

# Norwegian Aggregate Model (NAM)

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## 1 Introduction

This note describes model size and data sources, as well as some of the history of the NAM project, and the model's current use. Separate sections discuss treatment of basic national accounting identities, and theoretical and methodological issues connected to specification of wages and prices (the supply side); the main assets market (foreign exchange and housing) in the model; identification and relationship to DSGE models.

The source of this note is the NAM documentation in Bårdsen and Nymoen (2015). That documentation contains the detailed explanation of the relationships of the model, the full set of definitions of the exogenous and endogenous variables, as well as a listing of estimation results.

## 2 Model, size and data sources

NAM is not a large macro econometric model, by Norwegian standards. But NAM is not a miniature model either. The present version of the model contains 165 endogenous variables and 68 exogenous variables.<sup>1</sup> Among the exogenous variables, the majority is made up of deterministic variables for seasonality, trends and intermittent structural breaks. There are only 10 exogenous variables that need to be projected outside the model.<sup>2</sup> NAM is therefore a fairly closed model, so the most important variables for the Norwegian economy are determined by the model, while conditioning on foreign prices and output, the price of raw oil, and domestic policy variables like (a few) tax rates, government consumption and public investments.

The database of the model is constructed by using data from StatBank Norway ([www.ssb.no/en/statistikkbanken](http://www.ssb.no/en/statistikkbanken)) as well as from the web sites of other national and international organizations and institutions. The data input is also based on an agreement with Statistics Norway about access to data from the KVARTS model.

NAM is an equilibrium-correction model, but the equilibria can change due to for example institutions adapting to the changing environment. Technically, NAM therefore allows for both unit-root non-stationarity and for structural breaks.

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<sup>1</sup>The numbers of endogenous and exogenous variables vary between different user specific versions of the model. But the cited numbers for the main-model version are representative.

<sup>2</sup>One important caveat is that practitioners are will be aware of, are step-indicator functions that represent semi-permanent structural breaks. The change in Norges Bank interest rate setting when the the financial crisis arrived in Norway is an example.

NAM is, however, not a ‘natural rate’ (of unemployment) model. This follows from the theory of wage and price formation, which represent an important form of coordination of wage and prices through collective agreements, and their extension to the labour market.

The model is estimated by the use of quarterly data (not-seasonally adjusted). The main use of NAM is forecasting and analysing the Norwegian macro economy, over the short and medium run. Therefore the model is typically solved for a period of 1-4 years, although the solution period can be considerably longer when the purpose is to analyse the model’s steady-state properties.

### 3 History, documentation and current use

NAM is a model project which extends from the econometric assessment of wage- and price formation in Nymoen (1989,1991), further developed in Bårdsen, Fisher, and Nymoen (1998), Bårdsen and Fisher (1999), and the monetary transmission model of Bårdsen and Klovland (2000).

As mentioned above, the main reference and documentation is Bårdsen and Nymoen (2015). It is published on the internet, and is frequently updated following improvements and extensions of the model.<sup>3</sup>

NAM was first developed for research purposes, in particular the implications of collective bargaining between social partners for macroeconomic dynamics and equilibrium, in contrast to the natural rate/NAIRU implication of more individualistic wage setting system as represented by conventional Phillips curve models of wage dynamics (including the Phillips curves of the so called Scandinavian type), see Bårdsen, Eitrheim, Jansen, and Nymoen (2005, Ch. 3-6).. The strength of interest rate and expectations effects, and the role of alternative models of wage and price dynamics in monetary policy analysis have also been research topics, cf. Bårdsen et al. (2004), Akram and Nymoen (2009). Versions of the model that were formulated for these research projects are documented in Bårdsen and Nymoen (2001), Bårdsen, Jansen, and Nymoen (2003), and Bårdsen and Nymoen (2009).

In 2006, we began to use the model regularly to forecast the Norwegian macro economy<sup>4</sup>. NAM forecasts and their evaluation, have since then been published on the internet.<sup>5</sup>

Currently, versions of NAM are used by Finanstilsynet (The Financial Supervisory Authority of Norway), NHO (Confederation of Norwegian Enterprise) and LO (Norwegian Confederation of Trade Unions)<sup>6</sup>. Since 2013 the model has been regularly in use by KLP (Kommunal Landspensjonskasse), and before that KLP

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<sup>3</sup>[http://folk.uio.no/rnymoen/nam\\_main.pdf](http://folk.uio.no/rnymoen/nam_main.pdf); <http://www.sv.ntnu.no/iso/gunnar.bardsen/nam/>

<sup>4</sup>This was also an extension of the forecasting project by Falch and Nymoen (2011), who focused on improving on Norges Bank’s inflation forecasts by econometric methods.

<sup>5</sup><http://www.sv.ntnu.no/iso/gunnar.bardsen/nam/forecasts/index.html>

<sup>6</sup>For documentation of how NAM was used by Finanstilsynet in their reports *Finansielt utsyn* for 2014 and 2015, see Finanstilsynet (2014a) and Finanstilsynet (2014b). English versions of both reports are available from <http://www.finanstilsynet.no/en/>. The english name of the report is *Risk Outlook. The Financial Market in Norway*.

Table 1: Total supply (TOTS) and total demand (TOTD) in NAM, cf. Ch. 7.2 in Bårdsen and Nymoene (2015) for details.

Total Supply	TOTS	≡ TOTD	Total Demand
Imports	$B$	$A$	Exports
Gross Domestic Product	$Y$	$CP$	Private consumption
-GDP Mainland Norway	$YF$	$CO$	Public consumption
-GDP oil-sector	$YOIL = \begin{cases} YOIL1 \\ YOIL1 \end{cases}$	$JO$	Public investments
-GDP intern. shipping	$YSF$	$JBOL$	Investments in housing
Net product taxes	$AVGSUB$	$JFPN$	Private business investments
		$JOIL$	Oil-investments
		$JUSF$	Intern. transport
		$JL$	Changes in inventories

made use of NAM more intermittently, as part of KLP’s projections for actuarial purposes, of interest rates and wage growth.<sup>7</sup>

## 4 National Accounting identities

NAM does not have a very detailed representation of the definitional relationships of the Norwegian quarterly national account system. The model’s representation of the general budget relationship of Norway is shown in Table 1.<sup>8</sup> NAM represents private Mainland-Norway gross domestic product by three endogenous variables: manufacturing, production of other goods and service production, and retail trade; and one exogenous: government administration. Total GDP is obtained by adding value creation in the oil sector and in international transportation. Total supply is made up of Norway’s GDP and total imports (an endogenous variable).

On the demand side of the general budget equation, exports of raw oil and natural gas are treated as exogenous variables, the other variables are endogenous. As shown in Table 1, the two main government expenditure components, consumption (CO) and gross capital formation (JO), are exogenous variables in NAM. The income side of the budget is not represented in the operational version of NAM. Presently, NAM can be used to analyse effects on the macro economy of aggregate fiscal policy changes. Later model versions will incorporate the fiscal budget identity, following for example the experience with modelling the Swedish economy in Bårdsen et al. (2012).<sup>9</sup>

<sup>7</sup>Early documentation is represented by Nymoene (2007a,b, 2010).

<sup>8</sup>See ssb.no: Tabell: 09190: Makroøkonomiske hovedstørrelser.

<sup>9</sup>Incidentally, analysis using NAM shows the same picture as the so called structural model analysed in Coenen et al. (2012), namely that the multipliers are different depending on whether monetary policy is accommodating or reacts by raising interest rates.

## 5 Aggregate supply and demand

Table 1 gives the decomposition of total supply (TOTS) and total demand (TOTD) in term of NAM variables. In a solution of the model, i.e., in a dynamic simulation of the model, total supply is identical to total demand in all time periods, hence  $TOTS \equiv TOTD$  as noted in the table. All the variables in the TOTS-column of Table 1 are endogenized by econometric treatment in NAM. Hence both GDP and GDP for Mainland-Norway are formally determined from the supply of the product marked.  $TOTS \equiv TOTD$  therefore serves to determine one of the variables in the TOTD column of the table, and we have chosen the variable  $JL$ , which is changes in inventories. In a completely “demand driven” model,  $JL$  is exogenous, and changes in  $JL$  contribute to GDP growth. In NAM,  $JL$  does not enter any other equations, and its role is to be a diagnostic of internal consistency: For example, if  $JL$  increases/decreases markedly (and away from historical levels) relative to GDP, we have an indication that the endogenous development of total demand is inconsistent with the model solution for total supply.

Although formally, as we has seen, GDP is determined “from the supply side”, value added in the three domestic production sectors are quite strongly related to the variables on the demand side. Logically, this requires a theory of firm behaviour and of wage-formation which makes it rational for firms to react to demand shocks with quantitative adjustment, while wage and prices mainly follow a common trend that reflects developments in productivity and in terms of trade.

## 6 Firm behaviour and wage formation

As Nickell (1988) explained, the key parts of the supply-side are represented by those equations that describe the behaviour of firms, in particular price setting, and those that reflect the determination of wages. In NAM, the main assumption is monopolistic competition and that product prices are determined by mark-up of prices over unit labour costs, Empirically, the modelled price indices are relatively inelastic with respect to demand.

Collective agreements is the main instrument of wage formation in Norway. Several commentators have noted the stability of the Norwegian norm-based system. For example by Visser (2013, p. 59-60), and also by OECD economists, OECD (2012, p. 15). One result of the modelling of wage-setting NAM is that this system may have qualitative implications for the medium-term macroeconomic equilibrium.

The formulation of a theory of a sustainable wage norm requires an assessment of not only self-interest among workers and firms, but also of compromise. As pointed out by Usher (2012), ‘compromise’ is then not just another way of talking about self-interest, and social, political and institutional forces are not merely cover-ups for imprecisely modelled individuals rational actions, they are among the fundamental determinants of decisions. In this view, even a full analysis of rational behaviour leads to an indeterminacy of wages, and other considerations had to be introduced to resolve it.

The recognition among economists that there is an indeterminacy in the economic theory of wages goes back to the 1950s, see Forder (2014, Ch. 1.4) who cites Samuelson (1951, p. 312) and Hicks (1955, p. 390) and other leading theorists. The economic theory of supply and demand could set some limits to what wages can be

set, but within those limits closer determination requires that other relationships are introduced. The indeterminacy of wages from theory also characterizes the now standard Diamond-Mortensen-Pissarides (DMP) search and matching model, and as a result the DMP-literature refers to as wage ‘stickiness’, Hall (2005).<sup>10</sup>

At the same time as we find it challenging to determine wages theoretically, we also observe that actual wage bargains are struck year after year, and that they are rationalized by considerations of profits, actual and required (to attract investments), cost of living and relative wages (fairness). Observed regularities like these make it easy to imagine that a local data generating process exists, and that wage formation can be subject to econometric treatment.

It is in this light that the modelling on wages and prices in NAM must be seen. For example, the idea of a wage norm (i.e. “general wage level” in the OECD citation) is treated econometrically using cointegration methods and equilibrium correction modelling.

In a model with stochastic trends, monopolistic competition and collective bargaining based wage formation have important implications for the analysis of macroeconomic stability. As noted, it implies that the markets for industrial products mainly clear through quantity, rather than mainly through price and wage adjustment mechanisms. As a result, the unemployment rate and the employment rate, will also be vulnerable to shocks—both from outside and from domestic shocks from e.g., financial imbalances. On the other hand, such an economy may be responsive to the instruments of monetary and fiscal policy.

Finally, based on the theoretical analysis and the empirical evidence, NAM is not a natural rate/NAIRU model, see Bårdsen and Nymoén (2015, Ch. 6 and 7.1) and Bårdsen and Nymoén (2014).<sup>11</sup> This property is robust to so called dynamic price-wage homogeneity, cf. Kolsrud and Nymoén (2014,2015).

## 7 The market for foreign exchange and the real-exchange rate

In NAM, the real wage and the real exchange rate are jointly determined, since the real exchange rate has “internal devaluation” as one of its determinants. But, the solution is of course also influenced by the market for foreign exchange. With nominal wage and price rigidity, changes in the nominal exchange rate affect the real exchange rate which is one determinant of aggregated demand of the open economy.

The starting point of the modelling of the nominal exchange rate is the portfolio approach (or stock approach) to the market for foreign exchange, cf. Rødseth (2000, Ch. 1 and 2). In this approach, the market for foreign exchange is linked to the financial sector via the risk premium, defined as the difference between the domestic interest rate and the foreign interest rate, adjusted for investors’ anticipations about currency depreciation.

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<sup>10</sup>Following Hall (2005), several papers have incorporated rigid wage setting in search models. Gertler and Trigari (2009) present a DMP model where the frequency of wage bargaining is constrained by Calvo (1983) style lottery. Blanchard and Galí (2010) combine a reduced form search model with real wage rigidity, with a New Keynesian model. Krogh (2015) generalizes the Hall-approach to a small open economy model.

<sup>11</sup>NAIRU: *Non-Accelerating Inflation rate of Unemployment*

## 8 Housing and credit markets

In NAM, domestic credit is modelled on a disaggregated basis for households, non-financial firms and municipalities. Household debt increases with rising disposable income and house prices and with lower lending rates. The model contains an accelerator mechanism whereby higher house prices, contributing to higher collateral values, lead to heavier household debt, which in turn fuels a further increase in house prices, and thereby even heavier borrowing by households, cf. Anundsen and Jansen (2013).

Housing prices and credit have effects on the real economy, and are affected by it. The best documented empirical effect is perhaps the effect of housing dominated private wealth on consumption expenditure, cf. Brodin and Nymoene (1992), Eitrheim et al. (2002). The relationships between credit, house prices and aggregated demand have been useful in the modelling of imbalances in the household sector, see Finanstilsynet (2014b). For example households' "interest payment burden" is determined by the lending rate and household debt. An increase in the debt burden tightens households' liquidity, thereby reducing housing demand. This effect is highly non-linear in the model.

## 9 Identification, estimation and specification

The model contains blocks with simultaneous equations, for wage and price formation and housing prices and credit. For these sub-systems identification is achieved in the two well known steps: First, identification of the cointegration relationships, and second, of the short-run dynamics, cf. Hsiao (1997). Estimation is by FIML. The rest of the model consists of single equations estimated by OLS, with the interpretation of conditional expectations, where agents form and act on contingent plans. The parameters of interest of these equations are therefore regression parameters, and they are identified.

Although the model in its present form has proven to be of some use in forecasting and policy analysis, it also has weaknesses that are easy to see. It is always a question whether this is mainly due to choice of parameters of interest and identification, or whether there are more mundane reasons like invalid conditioning, or simply poor empirical modelling. Based on experience, gradual model improvement is a viable way forward, and that dialogue with model users is essential in that process. In this we have found confirmation of the observations made by Granger (1990). With frequent structural breaks in the economy, there is a price to pay in the form of forecast-failures (and maybe wrong policy advice) for being non-adaptive in the model specification.

## 10 Relationship to DSGE models

At one level, there is a close relationship between DSGEs and NAM. In NAM, the reduced form is a (high dimensional) VAR with a well defined companion form representation. The solution of a DSGE model, if it exists and is unique, is also a VAR, see Bårdsen and Fanelli (2015). Hence, the principal difference between NAM and a DSGE is the respective identifying restrictions on the VAR. Identification is

a question of economic theory, and therefore the relevance and evaluation of the identifiable theory for the Norwegian economy remains a topical issue. For example, In NAM the steady state is not imposed *a priori*, but estimated as cointegrated relationships.

Another difference is the direct modelling of the macroeconomic data in NAM, versus the “prepared” data modelled in DSGEs. In NAM the deviation from equilibrium is represented explicitly in the model, with estimated steady-state parameters, while in DSGEs the variables are usually filtered, representing deviations from steady-state paths. Since both types of models will be damaged by structural breaks in the equilibrium relationships, it seems better to have steady-state parameters explicitly in the model specification, to assess their significance and to monitor signs of breaks.

## 11 NAM and econometric software: EViews and OxMetrics

NAM is implemented as a program file (recognized by the filename extension “.prg”) in the econometric software package Eviews.<sup>12</sup> The NAM prg-file serves several functions. The first is to load a number of files with quarterly data sets that are needed to estimate the model’s equations, and to complete the model with definitional relationships. Maintaining and updating the set of data files is a main task connected to using NAM, and the agreement with Statistics Norway about access to KVARTS data is very important.

The data files that are loaded by the NAM-prg file are either recognized directly as EViews databases, or they can be transformed to such databases. The file format of the OxMetrics family of econometric software is an example of a format which is recognized as a database. We use the econometrics program PcGive in OxMetrics in the specification of the sub-models that are implemented in NAM . PcGive is a manifestation of a coherent approach to dynamic econometric modelling, Doornik and Hendry (2013a,b), Hendry and Doornik (2014).<sup>13</sup>

A NAM program file also estimates the model and simulates the models for a user specified sample period. If the purpose of the simulation is forecasting, the user needs to provide values for the non-modelled random variables in the forecast period. Add-factors (for so called intercept correction) can also be provided by the user. The NAM program file will solve the model deterministically or stochastically (Monte-Carlo simulation) depending on choices made by the user. Finally output is produced in the form of EViews tables and graphs. In addition to within sample simulation and forecasting, a NAM program file will execute user specified scenario analysis (for example policy analysis), again either deterministically or by Monte-Carlo simulation.

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<sup>12</sup>EViews is provided by IHS Global Inc. See <http://www.eviews.com/home.html>.

<sup>13</sup>See <http://www.oxmetrics.net/> for information about Oxmetrics and PcGive.

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