1.05} * \ln\frac{assetb_t^{tot,ww}}{assetb_t^{tot}} \end{aligned} \quad (176)$$

These coefficients imply a scale elasticity with respect to output of 0.5 for loans and approximately zero for other assets. This suggests modest increasing returns to scale with respect to loans. These results are broadly in line with international research.[22] The control variable is significant in estimation and the results suggest that non-MFI assets have a slightly higher impact on operational costs than MFI assets.

Net impairments for bad loans imp^b. Profits are reduced when banks expect that creditors will (partially) default on their obligations and make provisions for this. We model loan loss provisions as a function of changes in producer confidence $pconf$ and real GDP growth y. Loan loss provisions in the current quarter imp_t^b are modelled as a share of total loans in the previous quarter $loanstot_{t-1}$. Total loans are adjusted to a consolidated basis using the ratio $\frac{assetb_t^{tot,ww}}{assetb_t^{tot}}$ since loan loss provisions data are from the consolidated accounts.

$$\begin{aligned} \frac{imp_t^b}{loanstot_{t-1} * \frac{assetb_t^{tot,ww}}{assetb_t^{tot}}} = & \underset{(2.0)}{0.07} + \underset{(9.6)}{0.79} * \frac{imp_{t-1}^b}{loanstot_{t-2} * \frac{assetb_{t-1}^{tot,ww}}{assetb_{t-1}^{tot}}} \\ & \underset{(-2.0)}{-0.01} * (\frac{\Delta_4 y_{t-1}}{y_{t-5}} - \underset{(9.6)}{0.79} * \frac{\Delta_4 y_{t-2}}{y_{t-6}}) \underset{(-3.2)}{-0.009} * \frac{1}{3}\sum_{i=4}^{6} \Delta pconf_{t-i} \end{aligned} \quad (177)$$

$\bar{R}^2 = 0.84$; $S.E. = 0.06$; $p(LM_4) = 0.07$; $p(JB) = 0.05$

Estimation period: 1991Q1 - 2016Q4

[21] The equation is estimated as a system, with both the cost function and one factor demand equation.

[22] Cavallo and Rossi (2001) find evidence of economies of scale, especially for small banks, while their results suggest almost constant returns to scale for large banks. On a product specific basis, they find that loans have diseconomies while financial investments have significant increasing returns to scale.

The **net operating surplus of MFI institutions domestically** Z^b is modelled as a direct function of the profits of the banking sector. There is a step increase in the coefficient from 2010Q1 onwards to reflect the shift away from foreign operations in the banking sector from 2010 onwards.

$$Z_t^b \quad = \quad \left(\underset{(4.6)}{0.27} * I_{2010Q1,t} + \underset{(8.1)}{0.66}\right) * profitb_t \tag{178}$$

$\bar{R}^2 = 0.27$; $S.E. = 783.7$; $p(LM_4) \ = 0.00$; $p(JB) \ = 0.00$

Estimation period: 1993Q1 - 2016Q4

Bank capital accumulation: Bank capital in DELFI is measured as total (accounting based) Tier capital as reported to the regulator. It is not a market value measure of equity. The accumulation of bank capital is defined as follows:

$$Kb_t^{ww} \quad = \quad Kb_{t-1}^{ww} + profitb_t - taxb_t + \underbrace{\Delta Kb_t^{new,ww} + \Delta Kb^{oth,ww}t}_{\Delta Kb_t^{res,ww}} - divb_t \tag{179}$$

where bank capital in period t Kb_t^{ww} is equal to capital in the previous period plus profits made in period t from equation (172) minus taxes paid on those profits $taxb_t$. In addition to this, new capital issued $\Delta Kb_t^{new,ww}$ and/or other changes in equity, $\Delta Kb_t^{oth,ww}$ (e.g. revaluation of assets or unrealized losses) will add to the stock of bank capital, while dividends paid out, $divb_t$, will reduce it. Detailed data on both new capital issued and other changes in equity are not available on a consistent basis so their sum, net change in capital $\Delta Kb_t^{res,ww} = \Delta Kb_t^{new,ww} + \Delta Kb^{oth,ww}t$, is included as an exogenous contribution to equation (179).

Equation (180) links **corporate tax paid by banks** to the level of bank profits. The rate at which taxation is paid is a function of the statutory corporate tax rate τ^{firms}, which is the marginal rate charged in a given year. In 2016 that was 0.25, down from 0.35 in 1993. The effective tax rate paid by the consolidated banking sector mirrors this pattern; the annual average tax paid by the sector fell from 31% of pre-tax profits in 1993 to 25% in 2016. The effective tax rate is consistently lower than the statutory rate, because of this equation (180) explicitly allows the coefficient on τ^{firms} to differ from 1. The estimated coefficient suggests that the effective average tax rate for the banking sector is approximately four-fifths of the official marginal tax rate.[23]

$$\frac{taxb_t}{profitb_t} = \underset{(31.2)}{0.79} * \tau_t^{firms} \tag{180}$$

$\bar{R}^2 = 0.96$; $S.E. = 6.5$; $p(LM_4) \ = 0.02$; $p(JB) \ = 0.00$

Estimation period: 1993Q1 - 2016Q4

[23] These taxation data are from the consolidated accounts of the banking sector, they are not equal to taxation paid by the banking sector to the Dutch exchequer since they also include taxes paid in other jurisdictions. To provide a link between the banking sector and the Dutch government accounts, we estimate a simple linking equation where 60% of $taxb$ is included in tax, see equation (234).

Dividends paid by banks *divb*. We estimate a rule-of-thumb equation to model dividends paid to shareholders. Dividends are modelled as a percentage of last quarter's equity capital Kb^{ww}_{t-1}. In this rule-of-thumb banks pay out a fraction of their profits before taxes to shareholders as dividend. To exclude the possibility of negative dividend payouts, banks only pay a dividend when they are profitable. The specification allows dividends to be persistent, which means that banks continue to pay dividends in quarters where they make a loss. The deviation of the leverage ratio from target, $lev_b - \overline{lev_b}$ is included in the equation and is significant with a positive sign. The economic magnitude is large: if the target leverage ratio increases by 1 percentage point, dividend payouts will fall by 0.2% of available equity capital. Note that this specification implicitly assumes that all dividends are cash dividends, so that dividend payouts will always reduce the capital of the bank. In the case of stock dividend, all dividends except the dividend tax remain on the balance sheet as paid-in capital.

$$\frac{divb_t}{Kb^{ww}_{t-1}} = \underset{(1.3)}{0.001} + \underset{(3.1)}{0.29} * \frac{divb_{t-1}}{Kb^{ww}_{t-2}} + \underset{(2.2)}{0.002} * \frac{1}{4}\sum_{i=1}^{4}(lev_{b,t-i} - \overline{lev_b}) + I_{profitb_t>0} * \underset{(7.2)}{0.15} * \frac{profitb_t}{Kb^{ww}_{t-1}} \tag{181}$$

$\bar{R}^2 = 0.46$; $S.E. = 0.003$; $p(LM_4) = 0.70$; $p(JB) = 0.02$
Estimation period: 2001Q2 - 2016Q4

Risk weighted assets *rwa*. The *rwa* equation must respond both to changes in the balance sheet composition, e.g. if the fraction of riskier loans increases, and to changes in risk weights of asset classes, e.g. if the riskiness of loans to firms increases. Equation (182) distinguishes four different classes of assets and computes risk weights for each. Data on capital requirements are available from the COREP reports. Banks report in detail the breakdown of their capital adequacy requirements in each quarter. Risk weighted assets can be calculated by multiplying these capital requirements by 12.5 (giving an implied capital adequacy ratio of 8%). Firstly we compute credit risk weights from the COREP data for four asset classes: loans to households ($loansh$), loans to firms ($loansf$), other loans ($loanstot - laonsh - loansf$) and non-loan assets ($assetb^{tot} - loanstot$). These risk weights are calculated by dividing the assets weighted for credit risk by the balance sheet value of that asset class.[24] Secondly, we calculate a "general risk" weight, which is equal for all asset classes. This includes all risks other than credit risk. The total risk weight per asset class i $\omega_{rw,i}$ is then the sum of an asset-specific credit risk weight and the general risk weight, see Table A.1. These are intended to match as closely as possible the risk weights that regulators use when analysing

[24] It is not possible to derive a credit risk weight from COREP for non-loan assets, since these are not fully observed. Fortunately, we do know the total credit risk generated by all assets in COREP. So, we calculate the *rwa* generated by credit risk for all loans and subtract this from the total *rwa* belonging to credit risk.

Table A.1: Estimated risk weights for four asset classes[1]

		credit	general	total
Households	$\omega_{rw,h}$	0.368	0.047	0.415
Firms	$\omega_{rw,f}$	0.731	0.047	0.778
Other loans	$\omega_{rw,ol}$	0.147	0.047	0.194
Non-loan assets	$\omega_{rw,oa}$	0.085	0.047	0.132

[1] Based on 2014Q4 COREP data.

banks. Because rwa is based on the consolidated accounts, the equation is scaled by $\dfrac{assetb^{tot,ww}}{assetb^{tot}}$.

$$
\begin{aligned}
rwa \quad = \quad & (\omega_{rw,h} * loansh_t + \omega_{rw,f} * loansf_t + \omega_{rw,ol} * (loanstot_t - loansh_t - loansf_t) \\
& + \omega_{rw,oa} * (assetb_t^{tot} - loanstot_t)) * \frac{assetb_t^{tot,ww}}{assetb_t^{tot}}
\end{aligned}
\qquad (182)
$$

Equation (182) uses Basel III weights and is calibrated using the risk weights in 2014Q4 for each of the four asset classes identified[25].

Balance sheet indicators in the model. Changes in the composition of the banking sector balance sheet have direct effects on the key behavioural equations in the model. The standard battery of indicators that are used to summarise the structure of banking operations on the basis of the balance sheet are measures of solvency and liquidity. The model defines five key balance sheet variables: the risk-weighted capital ratio rwr_b, the simple leverage ratio lev_b, the target leverage ratio $\overline{lev_b}$, the funding mix $fundmix$ and the loan-to-deposit ratio ltd.

The Basel capital ratio = risk weighted capital ratio $rwr_b = \dfrac{Kb^{ww}}{rwa} * 100$ is defined as regulatory capital Kb^{ww} as a percentage of risk weighted assets rwa. Note that Kb^{ww} includes both Tier 1 and Tier 2 capital.

The simple leverage ratio $lev_b = \dfrac{Kb}{assetb^{tot}} * 100$ is equal to bank capital as a percentage of total assets. This definition of the leverage ratio is the inverse of that normally associated with measures of a firm's debt gearing.

The target leverage ratio $=\overline{lev_b}$ Deviations of the leverage ratio from its target $lev_{b,t} - \overline{lev_b}$ will trigger changes in bank behaviour. This target ratio functions as a proxy for regulatory capital requirements, or the bank's own internal targets. The simple leverage ratio lev_b is the capital ratio used in estimating the model. The choice to use lev_b rather than rwr_b as the key transmission variable is empirically based. To

[25]The estimated equation also includes two dummy variables: the first is equal to one in 1990-2007 to capture the regime change from Basel I to Basel II; the second equals one in 2008-2013 to capture the regime change from Basel II to Basel III.

explore the effects of changes in rwa on different loan and asset classes these two ratios need to be linked as shown in equation (183).

$$lev_b = \frac{Kb}{assetb^{tot}} = \underbrace{\frac{Kb^{ww}}{rwa}}_{lev_b^{rw}} * \underbrace{\frac{rwa}{assetb^{tot,ww}}}_{DensityR} * \underbrace{\frac{assetb^{tot,ww}}{assetb^{tot}}}_{non^{ww}} * \underbrace{\frac{Kb}{Kb^{ww}}}_{DifCap} \tag{183}$$

In other words the simple leverage ratio lev_b is equal to the risk-weighted leverage ratio rwr_b multiplied by 1) the "density ratio" $DensityR$ (the average risk weight of assets), 2) non^{ww} the ratio of total assets from the regulatory and monetary balance sheet, and 3) $DifCap$ the ratio of bank capital from the monetary and regulatory balance sheet. By substituting the value of $DensityR * non^{ww} * DifCap$ into (183) as a fixed parameter, lev_b can be replaced by rwr_b for specific simulations designed to explore the effects of changes in specific risk-weights on specific asset classes.

The funding mix $fundmix = \dfrac{deptot}{liabb^{tot} - Kb} * 100$ is defined as the ratio of total deposits to total bank debt. This variable is included in the long-run determination of lending rates to firms. This effect captures the fact that deposit funding is typically more expensive than other non-equity funding.

The loan-to-deposit ratio $ltd = \dfrac{loansh + loansf}{deph + depf} * 100$ is defined as total loans to households and firms divided by total deposits held by households and firms. This variable is included in the long-run determination of both deposits rates to households and firms. An increase in the ltd will ceteris paribus induce banks to increase deposit rates in order to attract more deposits.

A.6 Pension funds

Pension benefits ($transh_{pen}$) growth depends on the rate of growth of the population who have reached the old age pension age (n_{aow}) and on the annualised rate of indexation that pension funds offer ($indexpen$). The equation also includes an autonomous factor that captures the gradual improvement in pension benefits over time.

$$\Delta \ln transh_{pen,t} = \underset{(7.8)}{0.003} + \Delta \ln n_{aow,t} + \frac{1}{400} indexpen_t \tag{184}$$

Premiums paid to pension funds ($sce_{pen,paid}$) move in line with gross wages and salaries.

$$\Delta \ln sce_{pen,paid,t} = \Delta \ln W_{gross,t} \tag{185}$$

As a rule of thumb, we assume **employers' contributions to pension schemes** (scr_{pen}) move in line with premiums paid.

$$\Delta \ln scr_{pen,t} = \Delta \ln sce_{pen,paid,t} \tag{186}$$

Employees pay the remainder of the premium paid to pension funds. In addition, in the National Accounts **employees' contributions to pension schemes** (sce_{pen}) also include investment income of pension funds, mainly dividend and interest payments. Investment income of pension funds is estimated at 80 percent of investment income from life insurance technical reserves ($icpf$, which includes pension funds).

$$sce_{pen,t} = sce_{pen,paid,t} - scr_{pen,t} + 0.80 * icpf_t \tag{187}$$

Pension funds and life insurers earn **investment income from life insurance technical reserves including pension funds** ($icpf$). Growth in this investment income is driven by an estimate of the total return on pension fund investments $rpft$. The computation of this return is based on a microstudy of investment income earned from different sources. The total return on pension fund investments $rpft$ is computed on the assumption that 50% is invested in fixed income securities (return $rpfo$), 40% in equity markets (return $rpfa$) and 10% in real estate ($rpfv$), with the respective returns on each investment shown in brackets. The return on fixed income securities is a function of the long rate rl, the return on equities is determined by a combination of rl, equity prices and the exchange rate while the return on real estate is determined by the price of commercial property. In equation (188) $rpft$ is multiplied by a weighted three-year average growth in the long rate rl, where the estimated weights are intended to capture the different duration effects associated with the different types of investment.

$$\frac{icpf_t}{icpf_{t-1}} = (1 + 0.01 * rpft_{t-4}) * \frac{\frac{1}{2} * (0.4 * \frac{1}{4}\sum_{i=0}^{3} rl_{t-i} + 1.4) + \frac{1}{2} * (0.44 * \frac{1}{4}\sum_{i=4}^{7} rl_{t-i} + 0.68 * \frac{1}{4}\sum_{i=8}^{11} rl_{t-i})}{\frac{1}{2} * (0.4 * \frac{1}{4}\sum_{i=4}^{7} rl_{t-i} + 1.4) + \frac{1}{2} * (0.44 * \frac{1}{4}\sum_{i=8}^{11} rl_{t-i} + 0.68 * \frac{1}{4}\sum_{i=12}^{15} rl_{t-i})} \tag{188}$$

$$rpft_t = 0.5 * rpfo_t + 0.4 * rpfa_t + 0.1 * rpfv_t \tag{189}$$

$$rpfo_t = 0.44 * \frac{1}{4}\sum_{i=4}^{7} rl_{t-i} + 0.68 * \frac{1}{4}\sum_{i=8}^{11} rl_{t-i} - 8.1 * \Delta_4 \frac{1}{4}\sum_{i=0}^{3} rl_{t-i} \tag{190}$$

$$rpfa_t = 0.4 * \frac{1}{4}\sum_{i=0}^{3} rl_{t-i} + 1.4 + 1.29 * \left(\left(\frac{ps_t^{wo}}{ps_{t-4}^{wo}} / \frac{\sum_{i=0}^{3} exr_{t-i}}{\sum_{i=4}^{7} exr_{t-i}} \right)^{0.4} - 1 \right) * 100 \tag{191}$$

$$rpfv_t = 0.68 * \left(\frac{0.5 * pcp_t^h + 0.25 * pcp_t^{ret} + 0.25 * pcp_t^o}{0.5 * pcp_{t-4}^h + 0.25 * pcp_{t-4}^{ret} + 0.25 * pcp_{t-4}^o} - 1 \right) * 100 \tag{192}$$

The level of **indexation** ($indexpf$) offered by pension funds depends on the funding ratio. The indexation "ambition" for pension funds ($indexpen_{ambt}$) is a weighted average of 80% wage inflation and 20% HICP inflation. Full indexation is offered if the funding ratio is above 140. At levels below 100, no indexation is offered and for values between 100 and 140, pension funds offer partial indexation.

$$indexpen_{ambt,t} = 0.8 * \Delta_4 \ln w_{gross,t} + 0.2 * \Delta_4 \ln pc_t \tag{193}$$

$$indexpen_t = \begin{cases} 0 & \text{if} \quad frpf_{t-1} < 100 \\ indexpen_{ambt,t-1} * (frpf_{-1} - 100)/40 & \text{if} \quad 100 < frpr_{t-1} < 140 \\ indexpen_{ambt,t-1} & \text{if} \quad frpr_{t-1} > 140 \end{cases} \tag{194}$$

Households' net equity in life insurance and pension funds reserves v^{hh}_{pen} is modelled in equation (195). This is assumed to grow in line with the growth in total pension funds' liabilites which form about 60 percent of v^{hh}_{pen} in the National Accounts. Growth in total pension liabilities depends on the long term interest rate, where the duration of these liabilities is about 14 years. The value of these liabilities also increases through indexation of existing pension rights and through the buildup of new pension rights. This buildup is captured using the actuarial premium $prem^{act}$ net of benefits paid out ($transh_{pen}$).

$$\frac{v^{hh}_{pen,t}}{v^{hh}_{pen,t-4}} = \frac{1}{4}\sum_{i=0}^{3}\left[(1+0.01*indexpen_{t-i})*\frac{(1+0.0025*\sum_{j=0}^{3}rl_{t-i-j-4})^{15}}{(1+0.0025*\sum_{j=0}^{3}rl_{t-i-j})^{14}} + \frac{(prem^{act}_{t-i}-transh_{pen,t-i})}{0.6*v^{hh}_{t-i-4}}\right] \quad (195)$$

The **term structure of interest rates** on pension fund liabilities is defined for four different durations, namely 1 year ($rts1$), 2 year ($rts2$), 16 year ($rts16$) and 17 year ($rts17$). These are estimated as simple bridging equations linking the term structure rates to the official short (3-month) rate rs, the 2-year bond rate $rl2$ and the 10-year bond rate rl.

$$rts1_t = \underset{(14.8)}{0.26} + \underset{(34.9)}{0.65} * rs_t + 0.35 * rl2_t \quad (196)$$

$$rts2_t = \underset{(21.4)}{0.41} + rl2_t \quad (197)$$

$$rts16_t = \underset{(49.1)}{0.49} + rl_t \quad (198)$$

$$rts17_t = \underset{(47.6)}{0.51} + rl_t \quad (199)$$

Estimation period: 1984Q1 - 2016Q4

The **forward rates** at duration 1 year ($rforw1$) and 16 years ($rforw16$) are estimated from these term structure rates as follows:

$$rforw1_t = \left(\frac{(1+0.01*rts2_t)^2}{1+0.01*rts1_t} - 1\right)*100 \quad (200)$$

$$rforw16_t = \left(\left(\frac{(1+0.01*rts17_t)^{17}}{(1+0.01*rts1_t)}\right)^{1/16} - 1\right)*100 \quad (201)$$

Pension funds' funding ratio ($frpf$) is defined as the present value of pension funds' assets over pension funds' liabilities ($= 0.6 * v^{hh}pen$). The year-on-year change in percentage points in the funding ratio is modelled using six distinct factors which can either increase of decrease the ratio.

$$\Delta_4 frpf_t = frpfr_{1,t} + +frpfr_{2,t} + frpfr_{3,t} + frpfr_{4,t} + frpfr_{5,t} + frpfr_{6,t} \quad (202)$$

$frpfr_1$ measures the impact of **pension contributions** on the funding ratio. If the actual pension contribution is greater than the actuarially fair contribution $prem^{act}$ then this will increase the funding ratio.

$$frpfr_{1,t} = 100 * \frac{(sce_{pen,paid,t}/prem_t^{act} - 0.01 * frpf_{t-4}) * \sum_{i=0}^{3} prem_{t-i}^{act}}{0.6 * v_{pen,t-4}^{hh} + \sum_{i=0}^{3} prem_{t-i}^{act}} \quad (203)$$

$frpfr_2$ measures the impact of **pension benefits** on the funding ratio, with a threshold of 100%.

$$frpfr_{2,t} = \frac{(frpf_{t-4} - 100) * \sum_{i=0}^{3} transh_{pen,t-i}}{0.6 * v_{pen,t-4}^{hh} - \sum_{i=0}^{3} transh_{pen,t-i}} \quad (204)$$

$frpfr_3$ captures the effect of higher **indexation** allowances in reducing the funding ratio.

$$frpfr_{3,t} = -\frac{frpf_{t-4} * indexpf_t * 0.01}{1 + indexpf_t * 0.01} \quad (205)$$

$frpfr_4$ will add to the funding ratio if changes in the **term structure of interest rates on liabilities**, $rts^{16} - rts^{forw16}$, are positive.

$$frpfr_{4,t} = 16 * frpf_{t-4} * (rts_t^{16} - r_{t-4}^{forw16}) * 0.01 \quad (206)$$

A positive **return on savings** $frpfr_5$, with the portfolio return higher than the one-year forward rate $(rpft - rts^{for1})$, will add to the funding ratio.

$$frpfr_{5,t} = fprf_{t-4} * (rpft_t - rts_{t-4}^{forw1})/(100 + rts_{t-4}^{for1}) \quad (207)$$

An increase in **life expectancy** $frpfr_6$ will reduce the funding ratio.

$$frpfr_{6,t} = -0.09 * 100 * \frac{1}{2} * \left(\Delta_4 \frac{1}{4} \sum_{i=0}^{3} life_{m,t-i} + \Delta_4 \frac{1}{4} \sum_{i=0}^{3} life_{w,t-i} \right) \quad (208)$$

A.7 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 in turn.

$$xmca_t = px_t * x_t - pm_t * m_t + fir_t - fip_t + transfr_t - transfp_t \quad (209)$$

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

$$x_t = x_t^{dom,-e} + x_t^{re,-e} + x_t^e \quad (210)$$

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

$$m_t = m_t^{dom,-e} + m_t^{re,-e} + m_t^e \quad (211)$$

Exports of domestically produced goods and services, excluding energy ($x^{dom,-e}$) are primarily driven by foreign demand (x^{wo}), both in the short term and in the long term. In addition, a decline in international price competitiveness ($px^{dom,-e}/px^{wo}$) harms exports where 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.

$$\begin{aligned}\Delta \ln x_t^{dom,-e} &= \underset{(2.5)}{-0.07} * \left[\ln x_{t-1}^{dom,-e} - \left(\underset{(178.7)}{6.35} + \ln x_{t-1}^{wo} - \underset{(4.5)}{0.63} * \frac{\ln x_{t-1}^{wo}}{y_{t-1}^{oecd}} - \underset{(3.1)}{1.77} * \ln \frac{px_{t-1}^{dom,-e}}{px_{t-1}^{wo}}\right)\right] \\ &\quad + \underset{(5.8)}{0.79} * \Delta \ln x_t^{wo} - \underset{(8.0)}{0.72} * \Delta \ln \frac{px_t^{dom,-e}}{px_t^{wo}} - \underset{(2.8)}{0.21} * \Delta \ln x_{t-1}^{dom,-e} \qquad (212)\end{aligned}$$

$\bar{R}^2 = 0.53$; $S.E. = 0.02$; $p(LM_4) = 0.09$; $p(JB) = 0.80$

Estimation period: 1980Q1 - 2016Q4

A large share of **re-exports** (x^{re}) consists of ICT-related products. These ICT-related products are measured by deflating the value of world semiconductors sales (*semcon*) by the US export deflator of ICT products (px^{it}). In equation (213) the long-run demand for re-exports other than these ICT-related products is driven by world demand net of ICT-related products. The gap between the investment to GDP ratio in the Netherlands and the investment to GDP in the euro area (*iodif*) is included to capture the effect of changes in non-price competitiveness, such as improved logistics. Finally, the ratio of foreign demand to OECD GDP is included to reflect the fact that re-exports are gaining in market share.

$$\begin{aligned}&\text{If} \quad t <= 2001Q1 \quad \text{then} \qquad (213) \\ \ln x_t^{re} - \ln \frac{semcon_t}{px_t^{it}} &= \underset{(53.4)}{4.5} + \underset{(74.1)}{0.75} * \left(\ln x_t^{wo} - \ln \frac{semcon_t}{px_t^{it}}\right) + \underset{(4.5)}{5.7} * \frac{1}{8}\sum_{i=1}^{8} iodif_{t-i} + \underset{(7.2)}{0.60} * \frac{\ln x_t^{wo}}{y_t^{oecd}} \\ &\text{else} \\ \ln x_t^{re} - \ln \frac{semcon_t}{px_t^{it}} &= \underset{(28.6)}{5.1} + \underset{(30.2)}{0.83} * \left(\ln x_t^{wo} - \ln \frac{semcon_t}{px_t^{it}}\right) + \underset{(2.2)}{1.20} * \frac{1}{8}\sum_{i=1}^{8} iodif_{t-i} + \underset{(6.6)}{0.54} * \frac{\ln x_t^{wo}}{y_t^{oecd}}\end{aligned}$$

$S.E. = 0.02$; $p(ADF) = 0.00$

Estimation period: 1987Q1 - 2016Q4

In the short term, the demand for of re-exports is driven by changes in foreign demand and changes in ICT-related products. This equation models re-exports including exports of energy x^{re}. To derive re-exports excluding energy, $x^{re,-e}$ this is adjusted ex-post using the share of non-energy exports in total re-exports $\chi_t^{x,re,-e}$.

$$\Delta \ln x_t^{re} = \underset{(2.7)}{0.01} - \underset{(6.2)}{0.38} * x_{ECM,t-1}^{re} + \underset{(9.7)}{0.87} * \Delta \ln x_t^{wo} + \underset{(3.5)}{0.15} * \Delta \ln \frac{semcon_t}{px_t^{it}} \qquad (214)$$

$\bar{R}^2 = 0.57$; $S.E. = 0.02$; $p(LM_4) = 0.14$; $p(JB) = 0.42$

Estimation period: 1987Q1 - 2016Q4

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.

$$\begin{aligned}\Delta \ln x_t^e \quad = \quad & \underset{(3.0)}{-0.16} * \left(\ln x_{t-1}^e + \underset{(1.9)}{6.8} - \underset{(7.1)}{2.7} * \ln y_{t-1}^{oecd} - \underset{(1.8)}{0.48} * \ln y_{va,t-1}^{min} \right) \\ & + \underset{(4.2)}{3.1} \ * \ \Delta \ln y_{t-1}^{oecd} \ + \ \underset{(4.1)}{0.24} \ * \ \Delta \ln y_{va,t}^{min} - \ \underset{(1.8)}{0.14} \ * \ \Delta \ln \frac{px_t^e}{px_t^{dom,-e}} \end{aligned} \tag{215}$$

$\bar{R}^2 = 0.27$; $S.E. = 0.04$; $p(LM_4) = 0.45$; $p(JB) = 0.41$

Estimation period: 1997Q1 - 2016Q4

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 the 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. Changes in stock building (excluding statistical discrepancies, Δds) is added separately to the equation. 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.

$$\begin{aligned}\Delta \ln m_t^{dom,-e} \quad = \quad & \underset{(4.2)}{-0.19} * \left(\ln m_{t-1}^{dom,-e} + \underset{(18.6)}{0.18} - \ln fdm_{t-1} + \underset{(16.7)}{0.73} * \ln \frac{pm_{t-1}^{dom,-e}}{py_{t-1}^{-x+m}} \right) \\ & + \underset{(9.5)}{1.65} \ * \ \Delta \ln fdm_t - \ \underset{(3.2)}{0.32} \ * \ \Delta \ln \frac{pm_t^{dom,-e}}{py_t^{-x+m}} \ + \ \underset{(2.2)}{0.23} \ * \ \frac{\Delta ds_t}{\frac{1}{4}\sum_{i=1}^{4} m_{t-i}^{dom,-e}} \end{aligned} \tag{216}$$

$\bar{R}^2 = 0.57$; $S.E. = 0.02$; $p(LM_4) = 0.51$; $p(JB) = 0.00$

Estimation period: 1981Q2 - 2016Q4

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. We derive imports for re-export excluding energy, $m^{re,-e}$ ex-post using the share of non-energy exports in total re-exports $\chi_t^{x,re,-e}$.

$$\Delta \ln m_t^{re} \quad = \quad \underset{(13.1)}{0.80} \ * \ \Delta \ln m_{t-1}^{re} \ + \ (\Delta \ln x_t^{re} \ - \ \underset{(13.1)}{0.80} \ * \ \Delta \ln x_{t-1}^{re}) \tag{217}$$

$\bar{R}^2 = 0.999$; $S.E. = 0.00$; $p(LM_4) = 0.00$; $p(JB) = 0.92$

Estimation period: 1995Q1 - 2016Q4

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.

$$\Delta \ln m^{e_t} \quad = \quad \Delta \ln ce_t - \Delta \ln \chi_t^e \tag{218}$$

Factor income received from the rest of the world (fir) is modelled as a share of OECD GDP in current prices $px^{wo} * y^{oecd}$ lagged one quarter. The ratio of world demand for Dutch goods relative to OECD GDP is the key determinant of this share with an estimated coefficient is 1.8 indicating the very strong influence increased globalisation has in driving factor income flows into the Netherlands.

$$\frac{fir_t}{px^{wo}_{t-1} * y^{oecd}_{t-1}} = \underset{(2.9)}{1.44} + \underset{(2.7)}{1.81} * \ln \frac{x^{wo}_{t-1}}{y^{oecd}_{t-1}} + \underset{(7.3)}{0.72} * \frac{fir_{t-1}}{px^{wo}_{t-2} * y^{oecd}_{t-2}} \tag{219}$$

$\bar{R}^2 = 0.94$; $S.E. = 0.42$; $p(LM_4) = 0.11$; $p(JB) = 0.00$

Estimation period: 1987Q1 - 2016Q4

Similarly to factor income received, **factor income paid to the rest of the world** (fip) is modelled as a share of nominal domestic GDP lagged one quarter. The coefficient on the globalisation term is 0.12.

$$\frac{fip_t}{py_{t-1} * y_{t-1}} = \underset{(3.9)}{0.10} + \underset{(3.6)}{0.12} * \ln \frac{x^{wo}_{t-1}}{y^{oecd}_{t-1}} + \underset{(8.8)}{0.69} * \frac{fip_{t-1}}{py_{t-2} * y_{t-2}} \tag{220}$$

$\bar{R}^2 = 0.94$; $S.E. = 0.02$; $p(LM_4) = 0.20$; $p(JB) = 0.00$

Estimation period: 1987Q1 - 2016Q4

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, this share is increasing over time.

$$transfr_t = transgrf_t + pm^{wo}_t * y^{oecd}_t * (\underset{(2.4)}{-0.02} + \underset{(18.4)}{0.27} * \frac{x^{wo}_{t-1}}{y^{oecd}_{t-1}}) \tag{221}$$

$\bar{R}^2 = 0.85$; $S.E. = 0.02$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1980Q1 - 2016Q4

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 ($py * y$).

$$transfp_t = transgpf_t + py_t * y_t * (\underset{(8.3)}{0.01} + \underset{(8.8)}{0.01} * \frac{x^{wo}_{t-1}}{y^{oecd}_{t-1}}) \tag{222}$$

$\bar{R}^2 = 0.47$; $S.E. = 0.00$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1980Q1 - 2016Q4

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 ($transgpf_{eu}$), value added tax paid to the EU budget ($taxvat_{eu}$), international cooperation funds paid to the EU budget ($transgpf_{int}$), which are exogenous to the model, and other transfers ($transgpf_{int}$). GNP payments to the EU Budget are related to changes in domestic nominal GDP plus contributions related to the UK rebate. Value added tax paid move in line with private consumption and housing investment, the main determinants of VAT. Other transfers paid to the rest of the world by the general government are assumed to be related to changes in domestic nominal GDP.

$$transgpf_t = transgpf_{eu,t} + taxvat_{eu,t} + transgpfo_t + transgpf_{int,t} \tag{223}$$

$$transgpf_{eu,t} = ukrebate_t + (transgpf_{eu,t-1} - ukrebate_{t-1}) * \frac{py_t * y_t}{py_{t-1} * y_{t-1}} \tag{224}$$

$$taxvat_{eu,t} = taxvat_{eu,t-1} * \frac{pc_t * c_t + pih_t * ih_t}{pc_{t-1} * c_{t-1} + pih_{t-1} * ih_{t-1}} \tag{225}$$

$$transgpfo_t = transgpfo_{t-1} * \frac{py_t * y_t}{py_{t-1} * y_{t-1}} \tag{226}$$

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 countries outside the euro area are modelled as a share of total exports, and are determined one-for-one by the share of foreign demand from outside the euro area relative to total foreign demand ($\frac{x^{wo,extra}}{x^{wo}}$).

$$\ln x_t^{extra} = \ln x_t - \underset{(16.0)}{0.8} + \ln \frac{x_t^{wo,extra}}{x_t^{wo}} \tag{227}$$

$$\Delta \ln \frac{x_t^{extra}}{x_t} = \underset{(2.9)}{-0.05} * x_{ECM,t-1}^{extra} + \Delta \ln \frac{x_t^{wo,extra}}{x_t^{wo}} - \underset{(1.6)}{0.24} * \Delta \ln \frac{x_{t-1}^{extra}}{x_{t-1}}$$

$\bar{R}^2 = 0.39$; $S.E. = 0.02$; $p(LM_4) = 0.06$; $p(JB) = 0.00$

Estimation period: 1996Q3 - 2016Q4

Imports from countries outside the euro area are modelled as a share of total imports, and are determined by the share of imports destined for re-export in total imports ($\frac{m^{re}}{m}$). In the short run changes in the share of imports from outside the euro area are negatively related to changes in total investment demand (it).

$$\ln m_t^{extra} = \ln m_t - \underset{(16.8)}{0.9} + \underset{(7.1)}{0.8} * \frac{m_t^{re}}{m_t} \tag{228}$$

$$\Delta \ln \frac{m_t^{extra}}{m_t} = \underset{(4.0)}{-0.21} * m_{ECM,t-1}^{extra} + \underset{(1.8)}{0.18} * \Delta \ln \frac{m_{t-2}^{re}}{m_{t-2}} - \underset{(2.4)}{0.16} * \frac{1}{2} \sum_{i=1}^{2} it_{t-i}$$

$\bar{R}^2 = 0.28$; $S.E. = 0.01$; $p(LM_4) = 0.14$; $p(JB) = 0.20$

Estimation period: 1996Q4 - 2016Q4

A.8 Government and social security

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

$$gdebt_t = gdebt_{t-1} - gbal_t + dda_t \tag{229}$$

The **general government's balance** ($gbal$) is defined as total revenues minus total expenditures. Total government revenues is the sum of taxes on income and wealth (tax), indirect taxes ($taxind$), social security contributions (sc_{sec}), imputed social contributions of the government (scg_{imp}), interest received by general government ($r^{gov}_{received}$), dividends received related to gas production ($divggas$), other dividends received ($divgo$), interest received ($r^{gov}_{received}$), other transfers received ($transgro$), sales ($sales$), taxes on capital ($taxcap$), and other capital transfers received ($transcapgr$). The last component $transcapgr$ is exogenous in the model.

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 ($transcapgp$). The latter two components are exogenous in the model.

$$\begin{aligned} gbal_t \quad = \quad & tax_t + taxind_t + sc_{sec,t} + scg_{imp,t} + r^{gov}_{received,t} + divggas_t + divgo_t + transgro_t \\ & + sales_t + taxcap_t + transcapgr_t \\ & - \Big(transgp_t + r^{gov}_{paid,t} + W^{gov}_t + CGI_t + pig_t * ig_t + gacq_t + transcapgp_t \Big) \end{aligned} \tag{230}$$

We discuss each of the endogenous components of revenue and expenditure in turn below.

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 ($taxo$)

$$tax_t = taxf_t + taxh_t + taxo_t \tag{231}$$

Taxes paid by firms distinguishes between corporate taxes on gas revenues ($taxfgas$), corporate taxes paid by banks domestically ($taxb^{dom}$), corporate taxes on revenues net of gas and banking ($taxfoc$), and other direct taxes paid by firms ($taxfo$).

$$taxf_t \quad = \quad taxfgas_t + taxb^{dom}_t + taxfoc_t + taxfo_t \tag{232}$$

Corporate taxes from gas revenues ($taxfgas$) are estimated as a function of the statutory corporate tax rate (τ^{firms}) applied to value added in mining and quarrying ($py_{va,min} * y_{va,min}$). There is a downward structural shift in the relationship from 2010Q1 onwards (I_{2010Q1} equals zero before 2010Q1, 1 thereafter).

$$taxfgas_t \quad = \quad \Big(\underset{(7.6)}{-0.14} * I_{2010Q1,t} + \underset{(68.2)}{0.45} \Big) * \Big(\tau^{firms}_t \; * \; (py_{va,min,t} * y_{va,min,t}) \Big) \tag{233}$$

$\bar{R}^2 = 0.91$; *S.E.* $= 44.2$; *p(ADF)* $= 0.00$

Estimation period: 1977Q1 - 2016Q4

Corporate taxes from banking that accrue domestically $taxb^{dom}$ are modelled as a function of total corporate taxes paid by the banking sector $taxb$.

$$taxb_t^{dom} = \underset{(14.2)}{0.59} * taxb_t \tag{234}$$

$\bar{R}^2 = 0.91$; *S.E.* $= 154.0$; *p(LM$_4$)* $= 0.00$; *p(JB)* $= 0.02$

Estimation period: 1993Q1 - 2016Q4

Corporate taxes net of gas or banking ($ta\dot{x}foc$) are a function of the statutory corporate tax rate where the tax base is defined as Z^*. This is equal to the gross operating surplus net of imputed wages of the self-employed (W^s) and value added in mining and quarrying: $Z^* = Z - W^s - py_{va,min} * y_{va,min}$. To exclude banking revenues from the tax base it is also adjusted for Z^b, the net operating surplus of MFIs.

$$\frac{taxfoc_t}{Z_t^* - Z_t^b} = \underset{(1.7)}{0.05} * \tau_t^{firms} + \underset{(18.0)}{0.92} * \frac{taxfoc_{t-1}}{Z_{t-1}^* - Z_{t-1}^b} \tag{235}$$

$\bar{R}^2 = 0.86$; *S.E.* $= 0.01$; *p(LM$_4$)* $= 0.16$; *p(JB)* $= 0.82$

Estimation period: 1989Q1 - 2016Q4

The annual growth rate in **other direct taxes paid by firms** ($taxfo$) is assumed to move in line with the annual growth rate in gross operating surplus (Z) net of imputed wages of self-employed (W^s) and value added in mining and quarrying: $Z^* = Z - W^s - py_{va,min} * y_{va,min}$. Moving averages account for lags in tax collection.

$$\frac{\Delta_4 taxfo_t}{taxfo_{t-4}} = \frac{1}{4}\sum_{i=0}^{3} \frac{\Delta_4 Z_{t-i}^*}{Z_{t-i-4}^*} \tag{236}$$

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 ($taxho$).

$$taxh_t = taxhw_t + taxhd_t + taxho_t \tag{237}$$

We distinguish between three distinct types of household income for tax purposes: labour income, taxes on old age pensions and taxes on social benefits including social assistance benefits. Labour income W^* includes gross wages and salaries, imputed wages of self-employed and imputed employer's social contributions. We allow for tax deductability of pension premiums 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.

$$\begin{aligned}
W_t^* &= W_{gross,t} + W_t^s - scr_{sec,t} - sce_{pen,paid,t} \\
&\quad -\frac{0.88}{400}\left(0.5*\frac{1}{8}\sum_{i=0}^{7} r_{t-i}^m + 0.25*\frac{1}{8}\sum_{i=8}^{15} r_{t-i}^m + 0.25*\frac{1}{16}\sum_{i=16}^{31} r_{t-i}^m\right) * loanshmor_t \\
transh_{pen,t}^* &= transh_{pen} + transh_{aow} \\
&\quad -\frac{0.12}{400}\left(0.5*\frac{1}{8}\sum_{i=0}^{7} r_{t-i}^m + 0.25*\frac{1}{8}\sum_{i=8}^{15} r_{t-i}^m + 0.25*\frac{1}{16}\sum_{i=16}^{31} r_{t-i}^m\right) * loanshmor_t \\
transh_{ss,t}^* &= transh_{ss,t} - transh_{aow,t} + (transh_{bw,t} + transh_{akw,t} + transh_{zt,t} + transh_{wj,t})
\end{aligned}$$

Taxes on wages and income ($taxhw$) grow in proportion to changes in the relevant tax base, this is modelled using the shares $\chi^{tax,w}$, $\chi^{tax,pen}$ and $\chi^{tax,ss}$, respectively, where$\widehat{\ }$ denotes quarterly growth rate. Taxes on labour income move in line with the number of employed persons (e_n).

$$\widehat{taxhw_t} = \chi_t^{tax,w} * (\underset{(0.24)}{0.24} * \widehat{W_t^*} + \widehat{e}_{n,t}) + \chi_t^{tax,pen} * \widehat{transh_{pen,t}^*} + \chi_t^{tax,ss} * \widehat{transh_{ss,t}^*} \tag{238}$$

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

$$taxhd_t = \underset{(13.2)}{0.27} * \frac{1}{4}\sum_{i=1}^{4} divh_{t-i} \tag{239}$$

$\bar{R}^2 = 0.68$; $S.E. = 185.7$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1978Q1 - 2016Q4

Other direct taxes paid by households ($taxho$) are estimated using gross wages and salaries as the base.

$$taxho_t = \underset{(5.8)}{379.0} + \underset{(5.3)}{0.01} * \frac{1}{4}\sum_{i=1}^{4} W_{gross,t-i} \tag{240}$$

$\bar{R}^2 = 0.42$; $S.E. = 200.7$; $p(LM_4) = 0.00$; $p(JB) = 0.00$

Estimation period: 1979Q1 - 2016Q4

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.

$$\Delta taxo_t = \underset{(4.2)}{0.43} * \Delta taxhd_t \tag{241}$$

$\bar{R}^2 = 0.14$; $S.E. = 47.9$; $p(LM_4) = 0.61$; $p(JB) = 0.00$

Estimation period: 1979Q2 - 2016Q4

Indirect taxes received by the general government (*taxind*) consists of value added tax (*taxvat*), energy levies (*taxe*), transfer tax on dwellings (*taxd*) and other indirect taxes (*taxindo*). This is net of taxes paid to the EU, see equations (225) and (263) below.

$$taxind_t = taxvat_t + taxe_t + taxd_t + taxindo_t - (taxvat_{eu,t} + taxindo_{eu,t}) \tag{242}$$

Value added tax receipts (*taxvat*) are modelled as a function of private consumption, total investment, government consumption, social benefits in kind and domestic non-energy exports. Fixed weights are allocated to each expenditure category based on the average share in the period 2007-2016 from the National Accounts.

$$\begin{aligned} taxvat_t = {} & 0.0916 * c_t * pc_t + 0.0792 * it_t * pit_t + 0.1011 * cgo_t * pcg_t + 0.0360 * sb_t \\ & + 0.0092 * x_t^{dom,-e} * px_t^{dom,-e} - \underset{(4.1)}{229.5} \end{aligned} \tag{243}$$

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

$$\Delta taxe_t = \underset{(5.1)}{0.05} * \frac{1}{4} \sum_{i=0}^{3} \Delta(pc_{t-i} * c_{t-i}) \tag{244}$$

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

$$\Delta taxd_t = \underset{(3.6)}{0.003} * \frac{1}{4} \sum_{i=0}^{3} \Delta hwealth_{t-i} \tag{245}$$

Finally *taxindo* incorporates all **other indirect taxes** paid. This includes other indirect taxes paid to the EU ($taxindo_{eu}$), see equation (263), and an exogenous non-modelled item $taxindo_{res}$ which includes for example bank levies and levies on housing corporations. All other indirect taxes are modelled as a function of the growth in nominal (weight one-third) and real (weight two-thirds) private consumption.

$$\Delta(taxindo_t - taxindo_{eu,t} - taxindo_{res,t}) = \underset{(0.4)}{0.02} * \left(\frac{1}{3} \Delta(c_t * pc_t) + \frac{2}{3} \Delta c_t \right) \tag{246}$$

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.

$$sc_{sec,t} = scr_{sec,t} + sce_{sec,t} + scs_{sec,t} \tag{247}$$

$$scr_{sec,t} = scr_{sec,t-1} * W_{gross,t} / W_{gross,t-1} \tag{248}$$

$$sce_{sec,t} = sce_{sec,t-1} * W_{gross,t} / W_{gross,t-1} \tag{249}$$

$$scs_{sec,t} = scs_{sec,t-1} * W_{gross,t} / W_{gross,t-1} \tag{250}$$

Employers' social contribution paid by the government (scg) is the sum of social security contributions paid by the government (scg_{sec}), which are assumed to move in line with gross wages in the government sector, and implied social contributions paid by the government (scg_{imp}). The latter estimates employee unfunded social benefits, which are assumed to grow at the rate of unemployment insurance transfers $transh_{ww}$, plus an exogenous provision for military pensions (scg^{mp}_{imp}).

$$scg_t = scg_{sec,t} + scg_{imp,t} \tag{251}$$

$$scg_{sec,t} = scg_{sec,t-1} * \frac{W^{gov}_t - scg_t}{W^{gov}_{t-1} - scg_{t-1}} \tag{252}$$

$$scg_{imp,t} = \left(scg_{imp,t-1} - scg^{mp}_{imp,t-1}\right) * transh_{ww,t}/transh_{ww,t-1} \tag{253}$$

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[26].

$$\chi^o_t = scg_t/(scr_{sec,t} + scr_{pen,t} + scr_{imp,t}) \tag{254}$$

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.

$$\tau_{r,t} = (1 - \chi^o_t) * (scr_{sec,t} + scr_{pen,t} + scr_{imp,t})/W^{pr}_t \tag{255}$$

The **rate of employees' social contributions and income taxes** (τ_n) is defined as 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.

$$\tau_{n,t} = \frac{sce_{sec,t} + taxhw_t * sce_{sec,t}/scn_{sec,t}}{W_{gross,t}} \tag{256}$$

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.

$$\Delta divggas_t = \underset{(63.2)}{0.74} * \Delta(py_{va,min,t} * y_{va,min,t}) \tag{257}$$

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, $Z^* = Z - W^s - py_{va,min} * y_{va,min}$.

$$\Delta divgo_t = \underset{(0.7)}{0.02} * \Delta(Z_t - W^s_t - py_{va,min,t} * y_{va,min,t}) \tag{258}$$

[26] Note that employer's imputed social contributions scr_{imp} track scg_{imp} plus an exogenous adjustment.

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

$$r^{gov}_{received,t} = \underset{(27.0)}{0.68} * \frac{1}{400}\left(\underset{(10.7)}{0.73} * \frac{1}{20}\sum_{i=0}^{19} r^{f}_{t-i} + (1-0.73) * r^{s}_{t}\right) py_t * y_t \tag{259}$$

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

$$\Delta sales_t = \underset{(8.0)}{0.03} * \frac{1}{16}\sum_{i=0}^{15} \Delta(py_{t-i} * y_{t-i}) \tag{260}$$

Capital taxes (*taxcap*), which are mainly inheritance taxes, are increasing in net household wealth.

$$taxcap_t = -\underset{(3.2)}{19.8} + \underset{(37.0)}{0.0004} * \sum_{i=1}^{2} wealth_{t-i} \tag{261}$$

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 ($transcapgp_{eu}$).

$$\begin{aligned} gbaleu_t = {} & subs_{eu,t} + transgrf_{eu,t} + transcapgr_{eu,t} \\ & - (taxvat_{eu,t} + taxindo_{eu,t} + transgppf_{eu,t} + transgpf_{int,t} + transcapgp_{eu,t}) \end{aligned} \tag{262}$$

Many of the transactions with the EU budget are exogenous in the model, with the exception of value added tax (see equation (225)), other indirect taxes paid and GDP payment of government to EU budget (see equation (224)).

Since **other indirect taxes paid to EU Budget** ($taxindo_{eu}$) are mostly related to trade transactions, we assume it grows at the same rate as imports excluding energy in current prices.

$$taxindo_{eu,t} = taxindo_{eu,t-1} * \frac{pm_t * m_t - pm^e_t * m^e_t}{pm_{t-1} * m_{t-1} - pm^e_{t-1} * m^e_{t-1}} \tag{263}$$

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*), unfunded social benefits (scg_{imp}) subsidies on production (*subsprod*) net of EU subsidies ($subs_{eu}$) and other transfers paid (*transgpo*).

$$\begin{aligned} transgp_t = {} & transh_{ss,t} + transh_{bw,t} + transh_{akw,t} + transh_{zt,t} + transh_{wj,t} + sb_t \\ & + scg_{imp,t} + (subs_t - subs_{eu,t}) + transgpo_t \end{aligned} \tag{264}$$

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 ($transh_{anw}$) and benefits from unemployment insurance ($transh_{ww}$).

$$transh_{ss,t} = transh_{wao,t} + transh_{aow,t} + transh_{anw,t} + transh_{ww,t}$$

The total **number of inactive persons (fte)** in the population includes those claiming disability insurance (n_{wao}), old age pensions (n_{aow}), surviving relatives (n_{anw}), unemployment insurance benefits (n_{ww}), unemployment insurance assistance (n_{bw}) and within-work sickness benefits (n_{zw}). These variables are used below to generate cohort-specific per capita benefit rates. n_{ww}, n_{bw} and n_{zw} relate to the labour market and are endogenous in the model, while the others are exogenous.

Those unemployed receive either benefits from unemployment insurance or from social assistance. Both the **number of persons (fte) receiving benefits from unemployment insurance** (n_{ww}) and the **number of persons (fte) receiving benefits from social assistance** (n_{bw}) are affected by the change in unemployment, and lagged changes in unemployment. Since the number of persons receiving benefits changes sluggishly, we only impose full pass-through from n_u to $n_{ww} + n_{bw}$ after more than one year, by imposing lagged cross-equation restrictions.

$$\begin{aligned} \Delta n_{ww,t} &= \underset{(7.0)}{0.34} * \Delta n_{u,t} + \underset{(4.6)}{0.31} * \frac{1}{4}\sum_{i=1}^{4} \Delta n_{u,t-i} \\ &\quad + (1 - 0.34 - 0.31 - 0.09 - 0.16 - 0.12) * \frac{1}{4}\sum_{i=5}^{8} \Delta n_{u,t-i} \\ \Delta n_{bw,t} &= -\underset{(4.2)}{1.52} + \underset{(3.2)}{0.09} * \Delta n_{u,t} + \underset{(4.3)}{0.16} * \frac{1}{4}\sum_{i=1}^{4} \Delta n_{u,t-i} + \underset{(4.4)}{0.12} * \frac{1}{4}\sum_{i=5}^{8} \Delta n_{u,t-i} \end{aligned} \tag{265}$$

The **number of persons (fte) receiving sickness benefits** (n_{zw}) is decreasing in the unemployment rate, as in a weak labour market fewer employees dare to report sick. A relatively high proportion of total sick leave among the working population negatively affects private sector wage drift w^{pr}_{drift}, see equation (52).

$$\frac{n_{zw,t}}{e_t} = \underset{(0.44)}{0.0004} + \underset{(50.5)}{0.99} * \frac{n_{zw,t-1}}{e_{t-1}} - \underset{(2.4)}{0.001} * \frac{1}{4}\sum_{i=0}^{3} \Delta u_{t-i} \tag{266}$$

$\bar{R}^2 = 0.98$; $S.E. = 0.00$

Estimation period: 1978Q1 - 2016Q4

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.

$$\Delta \ln transh_{wao,t} = \Delta \ln n_{wao,t} + 0.95 * \Delta \ln w_{min,t} + 0.05 * \Delta \ln w^{pr}_{gross,t} \tag{267}$$

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

$$\Delta \ln transh_{aow,t} \quad = \quad \Delta \ln n_{aow,t} + 0.83 * \Delta \ln w_{min,t} \tag{268}$$

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

$$\Delta \ln transh_{anw,t} \quad = \quad \Delta \ln n_{anw,t} + 0.80 * \Delta \ln w_{min,t} \tag{269}$$

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.

$$\Delta \ln transh_{ww,t} \quad = \quad \Delta \ln n_{ww,t} + 0.66 * \Delta \ln w_{min,t} + 0.34 * \Delta \ln w^{pr}_{gross,t} \tag{270}$$

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

$$\Delta \ln transh_{bw,t} \quad = \quad \Delta \ln n_{bw,t} + 0.75 * \Delta \ln w_{min,t} \tag{271}$$

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

$$\Delta \ln transh_{akw,t} \quad = \quad \Delta \ln n_{18-,t} + \frac{1}{8}\sum_{i=0}^{7} \Delta \ln hicp_{t-i} \tag{272}$$

We assume changes in **health care allowance** ($trans_{zt}$) move in line with changes in health care expenses, cf. equation (277).

$$\Delta \ln transh_{zt,t} \quad = \quad \Delta \ln sb_{ss,t} \tag{273}$$

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

$$\Delta \ln transh_{wj,t} \quad = \quad \Delta \ln n_{wj,t} + \Delta \ln w_{min,t} \tag{274}$$

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 and funding for social supports which are administered at municipality level (WMO). It is assumed to grow at the same rate as nominal GDP.

$$sb_t = sb_{ss,t} + sb_{sa,t} \tag{275}$$

$$sb_{sa,t} = sb_{sa,t-1} * \frac{y_t * py_t}{y_{t-1} * py_{t-1}} \tag{276}$$

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 teenagers (n_{15-}) as well as the average life expectancy of men ($life_m$) and women ($life_w$).

$$\ln \frac{sb_{ss,t}}{pcg_t * n_t} = \ln \frac{ypot_t}{n_t} + \underset{(1.4)}{0.49} * \frac{n_{65+,t-1}}{n_{15-,t}} + \underset{(3.3)}{0.08} * \frac{life_{m,t} + life_{w,t}}{2} \tag{277}$$

$$\ln \frac{sb_{ss,t}}{pcg_t * n_t} / \frac{sb_{ss,t-1}}{pcg_{t-1} * n_{t-1}} = -\underset{(3.0)}{1.8} - \underset{(3.4)}{0.10} * sb_{ss,ECM,t-1} + \underset{(3.1)}{0.31} * \Delta \ln \frac{sb_{ss,t-1}}{pcg_{t-1} * n_{t-1}} \tag{278}$$

$\bar{R}^2 = 0.5$; $S.E. = 0.01$; $p(LM_4) = 0.00$; $p(JB) = 0.48$
Estimation period: 1981Q2 - 2016Q4

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

$$subs_t = subsprod_t + subso_t \tag{279}$$

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

$$\Delta \ln subsprod_t = \Delta \ln (pc_t * c_t) \tag{280}$$

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

$$\Delta \ln subso_t = \Delta \ln w_{min,t} \tag{281}$$

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.

$$\Delta r^{gov}_{paid,t} = (dda_t - gba_t) * \frac{1}{400} * (0.897 * rl_t + 0.103 * rs_t) \tag{282}$$

Compensation of employees of the government sector (W^{gov}) is given in equation (59). 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.

$$\Delta \ln eg_t = -\underset{(1.8)}{0.01} * \left(\ln(pcg_{t-1} * cg_{t-1}) - \ln(py_{t-1} * ypot_{t-1}) + \underset{(185.2)}{6.07}\right) + \underset{(5.3)}{0.52} * \Delta \ln eg_{t-1} \quad (283)$$

$\bar{R}^2 = 0.32$; $S.E. = 0.00$; $p(LM_4) = 0.31$; $p(JB) = 0.00$
Estimation period: 1981Q2 - 2016Q4

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

$$CGI_t = pcg_t *\ cgo_t + sales_t - pdg_t *\ \delta_t^g *\ kg_{t-1} - ntaxprod_t \quad (284)$$

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

$$\Delta \ln ig_t = -\underset{(3.2)}{0.15} * (\ln(pig_{t-1} * ig_{t-1}) - \ln(py_{t-1} * ypot_{t-1})) - \underset{(1.9)}{0.17} * \Delta \ln ig_{t-1} - \underset{(3.3)}{1.19} \quad (285)$$

$\bar{R}^2 = 0.12$; $S.E. = 0.04$; $p(LM_4) = 0.01$; $p(JB) = 0.00$
Estimation period: 1981Q2 - 2016Q4

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

$$kg_t = (1 - \delta_t^g) * kg_{t-1} + ig_t \quad (286)$$

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

$$\Delta \ln pgd_t = \Delta \ln pig_t \quad (287)$$

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.

$$\Delta \ln cgo_t = -\underset{(2.2)}{0.03} * (\ln(pcg_{t-1} * cgo_{t-1}) - \ln(py_{t-1} * ypot_{t-1})) + \underset{(3.6)}{0.8} *\ \Delta \ln eg_t - \underset{(2.0)}{0.08} \quad (288)$$

Government value added at basic prices in current prices is the sum of compensation of employees in the government sector, depreciation of the government capital stock (kg) in current prices (pdg)

and net taxes on production ($ntaxprod$). The corresponding **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 ($dg = \delta^g * kg_{-1}$), and the net taxes on production in constant prices ($ntaxprodr$). Real compensation of employees in the government sector is deflated using the government sector wage rate adjusted for changes in labour productivity in the government sector.

$$py_{va,t}^{gov} y_{va,t}^{gov} = W_t^{gov} + pdg_t * \delta_t^g * kg_{t-1} + ntaxprod_t \quad (289)$$

$$y_{va,t}^{gov} = W_{real,t}^{gov} + dg_t + ntaxprodr_t \quad (290)$$

Taxes on products ($taxprod$) is the sum of value added tax ($taxvat$), energy levies ($taxe$), transfer tax on dwellings ($taxd$), indirect taxes on products ($taxindo_t - taxindo_{res,t}$) and a statistical discrepancy.

$$taxprod_t = taxvat_t + taxe_t + taxd_t + (taxindo_t - taxindo_{res,t}) \quad (291)$$

Taxes on products in constant prices ($taxprodr$) are modelled with varying weights on different components of expenditure, namely domestic (non-energy) exports, private consumption, real social benefits, other government consumption and total investment. The weights are based on average shares over the period 2007-2016.

$$taxprodr_t = \underset{(0.88)}{213} + 0.02 * x_t^{dom,-e} + 0.14 * c_t + 0.04 * sb_t/pcg_t + 0.11 * cgo_t + 0.12 * it_t \quad (292)$$

B The model variables

Name	Description
α	elasticity of value added with respect to capacity utilisation in manufacturing
η	economies of scale
σ	elasticity of substitution between capital and labour
θ	sample average share of labour income in sum of capital income and labour income
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
γ	elasticity of substitution between energy and capital-labour composite
ζ	sample average share of energy costs in total factor income
ν_E^1	energy-augmenting technical progress, linear part
ν_E^2	energy-augmenting technical progress, quadratic part
δ	depreciation rate capital stock (volume)
δ^g	depreciation rate government capital stock (volume)
δ^{ict}	depreciation rate ICT investments
δ^{ih}	depreciation rate of housing investments
δ^h	depreciation rate of housing stock (volume)
δ^o	depreciation rate private capital stock less dwellings (volume)
τ^c	Net indirect tax rate on consumption
τ^{cg}	Net indirect tax rate on government consumption
τ^{firms}	corporate tax rate
τ^{it}	Net indirect tax rate on investment
τ_n	rate of employees' social contributions and income taxes to gross wages
τ^{oil}	tax rate on petrol per litre in euro
τ_r	rate of employers' social contributions to compensation of employees
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
$\tau^{xdom,-e}$	Net indirect tax rate on domestic exports (excluding energy)
χ^e	ratio of volume of imports of energy (National Accounts) to Petajoule
χ^{es}	share self-employment in private sector employment

Name	Description
χ^{hicpe}	weight of energy in HICP
χ^{hicpf}	weight of food in HICP
χ^{ih}	share of total housing investment carried out by households
$\chi^{m,intra}$	share of euro area countries in volume of imports of goods and services
χ^{o}	government's share in employers' social contribution
$\chi^{tax,w}$	share of taxes on labour income in total households' taxes on wages and income
$\chi^{tax,pen}$	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
$\chi^{x,re,-e}$	Non energy share of exports in total re-exports of goods
ψ^{gov}	ratio persons per fte, government sector
ψ^{pr}	ratio persons per fte, private sector excluding self-employment
ψ^{s}	ratio persons per fte, self-employment
$\psi^{tot,struc}$	ratio persons per fte, total economy, structural
$assetb^{ext}$	external assets, MFI data
$assetb^{oth}$	other assets, MFI data
$assetb^{sec}$	securities on balance sheet, MFI data
$assetb^{tot,ww}$	total assets, supervisory data from consolidated accounts
$assetb^{tot}$	total assets, MFI data
$bkrupt$	bankruptcy rate
bls^{h}	BLS credit standards for mortgages, cumulated
c	volume of private consumption
$cconf$	Consumer confidence
cds	CDS spread in banking sector
ce	volume of use of energy, measured in Petajoule
cg	volume of general government consumption
CGI	intermediate government consumption, current prices
cgo	volume of other government consumption
cu	capacity utilisation rate in manufacturing industry
cy	production costs price
cye	production costs price including energy
d	depreciation capital stock, volume
dda	deficit-debt adjustment (stock flow adjustment)
$dels$	volume of changes in inventories, including statistical discrepancies
dep^{cg}	deposits of central government, MFI data

Name	Description
dep^{gg}	deposits of government, MFI data
dep^{ipf}	deposits by insurance and pension funds, MFI data
dep^{mfi}	deposits by MFIs, MFI data
dep^{ofi}	deposits by OFIs, MFI data
$depf$	deposits by NFCs with banks, MFI data
$depf^{dom}$	deposits by NFCs with banks, domestic firms, MFI data
$deph$	deposits by households, MFI data
$deph^{dom}$	deposits by households, domestic households, MFI data
$deptot$	total deposits, MFI data
dg	deprecation government capital stock, volume
dh	depreciation stock of dwellings, volume
$divb$	dividends distributed, supervisory data
$divf$	dividend yield
$divggas$	dividends related to gas production received by the government
$divgo$	other dividends received by the government
$divh$	dividend received by households
$divhr$	households' dividend return
do	deprecation private capital stock less dwellings, volume
ds	volume of changes in inventories
$dum_{Q1,Q3}$	dummy variable (Q1,Q3=1, Q2,Q4=0)
e	employment, fte
e_h	Employed, hours
e_n	employment, persons
eg	government sector employees, fte
eg_h	Employees of gen. government, hours, sector
eg_n	government sector employees, persons
em	employees, fte
em_h	Employees, hours
em_n	employees, persons
emp	private sector employees, fte
emp_h	Employees of business sector, hours, sector
emp_n	private sector employees, persons
ep	private sector employment, fte
ep^{struc}	potential private sector employment, fte
es	self-employment, fte

Name	Description
es_h	Self employed, hours
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
$fisim^{paid,hh}$	interest (FISIM) paid by households
$fisim^{received,hh}$	interest (FISIM) received by households
$frpf$	funding ratio pension funds
$frpfr_1$	pension contributions, contribution to change in $frpf$
$frpfr_2$	pension benefits, contribution to change in $frpf$
$frpfr_3$	indexation allowances for pensions, contribution to change in $frpf$
$frpfr_4$	term structure of interest rates, contribution to change in $frpf$
$frpfr_5$	returns on pension savings, contribution to change in $frpf$
$frpfr_6$	life expectancy, contribution to change in $frpf$
fsi	Financial stress indicator
$fundmix$	banks funding mix: ratio total deposits to other debt
$gacq$	net acquisitions of government
$gbal$	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
$hicp^{-ef}$	HICP excluding energy and food, seasonally adjusted
$hicp^{-ef}_{nsa}$	HICP excluding energy and food, not seasonally adjusted
$hicp^f$	HICP food
$hicp^{rents}$	HICP rents
hp	number of hours per fte in private sector
hp^{struc}	structural number of hours per fte in private sector
$hwealth$	households' gross housing wealth
$hwealthn$	net housing wealth = $hwealth$ - $loanshmor$
I_{1998Q4_t}	dummy variable $t < 1998Q4 = 0$, else 1
I_{2000Q1_t}	dummy variable $t < 2000Q1 = 0$, else 1
I_{2009Q1_t}	dummy variable $t < 2009Q1 = 0$, else 1

Name	Description
I_{2010Q1_t}	dummy variable $t < 2010Q1 = 0$, else 1
I_{2013Q1_t}	dummy variable $t < 2013Q1 = 0$, else 1
$I_{profitb_t}$	dummy variable =0 if $profitb < 0$, else 1
$icpf$	investment income from life insurance technical reserves, including pension funds
ict	share of ICT investment in total investment (excl. dwellings)
ig	volume of government investment
ih	volume of housing investment
imp^b	net impairments by banks, supervisory data
$indexpen$	annualised rate of indexation of pension benefits
$indexpen_{ambt}$	Indexation ambition of pension funds
io	volume of other private investment
$iodif$	difference between investment to GDP ratio in NL and in euro area
it	volume of total investment
k	capital stock
Kb	bank capital: equity and reserves on balance sheet, MFI data
Kb^{ww}	bank capital, supervisory data from consolidated accounts
$\Delta Kb^{res,ww}$	net other change in bank capital, consolidated data
kg	government capital stock
kh	stock of dwellings
ko	private sector capital stock less dwellings
lev_b	leverage ratio of banks, $\frac{Kb}{assetb^{tot}} * 100$
$\overline{lev_b}$	target leverage ratio
$\overline{ln(lev_b)}$	target leverage ratio, in logs
$liabb^{debt}$	debt securities, liabilites on balance sheet, MFI data
$liabb^{ext}$	external liabilities, MFI data
$liabb^{oth}$	other liabilities, MFI data
$liabb^{tot}$	total liabilities, MFI data = $assetb_{tot}$
$life_m$	life expectancy men
$life_w$	life expectancy women
$loans^{gg}$	loans of general government, MFI data
$loans^{ipf}$	loans to insurance corporations, pension funds, MFI data
$loans^{ipr}$	loans to insurance corps., pension funds and other fin institutions, MFI data
$loans^{mfi}$	loans to MFIs, MFI data
$loans^{ofi}$	loans to OFIs, MFI data
$loansf$	loans to (non-financial) firms

Name	Description
$loansf^{dom}$	loans to domestic NFCs incl securitisations, corrected for cash pooling, MFI data
$loansh$	loans to households, MFI data
$loansh^{c,cor}$	loans to households: consumer loans, corr. for securitization
$loansh^{cor}$	loans to households, corr. for securitization
$loansh^{h,cor}$	loans to households: mortgage, corr. for securitization
$loansh^{o,cor}$	loans to households: other loans, corr. for securitization
$loanshmor$	households' mortgage loans
$loansho$	households' other loans
$loanstot$	total loans, MFI data
ls	labour supply, persons
$lshare$	Labour income ratio
$lshare^{alt}$	Labour income ratio (alternative)
ltd	loans-to-deposits ratio of banking sector
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^{extra}	volume of imports of goods and services from outside euro area countries
m^{intra}	volume of imports of goods and services from euro area countries
$m^{re,-e}$	volume of imports for the purpose of re-exports, excluding energy
m^{re}	volume of imports for the purpose of re-exports
n	population
n_{15-}	population aged 15^{-}
n_{1575}	population aged between 15 and 75
n_{18-}	population aged 18^{-}
n_{4575}	population aged between 45 and 75
n_{65+}	population aged 65^{+}
n_{anw}	Volume of non-actives: Surviving Relatives Act, fte
n_{aow}	Population (AOW age) on a sliding base
n_{bw}	Volume of non-actives: Welfare, fte
n_{u}	unemployment
n_{wao}	Volume of non-actives: Disabled Benefits, fte
n_{ww}	Volume of non-actives: Unemployment Insurance Act, fte
n_{zw}	Volume of non-actives: Sickness Benefits Act, fte
$ntaxprod$	taxes on production minus subsidies
$ntaxprodr$	taxes on production minus subsidies, constant prices

Name	Description
ocb	operating costs for banks, supervisory data
p^b	overhead cost price for banks, per unit of $asset^{tot,ww}$
p_{oil}	crude oil price (Brent, level in \$ per barrel)
$part$	labour participation rate
$part^{struc}$	labour participation rate, long-term
pc	deflator of private consumption
pce	deflator of use of energy
$pcee$	price of domestic use of energy in efficiency units
pcg	deflator of government consumption
$pconf$	producer confidence
pcp^h	Commercial property prices: Residential property
pcp^o	Commercial property prices: Offices
pcp^{ret}	Commercial property prices: Retail property
pcp^{tot}	Commercial property prices: all types
pds	deflator of changes in inventories
$permits$	number of building permits issued
pgd	deflator of depreciation of government capital
ph	house price index
pig	deflator of government investment
pih	deflator of housing investment
pio	deflator of other private investment
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
$pm^{dom,-e}$	deflator of imports for domestic use excluding energy
pm^{dom}	deflator of imports for domestic use
pm^e	deflator of imports of energy
pm^i	deflator of imports of investment goods
$pm^{re,-e}$	deflator of imports for the purpose of re-exports, excluding energy
pm^{wo}	competitors' import prices

Name	Description
$prem^{act}$	actuarial estimate of pension premium contribution
$prod$	private sector labour productivity
$profitb$	profits before tax, banks, consolidated accounts
$profitb^{oth}$	other income, banks, consolidated accounts
$profq$	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 stock of inventories
px	deflator of exports of goods and services
$px^{dom,-e}$	deflator of exports of domestically produced goods and services, excluding energy
px^{e}	deflator exports of energy
px^{it}	deflator of US exports of computers, peripherals and parts
$px^{re,-e}$	deflator of re-exports of goods and services, excluding energy
px^{wo}	competitors' export prices
py	deflator of gross domestic product
py^{-x+m}	deflator of final domestic demand
py_{va}	deflator of value added at basic prices
py_{va}^{gov}	deflator of government value added at basic prices
py_{va}^{min}	deflator of value added of mining and quarrying at basic prices
py_{va}^{pr}	deflator of private sector value added at basic prices
$pyfin$	deflator of final demand
r_{paid}^{b}	Interest paid by banks, supervisory data
$r_{received}^{b}$	interest received by banks, supervisory data
r^{f}	composite lending rate (long term) loans to NFC's
r^{m}	mortgage interest rate
r^{oa}	margin on rs for other assets
r^{ol}	margin on rs for other liabilities
r_{paid}^{gov}	interest paid by government
$r_{received}^{gov}$	interest received by government
r_{paid}^{hh}	interest paid by households
$r_{received}^{hh}$	interest received by households
$rdep^{f}$	composite NFC's deposits rate
$rdep^{h}$	Interest rate on households deposits
$rforw1$	Forward rate, 1 year

Name	Description
$rforw16$	Forward rate, 16 year
rl	long term interest rate; 10 yr bond yield
$rl2$	long term interest rate; 2 yr bond yield
$rpfa$	Returns on asset markets, pension funds
$rpfo$	Returns on bond markets, pension funds
$rpft$	Total returns, pension funds
$rpfv$	Returns on property investments, pension funds
rpr	replacement rate
rs	short term interest rate; euribor 3 month rate
$rts1$	Term structure pension funds 1yr; zero coupon
$rts16$	Term structure pension funds 16yr; zero coupon
$rts17$	Term structure pension funds 17yr; zero coupon
$rts2$	Term structure pension funds 2yr; zero coupon
rwa	risk weighted assets, supervisory data
rwr_b	capital ratio, as percentage of RWA
s	volume of stock of inventories
$sales$	sales of government
$savh$	households' (gross) saving ratio
$savhp$	adjustment for net equity in pension funds reserves
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
sc_{sec}	social security contributions
$sce_{pen,paid}$	employees' contributions paid to pension schemes
sce_{pen}	employees' contributions to pension schemes
sce_{sec}	employees' social security contributions
scg	employers' social contributions of government
scg_{imp}	imputed social contributions of government
scg_{imp}^{mp}	Employee social benefits (unfunded) in cash: Military pension provisions
scg_{sec}	social security contributions paid by the government
scn	employees' social contributions incl. self-employed, excl. rest of the world
scn_{sec}	social security contribution net of employers' social security contributions
scr	employers' social contributions, excl. rest of the world
scr_{imp}	employers' imputed social 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
$subs$	subsidies
$subs_{eu}$	subsidies received from EU Budget
$subso$	other subsidies on production
$subsprod$	subsidies on products
$subsprodr$	subsidies on products in constant prices
t	time trend
tax	current taxes on income and wealth received by government
$taxb$	tax paid by banks, supervisory data
$taxb^{dom}$	Current taxes on income and wealth paid by monetary financials institutions
$taxcap$	capital taxes received by government
$taxd$	transfer tax on dwellings
$taxe$	energy levies and excise duties
$taxf$	current taxes on income and wealth paid by firms
$taxfgas$	corporate taxes on gas revenues
$taxfo$	other direct taxes paid by firms
$taxfoc$	corporate taxes less corporate taxes from gas and banking
$taxh$	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
$taxind$	taxes on production and imports received by gen. government
$taxindo$	other taxes on production and imports
$taxindo_{eu}$	other indirect taxes paid to EU Budget
$taxindo_{res}$	Other taxes on production, e.g. bank levies, levies on landlords
$taxo$	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
$transcapgp$	capital transfers paid by general government
$transcapgp_{eu}$	capital transfers paid by government to EU Budget
$transcapgr$	capital transfers received by general government

Name	Description
$transcapgr_{eu}$	capital transfers (investments grants) received from EU Budget
$transfp$	current transfers paid to the rest of the world
$transfr$	current transfers received from the rest of the world
$transgp$	current transfers paid by the general government
$transgpf$	current transfers paid by government to the rest of the world
$transgpf_{eu}$	GNP payment of government to EU Budget
$transgpf_{int}$	international co-operation paid by government to EU Budget
$transgpfo$	other current transfers paid by the government to the rest of the world
$transgpo$	other current transfers paid by general government
$transgrf$	current transfers received by government from the rest of the world
$transgrf_{eu}$	current transfers received by government from EU Budget
$transgro$	other transfers received by general government
$transh$	social benefits in cash
$transh_{akw}$	general family allowance act
$transh_{anw}$	social benefits from surviving relatives act
$transh_{aow}$	social benefits from old age pensions act
$transh_{bw}$	social benefits from social assistance act
$transh_{oth}$	other social benefits received by households
$transh_{pen}$	pension benefits
$transh_{ss}$	social security benefits in cash
$transh_{wao}$	social benefits from disability insurance act
$transh_{wj}$	social benefits from youth disability insurance act
$transh_{ww}$	social benefits from unemployment insurance act
$transh_{zt}$	health care allowances
u	unemployment rate
u^{eq}	equilibrium rate of unemployment
$ukrebate$	UK rebate
v^{hh}	long term bonds, shares and other financial assets of households excl. deposits
v^{hh}_{pen}	households' net equity in life insurance and pension funds reserves
W	compensation of employees
w^{b}	compensation per employee, banking sector
W^{gov}	compensation of employees, government sector
w^{gov}	compensation per employee, government sector
W^{pr}	compensation of employees, private sector
w^{pr}	compensation per employee, private sector

Name	Description
$W^{s,alt}$	imputed wages (alternative) of self employed persons
W^{s}	imputed wages of self-employed
w^{gov}_{cnt}	contractual wage, government sector
w^{pr}_{cnt}	contractual wage, private sector
w^{gov}_{drift}	wage drift, government sector
w^{pr}_{drift}	wage drift, private sector
W_{gross}	Wages and salaries
w^{gov}_{gross}	gross wage, government sector
w^{pr}_{gross}	gross wage, private sector
w_{min}	minimum wage
W^{gov}_{real}	compensation of employees, government sector in constant prices
$wealth$	net wealth of households, including housing wealth
x	volume of 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^{extra}	volume of exports of goods and services outside euro area countries
x^{intra}	volume of exports of goods and services to euro area countries
$x^{re,-e}$	volume of re-exports of goods and services excluding energy
x^{re}	volume of re-exports of goods and services
$x^{wo,extra}$	volume of foreign demand originating from outside the euro area
x^{wo}	volume of foreign demand
$xmca$	current account surplus
Y	value of gross domestic product at market prices
y	volume of gross domestic product at market prices
y^{oecd}	volume of GDP in OECD countries
y^{gov}_{va}	volume of government value added at basic prices
y^{min}_{va}	volume of value added of mining and quarrying at basic prices
y^{pr}_{va}	volume of private sector value added at basic prices
$YDIS$	disposable income of households
$ydis$	disposable income of households, deflated by pc
$YDIS^{*}$	$YDIS^{*} = YDIS - divh - r^{hh}_{received} + r^{hh}_{paid}$
$yfin$	volume final demand $c + it + x + cgo$
$ygap$	output gap: $(y - ypot)/ypot$
$ypot$	potential output, volume
$ypot^{pr}_{va}$	potential volume of private sector value added at basic prices

Name	Description
Z	gross operating surplus
Z^b	Net operating surplus of monetary financial institutions
Z^{hh}	mixed income of households

EUROSYSTEEM

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