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DYNAMIC-AAGE

A dynamic applied general equilibrium model of the Danish economy based on the AAGE and MONASH models

Philip Adams

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1. Preface

This report documents the development of a dynamic version the Agricultural Applied General Equilibrium (AAGE) model of the Danish Economy. The work reflects the first results of the co-operation between the Centre of Policy Studies, Monash University, Australia and the Danish Institute of Agricultural and Fisheries Economics (SJFI). The co-operation between the two institutions will continue the coming year and is expected to lead to further improvements of the data and the model, including the development of a realistic basecase forecast and the undertaking of a range of policy relevant applications with the model.

Dr. Philip Adams, Centre of Policy Studies, has during his stay at SJFI prepared this research report in co-operation with Lars-Bo Jacobsen and Søren E. Frandsen, both from the Agricultural Policy Division at SJFI. The development of a dynamic version of the AAGE model reflects the last 5 years work with static applied general equilibrium models at the SJFI and a wish to improve and extend the model even further allowing also for the analyses of dynamic adjustment processes in the Danish Economy. Such adjustment processes include for example short to medium run effects on employment and investments in the individual sectors of the Danish Economy – a major improvement relative to the present static version of the model.

Part 1,2 4 and 5 can be read independently of the more technical parts of the report (section 3 and the appendixes serving as a technical documentation of the model). Section 2 and 4, including a stylised representation of the model (4.2.2) and results from four simulations with the Dynamic-AAGE model (4.3), allow the reader to get a relative quick understanding of the major mechanisms, that underlie the model.

Danish Institute of Agricultural and Fisheries Economics, August 2000.

Agnete Gersing

1. Introduction

This is the first report on the development of Dynamic-AAGE, a dynamic version of the Agricultural Applied General Equilibrium (AAGE) model of the Danish economy.¹ Both models are maintained at the Danish Institute of Agricultural and Fisheries Economics. A second report is forthcoming in 2001. It will contain a set of case studies, in which the new model is used to analyse a range of *real-world* issues.

AAGE is a comparative static model. It shows for a single year the differences produced in the Danish economy by changes in taxes, tariffs and other exogenous variables. Dynamic-AAGE, on the other hand, produces sequences of annual solutions connected by dynamic relationships such as physical capital accumulation. Policy analysis with Dynamic-AAGE involves the comparison of two alternative sequences of solutions, one generated without the policy change, the other with the policy change in place. The first sequence, called the basecase projection, serves as a control path from which deviations are measured in assessing the effects of the policy shock.

Dynamic-AAGE was built by adding to the AAGE system many of the dynamic features of the MONASH model.² These were added as self-contained blocks, allowing Dynamic-AAGE to include AAGE as a special case. As such, Dynamic-AAGE retains all of the strengths of its predecessor, including a disaggregated multi-sectoral approach with a detailed representation of the agricultural sector, and an up-to-date parameter file. At the same time, Dynamic-AAGE represents a considerable advance over AAGE, especially with regard to dynamics, macroeconomics and closure options. These aspects are reviewed in Section 2.

¹ AAGE is a development of GESMEC, see Frandsen, S.E., J.V. Hansen and P. Trier (1994), "A General Equilibrium Model for Denmark with Two Applications", *Economic and Financial Modelling*, 1, pp. 105-138. The developments that transform GESMEC into AAGE are outlined in Jacobsen, L-B and S.E. Frandsen (1999), "Analyse af de Sektor-og Samfunds-Økonomiske Konsekvenser af en Reduktion i Forbruget af Pesticider i Dansk Landbrug", *Report number 104*, available from the Danish Institute of Agricultural and Fisheries Economics, Copenhagen.

Like AAGE, Dynamic-AAGE is solved by the Johansen/Euler technique implemented through GEMPACK. GEMPACK is documented in: Pearson, K.R. (1998), "Automating the Computation of Solutions of Large Economic Models", *Economic Modelling*, Vol. 7, pp. 385-395; and in Harrison W. Jill and K.R. Pearson (1996a) "Computing solutions for Large General Equilibrium Models Using GEMPACK", *Computational Economics*, Vol 9, pp. 83-127.

² MONASH is a dynamic applied general equilibrium model of the Australian economy being built at the Centre of Policy Studies, Monash University. MONASH is currently being documented. The most up-to-date reference is Peter B. Dixon and Maureen T. Rimmer (2000), "MONASH: A Disaggregated Dynamic Model of the Australian Economy", *mimeo*, available from the Centre of Policy Studies, Monash University, Clayton 3800, Australia.

The additions and enhancements to AAGE that transform it into Dynamic-AAGE are described in detail in Section 3. We explain the new equations as implemented in the model's computer code and discuss the data required for their implementation.

In writing Sections 2 and 3 we faced a dilemma. In most parts, it would have been quite easy to simply direct the reader to the relevant areas of the comprehensive MONASH documentation in Dixon and Rimmer (2000), adding comments about differences in implementation. However, this approach can lead to confusion in the reader's mind. It forces the reader to shuffle between two documents in an effort to understand two different sets of code written with different notation, different syntax and in a different ordering. Often this code is complicated and one miss reading of the documentation might lead to a substantial miss understanding of the underlying model. With this in mind, we have taken an inclusive approach to the writing of Sections 2 and 3, preparing them as if they were the only documentation available for the new code in Dynamic-AAGE. In doing so, we draw extensively on the MONASH documentation; often blending parts of it into our own account. Sometimes this is done with attribution, sometimes without.

In Section 4 we report four simulations of Dynamic-AAGE. The first two are comparative-static analyses conducted under short-run and long-run assumptions. The second two are dynamic analyses conducted with static and forward-looking expectations. The exogenous shock in each simulation is a ten per cent improvement in labour-saving technical progress in agriculture. The purpose of these simulations is three-fold:

- (a) to show how to set up the model for policy analysis in comparative-static and dynamic year-to-year modes;
- (b) to give the reader an understanding of the major mechanisms that underlie the model results; and
- (c) to compare the dynamic policy deviations with the comparative static outcomes.

The final section contains concluding remarks.

2. Dynamics, macroeconomics and model closure

In this section we give an overview of the main advances in Dynamic-AAGE relative to AAGE, namely dynamics, macroeconomics and the increased range of closure options.

2.1 Dynamics

There are three types of intertemporal links incorporated into Dynamic-AAGE: physical capital accumulation; financial asset accumulation; and lagged adjustment processes.

Physical capital accumulation

In Dynamic-AAGE we assume that investment undertaken in year t becomes operational at the start of year $t+1$. Under this assumption, capital in industry i accumulates according to:

$$K_{t+1}(i) = (1 - DEP(i)) \times K_t(i) + I_t(i) \quad (2.1)$$

where:

$K_t(i)$ is the quantity of capital available in industry i at the start of year t ;

$I_t(i)$ is the quantity of new capital created for industry i during year t ; and

$DEP(i)$ is the rate of depreciation in industry i , treated as a fixed parameter.

Given a starting point value for capital in $t=0$, $K_0(i)$, and with a mechanism for explaining investment through time, $I_t(i)$, equation (2.1) can be used to trace out the time paths of industry capital stocks.

Investment in industry i in year t is explained via a mechanism of the form

$$\frac{K_{t+1}(i)}{K_t(i)} - 1 = F_{it}[ERICAP_t(i)] \quad (2.2)$$

where

$ERICAP_t(i)$ is the expected rate of return on investment in industry i in year t ; and

F_{it} is an increasing function of $ERICAP_t(i)$ with a finite slope.

As in MONASH, we justify finite positive slopes for F_{it} by reference to investor caution and risk aversion. The values of the slopes vary with the values of the capital growth rates in a way that prevents the model from implying unrealistically large short-run investment responses to small changes in expected rate of return.

The expected rate of return in year t can be specified in a variety of ways. As in MONASH, we allow for two possibilities, static expectations and forward-looking model-consistent expectations. Under static expectations, we assume that investors only take account of current rentals and current unit assets prices when forming current expectations about rates of return. Under rational expectations we assume that:

$$ERICAP_t(i) = ARICAP_t(i) \quad (2.3),$$

where $ARICAP_t(i)$ is referred to as the *actual* rate of return on investment in year t . By *actual* we mean *model-consistent*. Investment in year t becomes productive in year $t+1$. Thus $ARICAP_t(i)$ is calculated as the present value in year t of investing in industry i , taking account of both the rental earnings and depreciated asset value of this investment in year $t+1$ as calculated in the model.

As noted in Dixon and Rimmer (2000), a practical advantage of static specifications is that they allow a recursive solution method. The solution for year 1 can be computed from assumptions for year 1 and data from year 0 and possibly earlier years. Then the solution for year 2 can be computed from assumptions for year 2 and data from year 1 and possibly earlier years, and so on.

With rational specifications the recursive approach breaks down. Investment in year 1 depends on rental rates and other variables in year 2. Consequently, the solution for year 1 cannot be computed before the solution for year 2. Similarly, the solution for year 2 cannot be computed before the solution for year 3, and so on.

In MONASH adopting an iterative algorithm solves the problem. We adopt the same approach with Dynamic-AAGE. The algorithm in Dynamic-AAGE works as follows.

In the first iteration, we compute solutions for the forecast years 1 to T under the assumption of static expectations. From the solutions for years 1 to T and the data for year 0, we compute the implied actual rates of return.

In the second iteration we relate the expected rate of return in year t for industry i to the actual rate of return deduced in iteration 1 according to the rule:

$$ERICAP_t^2(i) = ERICAP_t^1(i) + ADJ_RE(i) \times (ARICAP_t^1(i) - ERICAP_t^1(i)) \quad (2.4),$$

where $ADJ_RE(i)$ is a parameter with a value between 0 and 1. In (2.4) we use superscripts to identify the iteration number. Thus on the left hand side we have for industry i in year t the expected rate of return formed in the second iteration. On the right hand side we have expected and actual rates of return formed in the first iteration.

From the solutions for years 1 to T in the second iteration and the data for year 0, we recompute the implied actual rates of return. For the third and subsequent iterations, our caution increases and we adjust the expected rates of return according to

$$ERICAP_t^n(i) = ERICAP_t^{n-1}(i) + 0.5 * ADJ_RE(i) \times (ARICAP_t^{n-1}(i) - ERICAP_t^{n-1}(i)) \quad (2.5).$$

Convergence is achieved when

$$ERICAP_t^n(i) = ARICAP_t^n(i) \quad (2.6)$$

for all i and t .

Financial asset accumulation

Physical capital accumulation provides one intertemporal linkage. Another is provided by financial asset accumulation. Two types of financial assets are recognised in Dynamic-AAGE: net government debt and the economy's net holdings of foreign liabilities.

The value of these financial stocks accumulate through time according to equations of the form:

$$A_{t+1} = A_t + F_t \quad (2.7)$$

where:

A_t is the net value of the financial stock at the start of year t ; and

F_t is the appropriate flow variable in year t .

For government debt the relevant flow variable is the government's budget deficit. For the stock of foreign liabilities, the relevant flow variable is the deficit in the balance on current account in the Balance of Payments. In explaining movements in these flow variables, the model takes into account the "yields" from the respective stocks, namely, net interest payments on the stock of government debt and net interest and dividend payments on the stock of foreign liabilities. It is assumed that these payments accrue in year t on the basis of the average value of the financial stocks at the start and end of year t .

Lagged adjustment processes

MONASH contains a number of lagged adjustment processes. We include just one in Dynamic-AAGE. This relates to the operation of the labour market in year-to-year policy simulations.

In comparative static analysis, one of the following two assumptions is made about the operations of the labour market:

- real wages adjust instantaneously so that any policy shock has no effect on employment; or
- real wages are unaffected by the shock and employment adjusts.

MONASH's treatment of the labour market allows for a third, intermediate position, in which real wages can be sticky in the short run but flexible in the long-run and employment can be flexible in the short-run but sticky in the long-run. More specifically, for year-to-year policy simulations it is assumed that the deviation in the consumer's real wage increases through time in proportion to the deviation in employment from its basecase-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This labour market is consistent with macroeconomic modelling in which the NAIRU is exogenous.

2.2 Macroeconomics

Like most CGE models built in the Johansen/ORANI tradition, AAGE lacks a full macroeconomic closure. By this, we mean that there are insufficient equations to endogenise at the same time all of the major expenditure components of GDP (i.e., C, I, G, X and M). Accordingly, in any closure of AAGE, one or more of these macroeconomic variables must be made exogenous.

Dynamic-AAGE alleviates this problem by including equations that explain changes in:

- (a) the various components of household disposable income (HDI);
- (b) expenditure and income for the consolidated government sector; and
- (c) the components of the current-account balance in the Balance of Payments.

In calculating HDI, the model takes account of four broad components: primary factor income, unemployment benefit and other personal benefit payments from the government, net income accruing from overseas and direct taxes. In compiling the government accounts, the

model takes account of government final expenditure, transfer payments to households, net interest payments on government debt and direct and indirect tax revenue. In the balance of payments equations, the model defines the balance on current account as the sum of balances on the trade account and on the income account. In explaining changes in the income-balance, the model keeps track of changes in gross income flows (credit and debit) from dividends, interest and transfers.

With these macroeconomic equations in place, the user no longer needs to set one or more of C, I, G, X and M exogenously. For example, G can be endogenised by fixing the ratio of the government's budget balance as a per cent of GDP. At the same time C can be explained endogenously by fixing the average propensity to consume out of HDI. In the calculation of HDI, the model explicitly accounts for the net dividend and interest income generated in Denmark but accruing to foreigners. Thus when consumption is linked to HDI it is truly a valid indicator of welfare, regardless of the treatment of the balance of trade.

2.3 Closures of Dynamic-AAGE

Algebraically, models like MONASH and Dynamic-AAGE take the form

$$F(X) = 0 \tag{2.8},$$

where F is an m -vector of differentiable functions of n variables X , with $n > m$. In simulations with (2.8), given an initial solution for the n variables that satisfies (2.8), we compute the movements in m variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining $n - m$ variables (the exogenous variables). As noted in Dixon and Rimmer (2000), in year-to-year simulations the movements in the exogenous variables are from one year to the next. If the initial solution is for year t then our first computation creates a solution for year $t+1$. This solution can in turn become an initial solution for a computation that creates a solution for year $t+2$. In such a sequence of annual computations, links between one year and the next are recognised by ensuring, for example, that the quantities of opening capital stocks in the year t computation are the quantities of closing stocks in the year $t-1$ computation.

A choice of the $n-m$ variables to be made exogenous is called a closure. Dixon and Rimmer (2000) refer to four classes of closure for the MONASH model. For Dynamic-AAGE, we identify three classes:

- comparative-static closures;
- forecasting closures; and
- policy or deviation closures.³

Comparative static closures are used in single computation comparative static analyses. Forecasting and policy closures are used in year-to-year simulations.

Comparative-static closures

In a comparative-static closure, we include in the exogenous set all naturally exogenous variables in a CGE model. These may be observable variables such as tax rates or unobservable variables such as technology and preference variables. We also include in the exogenous set all variables that are naturally endogenous in a dynamic model, but which are naturally exogenous in a static model. These will typically include investment by industry and one of the capital stock or rate of return for each industry.⁴

Forecasting and policy closures

Forecasting and policy closures utilise the dynamic features of the model. Thus for both classes of closure we include in the endogenous set all variables that are naturally endogenous in a dynamic model, but naturally exogenous in a static model.

In forecasting with MONASH and Dynamic-AAGE we often want to take on board forecasts and information available from outside sources. Typical examples include macro forecasts made by specialist private or public-sector groups and information about future changes in tax and benefit rates announced by the government. To accommodate this information, numerous naturally endogenous variables are typically exogenised. These might include:

³ Comparative-static closures are also available for MONASH, but this class of closure is not explicitly discussed in Dixon and Rimmer (2000). The four classes of closure referred to in Dixon and Rimmer (2000) are: forecasting and policy closures; and historical and decomposition closures. The last pair is used in single-computation analyses of historical periods (see the next footnote).

⁴ A *decomposition* closure as defined for MONASH is similar to a comparative-static closure, in that it includes in the exogenous set all naturally exogenous variables. An *historical* closure includes in its exogenous set two types of variables: observables and assignable. Dixon and Rimmer (2000) define observables as variables for which movements can be readily observed from statistical sources for the historical period of interest. Assignable variables are naturally exogenous and are therefore exogenous in decomposition and historical closures. The key feature of an assignable variable in an historical simulation is that its movement can be assigned a value without contradicting anything that can be observed about the historical period or that is assumed about that period.

- the volumes of agricultural exports; and
- most macro variables.

To allow such naturally endogenous variables to be exogenous, an equal number of naturally exogenous variables must be made endogenous. For example, to accommodate forecasts for the volumes of agricultural exports we would make endogenous variables that locate the positions of foreign demand curves. To accommodate forecasts for macro variables, we would endogenise various macro coefficients such as the average propensity to consume.

In forecasting closures, tastes and technology are exogenous and normally set to historically average values. With MONASH, these historically average values are deduced in historical simulations. At this stage, we do not plan to conduct historical simulations with Dynamic-AAGE. Thus, in using Dynamic-AAGE for forecasting we may draw on values for taste and technology variables deduced in the MONASH work. Policy variables are also generally exogenous in forecasting closures. As indicated above, in forecasting values for these variables we can draw on information from extraneous sources such as government departments.

In policy closures naturally endogenous variables, such as the volumes of agricultural exports and macro variables are endogenous. They respond to the policy change under consideration. Correspondingly, in policy closures naturally exogenous variables, such as the positions of foreign demand curves and macro coefficients, are exogenous. They are set at the values revealed in the forecasts.

In a policy simulation, most, but not all, of the exogenous variables have the values they had in the associated forecast solution. The exceptions are the exogenous variables that are shocked. The policy simulation, therefore, generates deviations from the corresponding forecast simulation in response to the exogenously imposed change.

3. Detailed description of the new equations and data requirements

This section has two parts. In the first part we give a detailed explanation of the equations that transform AAGE into Dynamic-AAGE. This explanation is built around the Tablo representation of the model. In the second part we discuss the data requirements of the new equations. We identify the primary data that are required and describe the derivation from those primary data of values for the new coefficients in the model.

Notation

In the new code we follow, as far as possible, the existing naming conventions for variables and coefficients. However, the addition of several new conventions is unavoidable. To the existing set of first letters, we add:

- K to indicate capital stock;
- R to indicate a rate (e.g., r1cap means the percentage change in rate of return on capital);
- L to indicate level of rate or price (e.g., LR1CAP means the level of the rate of return on capital);
- Q to indicate quantity level; and
- M to indicate a two-dimension Matrix, with time as the second dimension (this is used only in the code that implements forward-looking expectations).

We use @1 at the end of a coefficient name to indicate a coefficient set via a formula (initial) statement to the value of a companion coefficient. The companion coefficient is updated through a multi-step computation. If the initial value of the companion coefficient is drawn from a database reflecting the economy in the year prior to the current solution year, then the @1 coefficient carries the lagged value of the companion coefficient through the multi-step computation for the current year. Finally, we use _L at the end of a variable or coefficient name to indicate the lagged value of that variable or coefficient.

We also adopt a formal naming convention for the new equations. In all of the new code, the names of equations are of the form $E_{\langle variable \rangle}$, where $\langle variable \rangle$ is the variable that is explained by the equation in the long-run comparative static closure of the model.

3.1 New equations

The additional Tablo code required to implement Dynamic-AAGE is shown in Appendix A. The code is organised into a series of independent sections. Wherever possible, each section

contains all of the variable and coefficient declarations, formulae, reads and updates required to implement the new equations in that section. The section headings are as follows:

- 3.1.1 Supply equals demand for capital and capital accumulation;
- 3.1.2 Actual rates of return under static expectations;
- 3.1.3 Expected rates of return under forward-looking expectations;
- 3.1.4 Relationship between capital growth and expected rates of return;
- 3.1.5 Real domestic absorption and ratios of components of GDP;
- 3.1.6 Balance of Payments and the accumulation of foreign liabilities;
- 3.1.7 Household income and consumption;
- 3.1.8 The government accounts and accumulation of government debt;
- 3.1.9 Equations to facilitate forecasting simulations: twist variables;
- 3.1.10 Equations to facilitate forecasting simulations: commodity-c using technological change;
- 3.1.11 Equations to facilitate forecasting simulations: uniform shifts;
- 3.1.12 Equations to facilitate dynamic policy analysis: the employment/wage trade-off; and
- 3.1.13 Equations to facilitate dynamic policy analysis: changes in consumer welfare.

3.1.1 Supply equals demand for capital and capital accumulation

Dynamic-AAGE can be run in two basic modes: comparative static and year-to-year dynamic. These modes require alternative treatments of capital formation. In comparative-static mode, there is no fixed relationship between capital and investment. The user decides the relationship on the basis of the requirements of the specific simulation. For example, it is often assumed that the percentage changes in capital and investment are equal, implying for industry i that $x1cap(i) = x2tot(i)$.

In year-to-year dynamics, we interpret a model solution as a vector of changes in the values of variables between two adjacent years. Thus there is a fixed relationship between capital and investment. As explained in Section 2.1, we assume that capital available for production in the solution year t is the stock of capital at the start of year t . This is determined by investment in year $t-1$ and by capital at the start of year $t-1$ after depreciation. Growth in capital between the start of t and the end of t is determined in the model via an expected rate of return mechanism (equation 2.2). This puts in place investment for year t . Capital at the end of t is the capital available for production in year $t+1$.

This section of the Tablo code contains equations that set supply equal to demand for capital, and that handle the accumulation of capital stocks at the start and end of the current solution year. Actual rates of return under static expectations are defined in the next section (Section 3.1.2). Subsequent sections deal with expected rates of return under forward-looking expectations and with the relationship between capital growth and expected rates of return.

E_k1start

In this equation we set the percentage changes in capital at the start of the solution year, $k1start(i)$, equal to the percentage changes in demand for capital, $x1cap(i)$. Though this equation might look innocuous it is in fact a crucial link between the new dynamic code and the existing static code. In the latter there is no supply-side specification for the capital market. Thus one of the rate of return or capital stock for each industry must be exogenous. With the dynamic code and the model operating in year-to-year mode, we have a fully specified supply-side for the capital market, capable of tracing through time movements in the capital stock available for production in each industry.

E_del_f_k1start

The appropriate value for $k1start(i)$ in a year-to-year computation is the growth rate of capital between the start of year t-1 and the start of the solution year t. Algebraically, using a notation that emphasises the timing of each variable, we want

$$k1start_t(i) = 100 \times \left(\frac{QK1START_t(i)}{QK1START_{t-1}(i)} - 1 \right) \quad (i \in \text{IND}) \quad (3.1),$$

where $QK1START_t(i)$ is the quantity of capital available for production in industry i at the start of the current solution year t. Equation (3.1) can be rewritten as

$$k1start_t(i) = 100 \times \left(\frac{Q2TOT_{t-1}(i) - LRIDEP(i) \times QK1START_{t-1}(i)}{QK1START_{t-1}(i)} \right) \quad (i \in \text{IND}) \quad (3.2),$$

where $Q2TOT_{t-1}(i)$ is the quantity of investment in industry i in year t-1 and $LRIDEP(i)$ is a fixed parameter representing the rate of capital depreciation for industry i.

In making the computation for year t, we could treat $k1start_t(i)$ as an exogenous variable and compute its value outside the model in accordance with equation (3.2). It is more conven-

ient, however, to compute values for $kIstart_t(i)$ inside the model. This is done using equation $E_del_f_kIstart$.

To understand the levels form of $E_del_f_kIstart$, we start by re-writing (3.2) as:

$$QK1START_t(i) - QK1START_{t-1}(i) = 100 \times (Q2TOT_{t-1}(i) - LR1DEP(i) \times QK1START_{t-1}(i)) \quad (i \in IND) \quad (3.3).$$

If the initial solution for year t is drawn from values for year t-1, then the initial value of $QK1START_t(i)$ is $QK1START_{t-1}(i)$. The Euler solution method requires that the initial (database) values for variables form a solution to the underlying levels form of the model. Equation (3.3) makes it clear that unless net investment in year t-1 is zero in industry i, then the initial data for a year-t computation will not be a solution to (3.3).

We solve this problem of initial-value by the purely technical device of augmenting equation (3.3) with an additional exogenous variable $UNITY$ as follows:

$$QK1START_t(i) - QK1START_{t-1}(i) = UNITY_t \times 100 \times (Q2TOT_{t-1}(i) - LR1DEP(i) \times QK1START_{t-1}(i)) \quad (i \in IND) \quad (3.4).$$

We choose the initial value of $UNITY$ to be 0, so that (3.4) is satisfied when $QK1START_t(i)$ takes its initial value regardless of the initial value of net investment in industry i. $UNITY$ is often referred to as a “fudge factor”, while others call it a “homotopy parameter”. By moving $UNITY$ to one, we cause the correct deviation in the opening capital stock for year t from its value in the initial solution (i.e., from its value in year t-1).

Equation $E_del_f_kIstart$ is the change form of (3.4), after changes in notation. On the right hand side of the Tablo equation, the coefficients $Q2TOT @ 1(i)$ and $QK1START @ 1(i)$ are the levels of $Q2TOT(i)$ and $QK1START(i)$ in the initial solution for year t. Provided that the initial solution is drawn from values for year t-1, then $Q2TOT @ 1(i)$ corresponds to $Q2TOT_{t-1}(i)$ in (3.4) and $QK1START @ 1(i)$ corresponds to $QK1START_{t-1}(i)$. The variable del_unity is the ordinary change in $UNITY$. In year-to-year simulations, del_unity is always set to 1. The variable $del_f_kIstart(i)$ is an on/off shift variable. In year-to-year simulations this will be exogenous, causing $kIstart(i)$ to be set according to (3.4). In comparative static simulations, $del_f_kIstart(i)$ will be endogenous, effectively turning off $E_del_f_kIstart$ for industry i. In making $del_f_kIstart(i)$ endogenous we will make one of the rate of return or capital stock in industry i exogenous.

E_klend

Equation *E_klend* explains the percentage change in the capital stock of industry *i* at the end of the solution year. The levels form of this equation (with time made explicit) is

$$QK1END_t(i) = Q2TOT_t(i) + (1 - LR1DEP(i)) \times QK1START_t(i) \quad (i \in \text{IND}) \quad (3.5),$$

where $QK1END_t(i)$ is the stock of capital in industry *i* at the end of year *t* (or the start of year *t*+1). Note that equation (3.5) is satisfied by the initial solution for year *t*, and so there is no need to introduce the homotopy variable.

Taking ordinary changes of the left hand side and the right hand side of (3.5) gives, after dropping the time index, *E_klend*.

E_del_klgrow

In year-to-year simulations, growth in capital between the start and end of year *t* is determined by the expected rate of return on capital (see equation (2.2)). This relationship is modelled in a later part of this code. In this section we define the level of the growth rate in capital for industry *i*,

$$QK1END_t(i) = Q2TOT_t(i) + (1 - LR1DEP(i)) \times QK1START_t(i) \quad (i \in \text{IND}),$$

and in equation *E_del_klgrow* explain the change in that growth rate in terms of the percentage-change variables *kIstart(i)* and *kIend(i)*.

3.1.2 Actual rates of return on capital under static expectations

There is only one equation in this section, *E_p0cap*. This explains the ordinary change in the actual rate of return on capital in industry *i* under static expectations. To explain this equation we start with an expression for the present value (PV) of purchasing in the current solution year a unit of physical capital for use in industry *i*. In compact notation this is given as:

$$PV_t(i) = -\Pi_t(i) + \frac{R_{t+1}(i) + (1 - DEP(i)) \times \Pi_{t+1}(i)}{(1 + INF_t)} \quad (i \in \text{IND}) \quad (3.6),$$

where:

$\Pi_t(i)$ is the cost of buying or constructing a unit of industry i 's capital in year t ;
 $R_{t+1}(i)$ is the rental on industry i 's capital in year $t+1$;
 $DEP(i)$ is the rate of depreciation in industry i (a number like 0.05); and
 INF_t is the general rate of consumer-price inflation in year t .

It is assumed that units of capital in year t yield to their owner two benefits in year $t+1$: a rental; and a depreciated re-sale value. These benefits are converted to a present value in year t by discounting using the current inflation rate.

The present-value sum of benefits as defined in equation (3.6) is converted to a rate of return by dividing through by the cost of buying capital in year t . Thus we define

$$AR1CAP_t(i) = -1 + \frac{R_{t+1}(i) + (1 - DEP(i)) \times \Pi_{t+1}(i)}{\Pi_t(i) \times (1 + INF_t)} \quad (i \in \text{IND}) \quad (3.7),$$

to be the actual (i.e., model-consistent) rate of return in year t for units of capital invested in industry i .

Under static expectations, it is assumed that investors in year t expect that rental rates and asset prices will increase by the current rate of inflation (INF_t). Accordingly,

$$AR1CAP_SE_t(i) = \frac{R_t(i) - DEP(i) \times \Pi_t(i)}{\Pi_t(i)} = \frac{R_t(i)}{\Pi_t(i)} - DEP(i) \quad (i \in \text{IND}) \quad (3.8),$$

where $AR1CAP_SE_t(i)$ is the actual rate of return on investment in year t in industry i under static expectations.

Equation E_p0cap is the ordinary change form of (3.8) after appropriate changes in notation. The conditional "IF" ensures that we do not attempt to divide by zero.

3.1.3 Expected rates of return on capital under forward-looking expectations

Under forward-looking expectations (see Section 2.1 and equation (2.3)), we want the expected rate of return on investment in industry i in the computation for year t to equal the actual rate of return for industry i in year t . As noted earlier, the difficulty here is that the actual rate of return in year t depends on future rentals and future asset prices. In the sequential approach to computing solutions, the values of variables in year $t+1$ cannot normally be

known in the computation for year t . Thus we are forced to adopt an algorithmic approach when dealing with forward-looking expectations. The algorithm used in Dynamic-AAGE is similar to the algorithm used in MONASH, although it differs somewhat in its implementation.

Crucial to the forward-looking algorithm in Dynamic-AAGE are two data matrices, $MLARICAP(i,t)$ and $MLERICAP(i,t)$.⁵ Each has the dimension IND by TIME. TIME is a set that contains the time descriptors T0, T1, T2, At the end of an iteration⁶, $MLARICAP(i,t)$ contains values for $LARICAP(i)$ by industry and year deduced in that iteration. Similarly, at the end of an iteration, $MLERICAP(i,t)$ contains values for $LERICAP(i)$ by industry and year deduced in that iteration. The column of $MLARICAP(i,t)$ corresponding to the year of the current computation $t=YEAR$ ($YEAR$ is a coefficient, defined so that its value in a computation for year k equals k) is the IND-length coefficient $MLARI_T(i)$. The column of $MLERICAP(i,t)$ corresponding to $t=YEAR$ is the IND-length coefficient $MLERI_T(i)$.

Before the start of the first iteration, all elements of $MLARICAP(i,t)$ and $MLERICAP(i,t)$ are set to zero. In the first iteration ($n=1$), we compute solutions for $t=1$ to $t=NYEARS$ ($NYEARS$ is a coefficient showing the number of years in the simulation) under the assumption of static expectations. In other words, in iteration 1 the levels of the expected rate of return on capital in the solution year $t=YEAR$,

$$LERICAP^1(i) = LARICAP_SE^1(i) \quad (i \in \text{IND}) \quad (3.9).$$

In the first iteration, the initial values for $MLARICAP(i,t)$ are replaced, progressively year-by-year (i.e. from $t=0$ to $t=NYEARS-1$) using data for $LARICAP(i)$ lagged one year. For example, in the simulation for year $t=YEAR$, we compute values for $LARICAP(i)$ in $YEAR-1$. These are then inserted into the column of $MLARICAP(i,t)$ corresponding to $t=YEAR-1$. In the simulation for the final year ($t=NYEARS$), we do not generate information on future values of variables. We assume that the changes between $t=NYEARS-2$ and $t=NYEARS-1$ equal the changes between $t=NYEARS-1$ and $t=NYEARS$. In this first iteration, the initial va-

⁵ $MLERICAP$ and $MLARICAP$ are stored on the header array file, with logical name ACTROR (see also the next footnote).

⁶ An iteration is a series of year-to-year computations over the length of the forecast period. The first computation-year corresponds to T1. In that computation we draw on initial data reflecting the year T0. Unlike data stored on other header array files referred to in the code, the data in logical-file ACTROR do not revert to their initial ($t=0$, iteration=1) values at the end of an iteration. Instead, data in ACTROR after the final computation in iteration n are used as initial data at the start of the first computation in iteration $n+1$.

values for $MLERICAP(i,t)$ are replaced progressively using current (not lagged) values for $LARICAP_SE(i)$.

In the second iteration ($n=2$), we assume that the expected rates of return in years 0 to $NYEARS$ adjust towards the actual rates of return calculated from the first iteration according to:

$$LERICAP^2(i) = LERICAP^1(i) + ADJUST_EXP(i) \times (LARICAP^1(i) - LERICAP^1(i)) \quad (i \in IND) \quad (3.10),$$

where $ADJUST_EXP(i)$ is a positive parameter with a value between 0 and 1. If $ADJUST_EXP(i)$ is set at 1, then (3.10) implies that the expected rates of return in iteration n are the actual rates of return in iteration $n-1$. For MONASH, it has been found that convergence is more reliable when $ADJUST_EXP(i)$ is set at 0.5. At this setting, the likelihood of cycling (where low assumed values for expected rates of return cause capital scarcity and high actual rates of return, which then cause high expected rates of return in the next iteration resulting in capital abundance and low actual rates of return) is significantly reduced.

From the resulting solutions for years 1 to $NYEARS$, and from the initial data for $t=0$, the actual rates of return are re-evaluated. These progressively replace the initial values in $MLARICAP(i,t)$ (i.e. the values deduced in the first iteration). As in the first iteration, in the second iteration we assume that the changes between $t=NYEARS-2$ and $t=NYEARS-1$ equal the changes between $t=NYEARS-1$ and $t=NYEARS$. The initial values for $MLERICAP(i,t)$ are replaced progressively by values for $LERICAP_IT(i)$, a Tablo coefficient equivalent to $LERICAP^n(i)$ in iteration n .

In the third and subsequent iterations ($n>2$), we become more cautious than is indicated in (3.10), by setting

$$LERICAP^n(i) = LERICAP^{n-1}(i) + 0.5 \times ADJUST_EXP(i) \times (LARICAP^{n-1}(i) - LERICAP^{n-1}(i)) \quad (i \in IND) \quad (3.11).$$

From the resulting solutions for years 1 to $NYEARS$, we re-evaluate the implied actual rates of return. These progressively replace the initial values in $MLARICAP(i,t)$. The initial values for $MLERICAP(i,t)$ are replaced progressively by the expected rates of return calculated as in (3.11).

Iterations continue until convergence is observed, i.e. until

$$MLERICAP(i,t) = MLERICAP(i,t) \quad (3.12).$$

The discussion so far is intended to give the reader a general understanding of the iterative solution process for Dynamic-AAGE when expectations are forward-looking. We return now to the *Tablo* code.

E_del_er1cap

When expectation are static, or in the first iteration of a forward-looking simulation, the coefficient, *FORWARD* in equation *E_del_er1cap* is fixed on zero. Thus,

$$del_er1cap(i) = del_ar1cap_se(i) \quad (i \in IND),$$

i.e., the movements in expected rates of return in the year *t* computation of iteration 1 away from their initial levels (their levels in year *t-1*) equal the movements in the static expectations of rates of return away from their initial levels.

In iteration *n*, *n*>1, *FORWARD* is fixed on one. With *del_unity* being an exogenous variable having a value of one, *E_del_er1cap* sets

$$del_er1cap(i) = LER1_IT@1(i) - LER1_IT_L@1(i) \quad (i \in IND).$$

Thus the movements in expected rates of return away from their initial levels in iteration *n* equal the movements in *LER1_IT@1(i)* away from *LER1_IT_L@1(i)*. Values for *LER1_IT@1(i)* are set via a formula (initial) involving a number of conditional “if” statements.

If *ITER_NUM@1* = 1 (i.e., if iteration 1), then *LER1_IT@1(i)* = 0.

If *ITER_NUM@1* = 2 (i.e., if iteration 2), then *LER1_IT@1(i)* is set according to equation (3.10).

If *ITER_NUM@1* = *n*>2 (i.e., if iteration greater than 2), then *LER1_IT@1(i)* is set according to equation (3.11).

The values for *LER1_IT_L@1(i)* are set via a similar formula (initial). They equal the values for *LER1_IT@1(i)* lagged one year.

In the formula for *FORWARD*, the coefficient *ITER_NUM@1* equals the number of the current iteration. Thus, in a year-*t* computation in iteration *n*, *ITER_NUM@1* = *n*.

$ITER_NUM@1$ is set equal to $ITER_NUMBER$ via a formula (initial). $ITER_NUMBER$ is read from the data file $ACTROR$, and is updated by the update (change) statement

$$ITER_NUMBER = ITER_ADJUST \times del_unity \quad (3.13),$$

where the coefficient $ITER_ADJUST$ is equal to zero through the current iteration up to the final year. In the simulation for the final year, $ITER_ADJUST$ is set to one. This forces $ITER_NUMBER$ to remain unchanged through the iteration until the computation for the final year. At the end of the final-year computation, $ITER_NUMBER$ increases by 1 from its value before that computation. The new value for $ITER_NUMBER$ carries over into the next iteration.

$E_del_ar1cap_l$

The computation for year t includes the computation of actual rates of return for year $t-1$. If the initial solution for year t is drawn from values for year $t-1$, then in $E_del_ar1cap_l$ we define the movements in actual rates of return between years $t-2$ and $t-1$, i.e., we define the movements in lagged actual rates of return.

The levels from of $E_del_ar1cap_l$ can be written in the compact notation of equation (3.6) as:

$$AR1CAP_{t-1}(i) = -1 + \frac{R_t(i) + (1 - DEP(i)) \times \Pi_t(i)}{\Pi_{t-1}(i) \times INF_FACTOR_{t-1}} \quad (i \in IND) \quad (3.14),$$

where INF_FACTOR_{t-1} is one plus the rate of consumer price inflation lagged one year. Taking ordinary changes of the left hand side and right hand side of (3.14) gives after manipulation

$$\begin{aligned} del_AR1CAP_{t-1}(i) = & \\ & \frac{R_t(i) \times r_t(i) + \Pi_t(i) \times (1 - DEP(i)) \times \pi_t(i) - (R_t(i) + (1 - DEP(i)) \times \Pi_t(i)) \times (\pi_{t-1}(i) + inf_factor_{t-1})}{100 \times \Pi_{t-1}(i) \times INF_FACTOR_{t-1}} \end{aligned} \quad (i \in IND) \quad (3.15),$$

where lower-case letters are used to indicate percentage changes. To move from (3.15) to $E_dr_ar1cap_l$, we: multiply both sides of (3.15) by the denominator on the right hand side; replace the lagged time subscripts with the lag indicator ($_L$ or $_1$); and adopt the TABLO notation for coefficients and variables.

The variables del_ar1cap_l appear in no equations apart from $E_del_ar1cap_l$, and play no role in the determination of values for other variables in the solution for year t in the current iteration (n). Their role is in the updating of $MLARICAP(i,t)$ through the current iteration for use in the next iteration ($n+1$).

As with most of the code in this area, the update command for $MLARICAP(i,t)$ is rather complex. In the computation for $t = YEAR$, the coefficient $DUM_TIME_L(t)$ equals 1 if $t=YEAR-1$, or 0 otherwise.⁷ The coefficient $DUM_TIME(t)$ equals 1 if $t=YEAR$, or 0 otherwise. If $YEAR@1 < NYEARS$, i.e., if the current computation is for a year prior to the last year of the iteration, then for $t=YEAR-1$, the command replaces the initial elements of $MLARICAP(i,t)$ (deduced in the previous iteration) with new values contained in $LARICAP_L(i)$. If $YEAR@1 = NYEARS$, i.e., if the current computation is for the final year in the iteration, then for $t=NYEAR-1$ the command replaces the initial elements of $MLARICAP(i,t)$ with values for $LARICAP_L(i)$ and for $t=NYEAR$ it replaces the initial elements with values which imply that the changes between $NYEAR-1$ and $NYEAR$ are the same as the changes between $NYEAR-2$ and $NYEAR-1$.

Below the update statement for $MLARICAP(i,t)$ is the update statement for $MLERICAP(i,t)$. It is similar to that for $MLARICAP(i,t)$ except that it has two parts - one operates when $FORWARD = 0$, the other when $FORWARD = 1$. The two parts operate as follows.

If $FORWARD = 0$, then

- if $YEAR@1 < NYEARS$, i.e., if the current computation is for a year prior to the last year of the iteration, then for $t = YEAR-1$, replace the initial elements of $MLERICAP(i,t)$ with new values contained in $LARICAP_SE@1(i)$.
- if $YEAR@1 = NYEARS$, i.e., if the current computation is for the final year in the iteration, then for $t = YEAR-1$ replace the initial elements of $MLERICAP(i,t)$ with new values contained in $LARICAP_SE@1(i)$, and replace the initial elements for $t = YEAR$ with values in $LARICAP_SE(i)$.

If $FORWARD = 1$, then

- if $YEAR@1 < NYEARS$, i.e., if the current computation is for a year prior to the last year of the iteration, then for $t = YEAR-1$, replace the initial elements of $MLERICAP(i,t)$ with new values contained in $LERICAP_IT_L(i)$.

⁷ As indicated above, the coefficient $YEAR$ indicates the solution year of the current computation. $Year=1$ in the first year. $Year=NYEARS$ in the final year.

- if $YEAR@1 = NYEARS$, i.e., if the current computation is for the final year in the iteration, then for $t = YEAR-1$ replace the initial elements of $MLERICAP(i,t)$ with new values contained in $LERICAP_IT_L(i)$ and replace the initial elements for $t = YEAR$ with values in $LERICAP_IT(i)$.

E_p2tot_l

The right hand side of $E_d_ar1cap_l$ introduces two lagged variables. The first of these is $p2tot_l(i)$, the percentage deviation in the lagged asset price of capital in industry i in year t from its value in the initial solution for year t . In the usual case in which the initial solution for year t is drawn from values for year $t-1$, $p2tot_l(i)$ is the percentage change in i 's asset price of capital between year's $t-2$ and $t-1$. In this case, E_p2tot_l correctly generates $p2tot_l$ provided that del_unity is set exogenously at one and f_p2tot_l is set exogenously at zero.

$E_inf_factor_l$

The second lagged variable introduced on the right hand side of $E_d_ar1cap_l$ is inf_factor_l , the deviation in one plus the lagged rate of inflation in year t from its value in the initial solution for year t . In levels

$$INF_FACTOR_L = CPI_L / CPI_2L \quad (3.16)$$

where

- CPI_L is the general level of consumer prices lagged one year; and
- CPI_2L is the general level of consumer prices lagged two years.

$E_inf_factor_l$ is the percentage change form of (3.16). Notice that the right hand side of $E_inf_factor_l$ introduces two further lagged variables, CPI_L and CPI_2L .

E_cpi_l

This equation defines the percentage movement in the lagged CPI from its value in the initial solution for year t to its value in the final solution for year t . The coefficients, $LCPI@1$ and $LCPI_L@1$ appearing in the equation are the levels of the CPI and lagged CPI in the initial solution for year t . Provided that the initial solution is drawn from values for year $t-1$, then $LCPI@1$ is the CPI in year $t-1$ and $LCPI_L@1$ is the CPI in year $t-2$. In this case, cpi_l is correctly generated in E_cpi_l with del_unity set exogenously on one and f_cpi_l set exogenously on zero.

E_cpi_2l

This equation defines the percentage movement in the twice-lagged CPI ($xi3_2l$) from its value in the initial solution for year t to its value in the final solution for year t . The coefficients, $LCPI_L@1$ and $LCPI_2L@1$ appearing in the equation are the levels of the lagged and twice-lagged CPI in the initial solution for year t . Provided that the initial solution is drawn from values for year $t-1$, then $LCPI_L@1$ is the CPI in year $t-2$ and $LCPI_2L@1$ is the CPI in year $t-3$. In this case, cpi_2l is correctly generated in E_cpi_2l with del_unity set to one and f_cpi_l set to zero.

3.1.4 Relationship between capital growth and expected rates of return

In this section we put in place the MONASH theory of investment for year-to-year simulations. This amounts to a specification of capital supply functions that determine industries' capital growth rates between the start and end of the solution year. These functions imply that investors are willing to supply increased funds to industry i in response to increases in i 's expected rate of return. However, investors are cautious. In any year, the capital supply functions limit the growth in industry i 's capital stock so that disturbances in i 's rate of return are eliminated only gradually.

$E_del_eer1cap$

We start off with the idea that the expected rate of return on capital in industry i from the viewpoint of the investor has two components, an equilibrium component and a disequilibrium component. Accordingly,

$$LER1CAP(i) = LEER1CAP(i) + LEDR1CAP(i) \quad (i \in IND) \quad (3.17)$$

where:

$LEER1CAP(i)$ is the expected equilibrium rate of return; and

$LEDR1CAP(i)$ is a measure of the disequilibrium in the current expected rate of return.

$LEER1CAP(i)$ can be interpreted as the expected rate of return required by investors to sustain indefinitely the current rate of capital growth in industry i . It is specified in the equation that follows as a function of $LKIGROW$. The expected disequilibrium rate of return arises because the expected rates of return and capital growth rates in the year 0 database do not necessarily satisfy the inverse logistic function. Consequently, in the data for year 0, $LEDR1CAP(i)$ will normally be non-zero.

Equation $E_{del_eer1cap}$ is the ordinary change form of (3.17).

$E_{del_f_eer1cap}$

The theory of investment adopted here relates the expected equilibrium rate of return for industry i to the current rate of growth of capital in industry i . As shown in Figure 3.1, the relationship between the expected equilibrium rate of return for industry i and i 's current rate of capital growth has an inverse logistic form. Algebraically,

$$LEERICAP(i) = LRICAP_NORM(i) + F_EERICAP_I + F_EERICAP(i) + \frac{1}{CAP_SLOPE(i)} \times \{ [Log(LK1GROW(i) - LK1GROW_MIN(i)) - Log(LK1GROW_MAX(i) - LK1GROW(i))] - [Log(LK1GROW_NORM(i) - LK1GROW_MIN(i)) - Log(LK1GROW_MAX(i) - LK1GROW_NORM(i))] \} \quad (i \in IND) \quad (3.18),$$

where:

$LRICAP_NORM(i)$ is a coefficient representing the industry's historically normal rate of return;

$F_EERICAP_I$ and $F_EERICAP(i)$ allow for vertical shifts in the capital supply curves (the first variable allows for nation-wide shifts and the second variable for industry-specific shifts);

CAP_SLOPE is a coefficient that is related to the inverse of the slope of the capital supply curve in the region of $LK1GROW_NORM$ (for further details see Dixon and Rimmer, 2000);

$LK1GROW_MIN$ is a coefficient, which sets the minimum possible rate of growth of capital;

$LK1GROW_MAX$ is a coefficient, which sets the maximum possible rate of growth of capital; and

$LK1GROW_NORM$ is a coefficient, reflecting the industry's historical normal rate of capital growth.

Equation (3.18) is explained in Dixon and Rimmer (2000) as follows. Suppose that $F_EERICAP_I$, $F_EERICAP(i)$ and $LEERICAP(i)$ are initially zero. Then according to (3.17) and (3.18), for industry i to attract sufficient investment in year t to achieve a capital growth rate of $LK1GROW_NORM(i)$ it must have an expected rate of return equal to its long-term average, $LRICAP_NORM(i)$. For industry i to attract sufficient investment in year i for its capital growth to exceed its long-term average ($LK1GROW_NORM$), its expected

rate of return must be greater than $LRICAP_NORM$. Conversely, if the expected rate of return on the industry's capital falls below $LRICAP_NORM$, then investors will restrict their supply of capital to the industry to a level below that required to sustain capital growth at the rate of $LRICAP_NORM$.

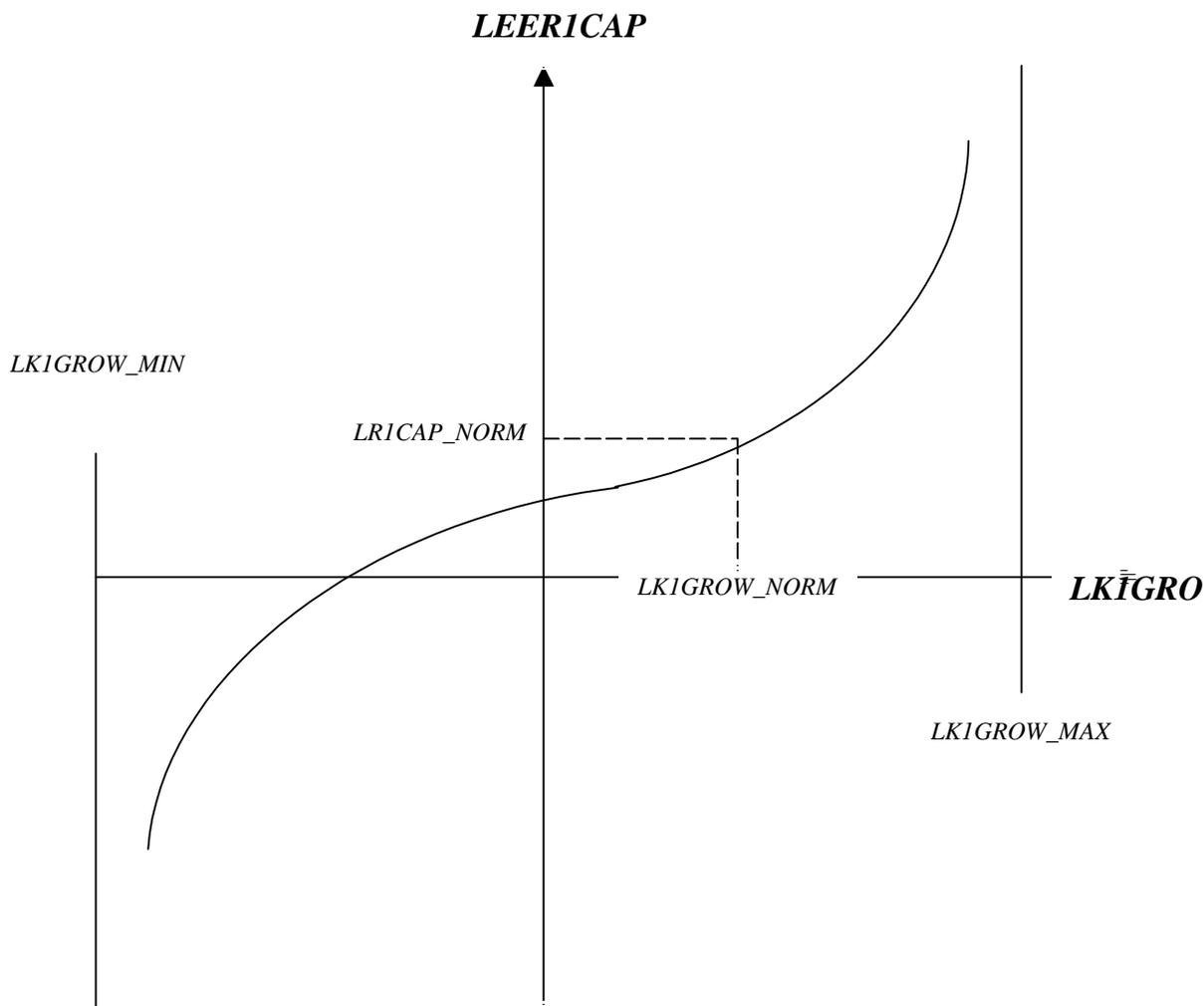


Figure 3.1: Relationship between Equilibrium Expected Rate of Return and Annual Rate of Capital Growth

Equation $E_del_f_eer1cap$ is the change version of (3.18) .

$E_del_edr1cap$

The initial disequilibrium in the expected rate of return for industry i , $LEDRICAP(i)$, is gradually eliminated over time according to the rule:

$$LDER1CAP(i) - LDER1CAP @ 1(i) = - ADJ_COEFF(i) \times LDER1CAP @ 1(i) \times UNITY \quad (i \in IND) \quad (3.19),$$

where $ADJ_COEFF(i)$ is a positive parameter determining the speed at which $LDER1CAP(i)$ moves towards zero.

Equation $E_del_edr1cap$ is the change form of (3.19).

3.1.5 Real domestic absorption and ratios of components of GDP

The first equation in this section, E_x0da , defines the percentage change in real final domestic absorption. Final domestic absorption is GDP less the balance on trade account (X-M). The remaining equations define percentage changes in various useful ratios that can play either active (exogenous) or passive (endogenous) roles. For example, we might set r_x3_x5 exogenously at zero, thereby forcing real public consumption to move by the same percentage as real private consumption. Alternatively, consumption might be determined elsewhere in our model, with r_w3_w0gdp merely telling us the implication for the ratio of consumption to factor income.

3.1.6 Balance of Payments and the accumulation of foreign liabilities

In this section we define various components of the balance of payments accounts and put in place equations for the accumulation of foreign liabilities. The balance of payments has two basic accounts, the current account and the capital account. In our modelling we assume that the balance on current account exactly offsets the balance on capital account.

The balance on current account equals the balance on trade account plus the balance on income account. The trade-account balance is defined in the static core of the model as the value (fob) of exports of goods and services (a credit item) less the value (cif) of imports of goods and services (a debit item). The balance on income account equals the value of income received from foreigners (credit) less the value of income paid to foreigners (debit). Income (credit) is the sum of: interest, dividends and transfers received. Income (debit) is the sum of interest, dividends and transfers paid.

The balance on current account in year t, or equivalently minus the balance on capital account in year t, can be interpreted as the net addition to the stock of foreign assets in year t.

Typically, Denmark's stock of net foreign assets is negative, meaning that the stock of liabilities exceeds the stock of assets. In Dynamic-AAGE we recognise this and model movements in the net stock of foreign liabilities. The net stock of foreign liabilities comprises the net stock of foreign debt (which yield interest payments) plus the net stock of foreign equity (which yield dividend payments).

$E_{del_cab}, E_{del_tab}, E_{del_iab}$

Equation E_{del_cab} defines the change in the balance on current account as the sum of changes in the balance on trade account (del_tab) and in the balance on income account (del_iab). Equation E_{del_tab} defines the change in the balance on trade account as the difference between the change in value (fob) of exports of goods and services and the change in value (cif) of imports of goods and services. These are concepts already defined in the model. Equation E_{del_iab} defines the change in the balance on income account as the change in income (credit) (del_IAB_CR) less the change in income (debit) (del_IAB_DR).

E_{iab_cr}, E_{iab_dr}

The two sides of the income account are defined in equations E_{iab_cr} and E_{iab_dr} . On both sides we account separately for interest payments, dividend payments and transfer (other) payments. The percentage changes in transfer payments are normally treated as exogenous variables.

$E_{iab_cr_int}, E_{iab_dr_int}$

These two equations explain the percentage changes in interest income received from foreigners (iab_cr_int) and interest income paid to foreigners (iab_dr_int). The underlying theory for both equations is

$$INTEREST = ROI \times \frac{(DEBT_{start} + DEBT_{end})}{2} \quad (3.20),$$

that is, we relate interest receipts (payments) to an exogenously given rate of interest (ROI) and to the average value of debt.⁸ The average stock is computed as the value of the stock at the start of the year ($DEBT_{start}$) plus the value of the stock at the end of the year ($DEBT_{end}$) divided by 2. Implicit in (3.20) is the assumption that interest is repayable in

⁸ Interest rates in models like MONASH and Dynamic-AAGE are normally treated as exogenous variables. More elaborate treatments would require integration with a financial model.

domestic currency. Thus we do not capture any valuation effects on stocks of debt arising from exchange-rate changes.

In Dynamic-AAGE we do not keep separate track of stocks of Danish holdings of foreign debt and foreign holdings of Danish debt. Neither do we keep separate track of Danish holdings of foreign equity and foreign holdings of Danish equity. The only stock that we explicitly account for is the net stock of foreign liabilities (*VFL*):

$$VFL = -(DEBT_CR - DEBT_DR + EQUITY_CR - EQUITY_DR) \quad (3.21),$$

where:

DEBT_CR and *DEBT_DR* are the stocks of foreign debt held by Danes and of Danish debt held by foreigners; and

EQUITY_CR and *EQUITY_DR* are the stocks of foreign equity held by Danes and of Danish equity held by foreigners.

To implement (3.20) we assume that the ratios of *DEBT_CR*, *DEBT_DR*, *EQUITY_CR* and *EQUITY_DR* to *VFL* are fixed. The levels of these ratios are denoted *LR_CR_INT*, *LR_DR_INT*, *LR_CR_DIV* and *LR_DR_DIV*.

To obtain *E_iab_cr* and *E_iab_dr*: substitute the relevant (ratio×*VFL*) terms into (3.20); convert the levels equations into their percentage-change equivalents; and adopt the TABLO notation for coefficients and variables.

E_iab_cr_div, *E_del_arIcap_ave*, *E_iab_dr_div*

In *E_iab_cr_div* the percentage movement in dividend receipts on foreign equity (*iab_cr_div*) is the percentage movement in the average rate of dividend (*rod*) plus the percentage movement in the average of the start- and end-values of Danish foreign equity holdings. The percentage change in the average value of Danish foreign equity holdings equals

$$100 \times \frac{del_r_cr_div}{(tiny + LR_CR_DIV)} + flave, \quad (3.22)$$

where *tiny* is a very small number, required to avoid numerical problems when *LR_CR_DIV* = 0. The percentage change in the average dividend rate is normally set exogenously.

$E_del_ar1cap_ave$ defines the economy-wide average movement in the rental rate of capital in Denmark. This is used in equation $E_iab_dr_div$ to measure the average movement in the rental rate of capital owned by foreigners.

$E_del_f_flstart$

We assume that the net stock for foreign liabilities at the start of the solution year t is equal to minus the current account balance in year $t-1$ plus the value of the stock of foreign liabilities at the start of year $t-1$, i.e.,

$$VFLstart_t = -VACB_{t-1} + VFLstart_{t-1} \quad (3.23).$$

In a simulation for year t , we want $VFLstart_t$ to change from its initial level (the value of the stock of foreign liabilities at the start of year $t-1$) to the value of the stock at the start of year t . As indicated in $E_del_f_flstart$, with the homotopy variable del_unity set to 1 and with the on/off shift variable $del_f_flstart$ equal to 0, this change equals minus the initial balance on the current account in year t (i.e., minus the balance on the current account in year $t-1$).

The on/off shift variable, $del_f_flstart$, is used to turn off the equation in one-year comparative-static simulations. In year-to-year simulations, making $del_f_flstart$ exogenous and $del_flstart$ endogenous activates the equation.

$E_del_f_flend$

The net stock of foreign liabilities at the end of the solution year t , $VFLend$, equals minus the current account balance in year t plus the value of the stock of foreign liabilities at the start of year t . The change in $VFLend_t$ from its initial level in year t is given in equation $E_del_f_flend$. The on/off shift variable, del_f_flend works in the same way as $del_f_flstart$ in $E_del_f_flstart$, enabling del_f_flend to be exogenous in comparative-static simulations, but endogenous in year-to-year simulations.

E_flave

$VFLave$ is the average of the start and end values of the net stock of foreign liabilities in year t . Equation E_flave explains the percentage change in $VFLave$ away from its initial level (the average of the start and end values stocks in year $t-1$) in terms of $del_flstart$ and del_flend .

$E_{del_r_dr_div}$

The final equation in this section recognises the relationship between the asset and liability shares of the net stock of foreign liabilities, implied in equation (3.22), namely that:

$$-(LR_INT_CR + LR_DIV_CR) + (LR_INT_DR + LR_DIV_DR) = 1. \quad (3.24).$$

Equation $E_{del_r_dr_div}$ is the change form of (3.24) with $del_r_dr_div$ chosen to be the left hand side variable.

3.1.7 Household income and consumption

In this section we put in place a Keynesian consumption function that relates private consumption to household disposable income (HDI). HDI is household income (HI) less income tax paid by households. We define HI as the sum of:

- payments to labour, land and capital (GDP at factor cost);
- government transfer payments to households, consisting of
 - unemployment benefits and
 - other benefits (age benefits, health benefits and other personal benefits);
- net income from foreigners; and
- implicit quota rents in agriculture and fisheries.

In modelling changes in unemployment benefits we take account of changes in the number of people unemployed, which reflect changes in the number of people employed and changes in the number of people in the labour force.

$E_{lab_uem}, E_{hi_gov_un}$

The first equation explains the percentage change in number of people unemployed as a function of the percentage changes in labour supply (typically an exogenous variable) and in the number of people employed (an existing variable in the model). The second equation explains the percentage change in unemployment benefit collections as the sum of the percentage change in the average unemployment benefit rate (typically an exogenous variable) and of the percentage change in number of people unemployed.

$E_{hi_gov_ot}, E_{hi_gov}$

In the absence of any theory to explain changes in other benefits, in equation $E_{hdi_gov_ot}$ we set the percentage change in those benefits equal to the percentage change in nominal

GDP. The percentage change in total government benefits is explained in equation E_hdi_gov .

E_hi, E_hdi, E_hi_tax

Percentage changes in household income are explained in equation E_hi . On the right hand side of this equation are: the total changes in factor income from land, labour and capital; the change in net income from foreigners captured by the change in the balance on income account from the balance of payments; the change in government transfer payments to households; and the change in implicit quota rents in agriculture (an existing variable of the model).

The percentage change in household disposable income is defined in equation E_hdi . We assume that all of household income – government transfers included – is taxable. The variable $rOwage_tax$ is the percentage change in the average rate of income tax paid by Danish households, normally treated as an exogenous variable. The percentage change in household income tax collections is explained in equation E_hi_tax .

E_apc

APC stands for the Average Propensity to Consume. The equation labelled E_apc allows us to relate private consumption to HDI via the APC. For example, if we set APC exogenously to zero change, then nominal consumption will move by the same percentage as HDI.

3.1.8 The government accounts and accumulation of government debt

Denmark has three levels of government: national, county, and local. However in Dynamic-AAGE we simplify reality by treating the public sector as a consolidated entity. The equations in this section allow the model to generate results for the consolidated government accounts, as summarised in Figure 3.2. Such results are useful in forecasting. Equations for the government accounts are also valuable in policy simulations, in which we might wish to implement assumptions such as revenue neutrality or zero impact on the budget deficit.

$E_del_gov_bal, E_r_gdp$

The first equation is a change-form of the government's budget balance. The budget balance is the difference between government revenue and expenditure. The second equation expresses the change in the budget deficit as a percentage of GDP.

E_gexp

As indicated on the right hand side of Figure 3.2, there are four components of government expenditure. Final government consumption expenditure is an existing variable in the model, the percentage change in which is denoted $w5tot$. We model the percentage change in final government investment expenditure as a weighted sum of government investment expenditures over industries. The weight for industry i equals the coefficient $LSHR_GINV(i)$ times the total value of investment in industry i , $V2TOT(i)$. $LSHR_GINV(i)$ is the level of the share of government ownership in the capital of industry i . Changes in government interest payments are explained in a later equation, based on changes in government debt. Movements in the final component of government expenditure, government transfer payments to households, are explained in the section of code dealing with household income (see Section 3.1.7).

FIGURE 3.2: Consolidated Government Accounts

Consolidated Government Revenue*	Consolidated Government Expenditure*
1. Income tax paid by households (<i>VHI_TAX</i>)	1. Final government consumption expenditure (<i>V5TOT</i>)
2. Commodity taxes: "other costs" (<i>V1OCT_I</i> , <i>V2OCT_I</i> , <i>V3OCT_H</i> , <i>V6OCT</i>)	2. Final government investment expenditure ($\text{Sum}(i, \text{IND}, LSHR_GINV(i) \times V2TOT(i))$)
3. Commodity taxes: taxes (<i>V0TAX_CSI</i>)	3. Government interest payments (<i>VGINT</i>)
4. Import tariffs (<i>V0TAR_C</i>)	4. Government transfers to households (<i>VHI_GOV</i>)
5. Indirect taxes on exports (<i>V4TAX_C</i>)	
6. Indirect taxes on capital (<i>V1TAXCAP_I</i>)	
7. Indirect taxes on land (<i>V1TAXLND_I</i>)	
Total government revenue (<i>VGREV</i>)	Total government expenditure (<i>VGEXP</i>)

* The names of Dynamic-AAGE coefficients are shown in parenthesis.

E_grev

This equation explains the percentage change in government revenue as a weighted sum of the percentage changes in the components identified on the left hand side of Figure 3.2.

E_int

The last four equations in this section of code are concerned with government net interest payments (interest payments less interest receipts) and government debt. In *E_int*, the percentage change in government interest payments is derived from:

$$VGINT = ROID \times \frac{VGDstart + VGDend}{2} \quad (3.25).$$

where:

VGDstart is the value of government debt at the start of the year;

VGDend is the value of government debt at the end of the year; and

ROID is the average interest rate on government debt.

Typically the percentage change in the rate of interest rate, *roid*, is treated as an exogenous variable.

E_del_f_gdstart, E_del_f_gdend, E_gdave

The equation for the change in the start-of-year stock of government debt, *E_del_f_gdstart*, is derived from the levels form:

$$VGDstart_t = -VGBAL_{t-1} + VGDstart_{t-1} \quad (3.26),$$

where *VGBAL_{t-1}* is the value of the government budget balance in year t-1. In year-to-year simulations we can use *E_del_f_gdstart*, with its shift variable set exogenously on zero and with *del_unity* set to one, to determine the movement in the start-of-year government debt.

Equation *E_del_f_gdend* explains the change in the end-of-year stock of government debt in year t from its initial level in the simulation for t (i.e., its level at the end of year t-1). This change equals the change in the government's budget balance in year t from its initial (t-1) level.

The final equation, *E_gdave*, explains the percentage movement in the average of the start-of-year and end-of-year stocks of government debt.

3.1.9 Equations to facilitate forecasting simulations: twist variables

In forecasting we frequently want to exogenise both the real wage rate and employment in order to utilise forecasts for both variables made by expert macro forecasters. Similarly, we

want to tie down the aggregate volume of imports, the aggregate components of real final domestic demand and the real exchange rate, setting them according to forecasts from expert sources. In a general equilibrium model, these closure settings are possible only if there is sufficient flexibility in the specifications of supply and demand. For example, it may be possible to tie down both the quantity and price in the labour market by making endogenous an all-industry labour-saving technological change variable. It may also be possible to fix simultaneously the real components of final domestic demand, the real exchange rate and the volume of imports by endogenising an appropriate economy-wide import/domestic preference variable in the Armington equations.

Experience with MONASH suggests that often there is insufficient flexibility on the supply and demand sides of commodity and factor markets to achieve the type of rigid closures that might be used for forecasting. Thus in MONASH, two new sets of variables have been introduced to enhance supply and demand flexibility. One set relates to labour and capital, the other set to imports and their domestically produced substitutes. These variables are known as *twist* variables because they allow for cost-neutral twists in labour/capital preferences in industry *i* and for cost-neutral twists in domestic/import preferences for commodity *c*. We introduce the same variables into Dynamic-AAGE.

The new twist variables are introduced into the existing code of the model. To see how the twist aspect of the new variables work, consider the operation of the import/domestic twist variables in the equation explaining source-specific changes in commodity demand by industry, E_{x1} . Prior to the introduction of the twist variables, E_{x1} appeared in the Tablo code as:

$$\begin{aligned} & \text{Equation } E_{x1} \text{ \# Source-Specific Commodity Demands \#} \\ & (All,c,COM)(All,s,SRC)(All,i,IND) \\ & x1(c,s,i)-a1(c,s,i) = IF (VIBAS(c,s,i) > 0,1)* \\ & \quad (x1_s(c,i) - SIGMA1(c)*\{p1(c,s,i)+a1(c,s,i) - p1_s(c,i)\}); \end{aligned}$$

After the introduction of the twist variable $twist_src(c)$, the equation appears as:

$$\begin{aligned} & \text{Equation } E_{x1} \text{ \# Source-Specific Commodity Demands \#} \\ & (All,c,COM)(All,s,SRC)(All,i,IND) \\ & x1(c,s,i)-a1(c,s,i) = IF\{s \text{ eq "dom", IF (VIBAS(c,s,i) > 0,1)*} \\ & \quad (x1_s(c,i) - SIGMA1(c)*\{p1(c,s,i)+a1(c,s,i) - p1_s(c,i)\}) - \\ & \quad VIBAS(c,"imp",i)/(tiny+Sum(k,SRC,VIBAS(c,k,i)))*twist_src(c)\} \\ & \quad + IF\{s \text{ eq "imp", IF (VIBAS(c,s,i) > 0,1)*} \\ & \quad (x1_s(c,i) - SIGMA1(c)*\{p1(c,s,i)+a1(c,s,i) - p1_s(c,i)\}) + \\ & \quad VIBAS(c,"dom",i)/(tiny+Sum(k,SRC,VIBAS(c,k,i)))*twist_src(c)\}; \end{aligned}$$

Assume that the "a" and price terms on the right hand side of the new equation are set at zero. Taking account of the fact that

$$\frac{V1BAS(c, "imp", i)}{V1BAS_S(c, i)} + \frac{V1BAS(c, "dom", i)}{V1BAS_S(c, i)} = 1$$

for all c and i, we see that

$$x1(c, "dom", i) - x1(c, "imp", i) = -twist_src(c) \quad (3.27).$$

Hence, in the absence of changes in prices and "a" terms, if $twist_src(c)$ were set at -10, then industry i would increase the ratio of its domestic to imported inputs of commodity c by 10 per cent. In other words, there is a 10 per cent twist by industry i in favour of the use of domestic good c relative to imported good c.

To see how the cost-neutral aspect works, continue to assume zero values for the "a" terms and no changes in prices. Also, for this particular example, assume $x1_s = 0$. Under these assumptions:

$$x1(c, "dom", i) = -\frac{V1BAS(c, "imp", i)}{V1BAS_S(c, i)} \times twist_src(c)$$

and

$$x1(c, "imp", i) = \frac{V1BAS(c, "dom", i)}{V1BAS_S(c, i)} \times twist_src(c).$$

By making a weighted sum of these percentage changes in industry i's inputs of domestic and imported good c, using as weights the shares of the two inputs in industry i's total costs, we find that the effect on i's costs is zero. In other words, shocks to $twist_src(c)$ are cost-neutral.

The corresponding twist variable for labour/capital preferences in industry i is labelled $twist_ik(i)$. A positive value for $twist_ik(i)$ implies a twist {towards labour, away from capital} in industry i. A negative value for $twist_ik(i)$ implies a twist {towards capital, away from labour}.

E_ftwist_src , E_ftwist_lk

The equations in this section of code allow for the flexible handling of the twist variables, $twist_src(c)$ and $twist_lk(i)$. Using equation E_ftwist_src , for example, we can impose a uniform all-commodity twist in the import/domestic preferences of the economy. This is done by making $ftwist_src(c)$ exogenous and $twist_src(c)$ endogenous for all c and shocking the uniform shifter $twist_src_c$.

Equations of this type are very useful in forecasting simulations. In forecasting, we need instruments that allow us to exogenise the aggregate volume of imports and both of aggregate employment and the real wage rate. E_ftwist_src and E_ftwist_lk give us those instruments in the form of $twist_src_c$ and $twist_lk_i$. To fix, say, the real wage rate when employment is also exogenous, we turn on the $ftwist_lk$ mechanism and then swap $twist_lk_i$ for the real wage rate. With this closure, the model determines the general twist in labour/capital requirements that is necessary to reconcile the macro-level exogenous settings for both employment and the real wage rate.

3.1.10 Equations to facilitate forecasting simulations: c-using technological change

The commodity-dimension variable $ac(c)$ allows for general commodity c -using changes in industry technologies for current production and capital creation.

E_f_a1 , E_f_a2

As can be seen in equations E_f_a1 and E_f_a2 , with the shift variables $f_a1(c,s,i)$ and $f_a2(c,s,i)$ set exogenously at zero, a value of 1.0 for $ac(c)$ imparts a one per cent increase in the existing technological change variables $a1(c,s,i)$ and $a2(c,s,i)$ across all s and i .

$E_del_f_altot$

This equation neutralises the effects on industry costs of changes in the ac variables. With the shift variable del_f_altot set exogenously at zero, $E_del_f_altot$ generates an all-input-saving/using technical change in industry i ($altot(i)$) that offsets the effects on i 's unit costs of the $ac(c)$'s. As noted in Dixon and Rimmer (2000), without such an offset, a positive value for $ac(c)$ would imply that industries are expanding their usage of commodity c per unit of output without reducing their usage of other inputs per unit of output. A positive value for $ac(c)$ would represent a technological deterioration that is avoided when we allow the positive $ac(c)$ to generate cost neutralizing reductions in all of industry i 's inputs per unit of output.

3.1.11 Equations to facilitate forecasting simulations: uniform shifts

E_{ft4q} , E_{ff4q_ntrad} , E_{ff4p} , E_{ff4p_ntrad}

The equations here operate in the same way as E_{ftwist_src} and E_{twist_lk} (see Section 3.1.9). Using equation E_{ff4q} , for example, we can impose a uniform vertical shift in the world demand schedules for traditional export commodities. This is done by making $ff4q(c)$ exogenous and $f4q(c)$ endogenous for all c in the set $TRADEXP$ and shocking the uniform shifter $f4q_general$. At the same time, we would keep $f4q_ntrad$ exogenous and $ff4q_ntrad$ endogenous, thus isolating the non-traditional exports from the effects of $f4q_general$.

We use these equations mainly for forecasting. For example, to hit an aggregate export volume target, we could turn on E_{ff4q_ntrad} and E_{ff4q} for all c in set $TRADEXP$ and make $x4tot$ exogenous by making $f4q_general$ endogenous. With this closure, all of the world demand schedules for traditional exports and the world demand schedule for non-traditional exports would shift to achieve the targeted change in exports.

E_{fallab} , E_{falcap} , E_{fallnd} , $E_{falprim}$

Here we introduce a new technological change variable ($a1prim(i)$) that allows for equi-proportional changes across the primary-factor technological change variables, $allab(i)$, $alcap(i)$ and (if industry i is a land-using industry) $allnd(i)$. Equation $E_{falprim}$, allows us to impose uniform all-industry changes in $a1prim(i)$. In forecasting we use this equation to hit a real-GDP target, with $a1prim_gen$ moving to generate the necessary all-input, all-industry technological change to meet an exogenously imposed value for $x0gdpxp$.

3.1.12 Equations to facilitate dynamic policy analysis: wage/employment trade-off

In this section we introduce equations from MONASH that deal with policy-induced deviations in wages and employment. They also allow for the convenient transfer of results from forecast simulations to policy simulations.

In most CGE analyses, one of the following two assumptions is made:

- real wages adjust to a shock so there is no effect on employment; or
- real wages remain unaffected and employment adjusts.

Here we introduce equations that allow for a third, intermediate position. We assume that the deviation in the real wage rate from its basecase forecast level increases in proportion to the deviation in employment from its basecase forecast level. This means, that in the short-

run, the real wage rate is sticky and employment adjusts to accommodate this stickiness. In the long-run, employment is sticky and the real wage rate adjusts. In between, employment and the real wage rate adjust. Thus favourable shocks generate short-run gains in aggregate employment and long-run gains in real wages.

Algebraically, the employment/wage trade-off equation in MONASH and Dynamic-AAGE can be written as:

$$\frac{W_t^P}{W_t^F} - 1 = \left(\frac{W_{t-1}^P}{W_{t-1}^F} - 1 \right) + ALPHA_L \times \left(\frac{E_t^P}{E_t^F} - 1 \right) \quad (3.28).$$

where:

W_t^P and W_t^F are the levels of the national real wage rate in year t in the policy and the base-case forecast simulations;

E_t^P and E_t^F are the levels of national employment in year t in the policy and the basecase forecast simulations; and

$ALPHA_L$ is the coefficient of proportionality.

Equation (3.28) says that the percentage deviation in the real wage rate in year t from its basecase forecast value equals the percentage deviation in the real wage rate in year t-1 plus a coefficient ($ALPHA_L$) times the percentage deviation in employment in year t. The coefficient of proportionality is chosen so that the employment effects of a shock to the economy are largely eliminated after 5 years. In other words, after about 5 years, the benefits of favourable shocks, such as outward shifts in export demand curves, are realized almost entirely as increases in real wage rates.

Implementing equation (3.28) is quite straightforward. We treat the policy and forecast variables, current and lagged (W_t^P , W_t^F , W_{t-1}^P , W_{t-1}^F , E_t^P and E_t^F) all as separate variables in the model. Initial data for these variables are read from separate headers in the data file *DYNAM* and are updated using the respective percentage-change variables. The setting of values for the percentage change forecast variables in a policy simulation are achieved using equations *E_bf_employ_i* and *E_bf_r0wage_c_pt*. The setting of the lagged wage equations occur in *E_r0wage_l* and *E_bf_r0wage_l*. But before coming to these equations we several measures of the real wage rate which can be used in the implementation of equation (3.28).

E_r0wage_p, E_r0wage_c, E_r0wage_c_pt

These equations explain the percentage changes in three different measures of the real wage rate: the producer real wage rate; the consumer real wage rate (before tax) and the consumer real wage rate (after tax). The first measure is the economy-wide nominal unit labour cost divided by the GDP deflator. The second measure is a CPI-deflated weighted average of the percentage movements in occupation/industry wage rates. Movements in the consumer real wage rate are often important in union/employer/government wage negotiations. The final measure, the consumer real wage rate (after-tax) is defined as:

$$LROWAGE_C_PT = LROWAGE_C \times (1 - LROWAGE_TAX),$$

where *LROWAGE_C* is the level of the consumer real wage rate (before tax). The inclusion of an after-tax version of the consumer real wage rate recognises that the employment decisions of households are affected not only by movements in their nominal wage rate relative to the CPI, but also by changes in rates of income tax. In the equations that follow, all wage variables and coefficients refer to the consumer real wage rate (after-tax).

E_r0wage_l, E_bf_r0wage_l

Equation *E_r0wage_l* defines the percentage movement in the lagged consumer real wage rate (after tax) in the policy simulation from its value in the initial solution for year t to its value in the final solution for year t. The coefficients on the right hand side, *LROWAGE@l* and *LROWAGE_L@l* are the levels of the relevant wage measure current and lagged in the initial (policy-simulation) solution for year t. Provided that the initial solution is drawn from values for year t-1, then *LROWAGE@l* is the relevant wage rate in year t-1 and *LROWAGE_L@l* is the relevant wage rate in year t-2. With *del_unity* set exogenously to one, *E_r0wage_l* correctly generates *r0wage_l*.

Equation *E_r0wage_l* defines the percentage movement in the lagged consumer real wage rate (after tax) in the basecase forecast simulation. The coefficients on the right hand side of this equation, *BF_LROWAGE@l* and *BF_LROWA_L@l* have similar interpretations as the coefficients on the right hand side of *E_r0wage_l*. They are derived via formula (initial) statements from coefficients that are updated by the percentage change variables, *bf_r0wage* and *bf_r0wage_l*. Provided that the values of these coefficients read from the initial data for t=0 are the same as the values for the coefficients *LROWAGE* and *LROWAGE_L*, and provided that the variable *bf_r0wage* correctly takes on the basecase forecast values for

$r0wage_c_pt$ (see equation $E_bf_r0wage_c_pt$), then with $del_unity = 1$, $E_bf_r0wage_l$ correctly generates bf_r0wage_l .

$E_bf_employ_i$, $E_bf_r0wage_c_pt$

These two equations allow us to transfer basecase forecast values of variables through to the policy simulation. They are of the form

$$r_x = x - bf_x \tag{3.29}.$$

where:

x is a variable such as real wage growth for which we need forecast results in policy simulations;

bf_x is the variable which, in policy simulations, is given the forecast simulation value of x ; and

r_x is the difference between x and bf_x .

These equations operate in conjunction with the GEMPACK software used to run year-to-year simulations with Dynamic-AAGE. With this software, a policy simulation for year t is run by:

- (1) reading the results generated in the forecast simulation for year t ;
- (2) reading the list of exogenous variables to be used in a policy simulation for year t ;
- (3) forming a CMF file in which exogenous variable r in the policy simulation is assigned the value that it had (either endogenously or exogenously) in the forecast simulation; and
- (4) adding a supplementary file of shocks for variables that are exogenous and shocked in the policy simulation.

Aided by this software we use (3.29) to transfer basecase forecast values for x to the policy simulation. In the forecasting simulation we set the shift variable r_x exogenously at zero change, resulting in the forecast result for bf_x being the same as that for x . In the policy simulation we change the closure by making bf_x exogenous and r_x endogenous. Thus, the forecast result for x is correctly passed to bf_x in the policy simulation.

Equations $E_bf_employ_i$, and $E_bf_r0wage_c_pt$ are applications of (3.29) for the policy variables $employ_i$ and $r0wage_c_pt$.

$E_{f_r0wage_c_pt}$

$E_{f_r0wage_c_pt}$ is the percentage change form of equation (3.28) written in Tablo notation and with the addition of the on/off shift variable, $f_r0wage_c_pt$. When this equation is turned on by exogenisation of $f_r0wage_c_pt$, we are assuming that wage bargains are made in real, *after-tax* terms. If, for example, there is an increase in income tax rates, then in this treatment of the employment/wage-trade-off, workers attempt to maintain their real after-tax wage rates by demanding higher before-tax wage rates.

There are three pairs of coefficients in equation $E_{f_r0wage_c_pt}$: two relating to wages, the other to employment.

The first pair of wage coefficients is on the left hand side, $LROWAGE$ and $BF_LROWAGE$. They correspond to w_t^P and w_t^F in equation (3.28). These coefficients are read from headers on the file *DYNAM* and are updated by $r0wage_c_pt$ and bf_r0wage . In constructing the initial $t=0$ database for the model, we make sure that the data from which $LROWAGE$ and $BF_LROWAGE$ are drawn imply that $LROWAGE = BF_LROWAGE$. In forecast simulations, with $r_r0wage_c_pt$ set at zero (see $E_{bf_r0wage_c_pt}$), $bf_r0wage = r0wage_c_pt$, and so in each year of the forecast simulation, $LROWAGE = BF_LROWAGE$. When we switch to a policy simulation, $BF_LROWAGE$ and bf_r0wage behave in the same way as in the forecast simulation. This is because $BF_LROWAGE$ is updated by bf_r0wage , which continues to reflect forecast values for $r0wage_c_pt$. Meanwhile, $LROWAGE$ and $r0wage_c_pt$ move in accordance with the real wage rate in the policy simulation.

The evaluation of the pair of lagged wage coefficients and the pair of employment coefficients in $E_{f_r0wage_c_pt}$, $\{LROWAGE_L, BF_LROWAGE_L\}$ and $\{QEMPLOY_i, BF_QEMPLOY_i\}$ is analogous to that of $\{LROWAGE, BF_LROWAGE\}$. Data for each pair are read off *DYNAM* and are updated by $\{r0wage_l$ and $bf_r0wage_l\}$ and $\{employ_i$ and $bf_employ_i\}$.

3.1.13 Equations to facilitate dynamic policy analysis: measures of changes in welfare

In this section we introduce two measures of the effect of policy changes on consumer welfare that have been developed for MONASH. Both are simple measures that have the advantage of not relying on a specific household utility function. The measures are called EV_OVER and CV_UNDER . Figures 3.3 illustrate the interpretation of these measures and their relationships to the equivalent variation (EV) and the compensating variation (CV).

EV can be thought of as the amount of additional income that consumers would require before a policy change to make them as well off as after the policy change. As shown in the first panel of Figure 3.3, before the policy change the consumer purchases at point "F". After the policy has been implemented, consumption has moved to point "P", with the EV as indicated. *EV_OVER* is sometimes referred to as a Laspeyre cost difference. As shown in Figure 3.3, it is the amount of money that would need to be given to consumers in the forecast situation (before the policy change) to enable them to just buy the policy consumption bundle. Thus, *EV_OVER* is an over-estimate of EV; it over-estimates the amount of money that must be given to consumers to enable them to buy a consumption bundle which generates the policy level of utility.

CV can be thought of as measuring the income that must compensate consumers for the policy change after it occurs in order to return consumers to their original level of utility. This is illustrated in the second panel of Figure 3.3 as the distance "CV". *CV_UNDER* is sometimes labelled a Paasche cost difference. As indicated in the diagram, it is the amount of money that could be taken away from consumers in the policy situation and leave them just able to buy the forecast consumption bundle. Thus, *CV_UNDER* is an under-estimate of compensating variation; it under-estimates the amount of money that could be taken away from consumers in the policy situation and leave them able to buy a consumption bundle which generates the forecast level of utility.

Dixon and Rimmer (2000) note that in MONASH computations it has been usually found that *EV_OVER* and *CV_UNDER* are close together with *CV_UNDER* being less than *EV_OVER*. Nevertheless, *EV_OVER*, *CV_UNDER* or an average of them are all adequate measures of the welfare effect of a policy change.

In the Tablo code, we treat the two welfare measures as coefficients (not variables) whose values are computed via formulae (not equations). For convenience, we specify two equations at the end of the section that allow the values of these coefficients in year t to be viewed along with values for variables in the solution for year t.

To allow comparisons with deviations in consumption, we calculate the values of both welfare measures as percentages of aggregate consumption. For *EV_OVER* we use the aggregate value of consumption in the basecase forecast. For *CV_UNDER* we use the aggregate value of consumption in the policy simulation. Thus, in terms of the Tablo-code notation we calculate *EV_OVER* via the formula:

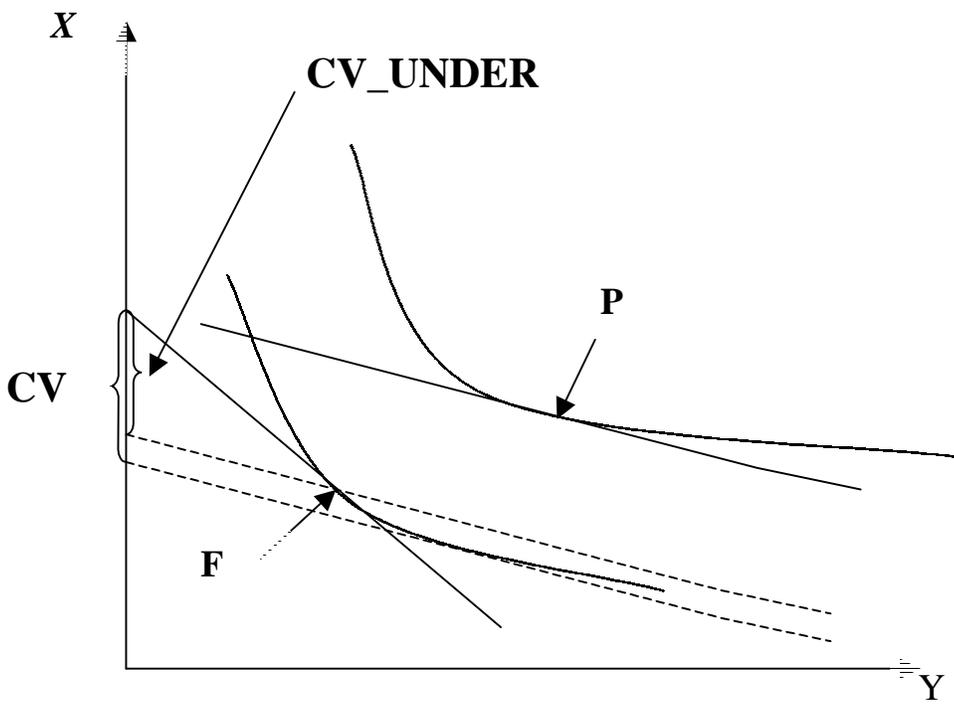
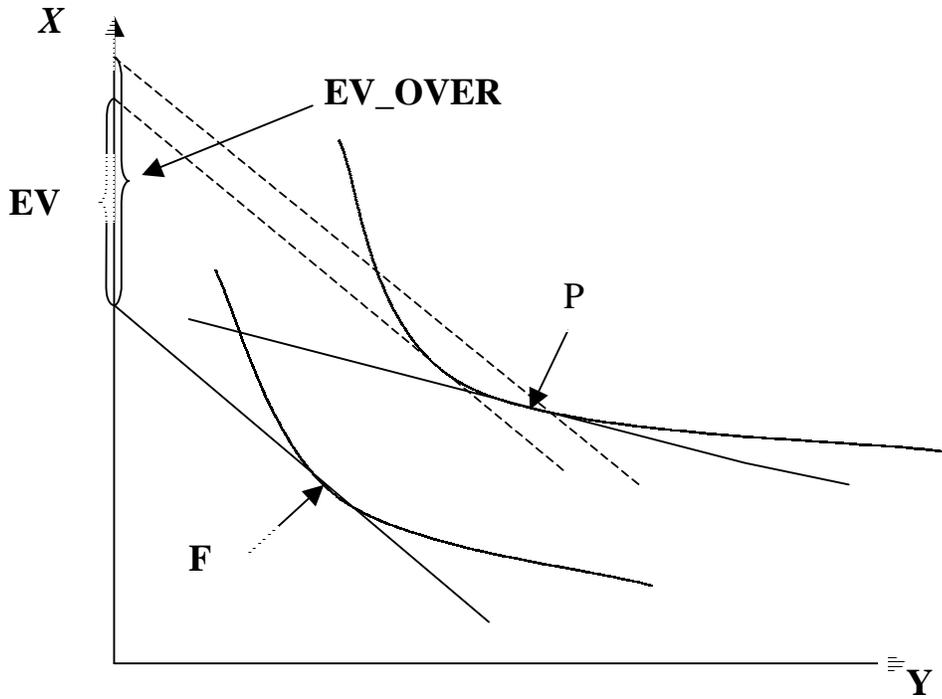


FIGURE 3.3: Measure of the Policy Effects on Welfare

$$LEV_OVER = 100 \times \frac{\sum_k BF_LP3_SC(k) \times (LX3_SC(k) - BF_LX3_SC(k))}{\sum_d BF_LV3PUR_SC(d)} \quad (3.30),$$

where:

$BF_LP3_SC(k)$ is the level of the consumer price of good k in set $COMHLU$ in the basecase forecast simulation;

$LX3_SC(k)$ is the level of the quantity of consumption of good k in set $COMHLU$ in the policy simulation;

$BF_LX3_SC(k)$ is the level of the quantity of consumption of good k in set $COMHLU$ in the basecase forecast simulation; and

$BF_LV3PUR_SC(k)$ is the level of the value of consumption of good k in set $COMHLU$ in the basecase forecast simulation.

On the right-hand side of (3.30), the coefficient $BF_LP3_SC(k)$ is read from the logical file DYNAM and is updated by $bf_p3_sc(k)$. The corresponding coefficient and variable for the level of the consumption price of good k in policy simulations are $LP3_SC(k)$ and $p3_sc(k)$. Data in the initial year=0 database are constrained to ensure that $BF_LP3_SC(k) = LP3_SC(k)$. In forecast simulations, with $r_p3_sc(k)$ set at zero (see $E_bf_p3_sc$), $bf_p3_sc(k) = p3_sc(k)$, and so in each year of the forecast simulation, $BF_LP3_SC(k) = LP3_SC(k)$. When we switch to a policy simulation, $BF_LP3_SC(k)$ and $bf_p3_sc(k)$ behave in the same way as in the forecast simulation. This is because $BF_LP3_SC(k)$ is updated by $bf_p3_sc(k)$, which continues to reflect forecast movements in the consumption price of good k . Meanwhile, $LP3_SC(k)$ and $p3_sc(k)$ move in accordance with the consumption price of good k in the policy simulation.

The coefficients $LX3_SC(k)$ and $BF_LX3_SC(k)$ on the right hand side of (3.30) are calculated via formulas:

$$LX3_SC(k) = \frac{LV3PUR_SC(k)}{LP3_SC(k)} \quad (k \in COMHLU) \quad \text{and}$$

$$BF_LX3_SC(k) = \frac{BF_LV3PUR_SC(k)}{BF_LP3_SC(k)} \quad (k \in COMHLU),$$

where $LV3PUR_SC(k)$ is the level of the value of consumption of good k in set $COMHLU$ in the policy simulation. $BF_LV3PUR_SC(k)$ and $LV3PUR_SC(k)$ are read from the data file DYNAM and are updated by the appropriate quantity and price variables. Data in the initial year=0 database imply that $BF_LV3PUR_SC(k) = LV3PUR_SC(k)$. In forecast simulations, with $r_p3_sc(k)$ and r_x3_sc set at zero (see $E_bf_p3_sc$ and $E_bf_x3_sc$), $bf_p3_sc(k) = p3_sc(k)$ and $bf_x3_sc(k) = x3_sc(k)$ in each year of the forecast simulation. Accordingly, $BF_LV3PUR_SC(k) = LV3PUR_SC(k)$ throughout the forecast. In a policy simulation, $BF_LV3PUR_SC(k)$ behaves in the same way as in the forecast simulation because it is updated using $bf_p3_sc(k)$ and $bf_x3_sc(k)$. On the other hand, $LV3PUR_SC(k)$ moves in accordance with the value of consumption of good k in the policy simulation.

The Tablo-code formula for CV_UNDER is:

$$LCV_UNDER = 100 \times \frac{\sum_k LP3_SC(k) \times (LX3_SC(k) - BF_LX3_SC(k))}{\sum_d LV3PUR_SC(d)} \quad (3.31),$$

where $LP3_SC(k)$ is the level of the consumer price of good k in set $COMHLU$ in the policy simulation. The technicalities underlying the formulas, variables and updates necessary to evaluate the right hand side of (3.31) are similar to those underlying the LEV_OVER calculation and require no further explanation.

E_ev_over, E_cv_under

With del_unity set exogenously at 1, the values of ev_over and cv_under generated by these two equations are the values of the coefficients LEV_OVER and LCV_UNDER . Thus, these two equations give a convenient method for viewing these coefficients.

$E_bf_p3_sc, E_bf_x3_sc$

These two equations allow us to transfer basecase forecast values for $p3_sc(k)$ and $x3_sc(k)$ through to bf_p3_sc and bf_x3_sc for use in the policy simulation. The equations have exactly the same form as $E_bf_employ_i$ and $E_bf_r0wage_c_pt$, and operate in conjunction with the GEMPACK software in the same way as $E_bf_employ_i$ and $E_bf_r0wage_c_pt$.

3.2 New data requirements

In Appendix B we list all of the new coefficients and parameters required to implement the new equations. For each item we describe how initial values have been compiled in preparation for the simulations reported in Section 4. In some cases, these initial values are just guesses. More realistic settings based on official data are the subject of on-going research.

4. Closures and illustrative simulations

This section has three parts. In the first part, we set-up the basic closures of Dynamic-AAGE (see Section 2.3). In the second part, we review most of the important aspects of the core static model and its database, and develop a stylised model that is used as an aid to explaining the simulation results. In the final part, we work through four simulations, designed to illustrate how Dynamic-AAGE can be used for policy analysis in comparative-static and dynamic year-to-year modes. The first two simulations are comparative-static analyses conducted under short-run and long-run assumptions. The second two simulations are year-to-year dynamic analyses conducted with static and forward-looking expectations. In each simulation the exogenous shock is the same: a once-off, ten per cent improvement in labour-saving technical progress in the agricultural industries. The same shock is used in each simulation to assist in making comparisons.

4.1 Setting up the closures

In Appendix C we list all the new variables introduced into Dynamic-AAGE, along with their endogenous/exogenous classification in a comparative static long-run closure. As indicated earlier, the endogenous variables in the comparative static long-run closure are those for which there are named equations and the exogenous variables are those for which there are no named equations. By swapping variables between exogenous and endogenous categories using the long-run closure as a starting point we develop the comparative static short-run closure. The forecasting and policy closures are developed, in a similar way, by a series of swaps applied to the short-run comparative static closure.

4.1.1 Short-run comparative static closure

In the long-run comparative static closure, the percentage changes in employment by occupation ($xllab_i$) are exogenous and occupation-specific real wage rates ($fllab_i$) are endogenous, adjusting to accommodate the fixed employment assumption. In the short-run closure, we reverse this setting: making employment by occupation endogenous and the real wage rates exogenous. Also, we tie the occupation wage rates together, so that employment in each occupation adjusts by the same percentage amount. These closure changes are put in place by swapping:

xllab_i with *fllab_i* and
fllab_io with *r0wage_c_pt*.⁹

After the first swap, employment by occupation is endogenous and occupational real wage rates are exogenous. The second swap involves making endogenous the economy-wide shift in money wages away from the price of consumption (*fllab_io*) and fixing the consumer real wage rate after tax (*f0wage_c_pt*) (see section 3.1.11). Together, these swaps ensure that employment changes by the same percentage amount across all industries and occupations, with money wage rates moving in line with the price of consumption after allowance for changes in the average rate of income tax.

The long-run comparative static closure generates results for capital available in year *t* (*klstart*) on the basis that rates of return (*del_ar1cap_se*) are fixed. In the short-run, capital availability is held fixed, and rates of return are allowed to respond to changes in the profitability of industries. This is enabled by swapping

del_ar1cap_se with *klstart*.

The treatment of final demand variables in the long-run closure is as follows. Aggregate investment is determined by exogenously imposed assumptions about movements in industry investment/capital ratios. The trade balance as a percentage of GDP is directly fixed via an exogenous setting for the variable *delbt*, while real public consumption is tied to real private consumption by an exogenous setting for the variable *f5tot2*. Given unchanged stock accumulation, these exogenous settings leave real private consumption as the swing variable to reconcile the change in real GDP from the expenditure side with the change in real GDP from the income (factor input) side.

In the short-run, we allow the trade balance to be endogenous by making real private consumption exogenous. In other words, we swap:

delbt with *x3tot*.

Thus in short-run comparative-static simulations, it is the trade balance that adjusts to reconcile changes in the expenditure and income sides of GDP.

⁹ In this section, all of the swaps have the form “A with B”, where variable A (exogenous before the swap) is made endogenous by making variable B (endogenous before the swap) exogenous.

4.1.2 Forecast closure

We develop the forecasting closure by a series of swaps from the short-run comparative-static closure.

The first task is to convert the one-period short-run closure to a year-to-year closure. Forecasting simulations are conducted as a sequence of year-to-year computations, with the base solution for the year t computation being generated from the final solution for year $t-1$.

Six swaps are required to set up the model for year-to-year simulations. The first five turn on the year-to-year accumulation equations for physical capital, the net stock of foreign liabilities and the net stock of government debt (see Sections 3.1.1, 3.1.6 and 3.1.8). We swap:

kIstart with *del_f_kIstart*;
flstart with *del_f_flstart*;
flend with *del_f_flend*;
gdstart with *del_f_gdstart*; and
gdend with *del_f_gdend*.

The sixth swap turns on the inverse-logistic determination of investment by industry (*E_del_f_eerIcap*) (see Section 3.1.4) and frees up investment/capital ratios. The swap is

ic_ratio with *del_f_eerIcap*

for all industries other than “Extraction of coal, oil and gas”. We choose not to rely on our endogenous determination for the oil and gas industry because it is a very capital-intensive industry, facing a relatively flat demand schedule. In industries like this, capital rentals tend to be quite volatile, leading to volatile investment if investment responds to changes in rates of return.

Having set up the model for year-to-year simulations, we now configure it to accept exogenous forecasts from expert forecasters. This involves swapping many naturally endogenous variables in the short-run comparative-static closure with an equal number of naturally exogenous variables. We deal first with the macro variables.

Introducing the macro forecasts

Here we swap:

f5tot2 with *x5tot*;
del_f_eer1cap_i with *x2tot_i*;
f4q with *ff4q* (for all *c* in the set *TRADEXP*)
f4q_ntrad with *ff4q_ntrad* and
f4q_general with *x4tot*;
allab_o with *fallab_o*,
alcap with *falcap*,
allnd with *fallnd*,
alprim with *falprim* and
alprim_gen with *x0cif_c*;
twist_src with *ftwist_src* and
twist_src_c with *p0realdev*.

With these swaps we allow Dynamic-AAGE to accept extraneous forecasts for real private consumption (already exogenous), real public consumption (*x5tot*), real investment (*x2tot_i*), the aggregate volume of exports (*x4tot*), the real exchange rate (*p0realdev*) and the aggregate volume of imports (*x0cif_c*).

In exogenising *x2tot* we endogenise the uniform shift variable in the inverse-logistic equations *E_del_f_eer1cap*. Thus the model accommodates exogenously specified movements in aggregate investment by uniform vertical shifts in the inverse-logistic curve of each industry (see Figure 3.1) for which *del_f_eer1cap* is an exogenous variable.

Exogenous settings for aggregate exports are handled by uniform vertical shifts in the world demand schedules for traditional and non-traditional exports. These vertical shifts are achieved by activating equations *E_ff4q* and *E_ff4q_ntrad* (see Section 3.1.11) and endogenising *f4q_general*.

Up to this point we have tied down all of the demand side components of real GDP except for imports, i.e., in typical macro notation, we have tied down C, I, G and X. Thus, with M determined by import-demand equations, real GDP is tied down from the expenditure side. If technological change were entirely exogenous, then GDP would also be tied down by the exogenous setting for aggregate employment (achieved in a later swap) and the pre-determined setting for capital. Accordingly, to exogenise M we need to free up an aspect of supply to allow GDP from the supply side to adjust to equal GDP from the expenditure side. This is achieved by activating equations *E_fallab_o*, *E_falcap*, *E_fallnd* and *E_falprim*

(see Section 3.1.11) and making endogenous overall all-factor-input saving technical change ($a1_{prim_gen}$).

The final pair of macro swaps serves to avoid a potential indeterminacy between the real exchange rate and the general shift in the export-demand curves. As noted in Dixon and Rimmer (2000), if both were endogenous, then an export target could be achieved with a high value for $f4p_general$ and a low value for $p0realdev$ or *vice versa*. By exogenising $p0realdev$ we not only remove this indeterminacy but we also allow the model to absorb ex-traneous exchange rate forecasts. We exogenise the real exchange rate by activating equation E_ftwist_src (see Section 3.1.9) and endogenising $twist_src_c$. After this swap, we have two mechanisms ($f4q_general$ and $twist_src_c$) to achieve two trade targets (X and M), along with a single mechanism ($a1_{prim_gen}$) for ensuring that changes on the expenditure side of real GDP add to the changes on the income side.

Introducing labour-market forecasts

Here we swap:

$twist_lk$ with $ftwist_lk$ and
 $twist_lk_i$ with $employ_i$.

These swaps allow us to introduce forecasts for changes in aggregate employment, along with forecasts for the real wage rate. The model accommodates forecasts for both variables via uniform twists in capital/labour technologies (see E_ftwist_lk , and Section 3.1.9).

Commodity-c saving technological change and cost-neutral offsets to ac shocks

Here we swap:

$a1$ with f_a1 ,
 $a2$ with f_a2 and
 $altot$ with del_f_altot .

The first two swaps allow us to use the variable $ac(c)$ to transmit commodity-c-specific shocks to the industry technology variables, $a1(c,s,i)$ and $a2(c,s,i)$. The third swap neutralises the cost effects of the input-saving technical change (see section 3.1.10).

Introducing forecasts for investment in dwellings

Here we exogenise investment in dwellings by swapping:

del_f_eer1cap with *x2tot*

for the “Dwelling ownership” industry. For this industry we choose to use direct forecasts for investment, rather than rely on the model’s endogenous determination of investment.

Introducing volume forecasts for individual traditional exports

Here we swap:

ff4q with *x4* (for commodities in the set *TRADEXP*).

The purpose of this swap is to allow Dynamic-AAGE to absorb extraneous forecasts of movements by commodity in export volumes for the traditional export group.

4.1.3 Policy closure

In policy simulations we allow the economy to move away from its basecase forecast path in response to exogenously imposed changes (see Section 2.3). Most, but not all, of the exogenous variables retain the values they had in the associated forecast simulation. The exceptions are the exogenous variables that are shocked.

In setting up the policy closure many naturally endogenous variables, such as the volumes of agricultural exports and macro variables that are exogenous in the forecast closure are endogenous. They respond to the policy change under consideration. Correspondingly, in the policy closure many naturally exogenous variables, such as the positions of foreign demand curves and macro coefficients, which are endogenous in the forecast closure are exogenous. They are set at the values revealed in the forecasts.

Like the forecast closure, we develop the policy closure by a series of swaps from the short-run comparative-static closure.

The first task is to repeat the swaps made for the forecast closure that convert the one-period short-run closure to a year-to-year closure:

k1start with *del_f_k1start*;
flstart with *del_f_flstart*;
flend with *del_f_flend*;
gdstart with *del_f_gdstart*;
gdend with *del_f_gdend*; and

ic_ratio with *del_f_ee1cap* (except for “Extraction of coal, oil and gas”).

The next task is to set up the appropriate macro closure for policy deviations. In the policy simulation, we assume that in year *t* private consumption deviates from its basecase forecast level in line with the deviation in household disposable income. Also, we assume that public consumption deviates to keep the government budget balance as a percent of GDP at its basecase level. Thus, from the short-run comparative static closure we swap:

x3tot with *apc*; and
f5gen2 with *del_rgbalgrp*.

With private and public consumption determined this way, and with the year-*t* deviation in aggregate investment reflecting the average deviation in industry-specific rates of return, the deviation in gross domestic absorption is determined. In this case, the trade-balance endogenously adjusts to reconcile deviations in the income and expenditure sides of GDP.

The remaining tasks are to invoke the model’s treatment of the employment/real wage trade off in policy simulations (see Section 3.1.12) and the mechanisms for calculating *EV_OVER* and *CV_UNDER*. (see Section 3.1.13). These are enabled via the following swaps:

r_employ_i with *bf_employ_i*;
r_r0wage_c_pt with *bf_r0wage*;
r_p3_sc with *bf_p3_sc*;
r_x3_sc with *bf_x3_sc*; and
r0wage_c_pt with *f_r0wage_c_pt*.

As explained in Sections 3.1.12 and 3.1.13, the first four swaps enable basecase forecast values for *employ_i*, *r0wage_c_pt*, *p3_sc* and *x3_sc* to be transferred to the policy simulation as values for *bf_employ_i*, *bf_r0wage*, *bf_p3_sc* and *bf_x3_sc*. The final swap turns on equation *E_f_r0wage_c_pt*, allowing the real wage rate after tax (*r0wage_c_pt*) to be endogenously determined. With these swaps in place, the deviation in the real wage rate from its basecase level in year *t* follows the rule given in equation (3.28).

4.2 Aspects of the core static model, and a stylised version of Dynamic-AAGE

4.2.1 Aspects of the core static model

AAGE is based on standard neo-classical assumptions: households are utility-maximises, industries are cost-minimises, prices equal costs and markets for commodities and services always clear. The simulations reported in Section 4.3 are run using the 1992 input/output

database for AAGE. This recognises 39 industries producing 44 commodities (see Table 4.1). The first five industries are land using. For our simulations, the total quantity of agricultural land is always fixed, though the usage of land can change across land-using industries. Large subsidies support the usage of land for cereal and oilseed production, while a quota prevents the production of milk from increasing.

TABLE 4.1: **Commodities and Industries in the 1992 AAGE database**

Industries			Commodities		
*	1	Cereal	1	Cereal	
*	2	Oil seeds	2	Oil seeds	
*	3	Potatoes	3	Potatoes	
*	4	Sugerbeets	4	Sugerbeets	
*	5	Roughage	5	Roughage	
	6	Meat cattle and milk producers	6	Cattle for slaughtering	
	7	Pigs	7	Milk	
	8	Poultry	8	Pigs	
	9	Horticulture	9	Poultry	
	10	Fishing	10	Horticulture	
	11	Agriculture nec.	11	Fishing	
	12	Extraction of coal, oil and gas	12	Agriculture nec.	
	13	Petroleum refineries	13	Extraction of coal, oil and gas	
	14	Electric light and power	14	Petroleum, refineries	
	15	Gas manufacture and distribution	15	Electric light and power	
	16	Steam and hot water supply	16	Gas manufacture and distribution	
	17	Cattle-meat products	17	Steam and hot water supply	
	18	Pig-meat products	18	Cattle-meat products	
	19	Poultry-meat products	19	Pig-meat products	
	20	Fish products	20	Poultry-meat products	
	21	Dairy products	21	Fish products	
	22	Processing of fruit and vegetables	22	Dairy products	
	23	Sugar factories and refineries	23	Processing of fruit and vegetables	
	24	Bread, grain mill and cakes	24	Sugar factories and refineries	
	25	Prepared animal feeds	25	Bread, grain mill and cakes	
	26	Tobacco. Beverages and alcohol	26	Prepared animal feeds	
	27	Textile, wearing apparel and leather	27	Tobacco. Beverages and alcohol	
	28	Manufactured wood, paper and glass products	28	Textile, wearing apparel and leather	
	29	Non-metallic building material	29	Manufactured wood, paper and glass products	
	30	Basic chemicals	30	Non-metallic building material	
	31	Chemical fertilizers and pesticides	31	Basic chemicals	
	32	Iron and steel	32	Chemical fertilizers and pesticides	
	33	Manufacture of transport equipment	33	Iron and steel	
	34	Construction	34	Manufacture of transport equipment	
	35	Wholesale and retail trade	35	Construction	
	36	Transport	36	Wholesale and retail trade	
	37	Services	37	Transport	
	38	Dwellings	38	Services	
	39	Government services	39	Dwellings	
			40	Government services	
			41	Coal imports	
			42	Manure	
			43	Fungicide	
			44	Insecticide	
			45	Herbicide	

* Sectors using land. # Commodities classed as traditional export commodities (producers of traditional export commodities face individual downward-sloping world-demand schedules for exports).

For the land-using industries, AAGE specifies nested substitution between:

- (a) capital, labour, energy and herbicides (CLEH);
- (b) land, fertiliser and insecticides (LFI);
- (c) CLEH and LFI (CLEHLFI); and
- (d) CLEHLFI and an aggregate of remaining intermediate inputs.

For non-land using industries substitution is allowed between capital, labour and energy (CLE) and between CLE and aggregate non-energy intermediate inputs. For all industries, AAGE includes the standard Armington specification for imported and domestically produced inputs. The Armington assumption is also used in input demands for industry investment and in household demands for consumptions.

Among commodities, three are classed as traditional export commodities. These face individual downward-sloping foreign demand schedules. The remaining commodities are classed as non-traditional exports. The commodity composition of aggregate non-traditional exports is treated as a Leontief aggregate. Total demand is related to the average price via a single downward-sloping foreign demand schedule.

4.2.2 A stylised model

When interpreting the results from Dynamic-AAGE, we refer to the stylised model in Table 4.2. This is similar, though more detailed, to the stylised model in Dixon and Rimmer (2000). Such models aid interpretation of the broad features of the results. However, for understanding the finer features it is necessary to consider aspects of the model's data and micro theory.

In the stylised model, equation (4.1) is the GDP identity in constant-price terms. Equation (4.2) is the economy's production function relating real GDP to inputs of labour (L), capital (K) and to a labour-saving technology term (A_L). In writing (4.2) and elsewhere in the stylised model we ignore the existence of agricultural land and the presence of distortions due to indirect taxes and subsidies. Equation (4.3) is the economy's consumption function, relating real consumption to real GDP via the average propensity to consume (Ω). Equation (4.4) defines the ratio (I) of private to public consumption. Equation (4.5) relates imports to the general level of activity (Y) and to the real exchange rate (RER). Equation (4.6) relates exports negatively to the real exchange rate. As indicated in equation (4.7), movements in the real exchange rate reflect movements in the ratio of the price of GDP (P_{GDP}) to the price

of GDP in the rest of the world (P_W). An increase in the real exchange rate (i.e., an increase in P_{GDP} / P_W) has a positive impact on imports and a negative impact on exports. Equation (4.8) relates the terms of trade (TOT) (i.e., the price of exports relative to the price of imports) negatively to exports. This is consistent with Denmark being a small country with respect to imports, but facing downward-sloping demand curves for its exports. Equation (4.9) defines the investment/capital ratio (Ψ). Equation (4.10) relates the capital/labour ratio to relative factor prices: $RP_L \times A_L$ is the real price of labour adjusted for technological change and RP_K is the real price of capital. This equation is a direct implication of the industry-level CES specification of capital and labour choice. Equation (4.11) is derived from:

$$P_{GDP} = (P_L \times A_L)^{S_L} \times P_K^{S_K} \quad (4.17),$$

where S_L and S_K reflect the shares of labour and capital in the economy ($S_L + S_K = 1$), and P_L and P_K are the nominal wage rate and rental on capital. To obtain (4.11), divide both sides of (4.17) by the price of GDP, redefine in terms of real prices, then re-arrange.

In deriving equation (4.12), we note that:

$$RP_L = \frac{P_L}{P_{GDP}} = \frac{P_L}{P_C} \times \frac{P_C}{P_{GDP}} \quad (4.18),$$

where P_C is the price of consumption. On the right hand side of (4.18), P_L / P_C is the consumer real wage rate, RW . The second term, P_C / P_{GDP} can be interpreted as a decreasing function of the terms of trade: the price of consumption includes the price of imports but not the price of exports, while the price of GDP excludes the price of imports but not the price of exports. In deriving (4.13), we note that:

$$RP_K = \frac{P_K}{P_{GDP}} = \frac{P_K}{P_I} \times \frac{P_I}{P_{GDP}} \quad (4.19),$$

where P_K is the rental price of capital and P_I is the price of investment. On the right hand side of (4.19), P_K / P_I can be interpreted as the average rate of return, ROR . The second term, P_I / P_{GDP} can be interpreted as a decreasing function of the terms of trade in the same way as P_C / P_{GDP} has been interpreted.

TABLE 4.2: A stylised macro model useful for analysing results from Dynamic-AAGE

Levels equations

$$Y = C + I + G + (X - M) \quad (4.1)$$

$$Y = F_Y(L / A_L, K) \quad (4.2)$$

$$C / Y = \Omega \quad (4.3)$$

$$C / G = \Gamma \quad (4.4)$$

$$M = F_M(Y, RER) \quad (4.5)$$

$$X = F_X(-RER) \quad (4.6)$$

$$RER = F_{RER}(P_{GDP} / P_W) \quad (4.7)$$

$$TOT = F_{TOT}(-X) \quad (4.8)$$

$$I / K = \Psi \quad (4.9)$$

$$K / (L / A_L) = F_{KL}(RP_L \times A_L / RP_K) \quad (4.10)$$

$$(RP_L \times A_L)^{S_L} = RP_K^{-S_K} \quad (4.11)$$

$$RP_L = F_{RP_L}(RW, -TOT) \quad (4.12)$$

$$RP_K = F_{RP_K}(ROR, -TOT) \quad (4.13)$$

$$I / K = G_I(ROR, H_I) \quad (4.14)$$

$$K = G_K(I - L, H_K) \quad (4.15)$$

$$RW / RW^{BF} = G_{RW}(L / L^{BF}, H_{RW}) \quad (4.16)$$

Linearised equations in the percentage changes of variables

$$y = S_C c + S_I i + S_G g + (S_X x - S_M m) \quad (4.1')$$

$$y = S_L(l - a_L) + S_K k \quad (4.2')$$

$$c = y + \omega \quad (4.3')$$

$$g = c + \varphi \quad (4.4')$$

$$m = f_M(y, rer) \quad (4.5')$$

$$x = f_X(-rer) \quad (4.6')$$

$$rer = p_{GDP} - p_W \quad (4.7')$$

$$tot = (1 / \sigma_X) x \quad (4.8')$$

$$i = k + \psi \quad (4.9')$$

$$k - (l - a_L) = \sigma_{KL}((rp_L + a_L) - rp_K) \quad (4.10')$$

$$(rp_L + a_L) = -S_K / S_L \times rp_K \quad (4.11')$$

$$rp_L = rw + f_{RP_L}(-tot) \quad (4.12')$$

$$rp_K = ror + f_{RP_K}(-tot) \quad (4.13')$$

$$i - k = g_I(ror, h_I) \quad (4.14')$$

$$k = g_K(i - l, h_K) \quad (4.15')$$

$$rw / rw^{BF} = g_{RW}(l / l^{BF}, h_{RW}) \quad (4.16')$$

Equations (4.14), (4.15) and (4.16) are implemented when the stylised model is used for interpreting results from a dynamic policy simulations. Equation (4.14) is equivalent to the main model's inverse-logistic relationship between the rate of capital growth (I/K) and the rate of return (ROR). The variable H_I is an on/off shift variable. In comparative-static simulations, equation (4.14) is turned off by making H_I endogenous. Equation (4.15) explains the accumulation of capital through time. Capital available for production in the current year is a function of investment in the previous period (I_L). H_K is the corresponding on/off shifter. The final equation, invokes the wage/employment trade-off for dynamic policy simulations described in Section (3.1.12). The superscripts indicate Base Forecast values for employment and the real wage rate. H_{RW} is the on/off shifter.

The linearised percentage-change forms of equations (4.1) to (4.16) are given as equations (4.1') to (4.16'). Lower-case letters identify the percentage changes in variables written in the corresponding upper-case letters. In the linearised model, the coefficients and parameters that have not yet been defined are: s_C, s_I, s_G, s_X and s_M , which reflect the shares of private consumption, investment, public consumption, exports and imports in GDP (the sum of these shares is one); σ_{KL} which reflects the average capital/labour substitution elasticity; and σ_X which reflects the average price elasticity of world demand for exports. From the 1992 AAGE database we infer the following values for the coefficients and parameters in the stylised model:

$$\begin{aligned} s_C &= 0.53, s_I = 0.15, s_G = 0.25, s_X = 0.30, s_M = 0.25, \\ s_L &= 0.70, s_K = 0.30, \\ \sigma_X &= -5.0, \sigma_{KL} = 0.6. \end{aligned}$$

In terms of the linearised stylised model, the endogenous variables in the long-run comparative-static closure are: $y, c, i, g, x, m, k, rer, tot, p_{GDP}, rp_L, rp_K, rw$, and the three on/off shift variables in the final three dynamic equations. The exogenous variables are $a_L, l, ror, \omega, \varphi, p_W, \psi, i_L, l^{BF}$ and rw^{BF} . To obtain the short-run comparative static closure, we endogenise l by exogenising rw , endogenise ror by exogenising k , and endogenise ω by exogenising c . To invoke the policy closure for year-to-year simulations, we start with the comparative-static closure and endogenise ψ, k and rw by exogenising the three on/off shift variables in the dynamic equations (H_I, H_K and H_{RW}), and exogenise ω by endogenising c . The stylised model is not designed for forecasting, so we make no effort to set up a forecasting closure.

4.3 Simulation results

First, we discuss the short-run comparative-static results. Generally, these are the easiest to understand in terms of known details about the underlying data, equations and closure. Second, we examine the long-run comparative-static results. These are more easily understood once the short-run outcomes have been explained. Third, we discuss the dynamic policy deviations under static expectations. Once-off shocks, such as that examined here to agricultural productivity, generally produce fairly smooth transition paths between start and end points that are related to the short-run and long-run comparative-static solutions. Finally, we discuss the dynamic policy deviations under forward-looking expectations. Generally, these are the most difficult to explain, and can only be understood after working through the static-expectations results. For the experiment reported here, the differences between the forward-looking and static results are negligible. So our discussion of the forward-looking results is very brief.

In all four cases, we simulate the effects of labour-saving technological progress in agriculture by imposing shocks of -10 per cent to the variable $a_{lab}(i)$ for $i = 1$ to 9 . In the stylised model (Table 4.2), this is equivalent to shocking the variable a_L by $\{-10 \times S_L^{Ag}\}$ per cent, where S_L^{Ag} is agriculture's share in the overall cost of labour. In the 1992 database, $S_L^{Ag} = 0.0198$. Thus in terms of the stylised model, we shock a_L by -0.198 per cent.

4.3.1 Short-run comparative static impacts (column (I) of Table 4.3)

The short-run comparative static effects of the shock are shown in column I of Table 4.3. First we discuss the macro effects, then the effects on industry production.

Macro effects

From the stylised model we can see that an improvement in labour-saving technology has three immediate effects. First, via equation (4.11'), it increases the aggregate real return to the fixed factor (RP_K), assuming no change in the real price of labour (RP_L). Second, via equation (4.10'), with capital (K) unchanged it increases effective employment (L/A_L). Finally, via equation (4.2') it increases the productive potential of the economy (Y). Given 1992 values for σ_{KL} , S_L and S_K , the stylised model suggests that in response to the shock RP_K will immediately increase by $(0.7/0.3 \times 0.198) = 0.46$ per cent, L/A_L by $(-0.6 \times (-0.198 - 0.46)) = 0.39$ per cent, and Y by $(0.7 \times 0.39) = 0.28$ per cent.

In the full model, instead of one short-run fixed factor there are three: capital, land and the quota on milk production. As can be seen in rows 16 and 17 of Table 4.3, in the short-run the real price of land rises 0.785 per cent and the value of the milk quota rent increases by 767.5 Dk million as a result of the technological improvement in agriculture. These increases absorb much of the benefits of the technological improvement, so that ultimately the real rental on capital (row 15) increases by only 0.060 per cent.¹⁰ Consequently effective labour input (row 9) expands by 0.113 per cent and real GDP (row 7) by 0.076 per cent. The percentage increase in effective labour input is less than the direct impact of the technological improvement, so employment in hours (row 9) falls.

The next effects are second round. In the short-run comparative static closure, real final domestic absorption ($C+I+G$) is fixed. Thus, as indicated in equation (4.1'), the trade balance ($X-M$) must change by an amount equivalent to the change in real GDP (Y). This is achieved by an increase of 0.263 per cent in the volume of exports (row 5) and by a decrease of 0.008 per cent in the volume of imports (row 6). To generate the necessary improvement in the balance of trade, real devaluation of the exchange rate (row 11) is necessary (see equations (4.5') and (4.6')). Real devaluation enhances the competitiveness of Danish import competing and export industries.

Finally, we note that the increase in aggregate export volume depresses the terms of trade (row 12) by 0.058 per cent, consistent with equation (4.8') and an average export elasticity of -5 . This is the main reason why, given a fixed real wage (RW), the real price of labour (RL_L) (row 14) increases (see equation (4.12')). The increase in the real price of labour mitigates some of the initial benefits of the technological improvement (see equations (4.11') and (4.12')), leading to smaller increases in real capital rental, effective employment and real GDP than would otherwise be the case.

¹⁰ In the 1992 database, the total cost of labour is about 512000 Dk million, the total cost of capital is about 245000 Dk million and the total return to land is about 3700 Dk million. Thus, in money terms, the shock is worth about $(0.198/100 \times 512000) = 972$ Dk million. Together, the increased milk quota and the increase in the real price of land absorb about 790 Dk million of the overall benefit. This leaves a gain for capital of around 182 Dk million, or $(100 \times 182/245000) = 0.07$ per cent of the total cost of labour. This is in line with the percentage increase in the real capital rental shown in row 15 of Table 4.4.

TABLE 4.3: Comparative-static Effects of a 10 per cent Improvement in Labour-saving Technological Progress in Agriculture: Projections from Dynamic-AAGE (percentage deviations from base, unless indicated)

Variable		(I)	(II)
		Short-run	Long-run
<i>Macro variables</i>			
1	Real private consumption (C)	0.000	0.209
2	Real investment (I)	0.000	0.040
3	Real public consumption (G)	0.000	0.209
4	Real final domestic absorption (C+I+G)	0.000	0.178
5	Export volume (X)	0.263	0.117
6	Import volume (M)	-0.008	0.103
7	Real GDP (Y)	0.076	0.177
8	Capital stock (K)	0.000	0.097
9	Effective labour input (L/A_L)	0.113	0.190
10	Employment in hours (L)	-0.077	0.000
11	Real devaluation of exchange rate (-RER)	0.043	-0.055
12	Terms of trade (TOT)	-0.058	-0.032
13	Effective real price of labour ($RP_L \times A_L$)	-0.170	-0.088
14	Real price of labour (RP_L)	0.020	0.102
15	Real rental on capital (RP_K)	0.060	0.016
16	Real price of land	0.785	0.845
17	Value of milk quota rent (Dk million)	767.471	496.334
<i>Output for selected industries</i>			
I1	Cereal	0.819	0.897
I2	Oil seeds	0.638	0.246
I3	Potatoes	0.485	0.268
I4	Sugerbeets	0.364	0.108
I5	Roughage	-0.725	-0.575
I6	Meat cattle and milk producers	0.002	0.002
I7	Pigs	0.919	2.393
I8	Poultry	0.295	0.190
I9	Horticulture	1.593	1.244
I17	Slaughtering etc. of cattle	0.919	2.393
I18	Slaughtering etc. of pigs	0.295	0.190
I19	Poultry killing, dressing, packing	1.593	1.244
I30	Manufacture of chemicals	0.021	-0.210
I32	Iron and steel production	0.023	-0.234
I34	Construction	0.012	0.119
I35	Wholesale and retail trade	0.076	0.108
I36	Transport	0.123	0.095
I37	Services	0.029	0.148
I38	Dwellings	0.001	0.212
I39	Producers of government services	0.002	0.208

Effects on industry output

In this simulation, the main influences on industry production are:

- the direct supply-side impacts of the technological improvements;
- input-output linkages;
- real exchange rate depreciation; and
- fixed real final domestic absorption.

The technological improvements generally yield increased output for the agricultural industries, with the largest gains accruing to the industries most exposed to trade. For example, I9 Horticulture, which has the largest increase in output, exports around 40 per cent of its production and faces strong import competition on the local market where imports account for around 35 per cent of overall sales. One agricultural industry, I6 Meat cattle and milk producers, experiences no change in output, while another, I5 Roughage, suffers a substantial output-decline. The main product of the cattle industry is milk, which is held fixed via a quota. The roughage industry sells only to the meat cattle industry. A first guess for the output of roughage would be no change, in line with the output of its only customer. However, in this model industries are able to substitute between primary factors and intermediate inputs. Roughage is produced with a capital- and land-intensive technology. Thus its output price is affected little by the labour-saving technological improvement. In the cattle industry, however, the technological improvement causes a fall in the average price of capital and labour. Consequently, the cattle industry substitutes primary factors for roughage, leading to a fall in roughage production.

Strong input-output linkages to agriculture explain why I17 Cattle-meat products, I18 Pig-meat products and I19 Poultry-meat products experience output gains. The poultry-meat industry is especially labour-intensive which helps to explain why its output responds by more than the other meat producers.

As indicated above, the technological improvement allows most of the agricultural and agriculture-related industries to improve their competitiveness against foreign competition. However, other industries with no connection to agriculture also experience increased competitiveness via depreciation of the real exchange rate. This is the main reason why production expands in industries like I30 Basic chemicals and I32 Iron and steel, both of who are classed as traditional exporters, I36 Transport and I35 Wholesale and retail trade.

Finally, fixed final domestic absorption explains the weak output effects for industries that are largely non-traded and which have close connections to final demand. Good examples of such industries are at the bottom of the table, namely I37 Services, I38 Dwellings and I39 Producers of government services.

4.3.2 Long-run comparative static impacts (column (II) of Table 4.3)

The long-run comparative static effects of improved labour productivity in agriculture are shown in column (II) of Table 4.3.

Macro effects

In a long-run comparative static simulation, technological improvements yield increased real returns to the factors fixed in the long run, namely labour, land and the quota on milk production. The long-run increases in real price of land (row 16) and milk-quota rent (row 17) absorb about half of the overall benefits of the technological improvements. The remaining portion accrues to labour. This amount is worth about 0.085 per cent of the total cost of labour in the 1992 database, which is roughly in line with the final increase in real price of labour (RP_L) shown in row 14. The increase in RP_L combined with the direct effects of the technological improvement leads to a fall of 0.088 per cent in the effective real price of labour ($RP_L \times A_L$) (row 13).

As indicated in equation (4.10'), a fall in the effective real price of labour relative to the real price of capital (RP_K), with employment (L) fixed generates an increase in capital (K). The stylised model suggests that, if RP_K is unchanged, then capital will increase by $(0.198 + 0.6 \times -0.088) = 0.145$ per cent. In the full model, capital (row 8) expands by 0.097 per cent. Part of the difference can be attributed to the fact that RP_K (row 15) increases due to a terms-of-trade (row 12) decline. An increase in the real price of capital relative to the effective real price of labour reduces the economy's capital to labour ratio. The remaining difference can be explained by sectoral effects, which are not captured in our stylised one-sector model. In a multi-sectoral model, the economy-wide ratio of capital to labour is affected not only by changes in the ratio of aggregate factor prices, but also by changes in the sectoral composition of GDP. The capital to labour ratio can fall by changes in the composition of the economy away from capital-intensive industries. This is what happens in this simulation. The crucial industries are the large service industries I34 to I39. The labour-intensive service industries are I34 Construction, I37 Services and I39 Producers of government services. The capital-intensive industries are I36 Transport and I38 Dwellings¹¹. I35 Wholesale and retail trade is fairly neutral. The shift away from capital-intensive industries is associated with a decline in the overall production of industries I36 and I38 relative to GDP and an average increase in the overall production of industries I34, I37 and I39 relative to GDP.

¹¹ The dwellings industry produces housing services from the housing capital stock of the economy.

The increase in effective labour input (row 9) and the increase in capital (row 8) allow an increase in real GDP (row 7) of 0.177 per cent (see equation (4.2')). In the long-run, the components of real final domestic absorption are allowed to respond to improvements in technology. Real private consumption (row 1) and real public consumption (row 3)¹² rise by 0.209 per cent, reflecting the increase in real household disposable income.¹³ Aggregate real investment (row 2) is determined via fixed industry ratios of investment to capital. The increase in aggregate investment is less than the increase in capital (row 8) because of different weights used to compile the two indices: industry costs of investment for aggregate investment; industry capital rentals for aggregate capital. Overall, real domestic absorption (row 4) increases by 0.178 per cent, in line with the increase in real GDP.

With real GDP (Y) and real final domestic absorption (C+I+G) increasing by the same percentage amount, equation (4.1') suggests, that if trade were balanced in the initial 1992 data, then we would see equal percentage changes in the volumes of exports (X) and imports (M). However, initially the trade-balance is in surplus, and so we see that export volume (row 5) increases by 0.117 per cent, a little more than the 0.103 per cent increase in import volume (row 6).

To generate the changes in trade volumes, the real exchange rate (row 11) must appreciate (see equations (4.5') and (4.6')). This is in contrast to the short-run result, where real devaluation was required.¹⁴ In the long-run, real appreciation is required because the initial effects of the shock generate an improvement in the net volume of trade (X-M) greater than allowed for by the movements in Y and in (C+I+G). The real appreciation generally enhances the competitiveness of imports and restricts the competitiveness of exports. Despite

¹² Recall that in the long-run comparative static closure we fix the ratio of real private consumption to real public consumption. In terms of the stylised model, this is equivalent to fixing φ .

¹³ In comparative-static simulations, real household income moves in line with real GDP, while the real collection of income tax moves in line with real labour income. Thus to a reasonable approximation

$$\text{real_hdi} = 1.4 \times \text{real_gdp} - 0.4 \times \text{real_labour},$$

where 1.4 and -0.4 are the ratios of household income and taxes to household disposable income. In this simulation, real GDP (row 7) increases by 0.177 per cent and real labour income (row 14 + row 10) by 0.102 per cent, which suggests an increase in real HDI of 0.21 per cent. This is very close to the final outcome indicated in rows 1 and 3.

¹⁴ The difference between the short-run and long-run results for the real exchange rate seems very large. This suggests that the real exchange rate is an inefficient mechanism for achieving a given trade-balance outcome. One reason for this lies with the large base-period shares of imports in the costs of many traded-goods industries. Hence, real devaluation, which increases the landed-cif prices of imports, tends to raise the costs of production in the traded-goods sector. The increase in import costs weakens the overall beneficial impact of the devaluation on competitiveness. On the other hand, real appreciation tends to reduce import costs, which weakens the overall negative effect of the devaluation on competitiveness.

the real appreciation, exports still increase and so the terms of trade (row 12) decline (see equation 4.8').

Overall, comparing the macro results in column (II) with the macro results in column (I), we see that the technological improvements generally have a more expansionary impact on the economy. Real GDP and the major components of domestic absorption increase by more in the long-run than in the short-run, as does the volume of imports. Exports, however, are stimulated by less in the long run reflecting the long-run real appreciation of the exchange rate (as opposed to the real devaluation in the short-run). In both simulations, the economy's terms of trade decline. This absorbs some of the benefits arising from the technological improvements, as do increases in the price of land and increases in the milk quota rent.

Effects on industry output

Our explanation of the industry results in column (II) of Table 4.3 concentrates on highlighting the main differences between them and the short-run results shown in column (I). These differences arise mainly from:

- increased flexibility of supply for capital-intensive industries in the long-run;
- a less competitive real exchange rate; and
- increased real domestic absorption.

The technological improvements have similar effects on the production of the land-using agricultural industries (I1 to I5) in columns (I) and (II), reflecting similar supply-side conditions. In both simulations, the total supply of land is fixed and the industries retain their relatively high capital/labour substitution elasticities¹⁵. High capital/labour substitution elasticities mean large elasticities of supply, regardless of whether capital is constrained (as in the short-run) or unconstrained (as in the long-run). Under these conditions, most of the variations between columns (I) and (II) in the production of land-using industries will reflect variations in demand. The production of I1 Cereal increases more in column (II) than in (I) because of increased demand from the pig industry (I7), offset somewhat by reduced exports and a fixed level of inventories. Cereal exports are stimulated less in column (II) because of a less competitive exchange rate. The deleterious exchange rate effects also account for the smaller positive impacts on I2 Oilseeds, I3 Potatoes and I4 Sugarbeet. The last two industries face strong foreign competition indirectly via their major downstream cus-

¹⁵ 1.35 for I1 Cereal, 1.24 for I2 Oilseeds, 1.16 for I3 Potatoes, 0.99 for I4 Sugarbeets and 0.73 for I5 Roughage.

tomers I23 Sugar factories and refineries and I25 Bread grain mills and cakes. The output of I5 Roughage depends entirely on demand from I6 Meat cattle and milk producers. Roughage production falls less in column (II) because of a reduced negative substitution effect (see our discussion of the short-run industry effects).

The main customer for I6 Meat cattle and milk producers is the dairy industry (I21). Dairy is a very export-oriented industry, which is stimulated less in column (II) than in column (I) because of the real appreciation. Accordingly, pressure on the primary supply of milk is less in column (II) than in column (I), which accounts for the smaller increase in the quota rent (row 17 of macro results). I6 also produces cattle for meat as a by-product. The reduction in quota rent between columns (II) and (I) means a lower cost of production for meat cattle generally. This, in turn, improves the competitiveness of the beef processing industry I17, allowing its output to rise by more in column (II) than in column (I).

The production of I7 Pigs increases more in column (II) than in column (I). This is despite a smaller increase in production of pig meat (I18). The pig industry is very capital intensive. Thus, its supply schedule is significantly more elastic in the long-run than in the short-run, allowing the pig-meat industry to substitute more towards pig and away from primary factors.

The effects of a less competitive exchange rate in column (II) are seen most clearly in the production of the traditional export industries, I30 Basic chemicals and I32 Iron and steel. In column (I) production of these industries increases slightly. In column (II) production falls. Reduced competitiveness also accounts for the more subdued response from the pig and poultry meat industries (I18 and I19).

The increase in domestic absorption between columns (I) and (II) occurs mainly in private and public consumption. Accordingly, the production of industries with strong connections to consumption increases more in column (II) than in column (I). Good examples are I38 Dwellings and I39 Government services. Investment is also higher in column (II), so we see increased output from the investment industries, especially I34 Construction.

4.3.3 Dynamic policy deviations with static expectations (Charts 4.1 to 4.14)

For the year-to-year policy analysis reported in this section and the next, we introduce the shocks to labour-saving technological change in year 4 of a 30 year simulation. To simplify

results, the basecase projection serving as a control path for the deviation projection has been made as plain as possible. It was produced by setting to zero all of the exogenous variables in the year-to-year forecast closure (see Section 4.1.2), apart from *del_unity* which is set to 1 in all years.¹⁶ For the forward-looking simulation, we required 30 iterations of the basecase simulation before convergence was achieved (see Section 2.1) and 20 iterations of the policy simulation.

The main effects of the labour-saving technological improvements are shown in Charts 4.1 to 4.14. The first eleven charts show, for year 1 to year 30, percentage deviations of the values of a range of macro variables in the policy simulation from their values in the base case forecast. We plot the deviations computed under static expectations and forward-looking expectations, and show the short-run and long-run comparative static deviations for comparison. Thus, for example, Chart 4.1 shows that the technological improvements would decrease employment in year 4 by about 0.06 per cent relative to its basecase forecast value when expectations are static and by about 0.04 per cent when expectations are forward-looking. The short-run comparative static deviation for employment is around 0.08 per cent and the long-run comparative-static deviation is zero per cent. On chart 4.12 we show values for the welfare measures, *EV_OVER* and *CV_UNDER* computed in the static-expectations simulation. The final two charts show, for year 1 to year 30, percentage deviations in industry output from the static-expectations simulation.

Our explanation of the dynamic policy deviations under static expectations follows. It is organised under a series of italicised headings that outline the main findings.

(A) *Imposition of the technological changes immediately reduces employment (Chart 4.1). However, this is only transitory. In the year after the shock, employment expands relative to base and remains above its basecase level for a number of years. As employment increases so does the real wage rate and this puts upward pressure on the economy's capital to labour ratio. Around four years after the shock, the employment deviation begins to fall, and employment steadily moves back towards its basecase level.*

¹⁶ Our basecase is not a balanced-growth path for the economy. In setting *del_unity* to one we set capital growth rates in the simulation for $t=1$ equal to the ratios of investment to capital (after depreciation) in the $t=0$ database (see Section 3.1.1). These ratios vary across industries. Thus, in year 1, even though all exogenous variables other than *del_unity* are set to zero, industries grow at varying rates, reflecting differences in initial conditions. This results in structural change, which continues for about 15 years. By then, most rates of return have settled and industry growth rates in investment and capital have become small. At this point the economy's structure is quite different from its structure in year 0. This must be kept in mind when comparing the long-run dynamic policy simulations with the long-run comparative static results. The latter are based on data for year 0. The former are based on quite different data, reflecting the economy in the forecast simulation many years after year 0.

In the first year of the shock ($t=4$), capital is fixed by investment in $t=3$, and the real wage rate (RW) is sticky. These conditions are similar to those underlying the short-run comparative-static simulation. Thus in $t=4$, employment falls relative to its basecase level, as it falls in the comparative static case. However, the fall is less than in the comparative static simulation. This is because RW is not absolutely fixed. In the labour-market specification for dynamic policy simulations (equation (4.16')) if employment is below (above) its basecase level, labour allows a reduction (demands an increase) in RW. Thus in the first year of the shock, when employment falls relative to base, RW also falls. This means that the real price of labour (RP_L) (see Chart 4.2), increases by less than in the short-run comparative static simulation, which mitigates some of the initial upward pressure on the economy's capital to labour ratio.

After year 4, there is a strong tendency for employment to rise above its basecase level in line with the deviation in capital (see Chart 4.4). Indeed, if there were no further response in the real price of labour, then as indicated in equations (4.11') and (4.10') the deviation in employment would match the deviation in capital. However, as indicated above, in the dynamic policy simulation when employment moves above base the real wage rate also moves above its basecase level. As the real wage rate rises, so does the real price of labour which intensifies the incentive for producers to substitute labour for capital. After a while, the deviation in employment stops increasing and begins to fall. Eventually, about 11 years after the shock, employment returns to its basecase level, leaving the real price of labour stabilised at around 0.09 per cent above base. We note that the long-run deviation in the real wage as computed in the dynamic policy simulation is less than the deviation in the long-run comparative static solution. This is discussed further, below.

- (B) *The technological improvements cause the average rate of return to rise, leading to increased investment (Chart 4.3). Capital (Chart 4.4) follows after a one-year lag. Industry capital stocks then slowly adjust to eliminate the initial disturbances in rates of return. Eventually the deviations in aggregate investment and aggregate capital move towards their long-run comparative-static solutions. At the industry level, rates of capital growth (i.e., ratios of net investment to capital) are related to rates of return via the inverse-logistic mechanism described in Section 3.1.4. Thus as the initial deviations in rates of return are eliminated so too are the initial deviations in the ratios of investment to capital. At the aggregate level, the long-run deviation in real investment (Chart 4.3) is consistent with the long-run comparative static solution. However, the long-run deviation in capital (Chart 4.4) is less, implying a smaller long-run increase in*

the economy's capital to labour ratio. This is consistent with a smaller long-run deviation in the real price of labour (Chart 4.2).

A relevant question to ask at this point is why the long-run deviation in capital in the dynamic policy simulation is less than the comparative-static deviation. The answer lies mainly with share effects. In the comparative static simulation:

$$k^{CS} = \sum_{i \in IND} S_i^{t=0} \times k_i^{CS} \quad (B1)$$

where: k^{CS} is the comparative-static deviation in aggregate capital, k_i^{CS} is the comparative-static deviation in capital for industry i and $S_i^{t=0}$ is the average share through the multi-step comparative static computation of industry i in aggregate capital. The initial shares are based on data in the $t=0$ database. In the dynamic policy simulation, the long-run deviation from base in the aggregate capital stock is

$$\text{approximately } \sum_{i \in IND} S_i^{AVE} \times k_i^{DY} \quad (B2)$$

where the superscript AVE denotes the average of values in the policy and forecast simulations. In the forecast simulation, capital growth in agricultural industries and in the agriculture-related industries is greater than in the rest of economy. Accordingly, in the forecast simulation the shares of these industries in aggregate capital increase through time relative to those implied by the $t=0$ data. It follows, therefore, that the technology-shocks, which result in relatively sharp reductions in agricultural capital, lead to a more subdued outcome for aggregate capital in the dynamic policy simulation than in the comparative-static simulation.

- (C) *In line with the deviations in factor inputs and the direct cost-savings arising from the technological change, real GDP (Chart 4.5) increases relative to base. The peak deviation occurs around five years after the shock. Thereafter, reflecting the deviations in capital and labour, the deviation in real GDP declines for a number of years, before stabilising at just over 0.15 per cent.*

In the dynamic policy simulation report here, it is quite straightforward to explain the deviation results for real GDP in terms of the deviations results for capital and labour and the once-off benefits from the technological improvements. However, it is not al-

¹⁷ Equation (B2) is an approximation because it ignores the type of compositional effects discussed in point (C).

ways this easy. Often we need to decompose the GDP result into its components. Dixon and Rimmer (2000) provide a detailed decomposition of GDP works. This work shows that deviations in real GDP depend not only on deviations in quantity variables (labour, capital, tax-carrying commodity flows, etc.) but also differences between forecast and policy simulations in the composition of GDP. If the policy in question increases the shares in GDP of slow-growing quantity variables relative to the shares of fast-growing quantity variables then this will cause real GDP growth to be reduced in the policy relative to the forecast. Similar phenomena affect the measurement of other macro indices. For example, the path of real consumption in a policy simulation can deviate from its forecast path not only because of deviations in quantities consumed of each commodity but also because of deviations in budget shares.

- (D) *The increase in real GDP is accompanied by a similar, though larger increase in real private consumption (Chart 4.6).* Deviations in real private consumption reflect deviations in real household disposable income (HDI). As in the comparative-static long-run simulation (see footnote 13), the dynamic policy deviations in real household disposable income tend to exceed the deviations in real GDP, leading to larger deviations in consumption than in real GDP (compare Chart 4.6 with Chart 4.5).
- (E) *Real public consumption is stimulated less than real private consumption.* In each year, real public consumption deviates from base to ensure that the ratio of the government budget deficit to GDP does not change from its basecase level. Government revenue is dominated by tax collections on labour income. In this simulation, the deviation from base in real labour income ($RP_L \times L$) (Charts 1 and 2) is generally less than the deviation in real GDP (Chart 4.5). Accordingly, the deviation in real public consumption is also generally less the deviation in real GDP.
- (F) *In each year, the increase in real GDP (Chart 4.5) exceeds the increase in real gross domestic absorption (C+I+G) (Chart 4.7), allowing the net volume of trade (X-M) to move towards surplus relative to base.* The deviations in real gross domestic absorption in the dynamic simulation are smaller than in the comparative-static simulation, reflecting the more subdued behaviour of public consumption. Consequently, the net volume of trade improves by more relative to base in each year of the dynamic policy simulation, with larger deviations in exports (Chart 4.8) and generally smaller deviations in imports (Chart 4.9). Because investment is import-intensive, the surge in investment immediately following the imposition of the shocks causes imports to increase relative to base by more than in the long-run comparative static simulation.

However, as the deviations in investment moderate, so too do the deviations in imports.

- (G) *The real exchange rate (Chart 4.10) appreciates relative to base when the technology shocks first occur. Thereafter, the deviations narrow and then stabilise. In the long-run, the exchange rate is more competitive than in the long-run comparative static solution. The immediate appreciation relative to base is required to prevent the trade-balance from moving too far into surplus as a result of the direct stimulus to exports and import-competing activity arising from the shock. The real exchange rate settles at a more competitive position than in the long-run comparative static case because of the need to maintain a stronger balance of trade (see point F).*
- (H) *The deviations in terms-of-trade (Chart 4.11) are a mirror image of the deviations in export volume (Chart 4.8). As would be expected from equation (4.8'), as exports rise relative to base, so the terms-of-trade fall relative to base. As the deviations in exports stabilise so do the deviations in the terms-of-trade. In the long-run, the deviations in exports stabilise at above the long-run comparative static solution. However, the deviations in the terms-of-trade settle on the comparative static solution. This reflects differences in the shares used to construct the terms of trade index in the two simulations (see point (B)).*
- (I) *Our two welfare measures CV_UNDER and EV_OVER (Chart 4.12) (see Section 3.1.13) indicate welfare improvements consistent with those indicated by the deviations in private consumption (Chart 4.6).*
- (J) *The deviations in output paths for industries (Charts 4.13 and 4.14) are very similar to the long-run comparative static deviations shown in column (II) of Table 4.3. The main winners from the technological improvements are I7 Pigs, I9 Horticulture, I17 Cattle-meat and I19 Poultry-meat. The main losers are I5 Roughage, I30 Basic chemicals and I32 Iron and steel.*

4.3.3 Dynamic policy deviations with forward-looking expectations (Charts 4.1 to 4.11)

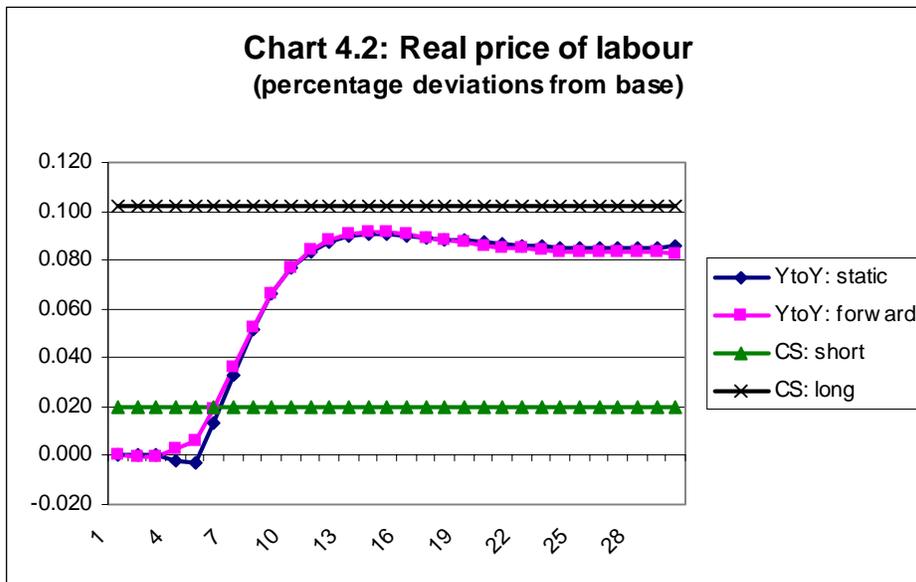
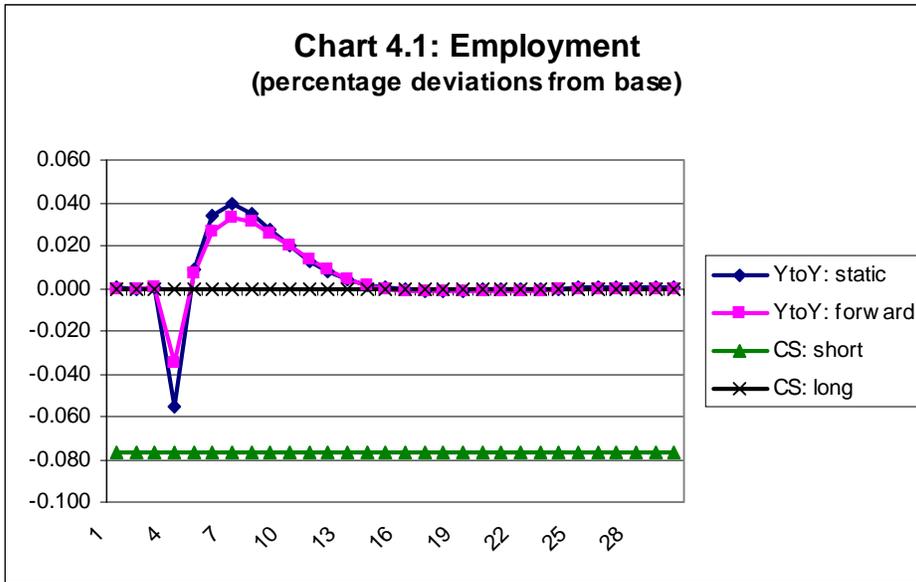
The effects of the technological improvements computed with forward-looking expectations are very similar to those computed with static expectations. This reflects the nature of the shock: once off and without announcement. Under these conditions, imposing one-year

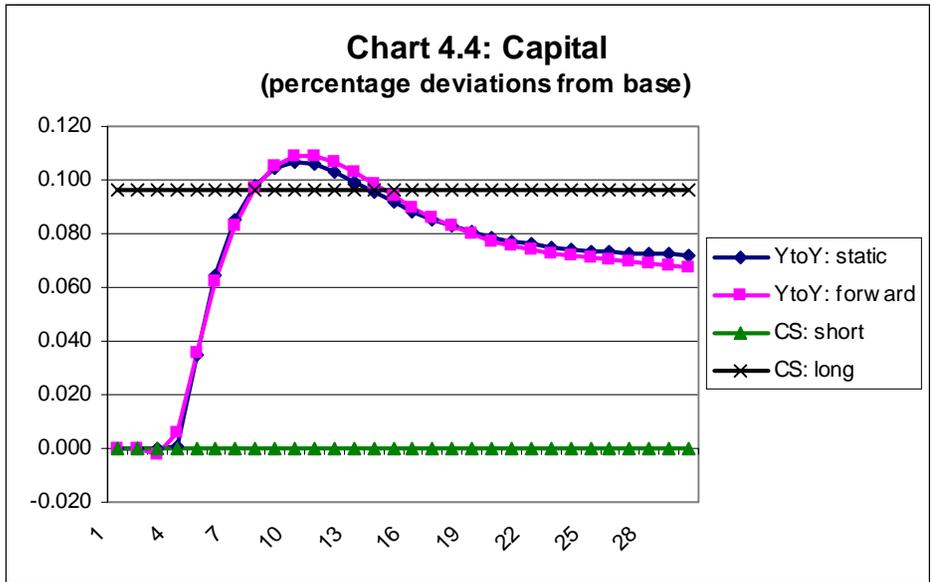
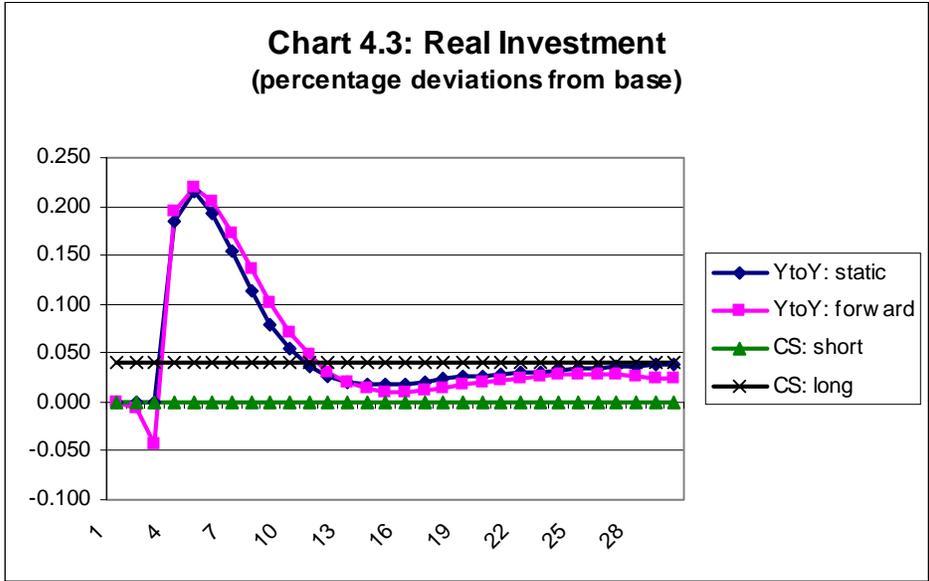
ahead model-consistent expectations as opposed to static expectations should have little effect in the long-run and only mild effects in the short-run. It is re-assuring to note from the charts that the medium-term effects are also small, indicating that forward-looking expectations in this model do not lead, necessarily, to extraneous cycling effects.

The most significant differences between the two sets of dynamic deviations are for investment (Chart 4.3). With static expectations, there can be no pre-shock effects. However, this is not a condition with forward-looking expectations. In the forward-looking simulation, we find that in the year prior to the shock (year 3), investment falls relative to base by about 0.05 per cent.¹⁸ The reason for this is as follows. With forward-looking expectations, investment in year 3 is determined by expected rates of return which reflect model-outcomes for capital rentals and the price of investment in year 4 relative to the price of investment in year 3 (see equation (3.7)). As indicated in point (B) in Section 4.3.2, the shocks cause capital rentals in year 4 to rise. They also cause the price of investment to fall. This is because investment is import intensive, and with the real appreciation of the exchange rate (Chart 4.10), the price of investment falls along with the general price of imports. From the point of view of the forward-looking investor in year 3, the fall in investment-price in year 4 represents a capital loss on investment undertaken in year 3. This capital loss more than outweighs the income gain from increased capital rentals, leading in year 3 to falls in expected rates of return. These falls account for the decline in aggregate investment in that year.

In year 4, the forward-looking investor forms expectations about rates of return based on correctly perceived values for capital rentals and the price of investment in year 5 relative to the price of investment in year 4. The fall in investment-price in year 4 means that expected rates of return in year 4 rise by more than in the static-expectations simulation. Accordingly, investment in year 4 increases by slightly more. Thereafter, there are only small differences in the deviations in expected rates of return between both dynamic simulations, leading to similar results for aggregate investment.

¹⁸ As a consequence, investment and other variables adjust in year 2 and hence in year 1. However, the effects in these years are negligible.





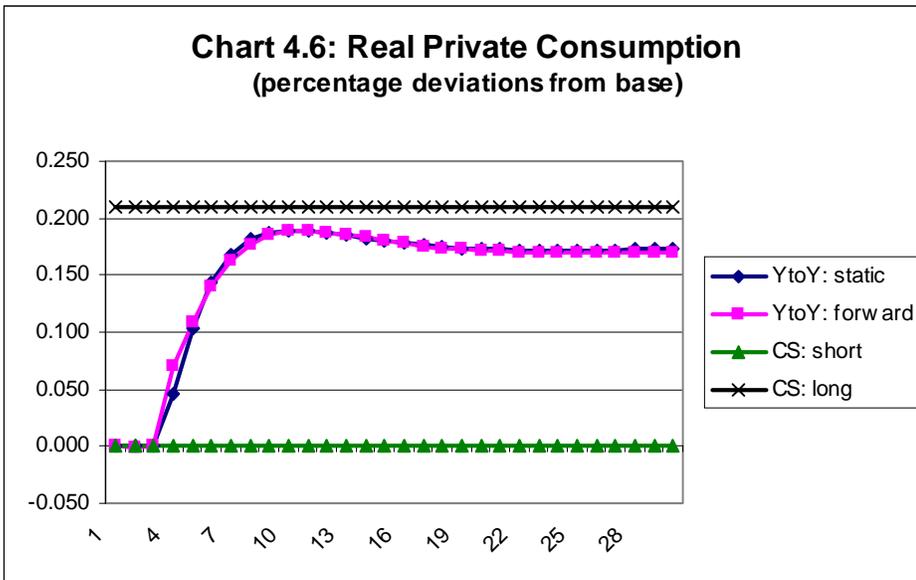
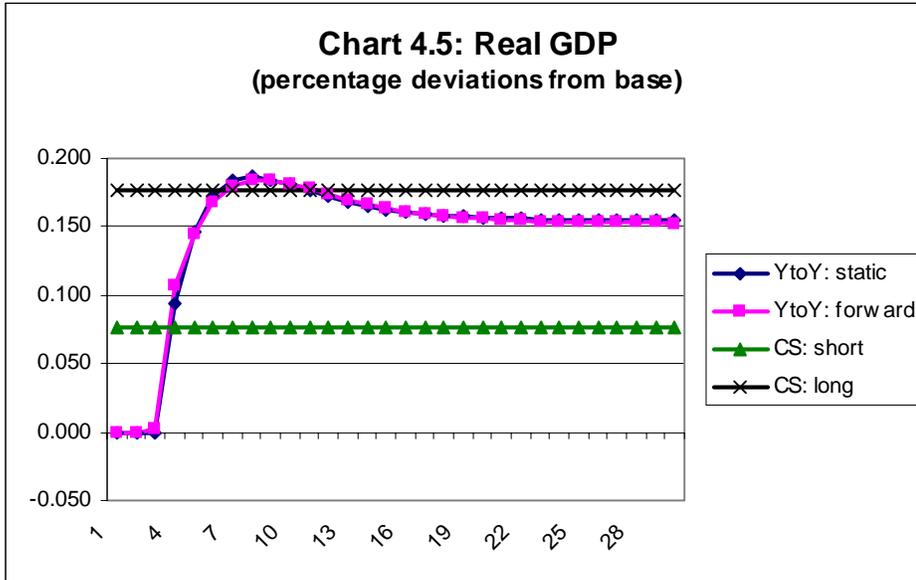


Chart 4.7: Real final domestic absorption
(percentage deviations from base)

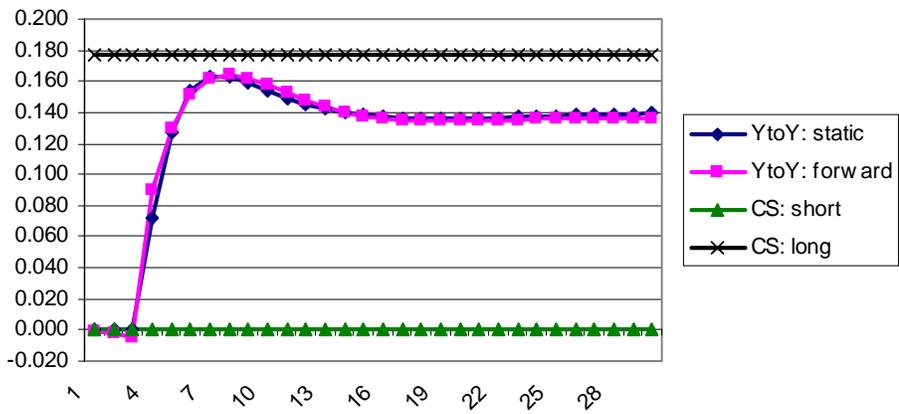
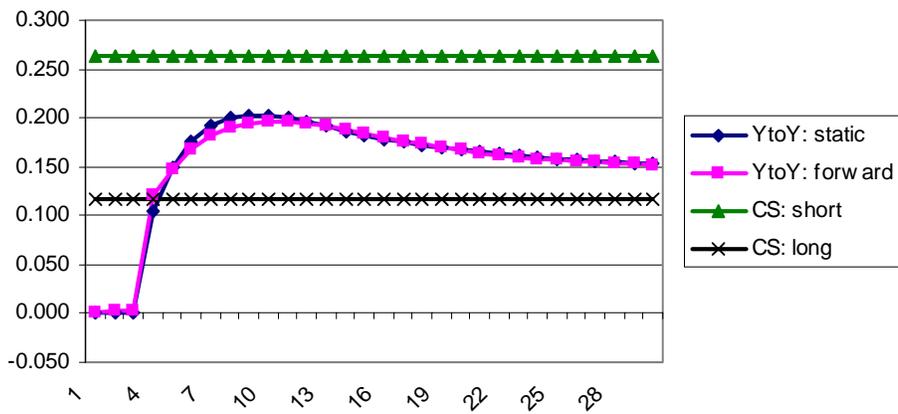
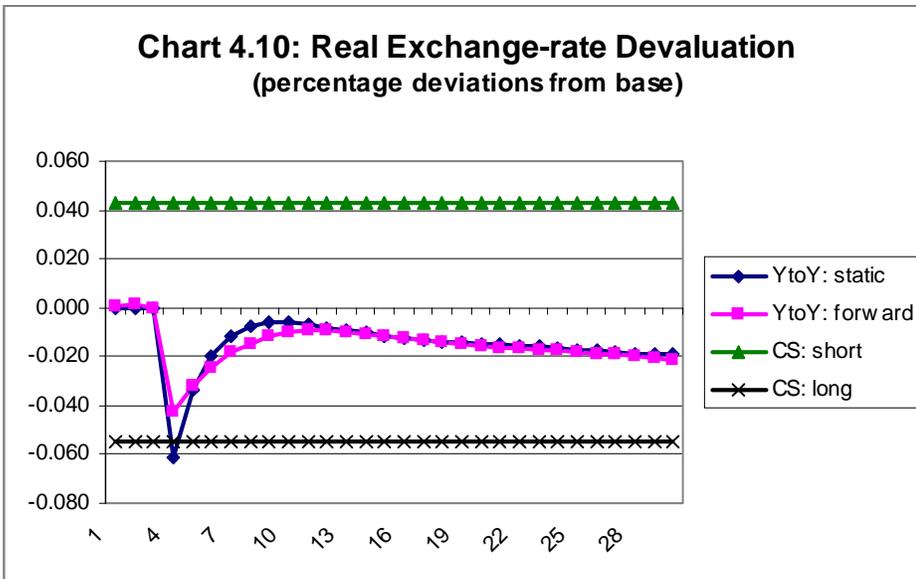
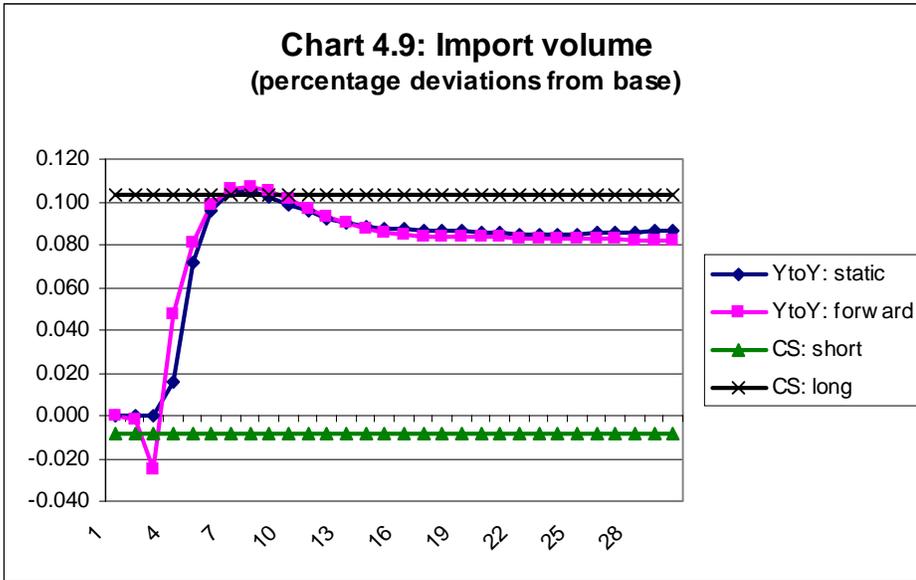
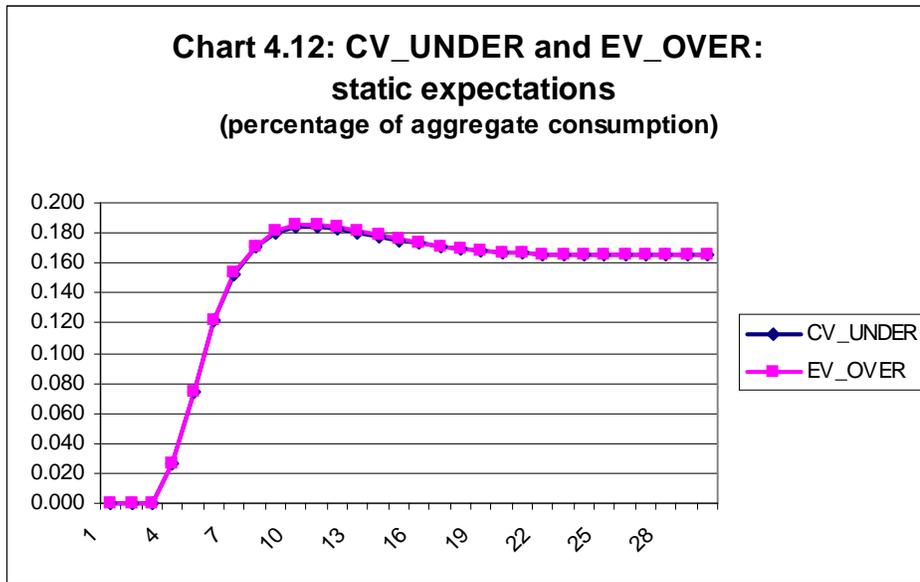
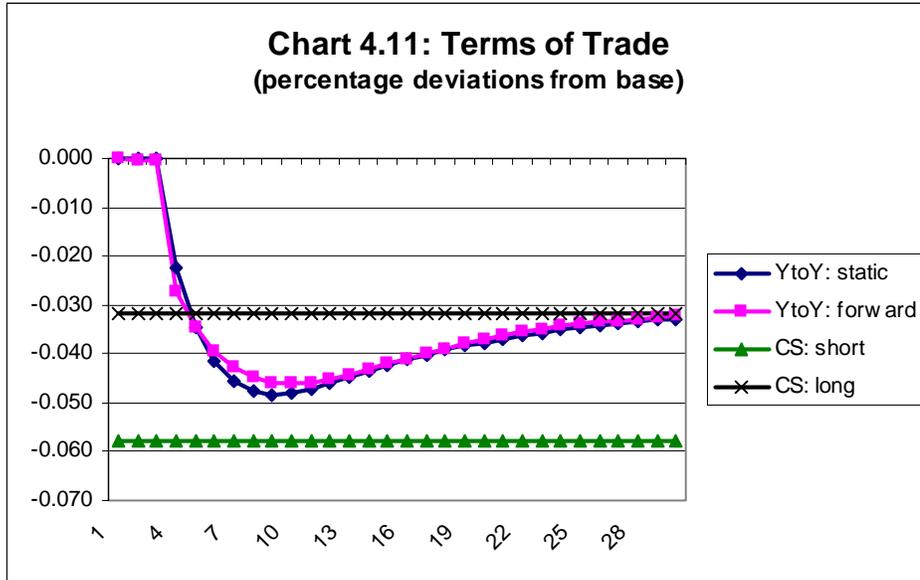
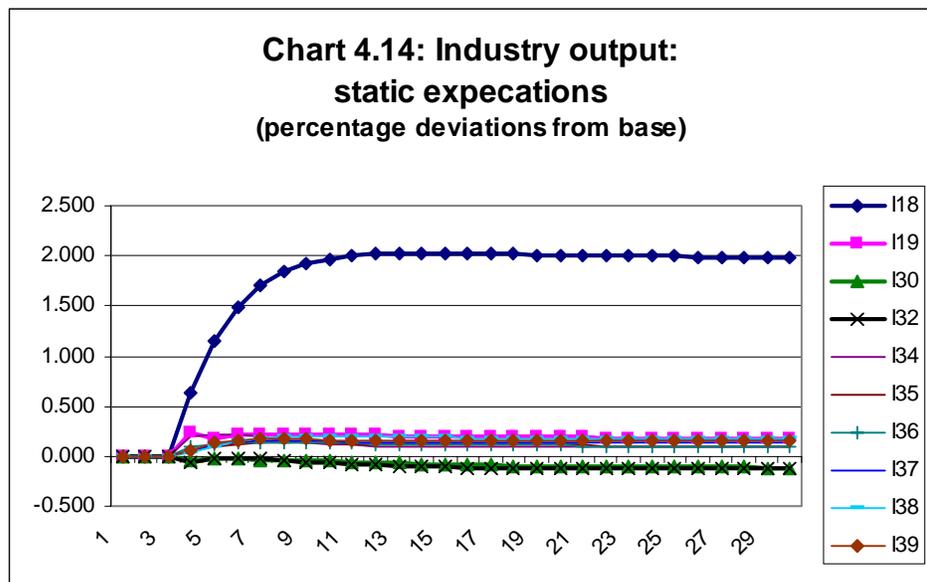
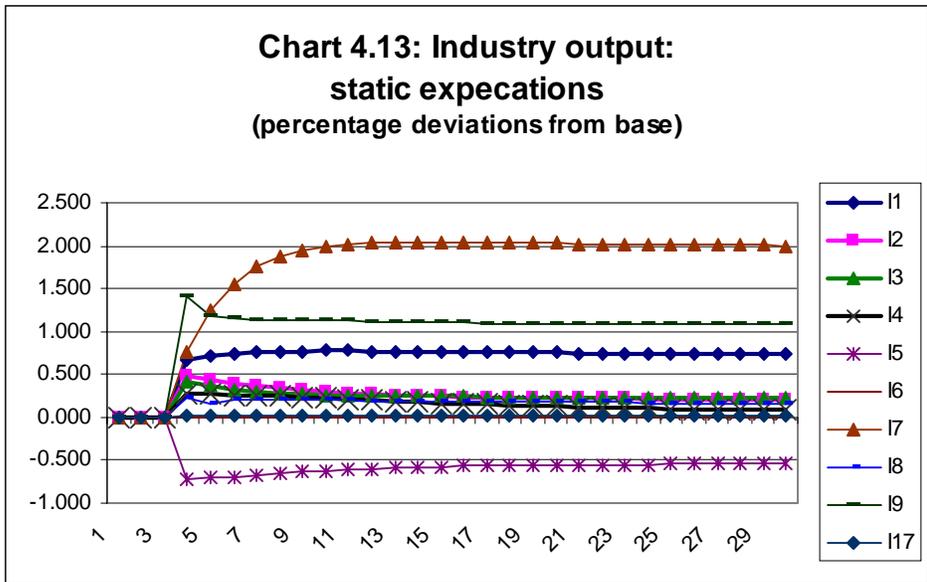


Chart 4.8: Export volume
(percentage deviations from base)









5 Final comments

We began this report with a general overview of the advances in Dynamic-AAGE: dynamics, macroeconomics and increased closure flexibility. Then, we described in detail the new code that transforms AAGE into Dynamic-AAGE. In Section 4, we provided details of model closure, developed a stylised model for explaining results, and reported four simulations of the full model. The simulations were designed to illustrate how the model can be used for policy analysis in comparative-static (short-run and long-run) and dynamic year-to-year modes (static and forward-looking expectations). Identical exogenous shocks were imposed in each simulation, namely ten per cent improvements to labour-saving technical progress in agricultural industries.

We think that the simulation results show clearly the value for policy analysis of the advances embodied in the new model. At the very least, these advances allow the effects of a shock to be traced through real time. But they do more than that. Keep in mind that the simulations reported in Section 4 were set up in a way that minimised the influence of some of the dynamic mechanisms: the shock was once-off and without notice, and the basecase projection serving as a control path for the deviation projection was made as plain as possible. Nevertheless, the dynamic results offered a richer account of the effects of technological improvements than did the comparative-static simulations. For example:

- with the employment/wage trade-off mechanism in place, the dynamic simulations showed, that while the technological improvements would harm employment in the very short run, in the medium run they led to gains in employment. Over the long-term these gains disappeared, leaving a higher real wage rate.
- with explicit relationships between investment and expected rates of return, and between investment and capital accumulation, the dynamic simulations showed that technological improvements would increase investment immediately, leading to an increase in capital. Over time, the deviations in investment narrow, but do not disappear, and the deviations in capital stabilise below the long-run comparative-static solution.
- with forward-looking investors, investment adjusts before the shock in line with changes in expectations of rates of return.
- with private consumption tied to household disposable income, deviations in private consumption correctly reflect changes in the income accruing to domestic residents.

- with public consumption determined via a constraint on movements in the government deficit, the dynamic results adequately took account of the main domestic financial constraint on the economy.¹⁹

Agenda for further work

This report brings to a conclusion stage 1 of the development of Dynamic–AAGE. There are two major tasks outstanding:

- (a) to complete the task of compiling a database for the model. The tasks here are summarised in Appendix B. The main requirements are for initial data on investment/capital ratios and rates of return, and initial macro data for the consolidated government accounts, for the household accounts, and for the Balance of Payments.
- (b) to develop a realistic basecase forecast, incorporating forecasts for macroeconomic variables, forecasts for export volumes and prices, forecasts for changes in technological progress and household tastes, and forecasts for changes in tax and subsidy rates.

Also, consideration is warranted of some aspects of the existing static equations and the input/output data. With the equations, we have concerns about the current treatment of exports, margins, sales taxes and “special imports”. With the data, a more disaggregated database is required, especially in the service sector. Around 75 per cent of value added is generated by service industries, yet the current database recognises only six service industries and commodities (see Table 4.1).

¹⁹ The economy faces two financial constraints, the need to finance the government deficit, and the need to finance the net stock of foreign liabilities. In the policy closure used for the dynamic simulations reported here, we explicitly account for the first constraint by exogenously fixing the size of the government deficit as a percentage of GDP. To explicitly account for the second constraint we could have adopted a policy closure in which the current account balance as a percentage of GDP was fixed. In doing so we would free up private consumption by making endogenous the average propensity to consumer (APC) out of household disposable income.

Appendix A: The new Tablo code for Dynamic-AAGE

Section 3.1.1: Supply equals demand for capital and capital accumulation

Variable

(All,i,IND)

k1start(i)

Percentage change in capital stock at start of year #;

(All,i,IND)

k1end(i)

Percentage change in capital stock at end of year #;

(change)(All,i,IND)

del_k1grow(i)

Change in capital growth rate between start and end of year #;

(change)(All,i,IND)

del_f_k1start(i)

On/off shifter in equation explaining k1start in year-to-year sims. #;

(change)

del_unity

Dummy variable set to one for year-to-year simulations #;

Coefficient

(All,i,IND)

LR1DEP(i)

Level of the rate of depreciation (number like 0.09) #;

(All,i,IND)

VK1start(i)

Value of the capital stock at start of year #;

(All,i,IND)

QK1start(i)

Quantity of capital at start of year #;

(All,i,IND)

QK1start@1(i)

(initial) Quantity of capital at start of year #;

(All,i,IND)

QK1end(i)

Quantity of capital at end of year #;

(All,i,IND)

LK1GROW(i)

Level of the capital growth rate between start and end of year #;

(All,i,IND)

LP2TOT(i)

Level of the price of a unit of capital in industry i #;

(All,i,IND)

$Q2TOT(i)$

Quantity of investment #;

(All,i,IND)

$Q2TOT@1(i)$

(initial) Quantity of investment #;

Read

$LR1DEP$ from File DYNAM Header "RIDP";

$VK1start$ from File DYNAM Header "VIKS";

$QK1start$ from File DYNAM Header "QIKS";

$LP2TOT$ from File DYNAM Header "PINV";

Update

(All,i,IND)

$VK1start(i) = p2tot(i)*k1start(i);$

(All,i,IND)

$QK1start(i) = k1start(i);$

(All,i,IND)

$LP2TOT(i) = p2tot(i);$

Formula

(Initial)(All,i,IND)

$QK1start@1(i) = QK1start(i) ;$

Formula

(All,i,IND)

$Q2TOT(i) = V2TOT(i)/LP2TOT(i) ;$

Formula

(initial)(All,i,IND)

$Q2TOT@1(i) = Q2TOT(i);$

Formula

(All,i,IND)

$QK1end(i) = Q2TOT(i) + (1-LR1DEP(i))*QK1start(i);$

Formula

(All,i,IND)

$LK1grow(i) = 0.0 + \text{If}(QK1start(i) \text{ ne } 0.0, \{QK1end(i)/QK1start(i) - 1\}) ;$

Equation E_k1start

Supply equals demand for capital

(All,i,IND)

$$k1start(i) = x1cap(i);$$

Equation E_del_f_k1start

Gives shock in yr-to-yr simulations to capital available for production

(All,i,IND)

$$(tiny+QK1start(i))*k1start(i) = 100*\{Q2TOT@1(i) - LR1DEP(i)*QK1start@1(i)\}*del_unity + 100*del_f_k1start(i);$$

Equation E_k1end

Capital available at end of year related to investment in the year

(All,i,IND)

$$(tiny+QK1end(i))*k1end(i) = (1-LR1DEP(i))*QK1start(i)*k1start(i) + (tiny+Q2tot(i))*x2tot(i);$$

Equation E_del_k1grow

Change in capital growth rate between the start and end of the year

(All,i,IND)

$$100*del_k1grow(i) = (LK1grow(i) + 1.0) * (k1end(i) - k1start(i));$$

Section 3.1.2: Actual rates of return under static expectations

Variable

(change)(All,i,IND)

del_ar1cap_se(i)

Change in actual rate of return: static expectations #;

Coefficient

(All,i,IND)

LAR1CAP_SE(i)

Level of the actual rate of return: static expectations #;

(All,i,IND)

LAR1CAP_SE@1(i)

(initial) Level of the actual rate of return: static expectations #;

Formula

(All,i,IND)

LAR1CAP_SE(i) = 0.0

+ IF{VK1start(i) ne 0.0, (VICAP(i)/VK1start(i) - LR1DEP(i))};

Formula

(initial)(All,i,IND)
LARICAP_SE@1(i) = LARICAP_SE(i);

Equation E_p0cap

Change in actual rate of return: static expectations #
(All,i,IND)
100*del_ar1cap_se(i) =
[IF{VK1start(i) ne 0.0,
VICAP(i)/VK1start(i)}] * (p0cap(i) - p2tot(i));

Section 3.1.3: Expected rates of return under forward-looking expectations

Set TIME # The sequence {T0,T1,T2, ...,T30} identifying time #
*(T0,T1,T2,T3,T4,T5,T6,T7,T8,T9,T10,T11,T12,T13,T14,T15,T16,T17,
T18,T19,T20,T21,T22,T23,T24,T25,T26,T27,T28,T29,T30);*

Variable

(change)(All,i,IND)
del_er1cap(i)
Change in expected rate of return on capital in industry i #;
(change)(All,i,IND)
del_ar1cap_l(i)
Change in actual rate of return lagged one year #;
(All,i,IND)
p2tot_l(i)
Percentage change in cost of a unit of capital lagged one year #;
inf_fact_l
Percentage change in inflation factor (one plus inflation rate) lagged #;
cpi_l
Percentage change in consumer price index lagged one year #;
cpi_2l
Percentage change in consumer price index lagged two years #;

(All,i,IND)
f_p2tot_l(i)
On/Off shift variable in E_p2tot_l, useful for homogeneity simulations #;
f_cpi_l
On/Off shift variable in E_cpi_l, useful for homogeneity simulations #;
f_cpi_2l
On/Off shift variable in E_cpi_2l, useful for homogeneity simulations #;

Coefficient

FORWARD

=0 if static expectations or iter. 1 of forward looking; =1 otherwise #;

ITER_NUMBER

Iteration number used when expectations are forward looking #;

ITER_NUM@1

(initial) Iteration number used when expectations are forward looking #;

ITER_ADJUST

Used to adjust the iteration number at the end of the iteration #;

NYEARS

Number of years in simulation #;

YEAR

Year of the solution: =1 in first solution year; =NYEARS in final year #;

YEAR@1

(initial) Year of the solution #;

(All,t,TIME)

DUM_TIME(t)

Equals 1 if t=YEAR, 0 otherwise #;

(All,t,TIME)

DUM_TIME_L(t)

Equals 1 if t=YEAR-1 or if t=NYEARS, else 0 #;

(All,t,TIME)

COEFF_TIME(t)

Vector of consecutive numbers 0,1,2,.....,NYEARS #;

(All,i,IND)(All,t,TIME)

MLARICAP(i,t)

Matrix for transfer of data for ARICAP between successive iterations #;

(All,i,IND)(All,t,TIME)

MLARICAP@1(i,t)

(initial) Matrix for transfer of data for ARICAP between iterations #;

(All,i,IND)(All,t,TIME)

MLERICAP(i,t)

Matrix for transfer of data for ERICAP between successive iterations #;

(All,i,IND)(All,t,TIME)

MLERICAP@1(i,t)

(initial) Matrix for transfer of data for ERICAP between iterations #;

(All,i,IND)

MLARI_T@1(i)

(initial) Column of MLARICAP corresponding to solution year t = YEAR #;

(All,i,IND)

MLARI_T_L@1(i)

(initial) Column of MLARICAP corresponding to solution year t = YEAR-1 #;

(All,i,IND)

MLER1_T@1(i)

*# (initial) Column of MLER1CAP corresponding to solution year t = YEAR #;
(All,i,IND)*

MLER1_T_L@1(i)

*# (initial) Column of MLER1CAP corresponding to solution year t = YEAR-1 #;
(All,i,IND)*

LER1_IT@1(i)

*# (initial) Expected ROR on capital in current iteration for t = YEAR #;
(All,i,IND)*

LER1_IT_L@1(i)

*# (initial) Expected ROR on capital in current iteration for t = YEAR-1 #;
(All,i,IND)*

LAR1CAP_L(i)

*# Level of the actual rate of return in current iteration for t = YEAR-1 #;
(All,i,IND)*

LAR1CAP_L@1(i)

*# (initial) Level of the actual ROR in current iteration for t = YEAR-1 #;
(All,i,IND)*

ADJUST_EXP(i)

*# Parameter set between 0 and 1; controls adjustment of expected ROR #;
(All,i,IND)*

LP0CAP(i)

*# Level of the rental on capital received by producers #;
(All,i,IND)*

LP2TOT@1(i)

*#(initial) Level of the price of a unit of capital #;
(All,i,IND)*

LP2TOT_L(i)

*# Level of the price of a unit of capital lagged one year #;
(All,i,IND)*

LP2TOT_L@1(i)

(initial) Level of the price of a unit of capital lagged one year #;

LINF_FACT_L

Level of the inflation factor (1+inflation rate) lagged one year #;

LCPI

Level of the Consumer price index #;

LCPI@1

(initial) Level of the Consumer price index #;

LCPI_L

Level of the Consumer price index lagged one year #;

LCPI_L@1

(initial) Level of the Consumer price index lagged one year #;

LCPI_2L

Level of the Consumer price index lagged two years #;

LCPI_2L@1

(initial) Level of the Consumer price index lagged two years #;

Read

ITER_NUMBER from file *ACTROR* header *"ITNO"*;

MLARICAP from file *ACTROR* header *"ARIC"*;

MLERICAP from file *ACTROR* header *"ERIC"*;

YEAR from file *DYNAM* header *"YEAR"*;

NYEARS from file *DYNAM* header *"NYER"*;

COEFF_TIME from file *DYNAM* header *"COET"*;

ADJUST_EXP from file *DYNAM* header *"ADJE"*;

LP2TOT_L from file *DYNAM* header *"LP2L"*;

LCPI from file *DYNAM* header *"LCPI"*;

LCPI_L from file *DYNAM* header *"LCPL"*;

LCPI_2L from file *DYNAM* header *"LC2L"*;

Formula

(Initial)

ITER_NUM@1 = ITER_NUMBER;

Formula

(Initial)

YEAR@1 = YEAR;

Formula

(Initial)(All,i,IND)(All,t,TIME)

MLARICAP@1(i,t) = MLARICAP(i,t);

Formula

(Initial)(All,i,IND)(All,t,TIME)

MLERICAP@1(i,t) = MLERICAP(i,t);

Formula

(Initial)

FORWARD = 0 + If(ITER_NUM@1 > 1, 1);

Formula

(Initial)

ITER_ADJUST = 0 + If(YEAR@1 >= (NYEARS-0.00001), 1) ;

Formula

(Initial)(All,t,TIME)

$$DUM_TIME(t) = 0 + \text{If}(\text{YEAR}@1 \geq \text{COEFF_TIME}(t) - 0.00001 \\ \text{and } \text{YEAR}@1 \leq \text{COEFF_TIME}(t) + 0.00001, 1);$$

Formula

(Initial)(All,t,TIME)

$$DUM_TIME_L(t) = 0 + \text{If}(\text{YEAR}@1 \geq \text{COEFF_TIME}(t) + 1 - 0.00001 \\ \text{and } \text{YEAR}@1 \leq \text{COEFF_TIME}(t) + 1 + 0.00001, 1);$$

Formula

(Initial)(All,i,IND)

$$MLAR1_T@1(i) = \text{Sum}(t, \text{TIME}, DUM_TIME(t) * MLAR1CAP@1(i,t));$$

Formula

(Initial)(All,i,IND)

$$MLAR1_T_L@1(i) = \text{Sum}(t, \text{TIME}, DUM_TIME_L(t) * MLAR1CAP@1(i,t));$$

Formula

(Initial)(All,i,IND)

$$MLER1_T@1(i) = \text{Sum}(t, \text{TIME}, DUM_TIME(t) * MLER1CAP@1(i,t));$$

Formula

(Initial)(All,i,IND)

$$MLER1_T_L@1(i) = \text{Sum}(t, \text{TIME}, DUM_TIME_L(t) * MLER1CAP@1(i,t));$$

Formula

(Initial)(All,i,IND)

$$\begin{aligned} LER1_IT@1(i) = \\ & \text{IF}(\text{ITER_NUM}@1 = 1, \\ & \quad 0) \\ & + \text{IF}(\text{ITER_NUM}@1 = 2, \\ & \quad \{(1-\text{ADJUST_EXP}(i))*MLER1_T@1(i)+\text{ADJUST_EXP}(i)*MLAR1_T@1(i)\}) \\ & + \text{IF}(\text{ITER_NUM}@1 > 2, \\ & \quad \{1- \\ & \quad (0.5*\text{ADJUST_EXP}(i))*MLER1_T@1(i)+(0.5*\text{ADJUST_EXP}(i))*MLAR1_T@1(i)\}); \end{aligned}$$

Formula

(Initial)(All,i,IND)

$$\begin{aligned} LER1_IT_L@1(i) = \\ & \text{IF}(\text{ITER_NUM}@1 = 1, \\ & \quad 0) \\ & + \text{IF}(\text{ITER_NUM}@1 = 2, \\ & \quad \{(1-\text{ADJUST_EXP}(i))*MLER1_T_L@1(i)+\text{ADJUST_EXP}(i)*MLAR1_T_L@1(i)\}) \end{aligned}$$

+ IF(ITER_NUM@1 > 2,
 {1-
(0.5*ADJUST_EXP(i))*MLER1_T_L@1(i)+(0.5*ADJUST_EXP(i))*MLAR1_T_L@1(i)});

Formula

(All,i,IND)

LP0CAP(i) = VICAP(i)/QK1start(i);

Formula

(Initial)(All,i,IND)

LP2TOT@1(i) = LP2TOT(i);

Formula

(Initial)(All,i,IND)

LP2TOT_1@1(i) = LP2TOT_1(i);

Formula

(Initial)

LCPI@1 = LCPI;

Formula

(Initial)

LCPI_L@1 = LCPI_L;

Formula

(Initial)

LCPI_2L@1 = LCPI_2L;

Formula

LINF_FACT_L = LCPI_L/LCPI_2L;

Formula

(All,i,IND)

LARICAP_L(i) = -1+[LP0CAP(i)+LP2TOT(i)*(1-
LR1DEP(i))]/(LP2TOT_L(i)*LINF_FACT_L);

Formula

(Initial)(All,i,IND)

LARICAP_L@1(i) = LARICAP_L(i);

Update

(change)

ITER_NUMBER = ITER_ADJUST * del_unity;

(change)

$YEAR = del_unity;$

(change)(All,i,IND)(All,t,TIME)

$MLARICAP(i,t) =$

$If(DUM_TIME_L(t) \neq 0,$

$del_ar1cap_l(i) + (LARICAP_L@1(i) - MLAR1_T_L@1(i)) * del_unity)$

$+ If(YEAR@1 \geq (NYEARS - 0.00001) \text{ and } DUM_TIME(t) \neq 0,$

$2 * del_ar1cap_l(i) + (LARICAP_L@1(i) - MLAR1_T@1(i)) * del_unity);$

(change)(All,i,IND)(All,t,TIME)

$MLERICAP(i,t) =$

$(1 - FORWARD) * \{$

$IF(DUM_TIME_L(t) \neq 0, (LARICAP_SE@1(i) - MLER1_T_L@1(i)) * del_unity)$

$+ If(YEAR@1 \geq (NYEARS - 0.00001) \text{ and } DUM_TIME(t) \neq 0,$

$del_ar1cap_se(i) + (LARICAP_SE@1(i) - MLER1_T@1(i)) * del_unity)\}$

$+$

$FORWARD * \{$

$If(DUM_TIME_L(t) \neq 0, (LER1_IT_L@1(i) - MLER1_T_L@1(i)) * del_unity)$

$+ If(YEAR@1 \geq (NYEARS - 0.00001) \text{ and } DUM_TIME(t) \neq 0,$

$(LER1_IT@1(i) - MLER1_T@1(i)) * del_unity)\};$

(All,i,IND)

$LP2TOT_l(i) = p2tot_l(i);$

$LCPI = p3tot;$

$LCPI_L = cpi_l;$

$LCPI_2L = cpi_2l;$

Equation E_del_er1cap

Change in expected ROR: Forward = 1 after iter. 1 of forward-looking

(All,i,IND)

$del_er1cap(i) = (1 - FORWARD) * del_ar1cap_se(i)$

$+ FORWARD * (LER1_IT@1(i) - LER1_IT_L@1(i)) * del_unity;$

Equation $E_del_ar1cap_l$

Change in actual rate of return lagged one year

(All,i,IND)

$(100 * LP2TOT_L(i) * LINF_FACT_L) * del_ar1cap_l(i) =$

$LP0CAP(i) * p0cap(i) + LP2TOT(i) * (1 - LR1DEP(i)) * p2tot(i)$

$- [LP0CAP(i) + LP2TOT(i) * (1 - LR1DEP(i))] * (p2tot_l(i) + inf_fact_l);$

Equation E_p2tot_l

Percentage change in price of a unit of capital lagged one year #
(All,i,IND)

$$LP2TOT_L(i)/100*(p2tot_l(i)-f_p2tot_l(i)) = (LP2TOT@1(i)-LP2TOT_L@1(i))*del_unity ;$$

Equation E_inf_factor_l

Percentage change in Inflation factor lagged one year

$$inf_fact_l = cpi_l - cpi_2l;$$

Equation E_cpi_l

Percentage change in Consumer price index lagged one year

$$LCPI_L/100*(cpi_l-f_cpi_l) = (LCPI@1-LCPI_L@1)*del_unity ;$$

Equation E_cpi_2l

Percentage change in Consumer price index lagged two years

$$LCPI_2L/100*(cpi_2l-f_cpi_2l) = (LCPI_L@1-LCPI_2L@1)*del_unity ;$$

Section 3.1.4: Relationship between capital growth and expected ROR

Variable

(change)(All,i,IND)

del_eer1cap(i)

Change in expected equilibrium rate of return on capital in industry i #;

(change)(All,i,IND)

del_edr1cap(i)

Change in disequilibrium in expected rate of return on capital in i #;

(change)

del_f_eer1cap_i

Change in the scalar shifter, EER1CAP/LK1GROW relationship #;

(change)(All,i,IND)

del_f_eer1cap(i)

Change in the vector shifter, EER1CAP/LK1GROW relationship #;

Coefficient

(All,i,IND)

ADJ_COEFF(i)

Speed of adjustment of disequilibrium in expected ROR to zero #;

(All,i,IND)

CAP_SLOPE(i)

Overall sensitivity of capital growth to changes in LEER1CAP #;

MURF_SLOPE

Macro-model sensitivity of capital growth to changes in LEER1CAP #;

DIFF

Maximum capital growth rate above the normal rate of capital growth #;
(All,i,IND)

LEERICAP(i)

Level of the expected equilibrium rate of return on capital in i #;
(All,i,IND)

LEDRICAP(i)

Level of the disequilibrium in expected rate of return on capital in i #;

F_EERICAP_I

Level of the scalar shifter, EERICAP/LKIGROW relationship #;
(All,i,IND)

F_EERICAP(i)

Level of the vector shifter, EERICAP/LKIGROW relationship #;
(All,i,IND)

LK1grow_MAX(i)

Maximum possible capital growth rate in industry i #;
(All,i,IND)

LK1grow_MIN(i)

Minimum possible capital growth rate in industry i #;
(All,i,IND)

LK1grow_norm(i)

Trend rate of growth in capital in industry i#;
(All,i,IND)

LRICAP_norm(i)

Normal rate of return in industry i, given as data #;

Read

ADJ_COEFF from file DYNAM Header "ADJC";
MURF_SLOPE from file DYNAM Header "MURF";
DIFF from file DYNAM Header "DIFF";
F_EERICAP_I from file DYNAM Header "FEEI";
F_EERICAP from file DYNAM Header "FEER";
LRICAP_norm from file DYNAM Header "RORN";
LK1grow_norm from file DYNAM Header "TRND";

Update

(change)

F_EERICAP_I = del_f_eer1cap_i;
(change)(All,i,IND)

F_EERICAP(i) = del_f_eer1cap(i);

Formula

(Initial)(All,i,IND)

LKIGROW_min(i) = - LR1DEP(i);

Formula

(Initial)(All,i,IND)

$$LKIGROW_max(i) = LKIGROW_norm(i) + DIFF + If(QK1start(i) \leq 0.00001, 1.0);$$

Formula

(Initial)(All,i,IND)

$$CAP_SLOPE(i) = MURF_SLOPE * (LKIGROW_max(i) - LKIGROW_min(i)) / [(LKIGROW_max(i) - LKIGROW_norm(i)) * (LKIGROW_norm(i) - LKIGROW_min(i))];$$

Formula

(All,i,IND)

$$LKIGROW(i) = LKIGROW(i) + If(LKIGROW_MIN(i) \geq LKIGROW(i), LKIGROW_MIN(i) - LKIGROW(i) + 0.005) + If(LKIGROW_MAX(i) \leq LKIGROW(i), LKIGROW_MAX(i) - LKIGROW(i) - 0.005);$$

Formula

(All,i,IND)

$$LEERICAP(i) = LRICAP_NORM(i) + F_EERICAP_I + F_EERICAP(i) + (1/CAP_SLOPE(i)) * \{ [Loge(LKIGROW(i) - LKIGROW_MIN(i)) - Loge(LKIGROW_MAX(i) - LKIGROW(i))] - [Loge(LKIGROW_NORM(i) - LKIGROW_MIN(i)) - Loge(LKIGROW_MAX(i) - LKIGROW_NORM(i))] \};$$

Formula

(Initial)(All,i,IND)

$$LEDRICAP(i) = \{(1 - FORWARD) * LARICAP_SE@1(i) + FORWARD * LERI_IT_L@1(i)\} - LEERICAP(i);$$

Equation E_del_eer1cap

Expected ror equals expected equilibrium ror plus expected diseq. ror

(All,i,IND)

$$del_edr1cap(i) = del_er1cap(i) - del_eer1cap(i);$$

Equation E_del_f_eer1cap

Expected equilibrium rate of return

(All,i,IND)

$$del_eer1cap(i) = del_f_eer1cap_i + del_f_eer1cap(i) + 1/CAP_SLOPE(i) * [1/(LKIGROW(i) - LKIGROW_MIN(i)) + 1/(LKIGROW_MAX(i) - LKIGROW(i))] * del_k1grow(i);$$

Equation E_del_edr1cap

Gives shocks to disequilibrium in expected ror, moves them towards zero #
(All,i,IND)

$$del_edr1cap(i) = - ADJ_COEFF(i)*LEDRICAP(i)*del_unity ;$$

Section 3.1.5 Real domestic absorption and ratios of components of GDP

Variable

x0da

Percentage change in real gross domestic absorption (GDA) (GDP-(X-M)) #;

r_x3_x5

Percentage change real private consumption/real government consumption #;

r_x3_x0da

Percentage change in real private consumption/real GDA #;

r_x2_x0da

Percentage change in real investment/real GDA #;

r_x5_x0da

Percentage change in real public consumption/real GDA #;

r_w3_w0gdp

Percentage change in nominal private consumption/nominal GDP #;

Equation E_x0da

Percentage change in real gross domestic absorption (GDA) (=GDP-(X-M)) #
$$(V0GDPEXP-V4TOT+V0CIF_C+V0NCM)*x0da =$$
$$V3TOT*x3tot + V2TOT_I*x2tot_i + V5TOT*x5tot + V6TOT*x6tot ;$$

Equation E_r_x3_x5

Percentage change real private consumption/real government consumption

$$r_x3_x5 = x3tot - x5tot;$$

Equation E_r_x3_x0da

Percentage change in real private consumption/real GDA

$$r_x3_x0da = x3tot - x0da;$$

Equation E_r_x2_x0da

Percentage change in real investment/real GDA

$$r_x2_x0da = x2tot_i - x0da;$$

Equation E_r_x5_x0da

Percentage change in real public consumption/real GDA

$$r_x5_x0da = x5tot - x0da;$$

Equation $E_{r_w3_w0gdp}$

Percentage change in nominal private consumption/nominal GDP
 $r_{w3_w0gdp} = w3_{tot} - w0gdpinc;$

Section 3.1.6: Balance of payments and accumulation of foreign liabilities

Variable

(change)

del_tab

Change in balance on trade account #;

(change)

del_iab

Change in balance on income account #;

(change)

del_cab

Change in balance on current account ($del_cap = del_tab + del_inb$) #;

iab_cr

Percentage change in income received from foreigners (credit item) #;

iab_cr_int

Percentage change in inc. received: interest from foreigners (credit) #;

iab_cr_div

Percentage change in inc. received: dividends from foreigners (credit) #;

iab_cr_trn

Percentage change in inc. received: transfers from foreigners (credit) #;

iab_dr

Percentage change in income paid to foreigners (debit item) #;

iab_dr_int

Percentage change in inc. paid: interest to foreigners (debit) #;

iab_dr_div

Percentage change in inc. paid: dividends to foreigners (debit) #;

iab_dr_trn

Percentage change in inc. paid: transfers to foreigners (debit) #;

(change)

$del_flstart$

Change in the stock of foreign liabilities at start of year #;

(change)

$del_f_flstart$

On/Off shifter in equation explaining $del_flstart$ in year-to-year sims. #;

(change)

del_flend

Change in the stock of foreign liabilities at end of year #;

(change)

del_f_flend
On/Off shifter in equation explaining *del_f_flend* in year-to-year sims. #;

flave
Percentage change in the average of the end and start stocks of FL #;
(change)

del_r_cr_int
Percentage change in stock of foreign equity held by Danes/stock FL #;
(change)

del_r_cr_div
Percentage change in stock of foreign debt held by Danes/stock FL #;
(change)

del_r_dr_int
Percentage change in stock of Danish debt held by foreigners/stock FL #;
(change)

del_r_dr_div
Percentage change in stock of Danish equity held by foreigners/stock FL #;

roid
Percentage change in domestic rate of interest #;

roif
Percentage change in foreign rate of interest #;

rodf
Percentage change in foreign rate of dividend payment #;

del_ar1cap_ave
Change in ave. ROR under static expectations on foreign owned equity #;

Coefficient

VIAB_CR_INT
Value of income received: interest from foreigners (credit) #;

VIAB_CR_DIV
Value of income received: dividends from foreigners (credit) #;

VIAB_CR_TRN
Value of income received: transfers from foreigners (credit) #;

VIAB_DR_INT
Value of income paid: interest to foreigners (debit) #;

VIAB_DR_DIV
Value of income paid: dividends to foreigners (debit) #;

VIAB_DR_TRN
Value of income paid: transfers to foreigners (debit) #;

VIAB_CR
Value of income received from foreigners (credit) #;

VIAB_DR
Value of income paid to foreigners (debit) #;

VCAB
Value of the current account balance #;

VCAB@1

(initial) Value of the current account balance #;

VFLstart

Value of the stock of foreign liabilities at start of year #;

VFLend

Value of the stock of foreign liabilities at end of year #;

VFLAVE

Value of the average of the start and end stocks of foreign liabilities #;

LR_CR_INT

Level of the stock of foreign equity held by Danes/stock FL #;

LR_CR_DIV

Level of the stock of foreign debt held by Danes/stock FL #;

LR_DR_INT

Level of the stock of Danish debt held by foreigners/stock FL #;

LR_DR_DIV

Level of the stock of Danish equity held by foreigners/stock FL #;

LARICAP_AVE

Level of ave. ROR under static expectations on foreign owned equity #;

Read

VIAB_CR_INT *from file DYNAM header "INCI";*

VIAB_CR_DIV *from file DYNAM header "INCD";*

VIAB_CR_TRN *from file DYNAM header "INCT";*

VIAB_DR_INT *from file DYNAM header "INDI";*

VIAB_DR_DIV *from file DYNAM header "INDD";*

VIAB_DR_TRN *from file DYNAM header "INDT";*

VFLSTART *from file DYNAM header "VFLS";*

LR_CR_INT *from file DYNAM header "LRCI";*

LR_CR_DIV *from file DYNAM header "LRCD";*

LR_DR_INT *from file DYNAM header "LRDI";*

Update

VIAB_CR_INT = *iab_cr_int;*

VIAB_CR_DIV = *iab_cr_div;*

VIAB_CR_TRN = *iab_cr_trn;*

VIAB_DR_INT = *iab_dr_int;*

VIAB_DR_DIV = *iab_dr_div;*

VIAB_DR_TRN = *iab_dr_trn;*

(change)

VFLstart = *del_flstart;*

(change)

$$LR_CR_INT = del_r_cr_int;$$

(change)

$$LR_CR_DIV = del_r_cr_div;$$

(change)

$$LR_DR_INT = del_r_dr_int;$$

Formula

$$VIAB_CR = VIAB_CR_INT + VIAB_CR_DIV + VIAB_CR_TRN;$$

Formula

$$VIAB_DR = VIAB_DR_INT + VIAB_DR_DIV + VIAB_DR_TRN;$$

Formula

$$VCAB = (V4TOT + VIAB_CR) - (V0IMP_CN + VIAB_DR);$$

Formula (initial)

$$VCAB@1 = VCAB;$$

Formula

$$VFLend = -VCAB + VFLstart;$$

Formula

$$VFLave = 0.5*(VFLend + VFLstart);$$

Formula

$$LR_DR_DIV = 1 + (LR_CR_INT + LR_CR_DIV) - LR_DR_INT;$$

Formula

$$LARICAP_AVE = \text{Sum}(k, IND, VICAP(k)*LARICAP_SE(k))/VICAP_I;$$

Equation E_del_cab

Change in balance on current account

$$del_cab = del_tab + del_iab ;$$

Equation E_del_tab

Change in balance on trade account

$$100*del_tab = V4TOT*w4tot - V0IMP_CN*w0imp_cn;$$

Equation E_del_iab

Change in balance on income account

$$100*del_iab = VIAB_CR*iab_cr - VIAB_DR*iab_dr;$$

Equation E_iab_cr

Percentage change in income received from foreigners (credit item)

$$VIAB_CR*iab_cr =$$

$$VIAB_CR_INT*iab_cr_int + VIAB_CR_DIV*iab_cr_div + VIAB_CR_TRN*iab_cr_trn;$$

Equation E_iab_dr

Percentage change in income paid to foreigners (debit item)

$$VIAB_DR*iab_dr =$$

$$VIAB_DR_INT*iab_dr_int + VIAB_DR_DIV*iab_dr_div + VIAB_DR_TRN*iab_dr_trn;$$

Equation E_iab_cr_int

Percentage change in inc. received: interest from foreigners (credit)

$$iab_cr_int = roif + 100/(tiny+LR_CR_INT)*del_r_cr_int + flave;$$

Equation E_iab_dr_int

Percentage change in inc. paid: interest to foreigners (debit)

$$iab_dr_int = roid + 100/(tiny+LR_DR_INT)*del_r_dr_int + flave;$$

Equation E_iab_cr_div

Percentage change in inc. received: dividends from foreigners (credit)

$$iab_cr_div = rodf + 100/(tiny+LR_CR_DIV)*del_r_cr_div + flave;$$

Equation E_del_ar1cap_ave

Change in ave. ROR under static expectations on foreign owned equity

$$VICAP_I*del_ar1cap_ave = \text{Sum}(k,IND,VICAP(k)*del_ar1cap_se(k));$$

Equation E_iab_dr_div

Percentage change in inc. paid: dividends to foreigners (debit)

$$iab_dr_div = 100/LARICAP_AVE*del_ar1cap_ave \\ + 100/(tiny+LR_DR_DIV)*del_r_dr_div + flave;$$

Equation E_del_f_flstart

Gives shock in year-to-year sims. to flstart

$$del_flstart = -VCAB@1*del_unity + del_f_flstart ;$$

Equation E_del_f_flend

Value of foreign liabilities at end of year related to CAB in the year

$$del_flend = del_flstart - del_cab + del_f_flend;$$

Equation E_flave

Percentage change in the average of the start and end stocks of FL

$$VFLAVE*flave = 100*\{0.5*(del_flstart + del_flend)\} ;$$

Equation *E_del_r_dr_div*

del_r_dr_div = (del_r_cr_int + del_r_cr_div) - del_r_dr_int;

Section 3.1.7: Household income and consumption

Variable

hi

Percentage change in household income #;

hdi

Percentage change in household disposable income #;

hi_gov

Percentage change in total government transfer payments to Danish hous. #;

hi_gov_un

Percentage change in unemployment benefits to Danish households #;

hi_gov_ot

Percentage change in other government transfer payments to Danish hous. #;

hi_tax

Percentage change in the value of income tax collected from households #;

r0wage_tax

Percentage change in average income tax rate applying to household inc. #;

lab_sup

Percentage change in number of people in labour force #;

lab_uem

Percentage change in number of people unemployed #;

lab_rben

Percentage change in average rate of unemployment benefit (money/person) #;

apc

Percentage change in the Average Propensity to Consume (APC) out of HDI #;

Coefficient

VHI

Value of household income #;

VHDI

Value of household disposable income #;

VHI_GOV

Value of total government transfer payments to Danish households #;

VHI_GOV_UN

Value of unemployment benefits accruing to Danish households #;

VHI_GOV_OT

Value of other government transfer payments to Danish households #;

VHI_TAX

Value of income tax collected from households #;

LROWAGE_TAX

Level of the average income tax rate applying to household income #;

QLAB_SUP

Number of people in labour force #;

QLAB_EMP

Number of people employed #;

QLAB_UEM

Number of people unemployed #;

LAPC

Level of the APC out of household disposable income #;

Read

VHI_GOV_UN from file DYNAM header "HDIU";

VHI_GOV_OT from file DYNAM header "HDIO";

LROWAGE_TAX from file DYNAM header "RWTX";

QLAB_SUP from file DYNAM header "LASU";

QLAB_EMP from file DYNAM header "LAEM";

Update

VHI_GOV_UN = *hi_gov_un*;

VHI_GOV_OT = *hi_gov_ot*;

LROWAGE_TAX = *r0wage_tax*;

QLAB_SUP = *lab_sup*;

QLAB_EMP = *employ_i*;

Formula

QLAB_UEM = *QLAB_SUP* - *QLAB_EMP*;

Formula

VHI_GOV = *VHI_GOV_UN* + *VHI_GOV_OT*;

Formula

VHI = {*VILND_I* + *VILAB_IO* + *VICAP_I* + (*VIAB_CR* - *VIAB_DR*) + *VHI_GOV*
+ *Sum(c,COM, Sum(i,IND, MAKETAX(c,i)))*};

Formula

VHDI = (1-*LROWAGE_TAX*)**VHI*;

Formula

VHI_TAX = *LROWAGE_TAX***VHI*;

Formula

LAPC = *V3TOT/VHDI*;

Equation E_lab_uem

Percentage change in number of people unemployed

$$QLAB_UEM*lab_uem = QLAB_SUP*lab_sup - QLAB_EMP*employ_i;$$

Equation E_hi_gov_un

Percentage change in unemployment benefits to Danish households

$$hi_gov_un = lab_rben + lab_uem;$$

Equation E_hi_gov_ot

Percentage change in other government benefits to Danish households

$$hi_gov_ot = w0gdpinc;$$

Equation E_hi_gov

Percentage change in total government benefits to Danish households

$$VHI_GOV*hi_gov = VHI_GOV_UN*hi_gov_un + VHI_GOV_OT*hi_gov_ot;$$

Equation E_hi

Percentage change in household income

$$VHI*hi = VILND_I*w1lnd_i + VILAB_IO*w1lab_io + VICAP_I*w1cap_i \\ + 100*del_iab + VHI_GOV*hi_gov + 100*delmaketax_ci;$$

Equation E_hdi

Percentage change in household disposable income

$$hdi = hi - LR0WAGE_TAX/(1-LR0WAGE_TAX)*r0wage_tax ;$$

Equation E_hi_tax

Percentage change in income taxes collected from households

$$hi_tax = hi + r0wage_tax ;$$

Equation E_apc

Private consumption moves with household disposable income

$$w3tot = apc + hdi;$$

Section 3.1.8: The government accounts and government debt

Variable

(change)(All,i,IND)

del_shr_ginv(i)

Change in the public-owned share (number like 0.1) of capital in i #;

gint

Percentage change in government interest payments #;

gexp

Percentage change in total government expenditure #;

grev

Percentage change in total government revenue #;
(change)

del_gdstart

Change in the stock of government debt at start of year #;
(change)

del_gdend

Change in the stock of government debt at end of year #;
(change)

del_f_gdstart

On/Off shifter in variable explaining del_gdstart in year-to-year sims. #;
(change)

del_f_gdend

On/Off shifter in variable explaining del_gdend in year-to-year sims. #;

gdave

Percentage change in the average of the end and start stocks of GD #;
(change)

del_gbal

Change in government's budget balance = gov_rev less gov_exp #;
(change)

del_rgbal_gdp

Change in ratio of the government's budget balance to GDP #;

Coefficient

(All,i,IND)

LSHR_GINV(i)

Level of the share of capital in industry which is publicly owned #;

VGINT

Value of government interest payments #;

VGEXP

Value of total government expenditure #;

VGREV

Value of total government revenue #;

VGBAL

Value of the government's budget balance = gov_rev less gov_exp #;

VGBAL@1

(initial) Value of the government's budget balance #;

LR_GBAL_GDP

Level of the ratio of the government's budget balance to GDP #;

VGDstart

Value of the stock of government debt at start of year #;

VGDend

Value of the stock of government debt at end of year #;

VGDave

Value of the average of the start and end stocks of government debt #;

Read

*LSHR_GINV from file DYNAM header "LSIG";
VGDSTART from file DYNAM header "VGDS";
VGINT from file DYNAM header "VGIT";*

Update

*(change)(All,i,IND)
LSHR_GINV(i) = del_shr_ginv(i);
(change)
VGDstart = del_gdstart;
VGINT = gint;*

Formula

*VGEXP = V5TOT + Sum(i,IND, LSHR_GINV(i)*V2TOT(i)) + VGINT + VHI_GOV;*

Formula

*VGREV = VHI_TAX + V1OCT_I + V2OCT_I + V3OCT_H + V6OCT + V0TAR_C +
V0TAX_CSI
+ V4TAX_c + VITAXCAP_I + VITAXLND_I;*

Formula

VGBAL = VGREV - VGEXP;

Formula (initial)

VGBAL@1 = VGBAL;

Formula

LR_GBAL_GDP = VGBAL/V0GDPEXP;

Formula

VGDend = -VGBAL + VGDstart;

Formula

VGDave = 0.5(VGDend + VGDstart);*

Equation E_del_gov_bal

*# Change in the government's budget balance #
100*del_gbal = VGREV*grev - VGEXP*gexp;*

Equation E_r_gbal_gdp

$$100*del_rgbalgdp = 100/V0GDPEXP*del_gbal - VGBAL/V0GDPEXP * w0gdpepx;$$

Equation E_gexp

Total government expenditure

$$\begin{aligned} VGEXP*gexp &= V5TOT*w5tot \\ &+ \text{Sum}(i,IND, LSHR_GINV(i)*V2TOT(i)* \\ &\{100/(tiny+LSHR_GINV(i))*del_shr_ginv(i)+p2tot(i)+x2tot(i)\}) \\ &+ VGINT*gint + VHI_GOV*hi_gov; \end{aligned}$$

Equation E_grev

Total government revenue

$$\begin{aligned} VGREV*grev &= VHI_TAX*hi_tax \\ &+ V1OCT_I*w1oct_i + V2OCT_I*w2oct_i + V3OCT_H*w3oct_h \\ &+ V6OCT*w6oct + V0TAR_C*w0tar_c + 100*delw0tax_csi \\ &+ V4TAX_c*w4tax_c ; \end{aligned}$$

Equation E_gint

Percentage change in government interest payments

$$gint = roid + gdave;$$

Equation E_del_f_gdstart

Gives shock in year-to-year sims. to gdstart

$$del_gdstart = -VGBAL@1*del_unity + del_f_gdstart ;$$

Equation E_del_f_gdend

Value of government debt at end of year related to del_gbal in the year

$$del_gdend = del_gdstart - del_gbal + del_f_gdend ;$$

Equation E_gdave

Percentage change in the average of the start and end stocks of GD

$$VGDAVE * gdave = 100*\{0.5*(del_gdstart + del_gdend)\};$$

Section 3.1.9: Forecasting simulations: twist variables

Variable

(All,c,COM)

ftwist_src(c)

Shift in Imp/dom twist by commodity #;

twist_src_c

Economy wide Imp/dom twist #;

(All,i,IND)

ftwist_lk(i)

Shift in Labour/capital twist by industry #;

twist_lk_i

Economy wide Labour/Capital twist #;

Equation E_ftwist_src

(All,c,COM)

twist_src(c) = twist_src_c + ftwist_src(c) ;

Equation E_ftwist_lk

(All,i,IND)

twist_lk(i) = twist_lk_i + ftwist_lk(i) ;

Section 3.1.10: Forecasting simulations: commodity-c using technological change

Variable

(All,c,COM)

ac(c)

Commodity-c using technical change in current production and investment #;

(change)(All,i,IND)

del_f_a1tot(i)

Allows for all-input-saving tech change to offset costs of ac shocks #;

(All,c,COM)(All,s,SRC)(All,i,IND)

f_a1(c,s,i)

On/Off shift variable in equation linking a1 with ac #;

(All,c,COM)(All,s,SRC)(All,i,IND)

f_a2(c,s,i)

On/Off shift variable in equation linking a2 with ac #;

Equation E_f_a1

(All,c,COM)(All,s,SRC)(All,i,IND)

a1(c,s,i) = ac(c) + f_a1(c,s,i) ;

Equation E_f_a2

(All,c,COM)(All,s,SRC)(All,i,IND)

a2(c,s,i) = ac(c) + f_a2(c,s,i) ;

Equation E_del_f_a1tot

All-input-saving tech change in i to offset cost effects of shocks to ac

(All,i,IND)

*-(tiny+**COSTS**(i))*a1tot(i) =*

*Sum(c,COM,Sum(s,SRC,VIBAS(c,s,i)*ac(c))) + 100*del_f_a1tot(i);*

Section 3.1.11: Forecasting simulations: uniform changes in industry variables

Variable

(All,c,TRADEXP)

ff4q(c)

On/off shift variable to allow uniform changes in f4q(c) #;

(All,c,TRADEXP)

ff4p(c)

On/off shift variable to allow uniform changes in f4p(c) #;

ff4q_ntrad

On/off shift variable to allow uniform changes in f4q_ntrad #;

ff4p_ntrad

On/off shift variable to allow uniform changes in f4p_ntrad #;

(All,i,IND)

fa1lab_o(i)

On/off shift variable, allowing uniform moves in a1lab(i) #;

(All,i,IND)

fa1cap(i)

On/off shift variable, allowing uniform moves in a1cap(i) #;

(All,i,INDA)

fa1lnd(i)

On/off shift variable, allowing uniform moves in a1lnd(i) #;

f4q_general

Equi-proportional shift in f4q(c) #;

f4p_general

Equi-proportional shift in f4p(c) #;

(All,i,IND)

a1prim(i)

Equi-proportional shift in a1lab(i), a1cap(i) and a1lnd(i) #;

(All,i,IND)

fa1prim(i)

On/off shift variable, allowing uniform moves in a1prim(i) #;

a1prim_gen

Equi-proportional shift in a1prim(i) #;

Equation E_ff4q

(All,c,TRADEXP)

$$f4q(c) = f4q_general + ff4q(c);$$

Equation E_ff4p

(All,c,TRADEXP)

$$f4p(c) = f4p_general + ff4p(c);$$

Equation E_ff4q_ntrad

$$f4q_ntrad = f4q_general + ff4q_ntrad;$$

Equation E_ff4p_ntrad

$$f4p_ntrad = f4p_general + ff4p_ntrad;$$

Equation E_fallab

(All,i,IND)

$$allab_o(i) = alprim(i) + fallab_o(i);$$

Equation E_falcap

(All,i,IND)

$$alcap(i) = alprim(i) + falcap(i);$$

Equation E_fallnd

(All,i,INDA)

$$allnd(i) = alprim(i) + fallnd(i);$$

Equation E_falprim

(All,i,IND)

$$alprim(i) = alprim_gen + falprim(i);$$

Section 3.1.12: Dynamic policy simulations: employment/wage trade-off

Variable

r0wage_p

Percentage change in producer real wage rate #;

r0wage_c

Percentage change in consumer real wage rate #;

r0wage_c_pt

Percentage change in consumer real wage rate, post tax #;

bf_employ_i

Basecase forecast value for employ_i #;

bf_r0wage

Basecase forecast value for r0wage_c_pt #;

r0wage_l

Percentage change in consumer real wage rate, post tax, lagged one year #;

bf_r0wage_l

Basecase forecast value for r0wage_l #;

r_employ_i

Ratio of deviation value for EMPLOY_I to basecase forecast value #;

r_r0wage_c_pt

Ratio of deviation value for ROWAGE_C_PT to basecase forecast value #;

(change)

f_r0wage_c_pt

On/Off shifter for wage/employment trade-off equation #;

Coefficient

ALPHA_L

Sensitivity of per. dev. in real wage to per. dev. in employment #;

LROWAGE

Level of consumer real wage, post tax #;

LROWAGE@1

(initial) Level of consumer real wage, post tax #;

LROWAGE_L

Level of consumer real wage, post tax, lagged one year #;

LROWAGE_L@1

(initial) Level of consumer real wage, post tax, lagged one year #;

BF_LROWAGE

Basecase forecast value for LROWAGE #;

BF_LROWAGE@1

(initial) Basecase forecast value for LROWAGE #;

BF_LROWAGE_L

Basecase forecast value for LROWAGE_L #;

BF_LROWA_L@1

(initial) Basecase forecsat value for LROWAGE_L #;

QEMPLOY_i

Quantity level of persons employed #;

BF_QEMPLOY_i

Basecase forecast value for QEMPLOY_i #;

Read

ALPHA_L from file *DYNAM* header "*ALPH*";

LROWAGE from file *DYNAM* header "*LRWG*";

LROWAGE_L from file *DYNAM* header "*LRWL*";

QEMPLOY_i from file *DYNAM* header "*EMPL*";

BF_LROWAGE from file *DYNAM* header "*LRWF*";

BF_LROWAGE_L from file *DYNAM* header "*LRLF*";

BF_QEMPLOY_i from file *DYNAM* header "*EMPF*";

Update

LROWAGE = *r0wage_c_pt* ;

LROWAGE_L = *r0wage_l* ;

QEMPLOY_i = *employ_i* ;

BF_LROWAGE = *bf_r0wage* ;

$BF_LR0WAGE_L = bf_r0wage_l;$
 $BF_QEMPLOY_i = bf_employ_i;$

Formula

(initial)

$LR0WAGE@1 = LR0WAGE;$

Formula

(initial)

$LR0WAGE_L@1 = LR0WAGE_L;$

Formula

(initial)

$BF_LR0WAGE@1 = BF_LR0WAGE;$

Formula

(initial)

$BF_LR0WA_L@1 = BF_LR0WAGE_L;$

Equation E_r0wage_p

Producer real wage rate

$r0wage_p =$
 $1/\text{Sum}(i,IND, VILAB_O(i))*\text{Sum}(i,IND,\text{Sum}(o,OCC,VILAB(i,o)*p1lab(i,o)))-p0gdpexp;$

Equation E_r0wage_c

Consumer real wage rate, before income tax

$r0wage_c =$
 $1/\text{Sum}(i,IND, VILAB_O(i))*\text{Sum}(i,IND, \text{Sum}(o,OCC,VILAB(i,o)*p1lab(i,o))) - p3tot;$

Equation E_r0wage_c_pt

Consumer real wage rate, post income tax

$r0wage_c_pt = r0wage_c - LR0WAGE_TAX/(1-LR0WAGE_TAX)*r0wage_tax;$

Equation E_r0wage_l

Percentage change in consumer real wage rate, post tax, lagged one year

$LR0WAGE_L/100*r0wage_l = (LR0WAGE@1 - LR0WAGE_L@1) * del_unity;$

Equation E_bf_r0wage_l

Basecase forecast value for r0wage_l

$BF_LR0WAGE_L/100*bf_r0wage_l = (BF_LR0WAGE@1 - BF_LR0WA_L@1) * del_unity;$

Equation $E_{bf_employ_i}$

Introduces forecast employment into deviation simulation
 $r_employ_i = employ_i - bf_employ_i ;$

Equation $E_{bf_r0wage_c_pt}$

Introduces forecast post-tax consumer real wage into dev simulation
 $r_r0wage_c_pt = r0wage_c_pt - bf_r0wage ;$

Equation $E_{f_r0wage_c_pt}$

Relates deviation in post-tax consumer r0wage to deviation in employment
 $(LR0WAGE/BF_LR0WAGE)*(r0wage_c_pt - bf_r0wage) =$
 $(LR0WAGE_L/BF_LR0WAGE_L)*(r0wage_l - bf_r0wage_l)$
 $+ ALPHA_L*(QEMPLOY_i/BF_QEMPLOY_i)*(employ_i - bf_employ_i) +$
 $f_r0wage_c_pt ;$

Section 3.1.13: Dynamic policy simulations: welfare measures

Variable

ev_over

A convenient method for viewing the values of EV_OVER/BF-Consumption #;

cv_under

A convenient method for viewing the value of CV_UNDER/POL-Consumption #;
 $(All,k,COMHLU)$

$bf_p3_sc(k)$

Basecase forecast value for p3_sc #;
 $(All,k,COMHLU)$

$bf_x3_sc(k)$

Basecase forecast value for x3_sc #;
 $(All,k,COMHLU)$

$r_p3_sc(k)$

Gap between p3_sc in policy simulation and basecase forecast simulation #;
 $(All,k,COMHLU)$

$r_x3_sc(k)$

Gap between x3_sc in policy simulation and basecase forecast simulation #;

Coefficient

LEV_OVER

Level of EV_OVER as a percentage of consumption in the BF #;

LCV_UNDER

Level of CV_UNDER as a percentage of consumption in the POL #;
 $(All,k,COMHLU)$

$LP3_SC(k)$

Level of P3_SC in deviation simulation #;
 $(All,k,COMHLU)$

BF_LP3_SC(k)

Level of P3_SC in basecase forecast simulation #;
(All,k,COMHLU)

LV3PUR_SC(k)

Level of V3PIR_SC in deviation simulation #;
(All,k,COMHLU)

BF_LV3PUR_SC(k)

Level of V3PIR_SC in basecase forecast simulation #;
(All,k,COMHLU)

LX3_SC(k)

Level of X3_SC in deviation simulation #;
(All,k,COMHLU)

BF_LX3_SC(k)

Level of X3_SC in basecase forecast simulation #;

Read

LP3_SC from file DYNAM header "LP3S";

BF_LP3_SC from file DYNAM header "LP3F";

LV3PUR_SC from file DYNAM header "LVP3";

BF_LV3PUR_SC from file DYNAM header "LV3F";

Update

(All,k,COMHLU)

LP3_SC(k) = p3_sc(k);

(All,k,COMHLU)

BF_LP3_SC(k) = bf_p3_sc(k);

(All,k,COMHLU)

*LV3PUR_SC(k) = x3_sc(k) * p3_sc(k);*

(All,k,COMHLU)

*BF_LV3PUR_SC(k) = bf_x3_sc(k) * bf_p3_sc(k);*

Formula

(All,k,COMHLU)

LX3_SC(k) = LV3PUR_SC(k)/LP3_SC(k);

Formula

(All,k,COMHLU)

BF_LX3_SC(k) = BF_LV3PUR_SC(k)/BF_LP3_SC(k);

Formula

LEV_OVER = 100{Sum(k,COMHLU, [BF_LP3_SC(k)*(LX3_SC(k)-BF_LX3_SC(k))])/*
Sum(d,COMHLU, BF_LV3PUR_SC(d))};

Formula

$$LCV_UNDER = 100 * \{ \text{Sum}(k, COMHLU, [LP3_SC(k) * (LX3_SC(k) - BF_LX3_SC(k))] / \text{Sum}(d, COMHLU, LV3PUR_SC(d)) \};$$

Equation E_ev_over

The value of LEV_OVER as a percentage of consumption in the BF #
 $ev_over = LEV_OVER * del_unity ;$

Equation E_cv_under

The value of LCV_UNDER as a percentage of consumption in Pol #
 $cv_under = LCV_UNDER * del_unity ;$

Equation E_bf_p3_sc

Introduces forecast value for p3_sc into deviation simulation #
(All, k, COMHLU)
 $r_p3_sc(k) = p3_sc(k) - bf_p3_sc(k);$

Equation E_bf_x3_sc

Introduces forecast value for x3_sc into deviation simulation #
(All, k, COMHLU)
 $r_x3_sc(k) = x3_sc(k) - bf_x3_sc(k);$
 $VICAP_I * employ_kw = \text{Sum}(i, IND, VICAP(i) * EMPLOY(i)) ;$

Appendix B: New Coefficients and Parameters in Dynamic-AAGE

Coefficient name, dimension and description			Source of initial data for t=1 computation
<i>LR1DEP(i)</i>	i ∈ IND	Level of the rate of depreciation	Read from <i>DYNAM</i> . Currently, initial values are set to 0.08 for all industries, approximately the average rate in the MONASH database.
<i>VK1start(i)</i>	i ∈ IND	Value of the capital stock at start of year	Read from <i>DYNAM</i> . There are no data available on capital stocks that are strictly compatible with CGE-core data on investment and capital rentals. We derive values for <i>VK1start</i> using the simple rule that the initial ratio of net investment to capital in each industry is 0.03. This implies a 3 per cent growth rate for capital, i.e., values of 3 for <i>k1start(i)</i> in a year=1 computation.
<i>QK1start(i)</i>	i ∈ IND	Quantity of capital at start of year	Read from <i>DYNAM</i> . Initially set to values for <i>VK1start</i> .
<i>QK1start@1(i)</i>	i ∈ IND	(initial) Quantity of capital at start of year	Set via formula (initial) to <i>QK1start</i> for all industries.
<i>QK1end(i)</i>	i ∈ IND	Quantity of capital at end of year	Calculated via formula using data for <i>Q2TOT</i> , <i>LR1DP</i> and <i>QK1start</i> .
<i>LK1GROW(i)</i>	i ∈ IND	Capital growth rate between start and end of year	Calculated via formula using data for <i>QK1start</i> and <i>QK1end</i> .
<i>LP2TOT(i)</i>	i ∈ IND	Price of a unit of capital in industry i	Read from <i>DYNAM</i> . Initially set to 1 for all industries.
<i>Q2TOT(i)</i>	i ∈ IND	Quantity of investment	Calculated via formula using data for <i>V2TOT</i> and <i>LP2TOT</i>
<i>Q2TOT@1(i)</i>	i ∈ IND	(initial) Quantity of investment	Set via formula (initial) to <i>Q2TOT</i> for all industries..
<i>LAR1CAP_SE(i)</i>	i ∈ IND	Level of the actual rate of return: static expectations	Calculated via formula using data for capital rentals from the CGE-core database (<i>V1CAP</i>) and data for <i>VK1start</i> and <i>LR1DEP</i> .
<i>LAR1CAP_SE@1(i)</i>	i ∈ IND	(initial) Level of the actual ROR: static expectations	Set via formula (initial) to <i>LAR1CAP_SE(i)</i> .
<i>FORWARD</i>		=0 (static or iter. 1 of forward-looking); =1 otherwise	Set via formula (initial) using data for <i>ITER_NUM@1</i> .
<i>ITER_NUMBER</i>		Iter. number when expect. forward looking	Read from <i>DYNAM</i> . Initially set to 1.
<i>ITER_NUM@1</i>		(initial) Iter. number when expect. forward looking	Set via formula (initial) to <i>ITER_NUMBER</i> .
<i>ITER_ADJUST</i>		Adjusts iteration number at the end of the iteration	Set via formula (initial) using data for <i>YEAR@1</i> and <i>NYEARS</i> .

Coefficient name, dimension and description		Source of initial data for t=1 computation
<i>NYEARS</i>	Number of years in simulation	Read from <i>DYNAM</i> . Initially set to 15. In general, when forward looking simulations are not called for this coefficient should be set to a large number, say > 50.
YEAR	Solution year: 1 in first year; <i>NYEARS</i> in final year	Read from <i>DYNAM</i> . Initially set to 1.
<i>YEAR@1</i>	(initial) Year of the solution	Set via formula (initial) to <i>YEAR</i> .
<i>DUM_TIME(t)</i>	$t \in \text{TIME}$ Equals 1 if $t = \text{YEAR}$, 0 otherwise	Calculated via formula using data for <i>YEAR@1</i> and <i>COEFF_TIME</i> .
<i>DUM_TIME_L(t)</i>	$t \in \text{TIME}$ Equals 1 if $t = \text{YEAR} - 1$ or if $t = \text{NYEARS}$, else 0	Calculated via formula using data for <i>YEAR@1</i> and <i>COEFF_TIME</i> .
<i>COEFF_TIME(t)</i>	$t \in \text{TIME}$ Vector of consecutive numbers 0,1,2,..., <i>NYEARS</i>	Read from <i>DYNAM</i> . Contains the numbers 0, 1, 2, 3 to <i>NYEARS</i> .
<i>MLAR1CAP(i,t)</i>	$i \in \text{IND}$ $t \in \text{TIME}$ Matrix for transfer of <i>AR1CAP</i> between iter.	Read from <i>DYNAM</i> . Initially all elements set to 0.0
<i>MLAR1CAP@1(i,t)</i>	$i \in \text{IND}$ $t \in \text{TIME}$ (initial) Matrix for transfer of <i>AR1CAP</i> between iter.	Set via formula (initial) to <i>MLAR1CAP</i>
<i>MLER1CAP(i,t)</i>	$i \in \text{IND}$ $t \in \text{TIME}$ Matrix for transfer of <i>ER1CAP</i> between iter.	Read from <i>DYNAM</i> . Initially all elements set to 0.0.
<i>MLER1CAP@1(i,t)</i>	$i \in \text{IND}$ $t \in \text{TIME}$ (initial) Matrix for transfer of <i>ER1CAP</i> between iter.	Set via formula (initial) to <i>MLER1CAP</i> .
<i>MLAR1_T@1(i)</i>	$i \in \text{IND}$ (initial) Column of <i>MLAR1CAP</i> for $t = \text{YEAR}$	Set via formula (initial) using data for <i>MLAR1CAP</i> .
<i>MLAR1_T_L@1(i)</i>	$i \in \text{IND}$ (initial) Column of <i>MLAR1CAP</i> for $t = \text{YEAR} - 1$	Set via formula (initial) using data for <i>MLAR1CAP</i> .
<i>MLER1_T@1(i)</i>	$i \in \text{IND}$ (initial) Column of <i>MLER1CAP</i> for $t = \text{YEAR}$	Set via formula (initial) using data for <i>MLER1CAP</i> .
<i>MLER1_T_L@1(i)</i>	$i \in \text{IND}$ (initial) Column of <i>MLER1CAP</i> for $t = \text{YEAR} - 1$	Set via formula (initial) using data for <i>MLER1CAP</i> .
<i>LER1_IT@1(i)1</i>	$i \in \text{IND}$ (initial) Expected ROR in current iter. for $t = \text{YEAR}$	Calculated via formula (initial) using data for <i>ITER_NUM@1</i> , <i>ADJUST_EXP</i> , <i>MLER1_T@1</i> and <i>MLAR1_T@1</i> .
<i>LER1_IT_L@1(i)</i>	$i \in \text{IND}$ (initial) Expected ROR in current iter. for $t = \text{YEAR} - 1$	Calculated via formula (initial) using data for <i>ITER_NUM@1</i> , <i>ADJUST_EXP</i> , <i>MLER1_T_L@1</i> and <i>MLAR1_T_L@1</i> .
<i>LAR1CAP_L(i)</i>	$i \in \text{IND}$ Actual ROR in current iter. for $t = \text{YEAR} - 1$	Calculated via formula using data for <i>LPOCAP</i> , <i>LP2TOT</i> , <i>LR1DEP</i> and <i>LINF_FACTOR_L</i> .
<i>LAR1CAP_L@1(i)</i>	$i \in \text{IND}$ (initial) Actual ROR in current iter. for $t = \text{YEAR} - 1$	Set via formula (initial) to <i>LAR1CAP_L</i> .

Coefficient name, dimension and description			Source of initial data for t=1 computation
<i>ADJUST_EXP(i)</i>	i ∈ IND	Speed of adjustment of expected diseq. ROR to zero.	Read from <i>DYNAM</i> . Initially set to 0.5. Thus in each year, half of the expected disequilibrium rate of return existing at the start of the year is eliminated.
<i>LP0CAP(i)</i>	i ∈ IND	Level of the rental on capital received by producers	Calculated via formula using data for <i>V1CAP</i> and <i>QK1Start</i> .
<i>LP2TOT@1(i)</i>	i ∈ IND	(initial) Price of a unit of capital	Set via formula (initial) to <i>LP2TOT</i> .
<i>LP2TOT_L(i)</i>	i ∈ IND	Price of a unit of capital lagged one year	Read from <i>DYNAM</i> . Initially all elements set to 1.0.
<i>LP2TOT_L@1(i)</i>	i ∈ IND	(initial) Lagged price of a unit of capital	Set via formula (initial) to <i>LP2TOT_L</i> .
<i>LINF_FACT_L</i>		Lagged inflation factor (1+inflation rate)	Calculated via formula using data for <i>LCPI_L</i> and <i>LCPI_2L</i> .
<i>LCPI</i>		Consumer price index	Read from <i>DYNAM</i> . Initially set to 1.0.
<i>LCPI@1</i>		(initial) Consumer price index	Set via formula (initial) to <i>LCPI</i> .
<i>LCPI_L</i>		Lagged consumer price index	Read from <i>DYNAM</i> . Initially set to 0.97, implying that the rate of growth of the CPI between t-2 and t-1 in the initial data of the year=1 computation is 3 per cent.
<i>LCPI_L@1</i>		(initial) Lagged consumer price index	Set via formula (initial) to <i>LCPI_L</i> .
<i>LCPI_2L</i>		Twice-lagged consumer price index	Read from <i>DYNAM</i> . Initially set to 0.94, implying that the rate of growth of the CPI between t-3 and t-2 in the initial data of the year = 1 computation is approximately 3 per cent.
<i>LCPI_2L@1</i>		(initial) Twice-lagged consumer price index	Set via formula (initial) to <i>LCPI_2L</i> .
<i>ADJ_COEFF(i)</i>	i ∈ IND	Speed of adjustment of diseq. in expected ROR to 0	Read from <i>DYNAM</i> . Initially set to 0.5 for all industries.
<i>CAP_SLOPE(i)</i>	i ∈ IND	Overall sens. of cap growth to changes in LEER1CAP	Set via formula (initial) using data for <i>MURF_SLOPE</i> , <i>LK1GROW_MAX</i> , <i>LK1GROW_MIN</i> and <i>LK1GROW_NORM</i> .
<i>MURF_SLOPE</i>		Macro-model sens. of cap growth to changes in LEER1CAP	Read from <i>DYNAM</i> . Initially set to 1.0 for all industries.
<i>DIFF</i>		Maximum capital growth rate above the normal rate	Read from <i>DYNAM</i> . Initially set to 0.1.

Coefficient name, dimension and description			Source of initial data for t=1 computation
<i>LEER1CAP(i)</i>	i ∈ IND	Level of the expected equilibrium ROR	Calculated via formula using data for <i>LR1CAP_NORM</i> , <i>F_EER1CAP_I</i> , <i>F_EER1CAP_CAP_SLOPE</i> , <i>LK1GROW</i> , <i>LK1GROW_MIN</i> , <i>LK1GROW_MAX</i> . <i>LK1GROW_NORM</i> .
<i>LEDR1CAP(i)</i>	i ∈ IND	Level of the disequilibrium in expected ROR	Set via a formula (initial) using data for <i>FORWARD</i> , <i>LAR1CAP_SE</i> , <i>LEER1CAP_IT</i> and <i>LEER1CAP</i> .
<i>F_EER1CAP_I</i>		Level of the scalar shifter in investment relationship.	Read from <i>DYNAM</i> . Initially set to 0.
<i>F_EER1CAP(i)</i>	i ∈ IND	Level of the vector shifter in investment relationship	Read from <i>DYNAM</i> . Initially set to 0 for all industries.
<i>LK1grow_MAX(i)</i>	i ∈ IND	Maximum possible capital growth rate in industry i	Calculated via conditional-formula (initial). In most cases equals <i>LK1grow_norm+DIFF</i> .
<i>LK1grow_MIN(i)</i>	i ∈ IND	Minimum possible capital growth rate in industry i	Calculated via formula (initial). Set to minus <i>LR1DEP</i> for all industries.
<i>LK1grow_norm(i)</i>	i ∈ IND	Trend rate of growth in capital in industry i	Read from <i>DYNAM</i> . Initially set to 0.03 for all industries, implying, in the computation for year=1, that the rate of capital growth = <i>LK1grow_norm</i> (see comments for <i>VK1start</i>).
<i>LR1CAP_norm(i)</i>	i ∈ IND	Normal rate of return in industry i, given as data	Read from <i>DYNAM</i> . The initial data for capital rentals from the CGE-core, along with the derived data for <i>VK1start</i> and values for <i>LR1DEP</i> , imply values for <i>LAR1CAP_SE(i)</i> . Initially, we set <i>LR1CAP_norm(i)</i> equal to these implied values for <i>LAR1CAP_SE(i)</i> . With <i>LK1grow_norm(i)</i> = <i>k1start(i)/100</i> = 0.03 in the year=1 computation, and with <i>LR1CAP_norm(i)</i> initially = <i>LAR1CAP_SE(i)</i> in the first year, then given zero as the initial values for <i>F_EER1CAP(i)</i> and <i>F_EER1CAP_I</i> , it must be that <i>LEDR1CAP(i)</i> is initially 0 for all industries in the first year.
<i>VIAB_CR_INT</i>		Income received: int. from foreigners (credit)	Read from <i>DYNAM</i> . Currently, initial value set by subjective judgement. True value to be derived from Balance of Payments data for the year-of-record of the core-CGE database.
<i>VIAB_CR_DIV</i>		Income received: dividends from foreigners (credit)	As for <i>VIAB_CR_INT</i> .

Coefficient name, dimension and description		Source of initial data for t=1 computation
<i>VIAB_CR_TRN</i>	Income received: transfers from foreigners (credit)	As for <i>VIAB_CR_INT</i> .
<i>VIAB_DR_INT</i>	Income paid: int. to foreigners (debit)	As for <i>VIAB_CR_INT</i> .
<i>VIAB_DR_DIV</i>	Income paid: dividends to foreigners (debit)	As for <i>VIAB_CR_INT</i> .
<i>VIAB_DR_TRN</i>	Value of income paid: transfers to foreigners (debit)	As for <i>VIAB_CR_INT</i> .
<i>VIAB_CR</i>	Value of income received from foreigners (credit)	Calculated via formula as the sum income credits.
<i>VIAB_DR</i>	Value of income paid to foreigners (debit)	Calculated via formula as the sum of income debits.
<i>VCAB</i>	Value of the current account balance	Calculated via formula as the sum of the initial trade and income balances.
<i>VCAB@1</i>	(initial) Value of the current account balance	Set via formula (initial) to <i>VCAB</i> .
<i>VFLstart</i>	Value of stock of foreign liabilities at start of year	As for <i>VIAB_CR_INT</i> .
<i>VFLend</i>	Value of stock of foreign liabilities at end of year	Calculated via formula using data for <i>VCAB</i> and <i>VFLstart</i> .
<i>VFLave</i>	Arithmetic average of <i>VFLstart</i> and <i>VFLend</i> .	Calculated via formula using data for <i>VFLstart</i> and <i>VFLend</i> .
<i>LR_CR_INT</i>	Ratio of stock of foreign equity held by Danes/FL	As for <i>VIAB_CR_INT</i> .
<i>LR_CR_DIV</i>	Ratio of the stock of foreign debt held by Danes/FL	As for <i>VIAB_CR_INT</i> .
<i>LR_DR_INT</i>	Ratio of stock of Danish debt held by foreigners/FL	As for <i>VIAB_CR_INT</i> .
<i>LR_DR_DIV</i>	Ratio of stock of Danish equit. held by foreigners/FL	Calculated via formula using data for <i>LR_CR_INT</i> , <i>LR_CR_DIV</i> and <i>LR_DR_INT</i> .
<i>LAR1CAP_AVE</i>	Level of ave. ROR_SE on foreign owned equity	Calculated via formula using data for <i>LAR1CAP_SE</i> and <i>V1CAP_I</i> .
<i>VHI</i>	Value of household income	Calculated via formula using data for the components of <i>VHI</i> .
<i>VHDI</i>	Value of household disposable income	Calculated via formula using data for <i>VHI</i> and <i>LROWAGE_TAX</i> .
<i>VHI_GOV</i>	Government transfer payments to households	Calculated via formula using data for <i>VHI_GOV_UN</i> and <i>VHI_GOV_OT</i> .

Coefficient name, dimension and description		Source of initial data for t=1 computation
<i>VHI_GOV_UN</i>	Unemployment benefits accruing to households	Read from <i>DYNAM</i> . Currently, initial value set by subjective judgement. True value to be derived from data for the Government financial accounts (consolidated across all government levels) for the year-of-record of the core-CGE database.
<i>VHI_GOV_OT</i>	Other government transfer payments to households	As for <i>VHI_GOV_UN</i> .
<i>VHI_TAX</i>	Value of income tax collected from households	Calculated via formula using data for <i>VHI</i> and <i>LROWAGE_TAX</i> .
<i>LROWAGE_TAX</i>	Level of the ave. tax rate applying to household income	Read from <i>DYNAM</i> . Currently, initial value set to 0.5. True value to be derived from National Accounts data for the year-of-record of the core-CGE database.
<i>QLAB_SUP</i>	Number of people in labour force	Read from <i>DYNAM</i> . Currently, initial value set by subjective judgement. True value to be derived from labour-force data for the year-of-record of the core-CGE database.
<i>QLAB_EMP</i>	Number of people employed	As for <i>QLAB_SUP</i> .
<i>QLAB_UEM</i>	Number of people unemployed	Calculated via formula using data for <i>QLAB_EMP</i> and <i>QLAB_SUP</i> .
<i>LAPC</i>	Level of the APC out of HDI	Calculated via formula using data for <i>V3TOT</i> and <i>VHDI</i> .
<i>LSHR_GINV(i)</i>	$i \in \text{IND}$ Share of capital in i which is publicly owned	Read from <i>DYNAM</i> . Currently, initial values set by subjective judgement. True values will have to be derived.
<i>VGINT</i>	Value of government interest payments	As for <i>VHI_GOV_UN</i> .
<i>VGEXP</i>	Value of total government expenditure	Calculated via formula using data for the components of <i>VGEXP</i> .
<i>VGREV</i>	Value of total government revenue	Calculated via formula using data for the components of <i>VGREV</i> .
<i>VGBAL</i>	Government's budget balance	Calculated via formula using data for <i>VGREV</i> and <i>VGEXP</i> .
<i>VGBAL@1</i>	(initial) Value of the government's budget balance	Set via formula (initial) to <i>VGBAL</i> .
<i>LR_GBAL_GDP</i>	Ratio of the government's budget balance to GDP	Calculated via formula using data for <i>VGBAL</i> and <i>VGDPEXP</i> .

Coefficient name, dimension and description		Source of initial data for t=1 computation
<i>VGDstart</i>	Stock of government debt at start of year	Read from <i>DYNAM</i> . Currently, initial value set by subjective judgement. True value to be derived from data for the Government financial accounts (consolidated across all government levels) for the year-of- record of the core-CGE database. If there are no data from primary sources, it maybe necessary to assume an average interest rate on government debt, and apply that to data for interest payments to deduce a value for the stock of debt.
<i>VGDend</i>	Stock of government debt at end of year	Calculated via formula using data for <i>VGBAL</i> and <i>VGDstart</i> .
<i>VGDave</i>	Arithmetic average of <i>VGDstart</i> and <i>VGDend</i>	Calculated via formula using data for <i>VGDstart</i> and <i>VGDend</i> .
<i>ALPHA_L</i>	Sensitivity of dev. in real wage to dev. in empl.	Read from <i>DYNAM</i> . Initially set to 0.7.
<i>LROWAGE</i>	Consumer real wage, post tax	Read from <i>DYNAM</i> . Initially set to 1.0.
<i>LROWAGE@1</i>	(initial) Consumer real wage, post tax	Set via formula (initial) to <i>LROWAGE</i> .
<i>LROWAGE_L</i>	Consumer real wage, post tax, lagged	Read from <i>DYNAM</i> . Initially set to 1.0, implying that the rate of growth of the real wage between t-2 and t-1 in the initial data of the year=1 computation is 0.
<i>LROWAGE_L@1</i>	(initial) Consumer real wage, post tax, lagged	Set via formula (initial) to <i>LROWAGE_L</i> .
<i>BF_LROWAGE</i>	Basecase forecast value for <i>LROWAGE</i>	Read from <i>DYNAM</i> . Initially set to value of <i>LROWAGE</i> .
<i>BF_LROWAGE@1</i>	(initial) Basecase forecast value for <i>LROWAGE</i>	Set via formula (initial) to <i>BF_LROWAGE</i> .
<i>BF_LROWAGE_L</i>	Basecase forecast value for <i>LROWAGE_L</i>	Read from <i>DYNAM</i> . Initially set to value of <i>LROWAGE_L</i> .
<i>BF_LROWA_L@1</i>	(initial) Basecase forecast value for <i>LROWAGE_L</i>	Set via formula (initial) to <i>BF_LROWAGE_L</i>
<i>QEMPLOY_i</i>	Level of persons employed	Read from <i>DYNAM</i> . Initially set to 1.0. Note that this is an index. It does not necessarily have to equal <i>QLAB_EMP</i> .
<i>BF_QEMPLOY_i</i>	Basecase forecast value for <i>QEMPLOY_i</i>	Read from <i>DYNAM</i> . Initially set to value of <i>QEMPLOY_I</i> .
<i>LEV_OVER</i>	<i>EV_OVER</i> as per cent of <i>BF</i> consumption	Calculated via formula using data for <i>BF_LP3_SC</i> , <i>LX3_SC</i> , <i>BF_LX3_SC</i> and <i>BF_LV3PUR_SC</i> .

Coefficient name, dimension and description			Source of initial data for t=1 computation
<i>LCV_UNDER</i>		CV_UNDER as per cent of POL consumption	Calculated via formula using data for <i>LP3_SC</i> , <i>LX3_SC</i> , <i>BF_LX3_SC</i> and <i>LV3PUR_SC</i> .
<i>LP3_SC(k)</i>	$k \in \text{COMHLU}$	Level of P3_SC in deviation simulation	Read from <i>DYNAM</i> . Initially set to 1.0 for all k.
<i>BF_LP3_SC(k)</i>	$k \in \text{COMHLU}$	Level of P3_SC in base-case forecast simulation	Read from <i>DYNAM</i> . Initially set to value of <i>LP3_SC</i> for all k.
<i>LV3PUR_SC(k)</i>	$k \in \text{COMHLU}$	Level of V3PIR_SC in deviation simulation	Read from <i>DYNAM</i> . Initially set to values deduced from <i>V3PUR</i> .
<i>BF_LV3PUR_SC(k)</i>	$k \in \text{COMHLU}$	Level of V3PIR_SC in basecase forecast simulation	Read from <i>DYNAM</i> . Initially set to value of <i>LV3PUR_SC</i> for all k.
<i>LX3_SC(k)</i>	$k \in \text{COMHLU}$	Level of X3_SC in deviation simulation	Calculated via formula using data for <i>LV3PUR_SC</i> and <i>LP3_SC</i> .
<i>BF_LX3_SC(k)</i>	$k \in \text{COMHLU}$	Level of X3_SC in base-case forecast simulation	Calculated via formula using data for <i>BF_LV3PUR_SC</i> and <i>BF_LP3_SC</i> .

Appendix C: New Variables in Dynamic-AAGE and their Classification in a Comparative Static Long-run Closure

Variable name, dimension and description			Classification in CS (long-run) closure
<i>k1start(i)</i>	i ∈ IND	Percentage change in capital stock at start of year	EN
<i>k1end(i)</i>	i ∈ IND	Percentage change in capital stock at end of year	EN
<i>del_k1grow(i)</i>	i ∈ IND	Change in capital growth rate between start and end of year	EN
<i>del_f_k1start(i)</i>	i ∈ IND	On/off shifter in equation explaining k1start in YtoY sims.	EN
<i>del_unity</i>		Dummy variable set to one for YtoY simulations	Exogenous
<i>del_ar1cap_se(i)</i>	i ∈ IND	Change in actual rate of return: static expectations	Exogenous
<i>del_er1cap(i)</i>	i ∈ IND	Change in expected rate of return on capital in industry i	EN
<i>del_ar1cap_l(i)</i>	i ∈ IND	Change in actual rate of return lagged one year	EN
<i>p2tot_l(i)</i>	i ∈ IND	Percentage change in cost of a unit of capital lagged one year	EN
<i>inf_fact_l</i>		Percentage change in inflation factor (one + inf. rate) lagged	EN
<i>cpi_l</i>		Percentage change in consumer price index lagged one year	EN
<i>cpi_2l</i>		Percentage change in consumer price index lagged two years	EN
<i>f_p2tot_l(i)</i>	i ∈ IND	On/Off shift variable in E_p2tot_l	Exogenous
<i>f_cpi_l</i>		On/Off shift variable in E_cpi_l	Exogenous
<i>f_cpi_2l</i>		On/Off shift variable in E_cpi_2l	Exogenous
<i>del_eer1cap(i)</i>	i ∈ IND	Change in expected equilibrium ROR on capital in industry i	EN
<i>del_edr1cap(i)</i>	i ∈ IND	Change in disequilibrium in expected ROR on capital in i	EN
<i>del_f_eer1cap_i</i>		Change in scalar shifter, EER1CAP/LK1GROW relationship	Exogenous
<i>del_f_eer1cap(i)</i>	i ∈ IND	Change in vector shifter, EER1CAP/LK1GROW relationship	EN
<i>x0da</i>		Percentage change in real gross domestic absorption (GDA)	EN
<i>r_x3_x5</i>		Percentage change in ratio of real private to public cons.	EN
<i>r_x3_x0da</i>		Percentage change in ratio of real private cons. to real GDA	EN
<i>r_x2_x0da</i>		Percentage change in ratio of real investment to real GDA	EN
<i>r_x5_x0da</i>		Percentage change in ratio of real public cons. to real GDA	EN

Variable name, dimension and description		Classification in CS (long-run) closure
<i>r_w3_w0gdp</i>	Percentage change in ratio of nominal private cons. to GDP	EN
<i>del_tab</i>	Change in balance on trade account	EN
<i>del_iab</i>	Change in balance on income account	EN
<i>del_cab</i>	Change in balance on current account	EN
<i>iab_cr</i>	Percentage change in foreign income received (credit)	EN
<i>iab_cr_int</i>	Percentage change in foreign inc. received: interest (credit)	EN
<i>iab_cr_div</i>	Percentage change in foreign inc. received: dividends (credit)	EN
<i>iab_cr_trn</i>	Percentage change in foreign inc. received: transfers (credit)	Exogenous
<i>iab_dr</i>	Percentage change in income paid to foreigners (debit)	EN
<i>iab_dr_int</i>	Percentage change in inc. paid to foreigners: interest (debit)	EN
<i>iab_dr_div</i>	Percentage change in inc. paid to foreigners: dividend (debit)	EN
<i>iab_dr_trn</i>	Percentage change in inc. paid to foreigners: transfers (debit)	Exogenous
<i>del_flstart</i>	Change in the stock of foreign liabilities at start of year	Exogenous
<i>del_f_flstart</i>	On/Off shifter in equation explaining <i>del_flstart</i> in YtoY sims.	EN
<i>del_flend</i>	Change in the stock of foreign liabilities at end of year	Exogenous
<i>del_f_flend</i>	On/Off shifter in equation explaining <i>del_flend</i> in YtoY sims.	EN
<i>flave</i>	Percentage change in the average of end and start stocks of FL	EN
<i>del_r_cr_int</i>	Percentage change in ratio of foreign equity held by Danes to FL	Exogenous
<i>del_r_cr_div</i>	Percentage change in ratio of foreign debt held by Danes to FL	Exogenous
<i>del_r_dr_int</i>	Percentage change in ratio of Danish debt foreign-held to FL	Exogenous
<i>del_r_dr_div</i>	Percentage change in ratio of Danish equity foreign-held to FL	EN
<i>roid</i>	Percentage change in domestic rate of interest	Exogenous

Variable name, dimension and description		Classification in CS (long-run) closure	
<i>roif</i>		Percentage change in foreign rate of interest	Exogenous
<i>rodf</i>		Percentage change in foreign rate of dividend payment	Exogenous
<i>del_ar1cap_ave</i>		Change in ave. ROR under static expect.: foreign-owned equity	EN
<i>hi</i>		Percentage change in household income	EN
<i>hdi</i>		Percentage change in household disposable income	EN
<i>hi_gov</i>		Percentage change in total gov. transfer payments	EN
<i>hi_gov_un</i>		Percentage change in unemployment benefits	EN
<i>hi_gov_ot</i>		Percentage change in other government transfer payments	EN
<i>hi_tax</i>		Percentage change in the value of income tax paid by households	EN
<i>r0wage_tax</i>		Percentage change in average income tax rate on household inc.	Exogenous
<i>lab_sup</i>		Percentage change in number of people in labour force	Exogenous
<i>lab_uem</i>		Percentage change in number of people unemployed	EN
<i>lab_rben</i>		Percentage change in average unemployment benefit rate	Exogenous
<i>apc</i>		Percentage change in the Average Propensity to Consume (APC)	EN
<i>del_shr_ginv(i)</i>	i ∈ IND	Change in the public-owned share (number like 0.1) of capital in i	Exogenous
<i>gint</i>		Percentage change in government interest payments	EN
<i>gexp</i>		Percentage change in total government expenditure	EN
<i>grev</i>		Percentage change in total government revenue	EN
<i>del_gdstart</i>		Change in the stock of government debt at start of year	Exogenous
<i>del_gdend</i>		Change in the stock of government debt at end of year	Exogenous
<i>del_f_gdstart</i>		On/Off shifter in variable explaining del_gdstart in YtoY sims.	EN
<i>del_f_gdend</i>		On/Off shifter in variable explaining del_gdend in YtoY sims.	EN
<i>gdave</i>		Percentage change in the average of end and start stocks of GD	EN
<i>del_gbal</i>		Change in government's budget balance: rev less exp	EN

Variable name, dimension and description			Classification in CS (long-run) closure
<i>del_rgbalgdp</i>		Change in ratio of the government's budget balance to GDP	EN
<i>ftwist_src(c)</i>	c∈COM	Shift in Imp/dom twist by commodity	EN
<i>twist_src_c</i>		Economy wide Imp/dom twist	Exogenous
<i>ftwist_lk(i)</i>	i∈IND	Shift in Labour/capital twist by industry	EN
<i>twist_lk_i</i>		Economy wide Labour/Capital twist	Exogenous
<i>ac(c)</i>	c∈COM	Commodity-c using tech. change in production and investment	Exogenous
<i>del_f_a1tot(i)</i>	i∈IND	Allows for all-input-saving tech change to offset ac shocks	EN
<i>f_a1(c,s,i)</i>	c∈COM s∈SRC i∈IND	On/Off shift variable in equation linking a1 with ac	EN
<i>f_a2(c,s,i)</i>	c∈COM s∈SRC i∈IND	On/Off shift variable in equation linking a2 with ac	EN
<i>ff4q(c)</i>	c∈TRADEX P	On/off shift variable to allow uniform percentage changes for f4q	EN
<i>ff4p(c)</i>	c∈TRADEX P	On/off shift variable to allow uniform percentage changes for f4p	EN
<i>ff4q_ntrad</i>		On/off shift to allow uniform percent changes for f4q_ntrad	EN
<i>ff4p_ntrad</i>		On/off shift to allow uniform percent changes for f4p_ntrad	EN
<i>f4q_general</i>		Equi-proportional shift in f4q	Exogenous
<i>f4p_general</i>		Equi-proportional shift in f4p	Exogenous
<i>fa1lab_o(i)</i>	i∈IND	On/off shift variable to allow uniform percent changes for a1lab	EN
<i>fa1cap_o(i)</i>	i∈IND	On/off shift variable to allow uniform percent changes for a1cap	EN
<i>fa1lnd_o(i)</i>	i∈INDA	On/off shift variable to allow uniform percent changes for a1lnd	EN
<i>a1prim(i)</i>	i∈IND	Equi-proportional shift in a1lab, a1cap and a1lnd	Exogenous
<i>fa1prim(i)</i>	i∈IND	On/off shift variable to allow uniform percent changes for a1prim	EN
<i>a1prim_gen</i>		Equi-proportional shift in a1prim	Exogenous
<i>r0wage_p</i>		Percentage change in producer real wage rate	EN
<i>r0wage_c</i>		Percentage change in consumer real wage rate	EN
<i>r0wage_c_pt</i>		Percentage change in consumer real wage rate, post tax	EN
<i>bf_employ_i</i>		Basecase forecast value for employ_i	EN

Variable name, dimension and description		Classification in CS (long-run) closure	
<i>bf_r0wage</i>		Basecase forecast value for r0wage_c_pt	EN
<i>r0wage_l</i>		Percentage change in consumer real wage rate, post tax, lagged	EN
<i>bf_r0wage_l</i>		Basecase forecast value for r0wage_l	EN
<i>r_employ_i</i>		Ratio of deviation value for EMPLOY_I to forecast value	Exogenous
<i>r_r0wage_c_pt</i>		Ratio of deviation value for R0WAGE_C_PT to forecast value	Exogenous
<i>f_r0wage_c_pt</i>		On/Off shifter for wage/employment trade-off equation	EN
<i>ev_over</i>		Value of EV_OVER, expressed as a % of consumption in the BF	EN
<i>cv_under</i>		Value of CV_UNDER, expressed as a % of consumption in Dev	EN
<i>bf_p3_sc(k)</i>	k∈COMHLU	Basecase forecast value for p3_sc	EN
<i>bf_x3_sc(k)</i>	k∈COMHLU	Basecase forecast value for x3_sc	EN
<i>r_p3_sc(k)</i>	k∈COMHLU	Gap between p3_sc in policy and forecast simulations	Exogenous
<i>r_x3_sc(k)</i>	k∈COMHLU	Gap between x3_sc in policy and forecast simulations	Exogenous