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241/2004

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WIFO Working Papers, No. 241
December 2004

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2004/401/W/0

WIFO-Macromod – An Econometric Model of the Austrian Economy[1]

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[1] We are grateful to Rudolf Zwiener (DIW, Berlin) and Thomas Warmedinger (ECB, Frankfurt) for their valuable comments and suggestions.

1. Introduction

WIFO-Macromod is the annual aggregate macroeconometric model of the Austrian economy developed at the Austrian Institute of Economic Research (WIFO).[2] The model serves a dual purpose: preparing the annual WIFO medium-term economic forecast with a forecast horizon of five years and performing economic policy simulations.[3]

This paper is organised as follows. In section 2, we briefly outline the scope of the model. Then we present its main structural equations and definitions (section 3), and discuss three simulations: public consumption shock, export shock and interest rate shock in section 4. The simulated economic shocks, although conceivable and realistic, do not relate to actual or potential developments but highlight the properties of the model. In *Warmedinger* (2004) and *Zwiener* (2004) WIFO-Macromod is compared with models for the Austrian economy run by the Oesterreichische Nationalbank (*Fenz and Spitzer*, 2004) and the Institute for Advanced Studies (*Hofer and Kunst*, 2004).[4]

2. The Scope of the Model

WIFO-Macromod can be described as a demand-driven structural econometric model with supply side elements used for price and wage determination. Focusing on the demand-side of the economy we explicitly model all major components of the use and distribution of the national income accounts. We estimate a trend output with a constant elasticity of

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[2] Macroeconometric modelling has a long tradition at WIFO (*Schebeck and Thury*, 1979, *Breuss and Schebeck,* 1990). Several other econometric models are currently in use at WIFO: A-LMM is a long-run macroeconomic model developed jointly with the Institute of Advanced Studies, Vienna (IHS). This model is designed to study the long-run consequences of population aging on employment, output growth, and the solvency of the social security system (*Baumgartner et al.,* 2004). In addition, an input-output model (*Kratena and Zakarias,* 2001) is available, and a multi-regional input output model (*Fritz et al*, 2004) will soon be available. Furthermore, several specialized models such as the multi-country tourism model (*Smeral,* 2004) and the PASMA, a disaggregated model of Austria's agricultural sector (*Sinabell and Schmid,* 2003), are regularly used for forecasting and simulation studies.

[3] The recent medium-term forecast of the Austrian economy is documented in *Baumgartner, Kaniovski and Walterskirchen* (2004). *Breuss, Kaniovski and Schratzenstaller* (2004) study the short and medium run effects of the Tax Reform 2004/2005. *Breuss, Kaniovski and Lehner* (2004) discuss simulations of the economic consequences of fiscal policy in the years 2000 to 2002. *Kaniovski ,Kratena and Marterbauer* (2003) present simulations of fiscal spending based on several models.

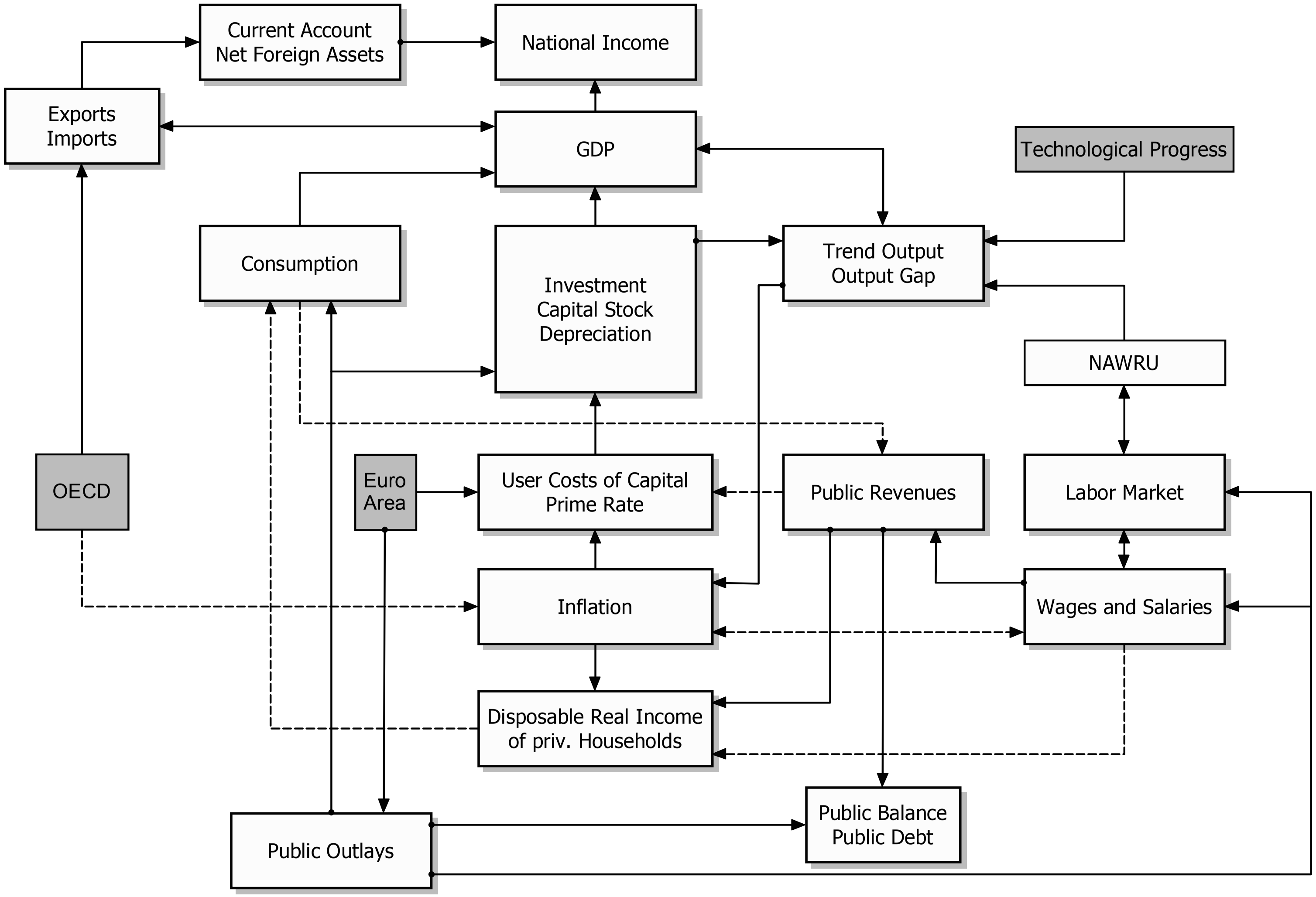
[4] In this paper we present only a brief description of the model. In reaction to the introduction of chaining in the European system of national accounts, the WIFO-Macromod will be completely revised. A comprehensive documentation of the model will then be made available.

substitution production function and use an output gap as a proxy for the aggregate rate of capacity utilisation. Due to the short forecasting horizon of five years and the demand-side focus of the model we treat technical progress as exogenous.

In WIFO-Macromod, Austria is described as a small open economy in the European Economic and Monetary Union (EMU). Thus, the repercussions of economic activity in Austria on the rest of the world are neglected and variables describing the world economic conditions, including those of European economic policy authorities, are set as exogenous. Specifically, we treat the income of Austria's trading partners, the euro-U.S. dollar exchange rate, short and long-term interest rates and world prices for tradable goods and services as exogenous. We impose that domestic excess savings correspond to the income balance in the current account. The financial relations with the EU budget on both sides (own resources and transfers from the EU) are also modelled as exogenous variables.

The basic structure of the model is shown in chart 1. The model contains 134 endogenous and 64 exogenous variables in 34 behavioural equations and 100 identities. Most behavioural equations are estimated using annual data of the national accounts published by Statistik Austria. These data are currently available for the period 1976 to 2003 and are supplemented by the sector accounts from 1995 onwards. A few structural equations are calibrated involving assumptions that yield more plausible projections. The small size of the available data sample narrows the choice of econometric techniques that can sensibly be applied. Except for several parameters in the production function, all structural equations were estimated as single equations using ordinary least squares. To satisfy the stationary requirement all equations were estimated using either static or dynamic specifications in first (logarithmic) differences or, in the case of co-integrated series, as error-correction models. All error-correction models were estimated as *Sims, Stock and Watson* (1990) regressions (henceforth SSW). This method is technically equivalent to estimating the single-equation error-correction model directly by nonlinear least squares, i.e. yields identical coefficients and fit. The principal merit of SSW regression lies in its simplicity and the small-sample properties superior to those of the classic Engle-Granger two-step procedure (*Engle and Granger,* 1987). Since the standard asymptotic distribution theory applies to all single coefficient tests in SSW, the long-run elasticity between the co-integrated variables can be readily estimated. What cannot be recovered, however, is the complete long-run relationship between the co-integrated variables.

Chart 1: Structure of WIFO-Macromod



Note: Shading indicates exogenous blocks. Solid and dotted lines are equivalent

The reason is that the coefficients of all deterministic terms in the long-run relationship, such as a constant or a trend, are not separately estimable using SSW (see the discussion in *Davidson and MacKinnon,* 1993, p. 723–725).

Although, most of the time we would use the estimated error-correction specification, in some cases only the long-run relationship implied by the error-correction term is used. In this case, we use a relationship in growth rates rather than in the levels, which confers an additional advantage of ensuring a smooth out of sample transition and avoids the indeterminacy in the deterministic part of the long-run relationship.

3. The Structure of the Model

3.1 Consumption

In the model we differentiate between consumption outlays of the private and public sector. We estimate an error-correction model for the consumption expenditures of private households as a function of their disposable real income. We do not further differentiate between durable and non-durable consumption goods. Consumption and the value added of the public sector are computed according to their respective ESA definitions and are only partially endogenous.

Like in most other developed economies, the time-series of private household consumption in Austria show high serial correlation and, therefore, a high degree of smoothness. The adjustment of consumption expenditure to shocks in income is sluggish and shows high sensitivity to past incomes. A challenge in the empirical modelling of consumer behaviour has been how to reconcile the empirical implications of the expected permanent life-cycle income hypothesis, i.e. a random walk in consumption expenditure on durable goods (*Hall,* 1978), with smooth consumption paths. The error-correction approach pioneered in *Davidson, Hendry, Srba and Yeo* (1978, henceforth DHSY) has been more successful in accounting for these empirical regularities and has become the standard methodology for modelling the consumption of non-durables. We follow the DHSY approach in modelling aggregate consumption expenditure of private households, but use the SSW regression instead of Engle-Granger's two-step method.

The relationship between private consumption expenditure, CP_t, and disposable income, YD_t, of private households at constant 1995 prices is estimated using the SSW regression[5]:

$$\Delta\log(CP_t) = -0.3 + 0.35\Delta\log(YD_t) - 0.212\log(CP_{t-1}) + 0.237\log(YD_{t-1}) \, , \qquad (1)$$

The estimation yields a short-run income-elasticity of consumption of 0.35. Although the estimated coefficient is lower than the average propensity to consume implied by the recent Austrian consumer survey of 0.6, the overall effect is offset by the long-run elasticity of slightly above unity (0.237/0.212 = 1.12). The implied speed of adjustment is such that a permanent income shock of 1% leads to a cumulative increase in consumer expenditures of 0.81 percentage points in the subsequent five years and 1.02 percentage points in ten years.

3.2 Investment, Capital Stock, and Depreciation

Investment is divided into three categories of capital goods: non-residential construction, residential construction or dwellings, and machinery and equipment. The latter category also includes investment in transport equipment, cultivated, and intangible fixed assets such as software. Except for residential construction, we differentiate between private and public investment outlays, for a total of five distinct investment categories. Public residential and non-residential investments as well as investment in dwellings are exogenous. Private non-residential construction and machinery and equipment are determined in the model.

The five investment categories are then used to project the corresponding stocks of capital. Here we do not differentiate between public and private stock of capital. The aggregate capital stock is a factor input in the production function for the determination of the trend output (see section 3.5). We follow Statistik Austria's methodology for computing the capital stock as described in *Böhm et al.* (2001) and *Statistik Austria* (2002).[6] We recover the implicit consumption of fixed capital from the perpetual inventory calculation.

Private investment in machinery and equipment, IPM_t, is modelled using an error-correction specification:

[5] In all equations in the text we omit any dummy variables, as those have no effect on out-of-sample projections and simulations.

[6] *Statistik Austria* (2002) uses a variant of the perpetual inventory method that assumes a uniform depreciation of the capital good within any given year. Other key elements of their methodology include age and constant depreciation profiles for different capital goods and their initial stocks.

$$\Delta\log(IPM_t) = -3.417 + 1.76\Delta\log(YP_t) - 0.46\Delta\log(UCM_t) - 0.226\log(IPM_{t-1}/YP_{t-1}) \, , \qquad (2)$$

where YP_t is the value added of the private sector and UCM_t represents the user costs of capital. The error-correction term, which describes the long-run relationship between value added, investment, and user costs of capital, is motivated by an accelerator model and the neoclassical investment theory. The above equation implies a short-run elasticity of private investment in machinery and equipment with respect to value added of 1.76 and a long-run unit elasticity. The elasticity with respect to user costs of capital of –0.46 is comparable to an estimate for Germany by *Harhoff and Ramb* (2001) and is lower than an estimate for the U.S.A. at the firm-level by *Chirinko, Fazzar and Meyer* (1999).

User costs of capital are calculated according to neoclassical investment theory developed in *Jorgenson* (1963), and *Hall and Jorgenson* (1967). The exact analytic expression for the user costs of capital depends on the underlying theoretical model of investment and the capital stock. Special care must also be taken to ensure the correct representation of the major fiscal instruments of the country's corporate tax code and the relevant national and international subsidy schemes. From a practical point of view, the more fiscal instruments are accounted for, the wider the scope of simulations that can be performed. On the other hand, adding detail to the model adds complexity and, since some variables are not readily observable, it also adds the difficulty of keeping the data up-to-date.

We found the following specification to offer sufficient detail and yet be simple enough. It is based on the derivation of the user costs of capital for Austria presented in *Kaniovski* (2002):

$$UCM_t = (PI_t/P_t)(RC_t - \Delta\log(PI_t) + RDM_t)RTUCM_t \, , \qquad (3)$$

where PI_t/P_t is the ratio of investment to the GDP deflator, RC_t the interest rate on business loans, $\Delta\log(PI_t)$ the inflation rate for the capital good, and RDM_t the rate of economic depreciation. The last factor in *(3)* reflects several characteristics of Austria's corporate tax system:

$$RTUCM_t = \frac{1 - Z_t \cdot RTCIT_t}{(1 - RTCIT_t)\sqrt{1 - RDM_t}} \, . \qquad (4)$$

Here Z_t is the present value of the depreciation tax allowance and $RTCIT_t$ the combined statutory rate of corporate taxation, which currently is identical to the statutory tax rate of the corporation tax (Körperschaftsteuersatz). The factor $\sqrt{1 - RDM_t}$ reflects the assumption that new investment goods depreciate uniformly already in the year of their purchase. The above specification for user costs of capital allows simulations of a change in the corporation tax, the depreciation allowance, or the investment tax allowance.

For the interest rate on business loans we estimate an equation in first differences:

$$\Delta RC_t = 0.00049 + 0.049\Delta RLN_t + 1.114\Delta RSN_t\,, \tag{5}$$

where $RSIN_t$ and $RLIN_t$ are the short-run (3 month) and long-run (10 year benchmark) GDP-weighted interest rates for the euro area. Both interest rates are exogenous. Equations (2) to (5) form the main monetary policy transmission channel in the model. Private sector non-residential investment follows a simple error-correction specification based on accelerator theory:

$$\Delta\log(IPC_t) = -5.79 + 1.32\Delta\log(YP_t) - 0.385\log(IPC_{t-1}/YP_{t-1}) + 0.397\log(YP_{t-1})\,. \tag{6}$$

The short and long run elasticities with respect to GDP in the private sector are 1.32 and around 2.0, respectively.

3.3 Foreign Trade and the Current Account

For total exports we estimate a specification which depends on income in OECD countries and the relative price of domestic and foreign goods. This approach is consistent with the Armington assumption of imperfect substitutability between traded goods, as the law of one price is not imposed. For total exports at constant 1995 prices, X_t, we estimate an error-correction model:

$$\Delta\log(X_t) = -3.47 + 1.03\Delta\log(YW_t) - 0.28\Delta\log\left(\frac{PX_t}{PW\$_t US\$_t}\right) - 0.154\log(X_{t-1}) + 0.369\log(YW_{t-1})\,. \tag{7}$$

In the above export equation, YW_t represents the weighted aggregate GDP of Austria's main exports markets with weights according to the destinations' shares in Austria's exports in the year 2003. The relative price term includes the export deflator, PX_t, and the world price deflator for traded goods in US dollars, $PW\$_t$, from the "World Economic Outlook" of the IMF. The world price is converted into euro using the exchange rate between the euro and US dollar, $US\$_t$. We observe a short run income elasticity of 1.03 and a price elasticity of 0.28. The long run income elasticity equals 2.4.

In modelling import demand, we differentiate the income effect depending on the use by taking into account different import contents of demand aggregates. Doing so is especially important when simulating the effect of fiscal policy measures. A comparison of import contents of different demand aggregates as shown in table 1 suggests that an increase in government consumption would, other things equal, induce less additional imports and therefore more value added than, say, a comparable increase in private investment in machinery and equipment. We compute a notional imports variable, MIO_t, as the sum of demand components weighted by their respective import contents. As import contents are computed from input/output tables and are not available as time series, we use the 1995 shares since this date coincides with our price basis. Import shares are held constant for the subsequent years.

Table 1: Import Content at Current Prices in Percent

	1995	2000
Demand aggregate		
Private consumption	23	27
Public consumption	9	11
Investment in		
Residential construction	21	22
Non-residential construction	22	22
Machinery and equipment	59	70
Exports	33	39
Total domestic demand	23	27

Source: I/O tables for Austria.

Table 1 shows that the import content of all demand components, with the exception of construction investment, has risen. The difference between M_t and MIO_t can be explained by the decrease in import prices relative to those of domestic goods. However, there may be factors other than prices which influence the import content. The increase in the import share can be partially explained by integration effects due to EU enlargement and deepening. Outsourcing could be another factor contributing to a steady increase in the import content of intermediate goods. Both, price and non-price effects are taken into account by the following specification:

$$\log(M_t / MIO_t) = 0.00446 + 0.232\log(PM_t / P_t) - 0.507\log(PM_{t-1} / P_{t-1}) + 0.856\log(M_{t-1} / MIO_{t-1}) , \qquad (8)$$

where PM_t and P_t are the import and the GDP deflator, respectively. By definition, the elasticity of MIO_t with respect to the actual imports is unity. A simulation of equation (8) for the time period 1995 to 2005 shows that a 1% increase in public consumption leads to 0.04% increase in total imports, whereas a similar increase in (private) investment in machinery and equipment leads to 0.14% more imports.

The current account balance, CA_t, contains three components: (i) the balance of trade in goods and services, $CAXMN_t$, (ii) the balance of income flows, CAY_t, (iii) and the balance of transfer payments, CAT_t:

$$CA_t = CAXMN_t + CAY_t + CAT_t \,. \tag{9}$$

The balance of trade at current prices is computed from the exported and imported quantities of goods and services and their respective deflators. The balance of income flows is proportional to the interest earned on the stock of net foreign assets, NFA_{t-1}, accumulated in the past:

$$CAY_t = QCAY\left(NFA_{t-1}RSN_t\right), \tag{10}$$

where $QCAY$ is a constant factor and RSN_t the short-term interest rate.

Domestic savings of the economy, SN_t, is the sum of private household savings, government savings and savings by the business sector:

$$SN_t = (YDN_t - CPN_t) + (GR_t - GE_t) + QSB(IN_t)\,. \tag{11}$$

Business sector saving is determined as a constant ratio, QSB, to investment at current prices. This formulation implies that a constant share of investment is financed out of cash flow. The cash flow financed amount of investment corresponds to business sector savings.

Equating excess saving to the balance of transfer payments closes the savings investment identity for an open economy. For savings and investment to be in equilibrium, excess savings given by the right hand side of the following equation must be equal to the balance of transfer payments, CAT_t:

$$CAT_t = (SN_t - (IN_t - DPN_t) - CAXMN_t - CAY_t)/(1 + QSNDIFFN_t)\,, \tag{12}$$

subject to statistical discrepancy, $QSNDIFFN_t$, in the past. Here $IN_t - DPN_t$ is the difference between investment and depreciation at current prices.

Current account imbalances will cumulatively change the net foreign asset position, where every year the current account balance is added to the previous year stock of assets. Ignoring changes in the valuation of net foreign assets we thus have:

$$\Delta NFA_t = CA_t + CADIFF_t , \qquad (13)$$

where $CADIFF_t$ accounts for the past statistical discrepancy.

By disaggregating current account into trade, income and transfer flows, we can distinguish the gross domestic product from the gross national product and derive the disposable income of the economy.

3.4 The Labour Market

Labour demand is derived from the first order conditions for the cost-minimization problem of a CES production function given the prices of factor inputs and the output. The rate of change in employment is explained by the growth in real GDP growth and the change in relative factor prices of labour and capital:

$$\Delta \log(LEA_t) = 0.41\Delta \log(Y_t) - 0.025\Delta \log(WP_{t-1} / UCM_{t-1}) , \qquad (14)$$

where LEA_t represent the number of employees, WP_t the average real wage per employee and UCM_t the user costs of capital.

In determining the change in the number of unemployed persons, ΔLU_t, we take both supply and demand factors into account:

$$\Delta LU_t = -0.64\Delta LEA_t + 0.428\Delta POP_t - 0.477\Delta PENPM_t + 18.45\Delta(100 LEAF_t / LEA_t) , \qquad (15)$$

The change in the number of unemployed persons decrease with the number of jobs created ΔLEA_t and the change in the number of early retirees $\Delta PENPM_t$. It increases with the working age population ΔPOP_t. The last term accounts for the effect of the share of foreign workers in the number of total employees, $LEAF_t / LEA_t$. For example, a rise of the labour demand by 1,000 persons, other things equal, would lead to 640 less unemployed persons. A 1 percentage point increase in the share of foreign labour leads to 18,450 more unemployed.

We define the trend rate of unemployment U_T_t as the moving average of the five most recent actual rates U_{t-j} for $j = 0,...,4$. The corresponding trend employment is used for determining the trend output Y_T_t at constant 1995 prices. We use the cyclical rate of unemployment, defined as the difference between the trend and the actual rates, as a proxy for the tightness of the labour market in the equation for wages.

3.5 Trend Output and the Output Gap

The trend output Y_T_t is defined as a Hodrick-Prescott filtered series of the actual output Y_t, and is projected with a constant elasticity of substitution (CES) production function that combines trend labour and physical capital under constant returns to scale. We assume an exogenous Hicks-neutral technical progress. Input intensities and the elasticity of substitution are derived from a pair of first order conditions to the cost minimization problem and estimated with Full Information Maximum Likelihood. After substituting factor shares and the elasticity of substitution into the production function, the intercept and the rate of change of factor productivity are estimated by OLS. After taking the natural logarithm and the first difference the production function becomes:

$$\Delta \log(Y\_T_t) = 0.017 - (1/0.65)\Delta \log(0.66K_t^{-0.65} + 0.44L\_T_t^{-0.65}) , \qquad (16)$$

where L_T_t is the trend number of full-time equivalent employees[7] and K_t is the stock of capital, assuming that the production capacity is always fully utilized. Given the substitution parameter $\rho = -0.65$, the elasticity of substitution between capital and labour is $1/(1-\rho) = 0.61$. The elasticity of substitution is a local measure of technological flexibility. It characterizes alternative combinations of capital and labour which generate the same level of output. Under the assumption of cost minimization on the part of the representative firm, the elasticity of substitution measures the percentage change in the relative factor input as a consequence of a change in the relative factor prices. In our case, factor prices are the real wage per full-time equivalent employee and the user costs of capital. Thus, other things being equal, an increase of 1% of the ratio of real wage to the user costs will lower the ratio of the number of employees to capital by 0.61%. In the baseline, we exogenously set the annual rate of change of the total factor productivity to 1.7%.

The output gap as a measure of the aggregate rate of capacity utilisation is defined as $YGAP_t = Y_t / Y\_T_t - 1$. It is thus positive whenever the actual GDP lies above its trend.

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[7] Following the ESA 1995 convention, the compensation of the self-employed are included in the gross operating surplus and therefore are not a part of the compensation of employees. We therefore exclude labour input by the self-employed from the production function.

3.6 Wages

Wages per employee in nominal terms are determined for the private sector. For the rate of growth of private sector wages, WPN_t, we estimate the following equation related to the Non-accelerating Wage Rate of Unemployment (NAWRU) concept:

$$\Delta\log(WPN_t) = 0.43\Delta\log(PCP_{t-1}) + 0.29\Delta\log(APLP_{t-1}) - 1.1(U_t - U\_T_t)/100 + 0.3\Delta\log(WPN_{t-1}), \qquad (17)$$

where PCP_t denotes the deflator of private consumption as a proxy for the consumer price index, $APLP_t$ the average labour productivity and $U_t - U\_T_t$ the cyclical unemployment. The above aggregate specification implies a sluggish rate of adjustment of wages to inflation and the productivity of labour. In the long run, however, the employees are almost fully compensated for an increase in the labour productivity (long-run elasticity of 0.96) and in the case of inflation, are even overcompensated (long-run elasticity of 1.43). The employment gap captures the tightness of the labour market against the background of the trend unemployment rate represented by U_T_t. The coefficient implies that a 1 percentage point change increases in the cyclical rate of unemployment leads to a fall by 1.1 percentage points in the nominal wage inflation rate.

We assume that wages in the public sector, WGN_t, adjust to those in the private sector within two periods:

$$\Delta\log(WGN_t) = 0.85\Delta\log(WPN_t) + 0.2\Delta\log(WPN_{t-1}). \qquad (18)$$

3.7 Prices

The dynamics of the deflator for domestic demand, $PYTD_t$, is central to price determination in the model since several other deflators directly depend on it:

$$PYTD_t = \frac{YTDN_t}{YTD_t} = \frac{YTDN_t \pm (TIND_t - SUB_t)}{YTD_t} = PYTDA_t + \frac{TIND_t - SUB_t}{YDT_t}, \qquad (19)$$

where $YTDN_t$ is the total demand at current prices, $TIND_t$ is the revenue from taxes on production and imports and SUB_t represents subsidies. We estimate an auxiliary equation net of indirect taxes and subsidies:

$$\Delta\log(PYTDA_t) = 0.38\Delta\log(ULC_t) + 0.36\Delta\log(PM_t) + 0.235\Delta(YGAP_t) + 0.329\Delta\log(PYTDA_{t-1}). \qquad (20)$$

Here we differentiate between domestic and foreign cost-push factors represented by the unit labour costs, ULC_t, and the import price deflator, PM_t, respectively, and demand pull factors by a proxy for the overall rate of capacity utilization, the output gap, $YGAP_t$. In addition to the effect of these factors, the actual deflator for domestic demand, $PYTD_t$, also includes the cost-effect of indirect taxes and subsidies as shown in equation (19).

All deflators for the components of final demand, with the exception of total imports and exports, are estimated as dynamic specifications in the rates of inflation. Whereas short-run elasticities may vary, we restrict the long-run elasticity with respect to the deflator for domestic demand to unity. This introduces price homogeneity in the long run and tends to stabilize the ratios of nominal individual demand components to total demand.

Deflators of total exports, PX_t, and imports, PM_t, are modelled as follows:

$$\Delta\log(PX_t) = 0.23\Delta\log(ULC_t) + 0.45\Delta\log(PM_t)\,; \qquad (21)$$

$$\Delta\log(PM_t) = 0.23\Delta\log(PW\$_t US\$_t) + 0.77\Delta\log(PM_{t-1})\,, \qquad (22)$$

with similar specifications estimated for exports and imports of goods omitted here.

3.8 Public Sector

We model public revenues, expenditures, consumption, and value added according to their ESA 1995 definitions. The legal and institutional framework of the Austrian economy is captured in several structural equations and identities. Whereas public revenues are mainly endogenous, most of public expenditures are policy instruments and are exogenous. This improves model forecasts since accurate information concerning future public expenditures is typically available from official sources and can be fed directly to the model. The public wage-bill and the interest payments on public debt are the exceptions and are endogenously determined expenditure items.

Public consumption and value added of the public sector follow their respective ESA definitions. For completeness these definitions require several variables, notably, public sector's gross operating surplus and depreciation. Whereas we exogenously assume the former, the latter is estimated from the past depreciations implied by the perpetual inventory method.

3.8.1 Public Revenues

We estimate the elasticity of the individual public revenue items such as taxes and social contributions with respect to a proxy for their revenue base.[8] The largest five items, their elasticities and base proxies are shown in table 2. All other items such as property income, received current transfers, and other taxes and duties on imports are exogenous. Exogenous is also public output for own final use.

Table 2: Public Revenue Items

Item	Elasticity	Base Proxy at Current Prices
Wage Tax	1.29	Compensation of Employees
Corporation Tax	0.84	see text below
Other Direct Taxes	0.79	GDP
Social Contributions*)	0.94	Compensation of Employees
The Value Added Tax	0.76	Private Consumption Outlays
Other Indirect Taxes	0.65	GDP

*) Except the Unemployment Insurance which is separately modelled.
Source: Authors' calculations

In modelling corporation tax revenues we take a different approach. Since in Austria corporate income is taxed at a flat rate, we model the dynamics of the tax base and then apply the statutory tax rate to compute the tax revenue. Since corporate profits are not separately available in ESA we use lagged differences between the private sector's gross operating surplus and depreciation as a proxy. The elasticity is obtained by regression of the actual corporate tax base taken from the Corporation Tax Statistics on the tax base proxy variable, and equals 0.84.

3.8.2 Public Expenditures

The expenditure side contains only a few endogenous variables, notably the compensation to employees in the public sector, unemployment benefits and the interest payments on

[8] Clearly this method is only approximate and can generate large forecasting errors due to changes in the institutional setting. Known or plausibly expected institutional changes may prove invaluable, when forecasting public revenues and should not be discarded.

public debt. The dynamics of the average wage per employee in the public sector follows that in the private sector (equation 18). Employment in the public sector is exogenous. Together they determine the compensation per employee and the wage-bill in this sector.

Among the exogenous variables we have the intermediate public consumption, public investment, subsidies including transfers from the European Union, social benefits (except unemployment benefits) and social transfers in kind, as well as other expenditures.

3.8.3 Public Deficit and Debt

Interest payments on gross government debt, GEI_t, are computed as the product of an implicit rate of interest, RGD_t, and the lagged level of debt GD_t:

$$GEI_t = RGD_t GD_{t-1}. \tag{23}$$

GEI_t is an endogenous component of government expenditures and therefore of the balance of the public sector GB_t.

The dynamics of government debt (24) is given by the difference between newly issued debt and amortized debt. Unfortunately, public debt data are readily available for the federal state only.[9] Therefore, we assume a constant ratio between the debt of the federal state and the rest of the public sector, and include an adjustment factor, $QGD_t GD_{t-1}$, to balance this gap.

The newly issued debt of the federal state, GCI_t, is almost identical to the difference of the amortized debt of the federal state, $GCRED_t$, and the deficit of the whole public sector GB_t:

$$\Delta GD_t = (GCI_t - GCRED_t) + QGD_t GD_{t-1}; \tag{24}$$

$$\log(GCI_t) = 1.025 + 0.9 \log(GCRED_t - GB_t). \tag{25}$$

The implicit rate of interest, RGD_t, is a weighted average of interest rates on outstanding debt, RGD_{t-1}, and on newly issued debt, RIN_t, where $QRGD_t$ is the share of the outstanding debt to total debt (subject to statistical difference $RGDDIFF_t$ in the past). The term structure of the newly issued debt is captured by the share of long-term to total debt, $QRLIN_t$. The interest rate on newly issued debt, RIN_t, is a weighted average of the long run, $RLIN_t$, and

[9] See report on the development of the Austrian federal debt (Bericht über die Finanzschuld des Bundes, Staatsschuldenausschuss, various years).

short run, $RSIN_t$, interest rates on public debt, which depend on long-run (26.3) and short-run (26.4) interest rates, respectively:

$$RGD_t = QRGD_t RGD_{t-1} + (1 - QRGD_t) RIN_t + RGDDIFF_t \text{;} \tag{26.1}$$

$$RIN_t = QRLIN_t RLIN_t + (1 - QRLIN_t) RSIN_t \text{;} \tag{26.2}$$

$$\Delta \log(RLIN_t) = 0.82 \Delta \log(RLN_t) \text{;} \tag{26.3}$$

$$\Delta \log(RSIN_t) = 0.5 \Delta \log(RSN_t) \text{.} \tag{26.4}$$

We compute the primary balance of the general government as the difference between the actual public sector balance and the interest payment on public debt.

4. Simulations

In this section we present three standard simulations to illustrate the main properties of the model:

- fiscal shock over five years
- export shock over five years
- interest rate shock over two years.

Each simulation covers a period of ten years. The shocks are implemented in the year 2004 and are removed after five (or two) years to highlight the adjustment paths. Given the scope of the model we do not consider international spillovers. In particular, the nominal euro-U.S. dollar exchange rate and foreign prices are kept constant in all simulations except for the third. In all three simulations we assume neither fiscal, such as a solvency condition, nor monetary policy rules, such as the Taylor rule. Only the automatic stabilizers that are built into the model are at work.

4.1 Fiscal Shock

4.1.1 Input

We simulate an increase in intermediate public consumption by 1% of real GDP as of 2004, sustained for five consecutive years. In nominal terms, the absolute size of the shock is EUR 2.4 billion or a 23% increase in intermediate public consumption compared to the baseline. The magnitude of the shock remains constant over the five years and, hence, decreases relative to nominal GDP. After five years, public intermediate consumption returns to the baseline level.

4.1.2 Results

Table 3 shows the effect of the public expenditure shock. As a result, public consumption increases by 6%, of which over 90% are due to the increase in intermediate public consumption; the remaining effect is attributed to endogenous variables such as the public wage bill. A direct shock of a GDP component has an immediate effect on GDP. We observe a dynamic fiscal multiplier of 1.17 in the first year, which reaches its maximum of 1.31 in the third year. Private consumption increases by 0.43 percentage points in the third year. The private household's short-term propensity to consume of 0.35 leads to a substantial increase in the savings ratio of around 0.3% in the first year. The average labour productivity, computed as the ratio of real GDP to the number of employees rises by 0.8 percentage points. This is attributed to an adjustment of nominal average compensation per employee to an increase in consumer price inflation. In the absence of a fiscal policy rule linking expenditures to revenues, the assumed increase in public expenditures leads to an increase in public deficit of 0.7% of GDP in the first and 0.5% in the third year. In the first year the public debt increases by 1.1% relative to the baseline. Since the output at current prices increase by 1.2%, the negative net effect on the public debt ratio to GDP is very small initially.

After the fifth year we have a negative fiscal shock in relation to the year before. We observe a strong investment cycle, with 1.5% less private investment spending in the last year of the simulation. This decrease is partially explained by the rise in the user costs of capital due to the rise in the real interest rate. Total imports continue to rise even after the subsequent decrease in GDP. The model shows sluggish price and wage adjustment. Despite the return to the baseline spending level after five years, the model predicts a steady accumulation of the public debt up to 3.6% of GDP in ten years. Since the term-structure of interest rate is exogenous in the model, a fiscal shock does not crowd-out private investment.

Table 3: Fiscal Shock for 5 years - Increase of public expenditure by 1 percent of 2004 GDP

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	Levels, percentage deviations from baseline									
HICP	0.02	0.15	0.32	0.46	0.57	0.60	0.49	0.31	0.10	– 0.08
Consumption Deflator	0.05	0.18	0.34	0.49	0.60	0.58	0.49	0.32	0.13	– 0.05
GDP Deflator	0.02	0.21	0.43	0.64	0.81	0.85	0.71	0.48	0.21	– 0.05
Investment Deflator	0.01	0.15	0.33	0.54	0.72	0.81	0.75	0.57	0.33	0.08
Unit Labour Costs	– 0.43	0.02	0.35	0.61	0.78	1.24	0.89	0.56	0.24	– 0.04
Compensation per employee	0.27	0.78	1.17	1.42	1.52	1.27	0.71	0.20	– 0.25	– 0.57
Productivity	0.69	0.75	0.80	0.80	0.73	0.04	– 0.17	– 0.35	– 0.48	– 0.53
Export Deflator	– 0.10	0.01	0.08	0.14	0.18	0.28	0.20	0.13	0.05	– 0.01
Import Deflator	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
GDP and Components	Levels, percentage deviations from baseline									
GDP	1.17	1.26	1.31	1.27	1.14	– 0.02	– 0.33	– 0.59	– 0.76	– 0.83
Consumption	0.20	0.32	0.43	0.50	0.54	0.36	0.22	0.07	– 0.06	– 0.18
Investment	1.56	1.82	1.91	1.78	1.48	– 0.25	– 0.85	– 1.28	– 1.50	– 1.51
Of which: Construction	0.99	1.26	1.42	1.47	1.40	0.41	– 0.04	– 0.44	– 0.75	– 0.95
Gov. Consumption	5.87	6.06	6.15	6.19	6.16	0.66	0.28	– 0.06	– 0.32	– 0.48
Exports	0.03	– 0.01	– 0.03	– 0.04	– 0.04	– 0.07	– 0.03	– 0.01	0.01	0.03
Imports	0.67	0.70	0.75	0.78	0.81	0.33	0.37	0.40	0.41	0.38
Contributions to Shock	Percentage of GDP, absolute deviations from baseline									
Domestic Demand	1.52	1.66	1.77	1.78	1.70	0.25	– 0.05	– 0.30	– 0.49	– 0.58
Trade Balance	– 0.35	– 0.40	– 0.46	– 0.52	– 0.57	– 0.27	– 0.28	– 0.29	– 0.27	– 0.24
Labour Market	Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline									
Total employment	0.46	0.49	0.48	0.45	0.40	– 0.06	– 0.16	– 0.23	– 0.28	– 0.29
Employees in employment	0.48	0.51	0.50	0.47	0.41	– 0.06	– 0.16	– 0.24	– 0.29	– 0.30
Unemployment rate	– 0.31	– 0.33	– 0.33	– 0.31	– 0.27	0.04	0.11	0.16	0.19	0.20
Household Accounts	Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline									
Disposable income	0.56	0.65	0.72	0.71	0.62	0.03	– 0.17	– 0.35	– 0.46	– 0.50
Saving rate	0.33	0.29	0.26	0.18	0.07	– 0.31	– 0.36	– 0.39	– 0.36	– 0.30
Public Sector	Percentage of GDP, absolute deviations from baseline									
Public balance	– 0.74	– 0.57	– 0.51	– 0.47	– 0.48	0.15	– 0.05	– 0.20	– 0.33	– 0.42
Public debt	– 0.06	0.30	0.61	0.93	1.35	1.88	2.18	2.63	3.13	3.58

4.2 Export Shock

4.2.1 Input

Here we assume an exogenous increase in Austria's real exports of goods and services by 1%, sustained over five years. Contrary to the previous simulation, the magnitude of the export shock relative to baseline is constant over time. In absolute values at constant 1995 prices, total exports increase by EUR 1.2 billion in 2004. To implement this shock we skip the otherwise endogenous export equations. Thus, we ignore the endogenous repercussions on the volume of exports via domestic price effects.

4.2.2 Results

Dynamics of adjustment after the export shock are similar to that discussed in the fiscal spending simulation. However, since the size of the shock relative to GDP is slightly above one half of that in the previous simulation, the magnitude of the resulting effects is smaller (table 4).[10] The 1% increase in the level of real exports generates 0.6% more real GDP after five years. The contribution of domestic demand is responsible for two thirds of the GDP effect; the rest is attributed to an improvement in the trade balance. The change in inflation is moderate and amounts to 0.3 percentage points in the medium term. Due to the delayed price response, the change in inflation peaks two years after that of the GDP. These sluggish price dynamics are attributed, in part, to the sluggish adjustment of nominal wages to the consumer price inflation. The increase in public revenues of 0.7%s relative to the baseline leads, given constant spending, to an improvement in public balances of the order of 0.3 percentage points relative to GDP. The ratio of public debt to the nominal GDP is reduced by 1 percentage point after ten years.

[10] When the shocks are standardised, the magnitudes of the effects are quite similar with the exception of total imports and public sector balance.

Table 4: Export Shock for 5 years - Increase by 1 percent

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	Levels, percentage deviations from baseline									
HICP	– 0.00	0.04	0.11	0.17	0.22	0.26	0.23	0.17	0.10	0.03
Consumption Deflator	– 0.00	0.04	0.10	0.16	0.21	0.25	0.23	0.18	0.11	0.04
GDP Deflator	– 0.05	0.01	0.08	0.16	0.23	0.35	0.33	0.26	0.16	0.06
Investment Deflator	– 0.03	– 0.01	0.05	0.12	0.19	0.30	0.32	0.28	0.20	0.11
Unit Labour Costs	– 0.15	– 0.00	0.11	0.22	0.30	0.52	0.40	0.29	0.18	0.07
Compensation per employee	0.09	0.28	0.45	0.58	0.67	0.61	0.42	0.22	0.04	– 0.11
Productivity	0.24	0.28	0.33	0.36	0.37	0.09	0.02	– 0.07	– 0.14	– 0.18
Export Deflator	– 0.03	– 0.00	0.03	0.05	0.07	0.12	0.09	0.07	0.04	0.02
Import Deflator	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
GDP and Components	Levels, percentage deviations from baseline									
GDP	0.41	0.49	0.55	0.58	0.59	0.12	– 0.01	– 0.13	– 0.23	– 0.28
Consumption	0.06	0.13	0.20	0.24	0.28	0.23	0.16	0.09	0.02	– 0.04
Investment	0.49	0.68	0.79	0.83	0.79	0.18	– 0.14	– 0.36	– 0.51	– 0.57
Of which: Construction	0.34	0.48	0.58	0.65	0.69	0.31	0.13	– 0.04	– 0.18	– 0.29
Gov. Consumption	0.06	0.19	0.29	0.36	0.39	0.33	0.19	0.06	– 0.05	– 0.13
Exports	1.00	1.00	1.00	1.00	1.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
Imports	0.60	0.65	0.68	0.71	0.74	0.13	0.13	0.14	0.15	0.14
Contributions to Shock	Percentage of GDP, absolute deviations from baseline									
Domestic Demand	0.16	0.26	0.33	0.38	0.40	0.21	0.08	– 0.03	– 0.12	– 0.18
Trade Balance	0.24	0.23	0.21	0.20	0.19	– 0.09	– 0.09	– 0.10	– 0.10	– 0.10
Labour Market	Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline									
Total employment	0.16	0.19	0.21	0.21	0.21	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Employees in employment	0.17	0.20	0.21	0.22	0.22	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Unemployment rate	– 0.11	– 0.13	– 0.14	– 0.15	– 0.14	– 0.02	0.02	0.04	0.06	0.07
Household Accounts	Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline									
Disposable income	0.19	0.25	0.30	0.32	0.32	0.11	0.02	– 0.06	– 0.12	– 0.15
Saving rate	0.11	0.12	0.11	0.10	0.07	– 0.08	– 0.12	– 0.14	– 0.14	– 0.13
Public Sector	Percentage of GDP, absolute deviations from baseline									
Public balance	0.10	0.17	0.22	0.26	0.30	0.21	0.14	0.08	0.03	– 0.02
Public debt	– 0.32	– 0.56	– 0.83	– 1.14	– 1.47	– 1.44	– 1.45	– 1.37	– 1.22	– 1.04

4.3 Monetary Policy Shock

The model includes six interest rates, two of which, the GDP-weighted short-term (3 month) and long-term (10 year benchmark) euro area rates are exogenous. As the short term interest rate for the euro area closely follows the European Central Bank rate on the main refinancing operations, which provide the bulk of liquidity to the euro area banking system, we implement a monetary policy shock via a change in the short term interest rate. The interest rate on business loans and the implicit rates of interest on public debt of short and long term maturities, and a weighted average of the two rates, are determined in the model (see Section 3.8.3).

4.3.1 Input

We assume a 1 percentage point increase in the nominal short term interest rate sustained over two years. To capture the effect of the term-structure of interest rates, we raise the long-term interest rate by 0.163 percentage points in the first year, followed by an increase of 0.063 in the second year. As the euro-U.S. dollar exchange rate is exogenous, we make a simple uncovered interest parity assumption that leads to an appreciation of the euro-U.S. dollar by 0.163% in the first and 0.063% in the second year. The input for this simulation includes all three assumptions, for the short and long term interest rates, and the exchange rate, taking effect in the first two years. In the third and the subsequent years these variables return to their baseline levels.

4.3.2 Results

The interest rate shock has an immediate impact on the interest rate on business loans of 1.1 percentage points in both years. This transmits into an increase in the user costs of capital between 1.2 to 1.3 percentage points. As the user costs of capital are a determinant of private investment in machinery and equipment only and the long term interest rate change is small in the second year the impact on total investment is the largest in the first year and diminishes afterwards. The resulting small GDP effect of around 0.1 percentage point mirrors the fact that construction and private consumption of durables are independent of the interest rates. After accounting for the last two effects, we would expect a larger negative impact on GDP in the medium term. The change in relative factor prices leads to substitution from capital to labour. Therefore, employment rises by up to 0.15% in the second and third year after the shock. The change in the short term interest rate has almost no impact on public finances.

5. Conclusions

WIFO-Mocromod was used to simulate three macroeconomic shocks. First, we analyse the effect of a fiscal expansion by 1% of nominal GDP as of 2004 sustained for five years. We observe a dynamic fiscal multiplier of 1.3 after three years. The second simulation studies an exogenous shock of 1% of total export demand at constant prices, which amounts to 0.6% of real GDP in Austria, sustained for five years. The dynamic export multiplier is 0.7 at the onset and increases to 0.9 in the fourth year. In the third simulation we evaluate a monetary policy shock. The simulation inputs include an increase in the short (1 percentage point) and long-term interest rates coupled with euro devaluation according to the uncovered interest rate parity hypothesis, over a period of two years. As a result, real GDP declines in the short-term by 0.1% compared to baseline.

Table 4: Export Shock for 5 years - Increase by 1 percent

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	Levels, percentage deviations from baseline									
HICP	– 0.00	0.04	0.11	0.17	0.22	0.26	0.23	0.17	0.10	0.03
Consumption Deflator	– 0.00	0.04	0.10	0.16	0.21	0.25	0.23	0.18	0.11	0.04
GDP Deflator	– 0.05	0.01	0.08	0.16	0.23	0.35	0.33	0.26	0.16	0.06
Investment Deflator	– 0.03	– 0.01	0.05	0.12	0.19	0.30	0.32	0.28	0.20	0.11
Unit Labour Costs	– 0.15	– 0.00	0.11	0.22	0.30	0.52	0.40	0.29	0.18	0.07
Compensation per employee	0.09	0.28	0.45	0.58	0.67	0.61	0.42	0.22	0.04	– 0.11
Productivity	0.24	0.28	0.33	0.36	0.37	0.09	0.02	– 0.07	– 0.14	– 0.18
Export Deflator	– 0.03	– 0.00	0.03	0.05	0.07	0.12	0.09	0.07	0.04	0.02
Import Deflator	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
GDP and Components	Levels, percentage deviations from baseline									
GDP	0.41	0.49	0.55	0.58	0.59	0.12	– 0.01	– 0.13	– 0.23	– 0.28
Consumption	0.06	0.13	0.20	0.24	0.28	0.23	0.16	0.09	0.02	– 0.04
Investment	0.49	0.68	0.79	0.83	0.79	0.18	– 0.14	– 0.36	– 0.51	– 0.57
Of which: Construction	0.34	0.48	0.58	0.65	0.69	0.31	0.13	– 0.04	– 0.18	– 0.29
Gov. Consumption	0.06	0.19	0.29	0.36	0.39	0.33	0.19	0.06	– 0.05	– 0.13
Exports	1.00	1.00	1.00	1.00	1.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
Imports	0.60	0.65	0.68	0.71	0.74	0.13	0.13	0.14	0.15	0.14
Contributions to Shock	Percentage of GDP, absolute deviations from baseline									
Domestic Demand	0.16	0.26	0.33	0.38	0.40	0.21	0.08	– 0.03	– 0.12	– 0.18
Trade Balance	0.24	0.23	0.21	0.20	0.19	– 0.09	– 0.09	– 0.10	– 0.10	– 0.10
Labour Market	Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline									
Total employment	0.16	0.19	0.21	0.21	0.21	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Employees in employment	0.17	0.20	0.21	0.22	0.22	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Unemployment rate	– 0.11	– 0.13	– 0.14	– 0.15	– 0.14	– 0.02	0.02	0.04	0.06	0.07
Household Accounts	Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline									
Disposable income	0.19	0.25	0.30	0.32	0.32	0.11	0.02	– 0.06	– 0.12	– 0.15
Saving rate	0.11	0.12	0.11	0.10	0.07	– 0.08	– 0.12	– 0.14	– 0.14	– 0.13
Public Sector	Percentage of GDP, absolute deviations from baseline									
Public balance	0.10	0.17	0.22	0.26	0.30	0.21	0.14	0.08	0.03	– 0.02
Public debt	– 0.32	– 0.56	– 0.83	– 1.14	– 1.47	– 1.44	– 1.45	– 1.37	– 1.22	– 1.04

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