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Danish Research Institute for
Economic Analysis and Modelling

MAKRO

Shock Reactions in MAKRO May 2025

The dynamic responses of the MAKRO model to various economic shocks

Grane H. Høegh, Emil H. Partsch, and Martin K. Bonde

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Contents

1 Introduction

This note aims to illustrate the properties of the most recent version of MAKRO to a series of shocks. This note is based on the current publicly available December 2024 version of the model.[1] Before analyzing the impact of specific shocks, we discuss general properties of the transmission mechanisms present in the model.

First, we describe the general response to demand shocks (Section 1.1), followed by similar considerations for supply shocks (Section 1.2 for labor supply and productivity, section 1.3 for shocks to foreign prices, and Section 1.4 for financial shocks). After this, we discuss how financing of public expenditure affects the model's dynamic responses (Section 1.5). Finally, we write briefly about the sectors in MAKRO. The individual shock analyses are described in the subsequent sections.

[1] The model is available for download on GitHub at https://github.com/DREAM-DK/MAKRO.

1.1 Fundamental mechanisms when demand increases

1.1.1 Initial shock changes one or more demand components

A positive demand shock is a shock that increases domestic demand for given prices. The demand curve shifts right. This occurs through changes in private consumption, public consumption, investments, exports, or imports. The shock can be direct, as with a shock to government consumption, but it is often indirect, as with shocks to the income tax, changing household income. Regardless, the way the different demand shocks propagate through the model economy is similar, and we discuss it in this section.

1.1.2 Increased demand leads to increased sector production

When demand increases, production from different sectors will increase via the input / output system. For given output prices and unit costs, firms will want to meet the increased demand to increase profits.

1.1.3 Increased sectoral production leads to increased production inputs

To increase production, firms must increase their input of intermediates, labor, and capital. Note that there is capacity utilization on labor, but not capital. Firms invest in capital based on their expectations for production in the coming periods. In the short and medium run, there are decreasing returns to scale due to installation costs, while in the long run, there are constant returns to scale. Capacity utilization means that production in the short run is not only affected by the amount of production inputs used. In this manner, output in the individual sectors can increase more than factor input in the short term.

Time-to-build and installation costs on capital mean that user costs on capital increase in the short run relative to other inputs. The K/L ratios in the individual sectors decrease. In the short run, it is thus easier to increase factor input from labor and intermediates compared to capital.

1.1.4 Increased intermediate inputs leads to increased imports and domestic sectoral output

Increased demand for intermediate inputs results in increased demand for goods and services from other sectors and imports.

1.1.5 Increased capital demand leads to increased investments from imports and domestic sectoral output

Increased investment also results in increased demand for production from domestic sectors and imports that deliver inputs to investment.

1.1.6 Increased labor demand leads to increased wages, employment and labor supply

The labor market is a search-match-labor market with bargaining between employers and labor determining the wage. To increase employment, firms must hire more employees and post more vacancies. The more vacancies posted relative to the number of job seekers, the more difficult it is to get a match by a vacancy posting. The marginal cost of hiring thus increases for firms (as posting vacancies is costly). Inversely, it becomes easier for the job seekers to get

a match. The expected marginal gain from applying for a job increases, causing households to increase the effective labor supply.

Increased marginal cost of hiring causes the marginal cost of labor to increase. It provides a larger wedge between the marginal cost of new employees the firm is willing to pay and the salary existing employees receive. This increases the bargaining power of existing employees, which puts upward pressure on salaries. Wages adapt sluggishly and gradually contribute to increasing the marginal cost of labor.

1.1.7 Increased employment and wages leads to higher household income and increased demand for private consumption and housing

Increased employment and wages increase household income. Households spread consumption throughout their life and save for bequests, considering relative prices and expectations of future wealth and income. Habit consumption provides a more gradual adjustment, and the benefit of wealth, including inheritance, ensures that they save when old and do not borrow too much when young. Reference consumption relative to liquid income (hand-to-mouth, HtM, consumption) ensures empirically realistic marginal propensities to consume out of temporary income increases, which ensures realistic short-run consumption properties. Furthermore, the effect will depend on which age groups experience the income increase, as younger age groups in MAKRO have a higher marginal propensity to consume. The increase in private consumption reflects an increase in consumption, excluding housing and housing consumption.

1.1.8 Increased housing demand leads to increased housing prices and investments in housing

The increased housing demand results primarily in higher prices because the supply of housing changes slowly. The marginal price for increasing the housing volume is very high in the short run because houses embody land that exists in rigid supply. The housing volume thus only changes slightly in the short run, while the house price is quite volatile.

1.1.9 Increased housing prices lead to increased liquidity and demand for private consumption and housing

Higher house prices lead to a redistribution of wealth from those who purchase houses to those who sell. In isolation, this prompts a negative effect on private consumption, as home buyers in MAKRO (typically younger households) have a higher marginal propensity to consume than home sellers (typically older households) do. However, this effect is dominated by the fact that all households can borrow through a mortgage. Overall, this mechanism means that increased housing prices lead to a higher propensity to consume as the liquidity gain of higher house prices enters into the HtM reference consumption income term. There is thus an amplifying effect on consumption through demand shocks via increased loan financing in the housing market - a so-called financial accelerator.

1.1.10 Increased production leads to a gradual increase in output prices

Increasing marginal vacancy posting costs and capital installation costs mean that firms' unit costs rise in the short run. Firms increase labor utilization to partly mitigate the increase in unit costs in the short run. Overall, firms' unit costs are rising, eroding their profit margins and putting upward pressure on output prices. Note that the increase in prices is gradual due to price-setting rigidity.

1.1.11 Higher output prices leads to higher demand prices

The input / output system mechanically links higher output prices to higher demand prices based on input shares.

1.1.12 Increased prices dampens the quantity demand over time

Increasing prices mean lower demand in the market for goods and services. Investments and intermediate inputs are generally not very sensitive to relative price changes. Investments are also generally not very sensitive to changes in investment prices and react more due to lower production due to the fall in other demand components. Private consumption reacts - primarily as a reaction to the fall in real income. Exports are much more sensitive to changing prices. The reaction is gradual. In the long run, exports will change significantly due to changes in relative prices.

In addition, rising prices significantly affect domestic demand through the effect of relative prices on import content. Thus, the demand for domestic production of intermediates or private consumption will fall, even though rising prices only affect the general demand for these components to a lesser extent. As with exports, this reaction to relative prices is gradual.

1.1.13 Full crowding out in employment for permanent demand shocks

A permanent exogenous increase in domestic demand will result in crowding out via foreign trade as a consequence of improved terms of trade, and higher real wages. In the short run, price and wage rigidities will increase employment. In the long run, however, structural employment will be re-established. Higher domestic demand pushes up domestic prices and reduces exports.[2]

[2]Wages will typically grow more than domestic output prices, so that product real wages will grow. This is because the user cost of capital in the long run mainly depends on the investment price. Due to the high import content of the investments, these investment prices will grow less than the sectors' output prices. This causes product-real-user cost to fall. In the long-run equilibrium, this will mean that real product wages grow and that there will be a substitution towards capital.

1.2 Fundamental mechanisms when supply increases

1.2.1 Increased supply decrease prices for given demand

A positive supply shock decreases prices for any given quantity produced. The supply curve shifts right. There is typically an effect via the production costs of the firm as with increased labor supply (lowers costs of labor), increased productivity (reduces effective costs of one or more production inputs), lower financial costs (lower capital costs), or lower foreign prices (lower intermediate input and investment costs). With output prices being set as a markup over costs, these prices also fall. Shocks to foreign prices also affect the demand prices directly through imports. Furthermore, shocks to foreign prices affect demand through the import shares and exports, both affected by foreign prices. Financial shocks are also often more than a pure shock to economic costs, and an interest rate shock will, for example, change the income flow, wealth, and hence the demand of the households.

In this section, we focus on labor supply and productivity shocks. Shocks to foreign prices and financial shocks are described in later sections.

1.2.2 Increased supply leads to fewer production inputs for given production and lower unit costs

A productivity shock lowers unit production costs, and labor, capital, and materials inputs are all reduced for a given production. The input of the more productive input is most often reduced as it is possible to produce the same with less input, and substitution effects do not dominate as elasticities of substitution in the production functions are usually below one. Input of the other factors are reduced due to substitution as the more productive factor has become cheaper in effective unit.

Total labor input is the product of the number of workers, hours pr. worker, and individual productivity. Hours worked depend on marginal taxes and a preference shifter for hours. Both preferences and taxes can be shocked. In addition, there is a preference shifter specific to the disutility of search. Reducing the disutility of search will increase the number of matches per vacancy posted by the firms and will decrease the marginal costs of hiring and, hence, the unit cost of firms.

1.2.3 Lower unit costs leads to lower output prices

Lower unit costs cause the firms to lower prices. The increase is gradual due to price adjustment costs.

1.2.4 Lower output prices leads to lower demand prices

The input/output system mechanically links lower output prices to lower demand prices based on input shares.

1.2.5 Lower prices increases quantity demand over time

Lower prices increase the quantity demand. As described in the subsection 'Increased demand,' prices dampen demand over time primarily through foreign trade - but with the reversed sign. The effects of higher demand are described in the section 'Fundamental mechanisms when demand increase'.

1.2.6 Full crowding out in the unemployment rate

Some permanent supply shocks can change the structural unemployment rate (e.g., changing the compensation rate of unemployment), but most shocks do not, and none of those mentioned above do. Increased demand will, over time, increase employment until the structural unemployment rate is unchanged.

Increasing hours or participation will make domestic prices and real wages fall if public consumption or foreign demand is exogenous. The reason is similar to the mechanism described under the demand shocks. The larger labor supply will result in more domestic goods being produced in the long run. Domestic prices must fall to sell more goods in the export market.

1.2.7 Increased supply will over time cause scale effects in exports

MAKRO has a scale effect on exports[3] as long-term growth in private structural gross value added (GVA) leads to a corresponding export growth over time. One would typically think of such supply effects as materializing on an extensive margin: Exports of new product types or to new markets. In other Danish macroeconomic models (e.g., DREAM, SMEC, or MONA), there is typically a significant effect on real wages in the event of a shock to labor supply. This effect is smaller in MAKRO due to the scale effect in exports. [4]

[3] That is, a reduced for modelling of "supply creating its own demand". We assume that since Denmark is a small economy, there is insatiable demand for Danish products abroad. For further details, see Section 6 in the MAKRO documentation.

[4] Both ADAM and DREAM have scale effect in exports as an option. In DREAM, the effect is not switched on in the standard version, while it is included as a starting point in ADAM in the event of a shock to the labor supply.(cf. *https://www.dst.dk/extranet/AdamMultiplikatorer/2020okt/Muleks20.html*).

1.3 Fundamental mechanisms when foreign prices increases

1.3.1 The initial shock increases import prices and/or export competing prices

In MAKRO, foreign prices can be divided into two main groups: Import prices and prices on goods/services that compete with domestic exports, henceforth called export competing prices.

Realistic shocks to foreign prices should affect the foreign demand market and interest rates as movements in different foreign variables are correlated. In MAKRO, these are exogenous and considered constant in the description of the shock effects. A realistic foreign shock (general equilibrium for the foreign economy) moves all these components.

1.3.2 Higher export competing prices increase exports

The only effect of higher export competing prices is to increase demand for exports. For the Danish economy, this is a positive demand shock to exports and follows the mechanisms described above.

1.3.3 Higher import prices reduce imports and increase domestic demand

Every type of demand has inputs from potentially all sectors and from imports or domestic production. These inputs are cells in the input-output (IO) matrix, either positive or zero. Import shares are endogenous and respond to prices. If the import price increases relative to the domestic price in a given sector, all IO-cells representing input from this sector (that are not 0 or 1) will have a lower import share. This substitution effect tends to increase domestic demand.

The import share of energy is exogenous and not affected by relative prices. The production of extraction is also exogenous. The only relevant sectors affected by substitution are manufacturing and services.

1.3.4 Higher import prices lead to higher demand prices

The input-output system mechanically links higher output prices to higher demand prices based on input shares.

1.3.5 Increased demand prices lead to lower domestic quantity demand

Increased prices affect domestic demand as described under the demand shocks in the subsection 'Increased demand' prices dampens quantity demand over time.

1.3.6 Sign of net effects from increased import prices on demand differs for demand components

Demand for specific components may increase or decrease following higher import prices. The substitution effect increases demand for manufacturing and services while the effect from increased demand prices lowers demand for all demand components. As manufacturing and services might be close substitutes to other components with low substitution, the net effect on these in the different cells may also be negative. An example is input of domestic services to private consumption of cars. Private consumption of cars has two inputs: Manufacturing with an import share of 1 and services with an import share of 0. Import shares of 1 and 0 indicate

that no substitution takes place at cell level. This means for higher import prices of manufacturing the demand will decrease by the same relative amount for imported manufacturing and domestic services. There are also examples where the net effect is positive.

1.3.7 Higher intermediate input prices increase unit costs and lead to substitution towards labor

Demand prices increase when import prices increase. This includes the price of intermediate inputs. When these prices increase the unit costs of production increase in all sectors. The effects are the same as described in the section 'Fundamental mechanisms when supply increase' - with the opposite sign.

Firms will substitute away from intermediate inputs as they are relatively more expensive compared to labor. Capital may become more or less costly as it is increased through investments with imported inputs.

1.3.8 Substitution towards labor dampens negative effects on wages and employment

The substitution towards labor dampens the opposing general equilibrium effects on employment and wages from the higher prices.

1.4 Fundamental mechanisms for financial shocks

1.4.1 Initial shock changes returns and asset prices

Financial shocks affect firms and households. Changes in asset prices and asset returns affect private income, wealth, and consumption. Changes to finance costs affect firms immediately in all their forward-looking decisions. Financial shocks can be shocks to the ECB key interest rate, foreign stock prices, asset-specific risk premia, etc. Changes to interest rates and risk premia will work through the discount factors firms and households use. Jumps in foreign stock prices work first through a wealth effect but have other nonlinear effects through the specification of household utility.[5]

1.4.2 Returns and asset prices are affected and will in turn affect household demand

Higher returns on assets will increase net returns for agents with positive portfolios and can affect the savings behavior of households. This will, in turn, impact private consumption and housing demand.

1.4.3 Increased finance costs of housing will decrease demand for housing investments

An increase in the cost of finance will increase the user cost for the relevant real variables. Housing is financed primarily through real estate bonds, but also through other financial savings. The last is affected by the household's marginal return on savings, determined by the return on assets and portfolio composition. Factors that increase housing finance, i.e., the real estate bond rate and other rates of return (also through composition), will increase the user cost of housing. This will, for given prices, lead to lower housing demand. This will then work like a negative shock to investments in housing through mechanisms described in the section 'Fundamental mechanisms when demand increases'.

1.4.4 Increased finance costs of firm capital will increase unit costs and substitution will decrease firm investments

The user cost for firm investments will also be affected by financial costs. Firm investments are financed partly by borrowing and partly by issuing equity. The cost of finance is, hence, a weighted average of the interest rate and the required return on equity. A higher interest rate and future return on domestic stocks will increase the user cost of firm investments. This will increase the unit costs and act like a negative supply shock described in the section 'Fundamental mechanisms when supply increases.' Furthermore, there will be substitution away from capital. This will decrease firm investment for given production.

[5] Specifically, households have wealth in utility and bequest utility. Refer also to the MAKRO documentation for more info.

1.5 The reaction of the public sector

The shocks analyzed below will change the basis of government revenue and expenditure. Given unchanged public consumption and transfer and tax rates, this makes fiscal policy either sustainable or unsustainable. Therefore, the public sector must eventually react by changing tax rates, transfer rates, and public spending. In many models, there is an endogenous public response function, such that the public sector automatically reconciles revenue and expenditure via pre-determined rules.

MAKRO is to be used in connection with fiscal policy planning, and therefore does not contain an endogenous financing constraint by default. Users can easily enable fiscal balance through a permanent lump-sum transfer between households and the public sector, a change in government consumption, or a combination of both. In analyzing shocks, we often see the mechanisms more clearly in unfinanced shocks, though financed shocks with fiscal policy balance are more realistic.

Whether and how a budget balance is financed matters significantly. This is partially because households in MAKRO are forward-looking and partially due to high year one and two MPC's. Taken together, this makes the effects of this choice far from trivial.

1.6 A brief note on the sectors in in MAKRO

There are 9 sectors (industries) in MAKRO. Several factors make some sectors less central to shock analysis than others. For example, the housing sector is driven solely by household demand and draws almost exclusively from the construction sector. Output and pricing is exogenous for the extraction industry and is thus not affected by shocks. Maritime transport (shipping) and agriculture are small industries with a limited share of GVA and employment, meaning their role is limited when describing the aggregate effects of shocks. This is especially true for maritime transport, where exports - due to high import content - are largely independent of Danish prices. The energy sector is interesting when energy taxes change, while it does not play a significant role in many other shocks. Although the public sector is large, it is exogenous and therefore only vital if it is shocked directly. The two main sectors are (private) services and manufacturing. Services are essential because of their size: they account for almost half of GVA, over half of employment, and approximately one-third of aggregate investment. The manufacturing sector is smaller, but it is still significant in describing the response to various shocks. This is because the manufacturing sector is the largest supplier to exports, just as most imports are from foreign manufacturing industries that substitute for domestic manufacturing.

Table 1.6.1: Sectors in MAKRO

	off	tje	fre	byg	ene	soe	lan	udv	bol
	Distribution across sectors in percentages								
GVA	21,0	46,1	14,6	4,9	1,6	1,5	1,3	1,3	7,8
Employment	27,4	52,0	10,0	6,3	0,4	0,7	2,5	0,1	0,6
Investment	16,4	30,6	16,1	1,6	4,3	3,9	3,1	2,5	21,5
	Deliveries from domestic sectors in percentages								
Direct exports	0,0	31,6	43,0	1,2	2,2	18,2	2,5	1,4	0,0
	Deliveries from foreign sectors in percentages								
Imports	0,0	37,9	56,4	0,0	5,7	0,0	0,0	0,0	0,0
	Measured in mil. DKK pr. employed, chained values								
GVA/Employment	0,46	0,49	0,80	0,44	2,67	2,12	0,32	6,71	6,77

Note: off = Public Sector, tje = Services (excl. maritime transport and public services), fre = Manufacturing (excl. energy), byg = Construction, ene = Energy, soe = Maritime Transport, lan = Agriculture, udv = Extraction, bol = Housing.
Source: Numbers are calculated by using the MAKRO databank for 2017.

The two main endogenous sectors are thus manufacturing and services. In particular, the demand for manufacturing is sensitive to changes in prices. However, pricing is markedly different in the two sectors. In the short run, they are assumed to have identical price rigidity. However, as their long-run prices are determined based on costs, the long-run price development in the two sectors is greatly affected by the different composition and evolution of their production inputs. The service sector is greatly affected directly and indirectly by labor costs via input from the service sector. The manufacturing sector is affected to a lesser extent by directly and indirectly by labor costs. It has a larger import input, so it is generally less affected by domestic wage and price changes.

Sector prices and taxes determine the prices of the demand components. As a general rule, the input structure is exogenous, independent of relative prices, and changes only to a limited extent over time. For unchanged taxes, Table 1.6.2 gives an overview of which sectoral output prices affect the prices of intermediate inputs, private consumption, public consumption, investment, and exports. Generally, intermediate input prices are affected mainly by services, imports,

and manufacturing. The price of private consumption excl. housing is primarily affected by services and imports. The housing deflator - used in the empirical calculation of total private consumption - is determined based on imputed regulated rents and follows consumer prices. The deflator for public consumption is determined primarily based on the output price of public production. The investment price of equipment capital is determined primarily based on the prices of services, manufacturing, and imports. In contrast, the price of investments in structures is primarily determined based on the price of construction and services. In isolation, the price of the construction sector is essential for the investment price of structures. However, this price is, in isolation, not so important for the rest of the economy, as structures capital only make up a small part of firm costs, and user costs in the short run primarily reflect installation costs. Export prices are mainly affected by manufacturing, services, and maritime shipping prices. However, as the price of shipping is almost unaffected by domestic conditions, the sector is not important for the volume of exports for most shocks.

Table 1.6.2: Sectors in MAKRO

	Materials	Private Consumption	Public Consumption	Invest.	Exports
			Distribution of inputs in percentages		
Public	0,0	5,3	94,3	4,5	0,0
Services	44,9	46,0	2,7	20,1	25,3
Manufacturing	10,9	4,3	0,3	13,1	34,4
Construction	3,9	0,4	1,5	39,8	0,9
Energy	2,1	5,6	0,0	0,2	1,7
Maritime Transport	0,4	0,1	0,0	0,0	14,6
Agriculture	3,0	0,5	0,1	0,6	2,0
Extraction	0,9	0,0	0,0	0,0	1,1
Housing	0,0	19,5	0,0	0,0	0,0
Imports	33,8	18,3	1,1	21,6	15,7

Source: Numbers are calculated by using the MAKRO databank for 2017.

2 Permanent unfinanced demand shocks

In this chapter, we look at unfinanced demand shocks. These are all classic demand shocks, as described in the introduction. The following mechanisms are described in the introduction:

- The initial shock directly or indirectly increases one or more demand components
- Increased demand leads to increased sectoral production
- Increased sectoral production leads to increased demand for production inputs
- Increased demand for intermediate inputs raises imports and domestic sectoral output
- Increased capital demand also raises imports and domestic sectoral output
- Increased labor demand leads to increased wages, employment and labor supply
- Increased employment and wages leads to higher household income and increased demand for private consumption and housing
- Increased housing demand leads to increased housing prices and housing investment
- Increased housing prices and leverage allowed by mortgages lead to increased liquidity and additional household demand
- Increased production raises unit costs and pushes output prices up from the cost side
- Higher output prices lead to higher demand prices
- Increased demand prices dampen quantity demand over time
- There is full crowding out in employment (as structural employment is unchanged).

The first shock we look at is a shock to government lump-sum transfers to the households. Since financed shocks by default occur via lump-sum transfers, understanding this shock is essential in relation to all financed shocks. The other shocks are other demand shocks. Note that all shocks are unfinanced.

2.1 Lump sum transfers to households

Lump-sum transfers to households are increased by 1 percent relative to the baseline GDP level.

Private consumption and housing investment increase through increased household income.

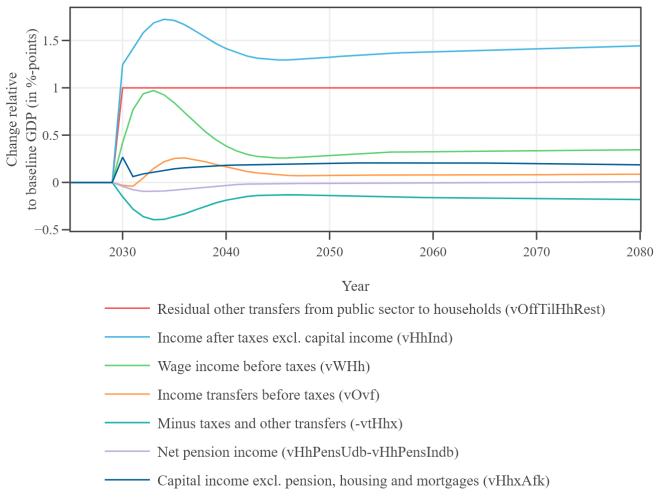
Note:

- The initial effect on private consumption is less than 1 percent if dampening effects from consumption smoothing and habit formation dominate the accelerating effects from increased income through employment, wages and increased liquidity through mortgages because of increased house prices
- The long-run effect on private consumption is higher than 1 percent of GDP if the effect from higher long-run real wages dominates adverse savings effects from increased liquidity
- There are negative effects on the government budget and fiscal sustainability
- The long-run effect on GDP is higher than long run effect on GVA. This is because:
  - Demand is shifted from exports to private consumption
  - Private demand has more duties than exports
  - Duties are part of GDP, but not a part of GVA
- The long-run GVA is higher as the economy becomes more capital-intensive. This is because:
  - Private consumption of housing has increased, and exports decreased (primary effect)
    - Private consumption of housing draws on the housing sector, which has a very high output per worker
  - Increased real wage relative to the user cost of capital make firms substitute from labor to capital (secondary effect)

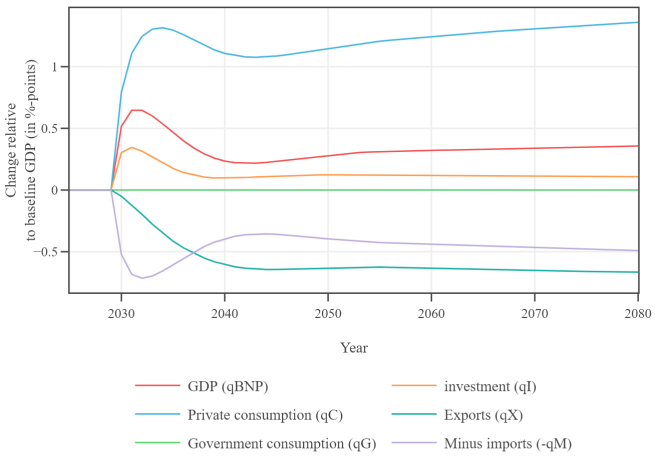
Shock Reactions in MAKRO

Permanent unfinanced demand shocks

Shock



GDP decomposition



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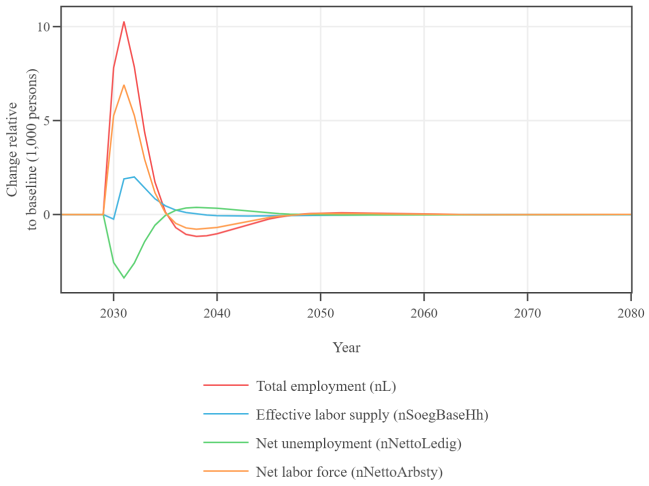
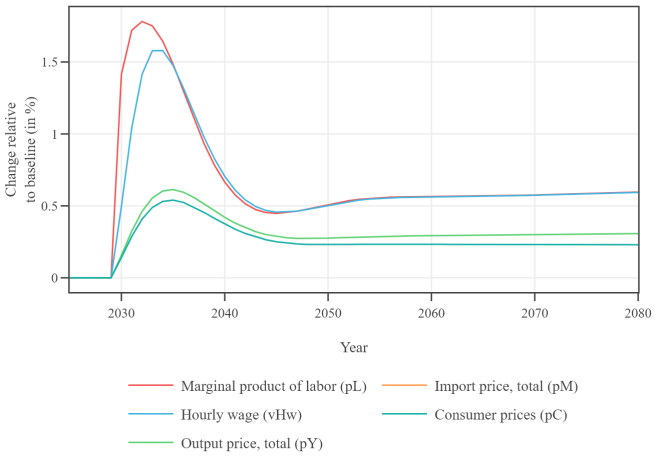
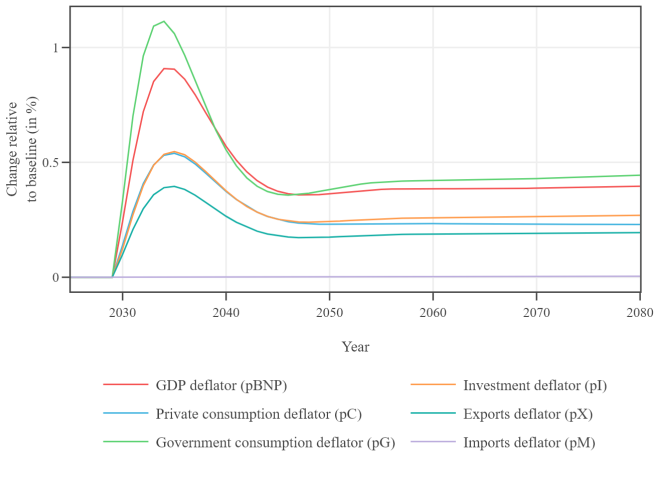


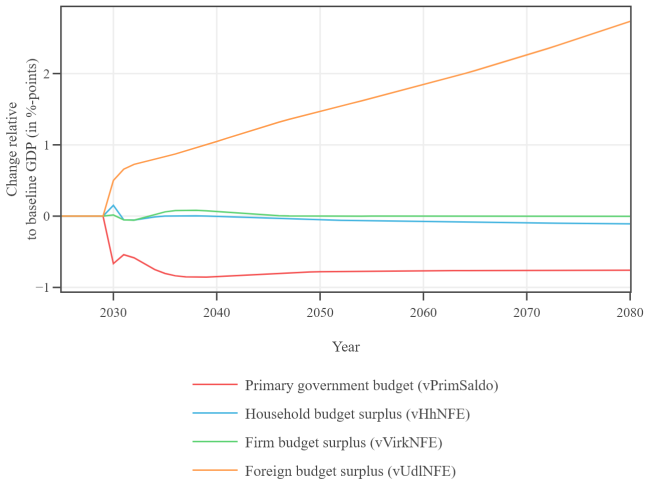
Wage



GDP deflator decomposition

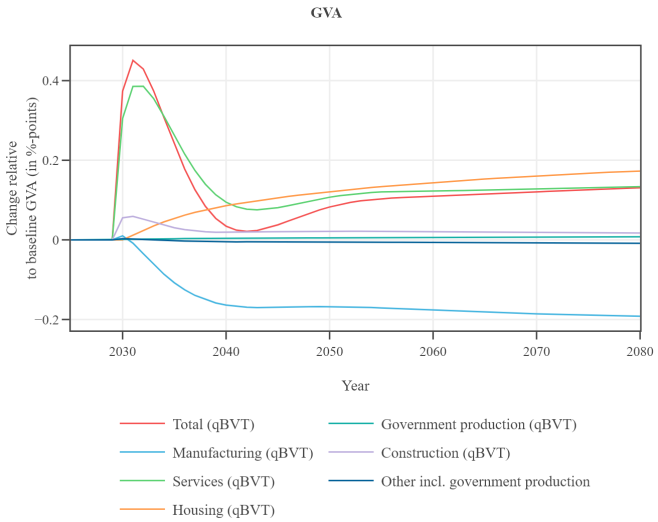


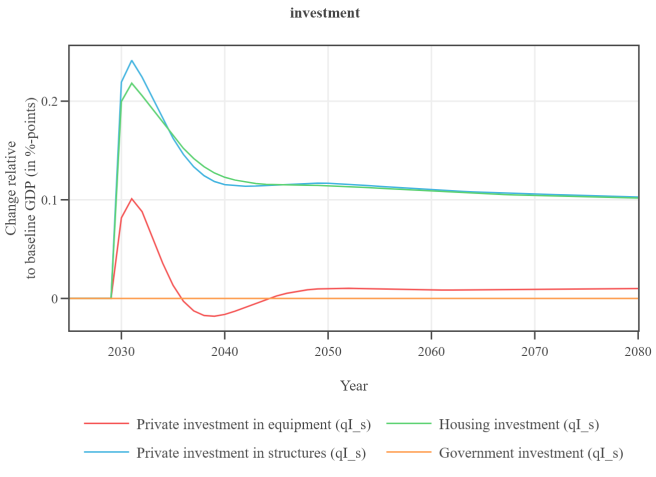
Budget surplus

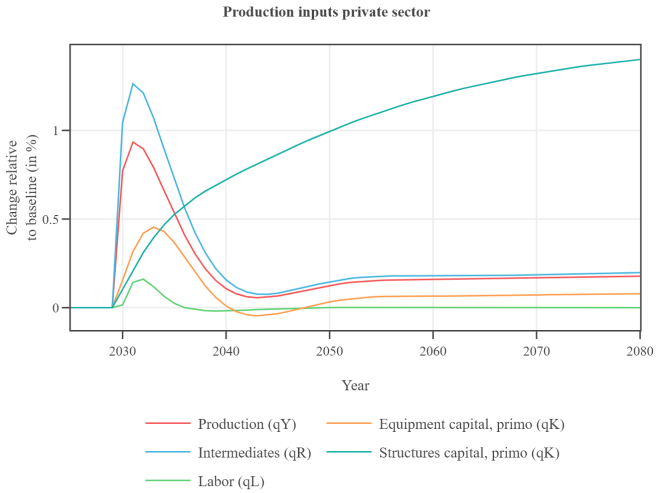


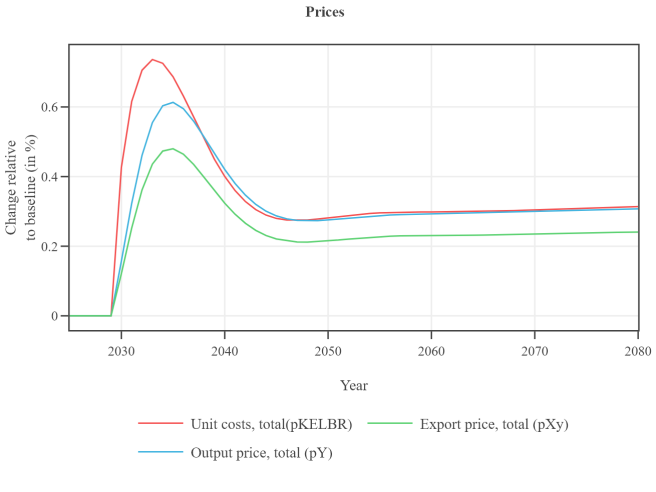
Shock Reactions in MAKRO

Permanent unfinanced demand shocks









2.2 Government employment

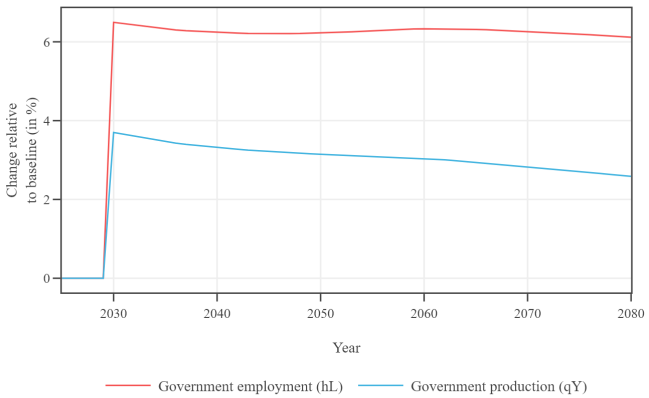
Government employment is increased by permanently increasing government payroll with 1 percent of baseline GDP.

Government consumption and production are increased through increased government employment.

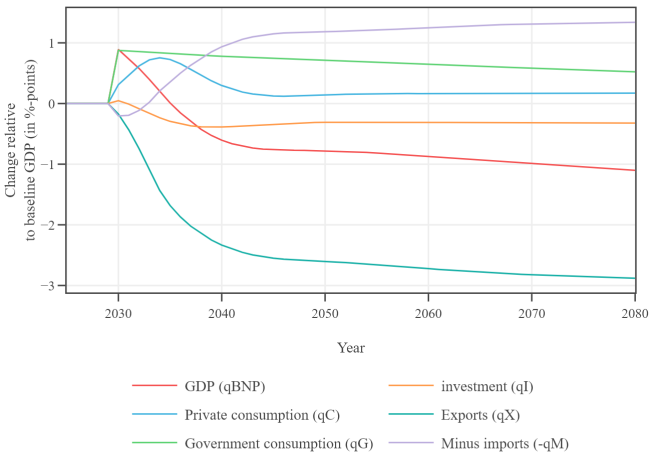
Note:

- There is a negative effect on the government budget and fiscal sustainability
- The long-run effect on GDP is negative. This is because:
  - Demand shifts from exports to government consumption
  - Lower exports decrease production in manufacturing and services
  - Production in manufacturing and services has higher output per worker than government production
  - An isolated shock to government employment decreases the capital intensity and output per worker in government production

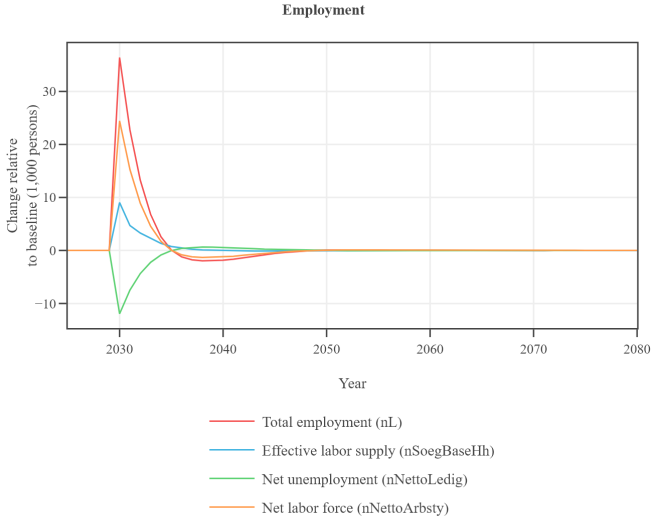
Shock



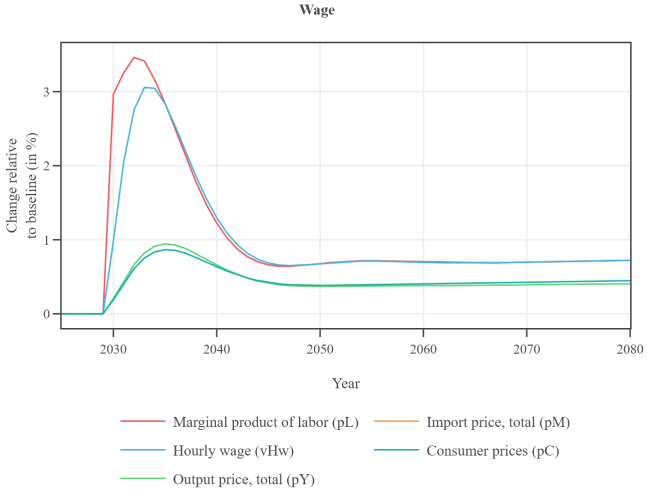
GDP decomposition



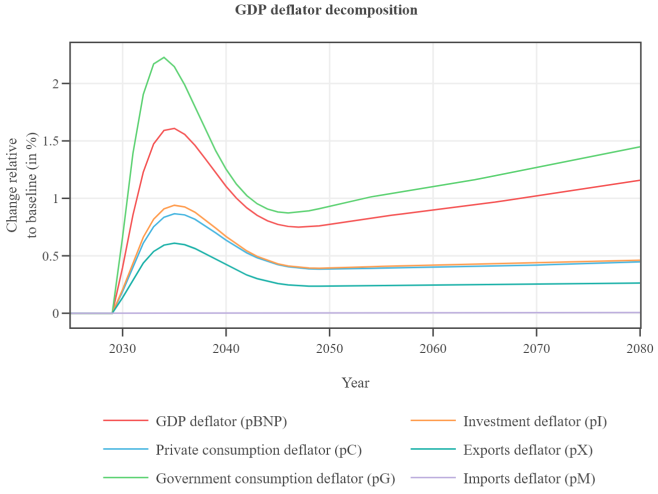
Employment



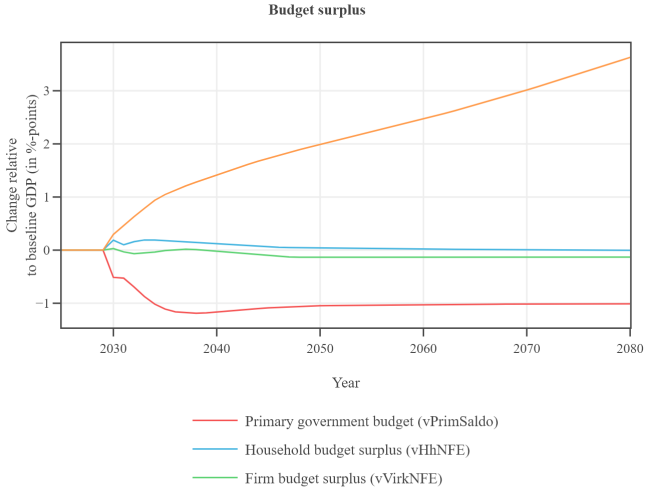
Wage



GDP deflator decomposition

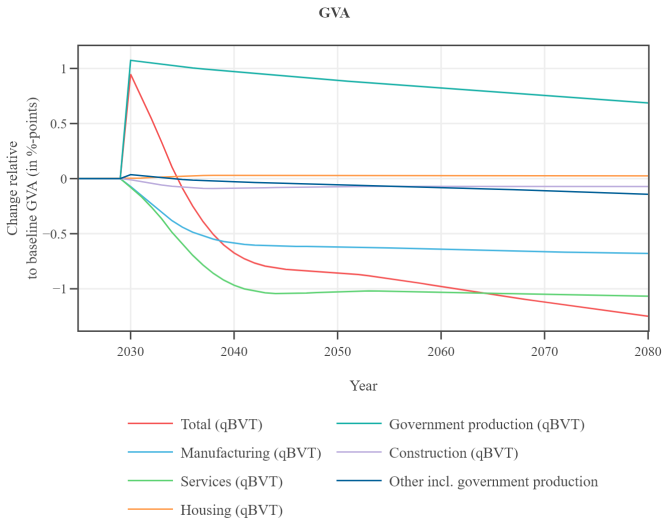


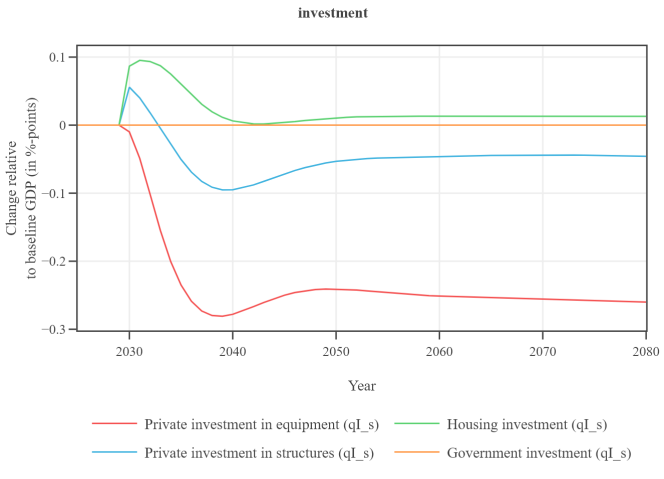
Budget surplus

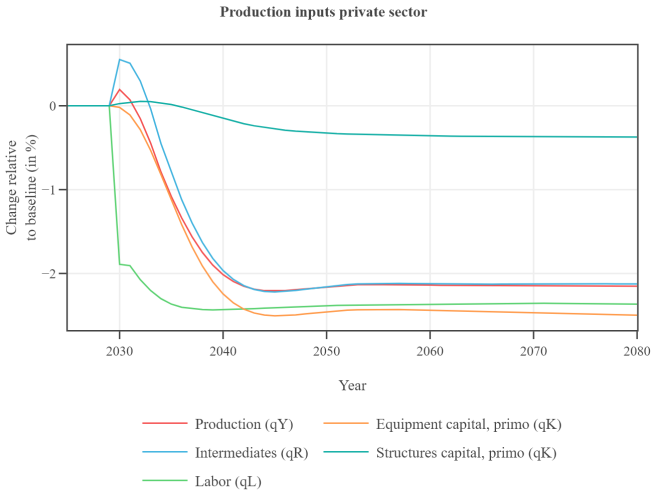


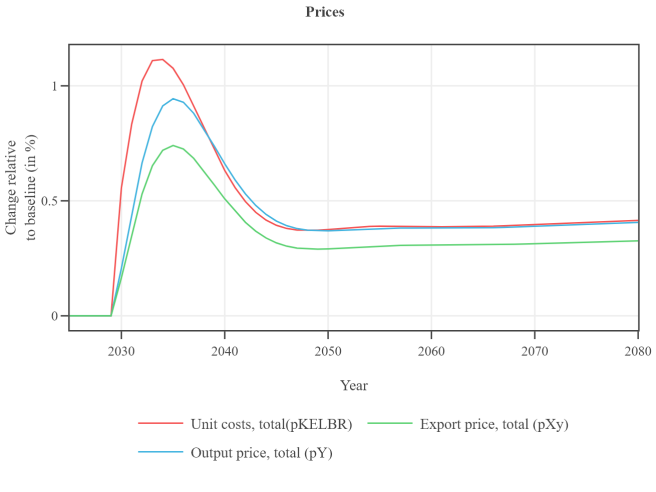
Shock Reactions in MAKRO

Permanent unfinanced demand shocks









2.3 Govenment purchases

Government purchases of intermediate inputs are permanently increased by 1 percent of baseline GDP.

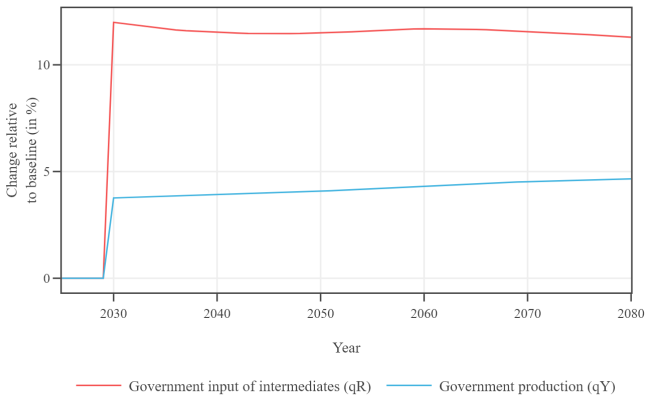
Government consumption and production increase through higher government purchases.

The main difference between this shock and the government employment shock is that here private production increases through intermediate inputs going into government production. The main input to government purchases is domestic input from the service sector. In the domestic service sector, increased production can be met by increased intermediate inputs, capital and labor, and in the short run also by increased factor utilization. This means employment needs to increase less in this shock since other factors of production can be used to increase the quantity of intermediate inputs in the public sector.

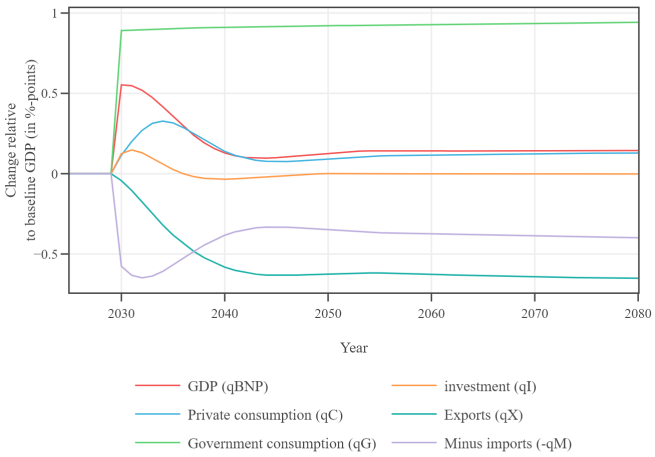
Note:

- There is a negative effect on the government budget and fiscal sustainability
- The long-run effect on GDP is positive as higher duties on government purchases than exports increase GDP for a given GVA

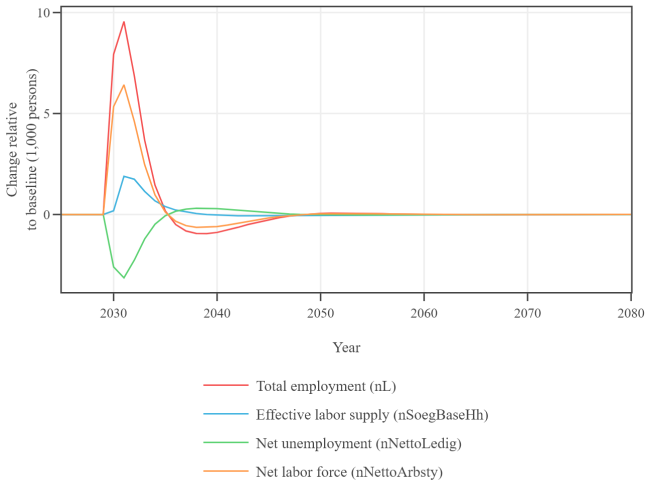
Shock



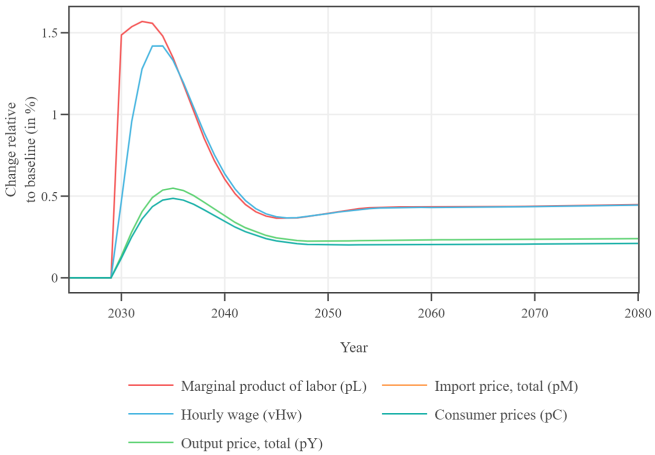
GDP decomposition



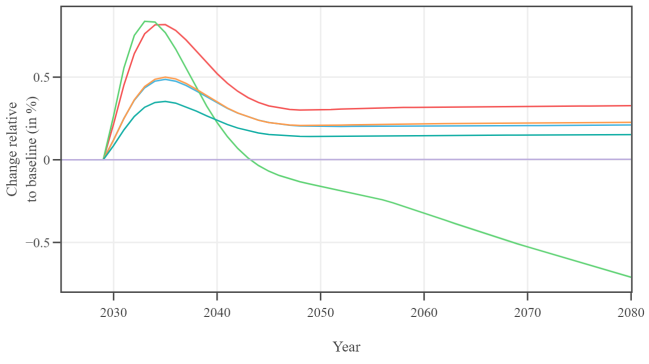
Employment



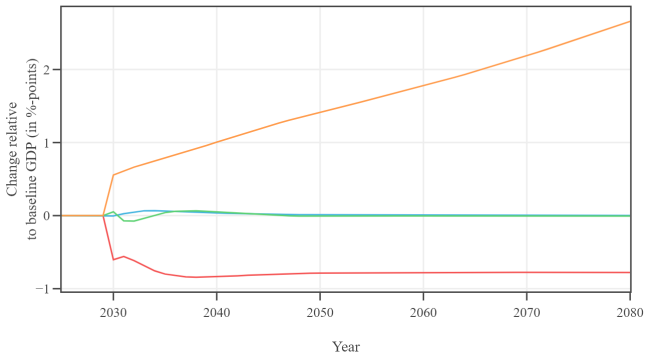
Wage



GDP deflator decomposition

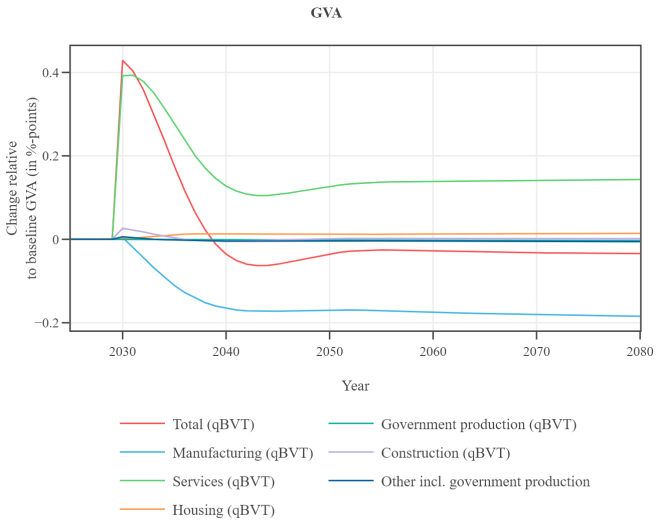


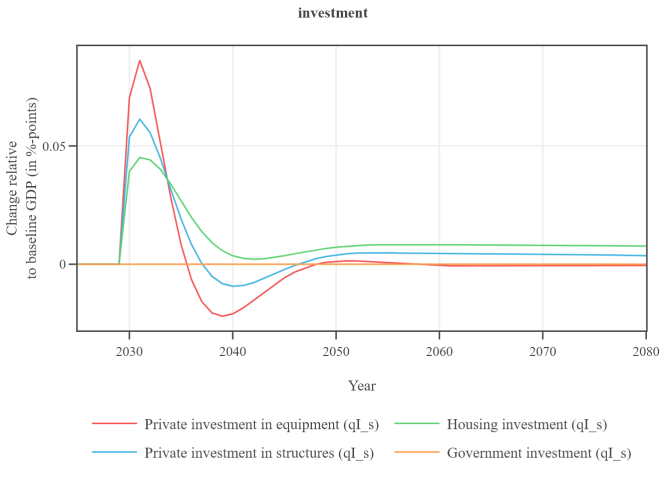
Budget surplus

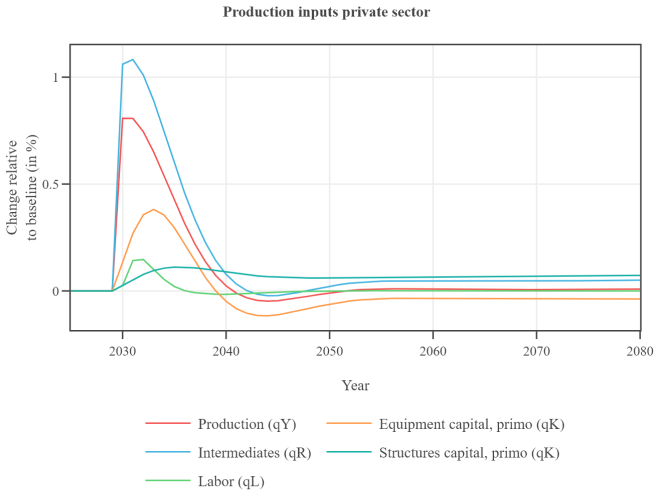


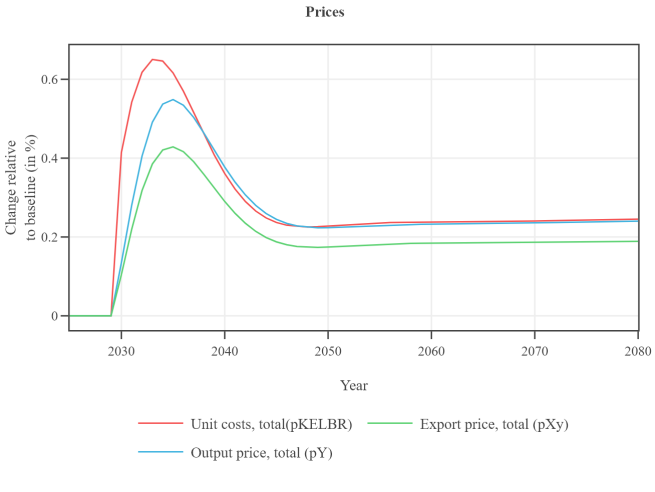
Shock Reactions in MAKRO

Permanent unfinanced demand shocks









2.4 Government investments

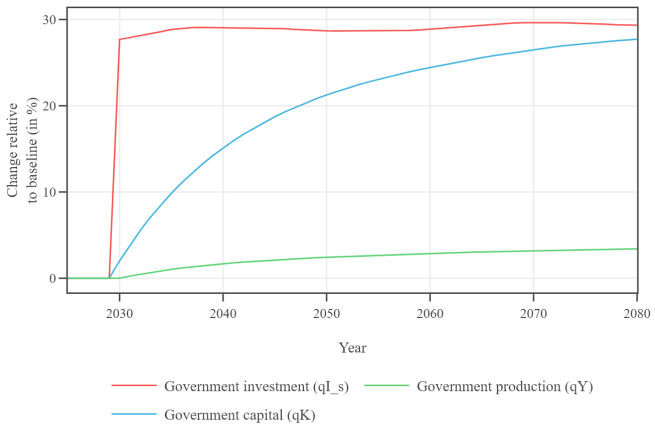
Government investments are permanently increased by 1 percent of baseline GDP.

The main shock concerns government investments that draw primarily on domestic construction and services.

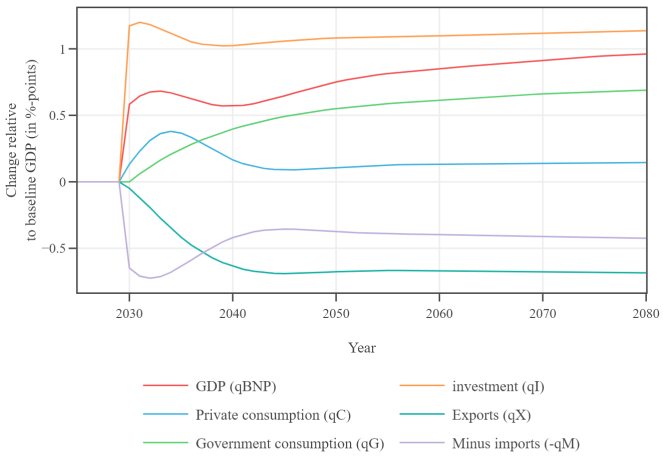
Note:

- There is a negative effect on the government budget and fiscal sustainability
- Increased government investments lead to a gradual increase in government capital, government production and government consumption
- The long-run effect on GDP is strong and positive
  - There is increased government GVA due to higher capital stock - no resources moved from private to government sector

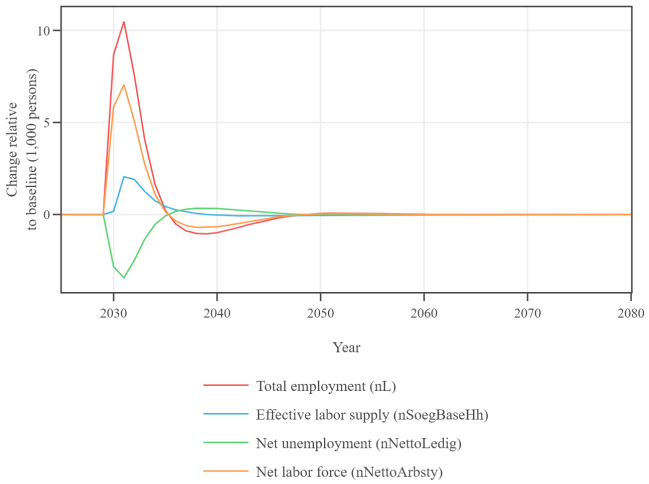
Shock



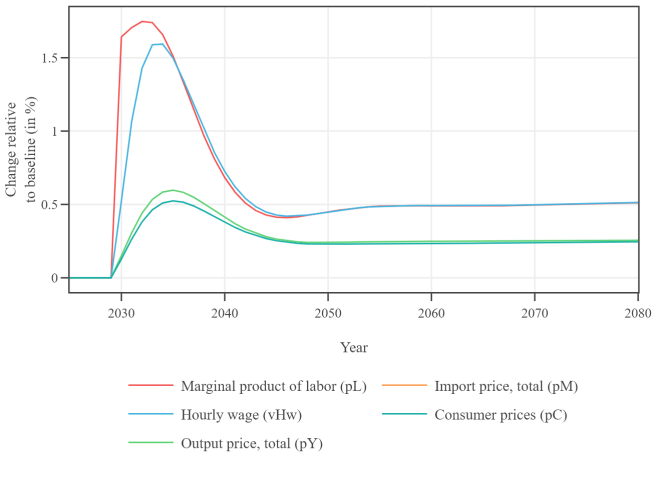
GDP decomposition



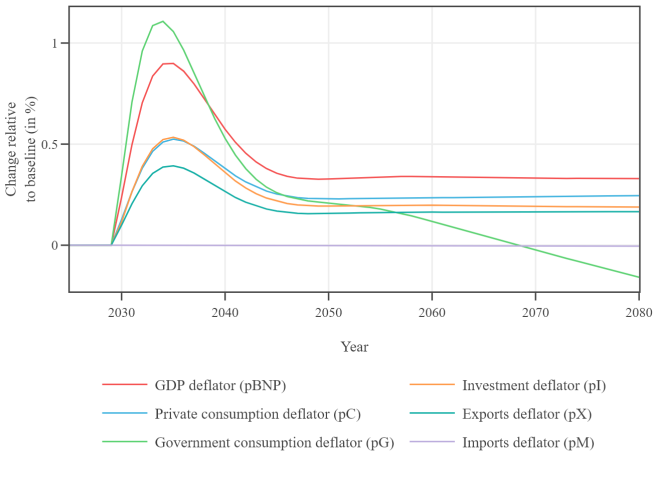
Employment



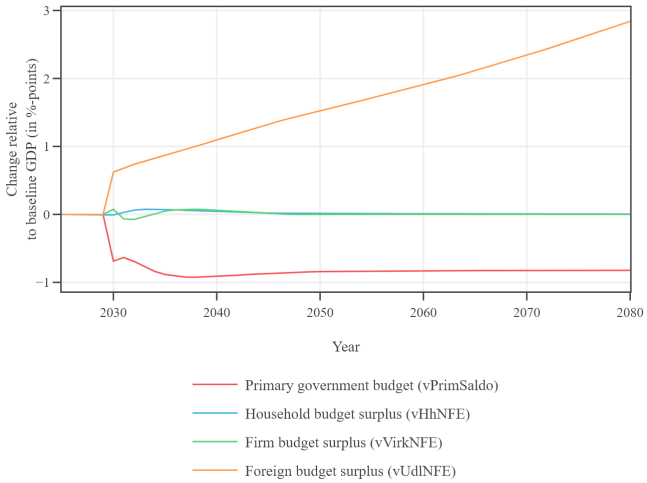
Wage

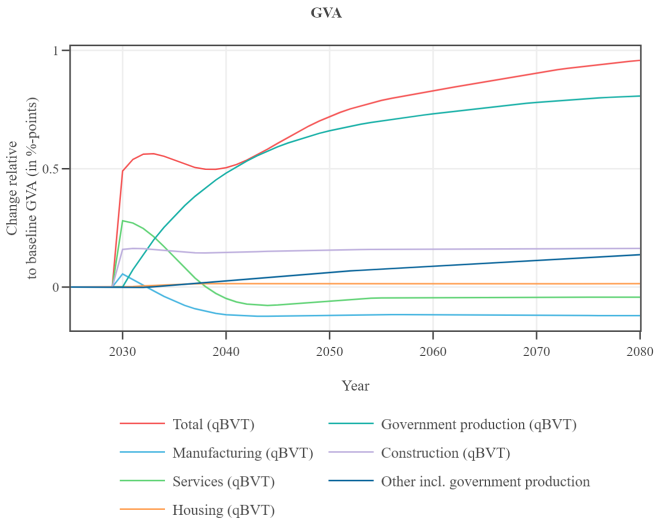


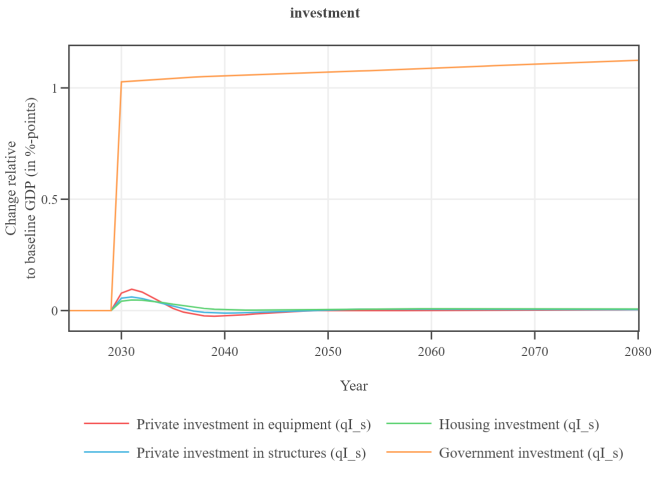
GDP deflator decomposition

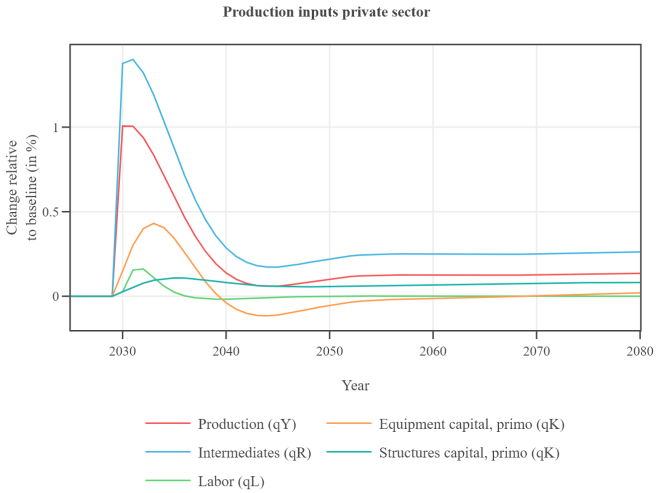


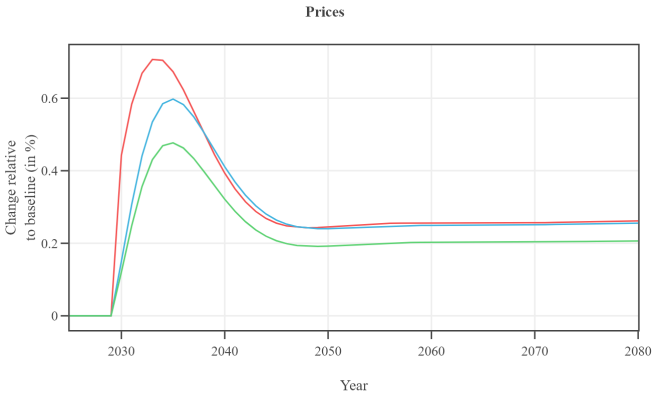
Budget surplus




GVA
Change relative to baseline GVA (in %-points)
1
0.5
0
2030
2040
2050
2060
2070
2080
Year
Total (qBVT)
Government production (qBVT)
Manufacturing (qBVT)
Construction (qBVT)
Services (qBVT)
Other incl. government production
Housing (qBVT)


investment
Change relative to baseline GDP (in %-points)
1
0.5
0
2030
2040
2050
2060
2070
2080
Year
Private investment in equipment (qI_s)
Housing investment (qI_s)
Private investment in structures (qI_s)
Government investment (qI_s)


Production inputs private sector
Change relative to baseline (in %)
1
0.5
0
2030
2040
2050
2060
2070
2080
Year
Production (qY)
Equipment capital, primo (qK)
Intermediates (qR)
Structures capital, primo (qK)
Labor (qL)


Prices
Change relative to baseline (in %)
0.6
0.4
0.2
0
2030
2040
2050
2060
2070
2080
Year
Unit costs, total(pKELBR)
Export price, total (pXy)
Output price, total (pY)

2.5 Foreign demand

The export market size is permanently increased, raising exports by 1 percent of baseline GDP for given prices.

The main shock is directly on exports, which draw primarily on domestic manufacturing and services and imports to re-exports of manufacturing.

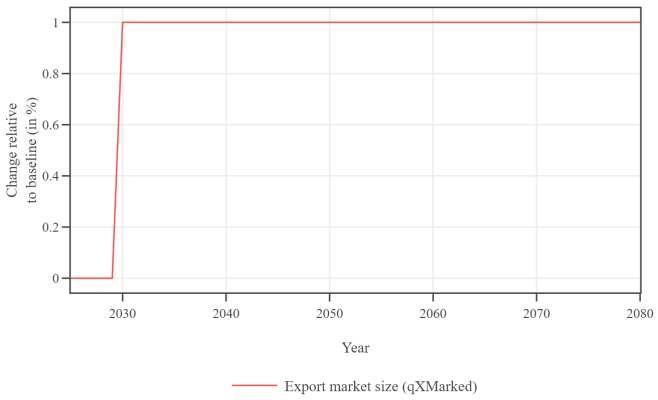
Note:

- There is a positive effect on the government budget and fiscal sustainability
  - The short-run effect on primary budget due to increased activity
  - Long-run effects are mainly due to interest revenue from initial surpluses
- Exports increase less than 1 percent in the short run due to investment adjustment costs (rigidities) and in the long run due to higher domestic wages and prices
- There is a positive long-run effect on GDP as maritime transport has a large export share:
  - Maritime transport has very little input of labor and domestic production so it is affected very little by higher wages. It does have capital input, which increases and makes long run GVA and GDP increase.
  - There is also a small effect from increased housing demand to increased capital and GVA in the housing sector

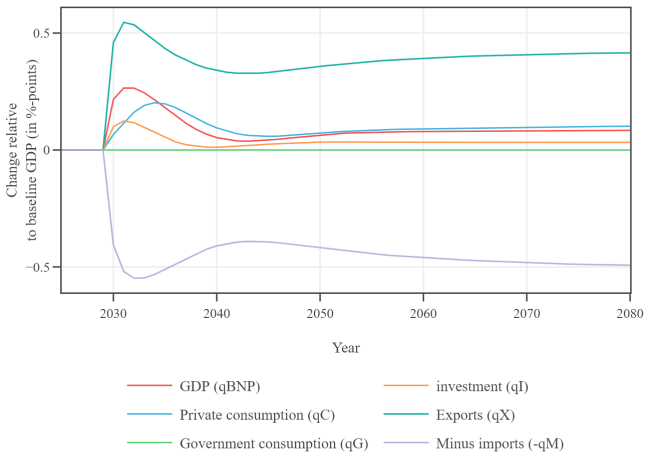
Shock Reactions in MAKRO

Permanent unfinanced demand shocks

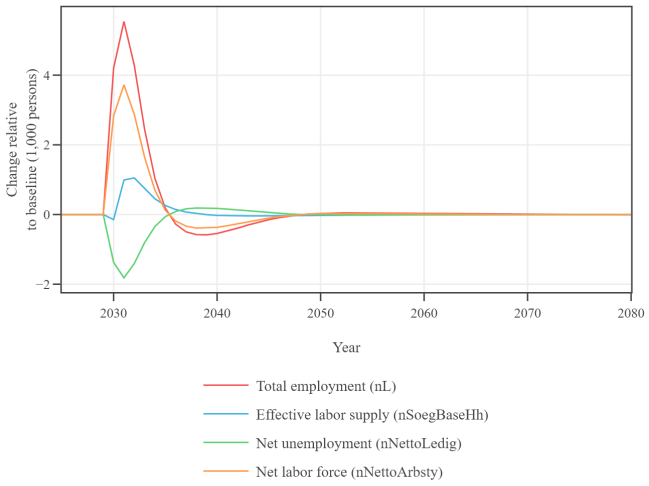
Shock



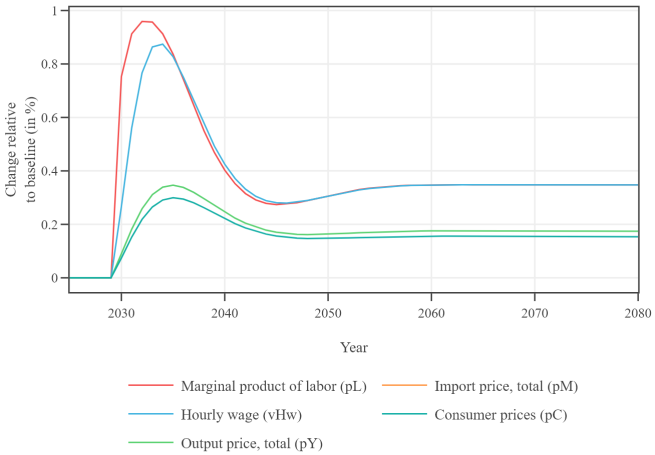
GDP decomposition



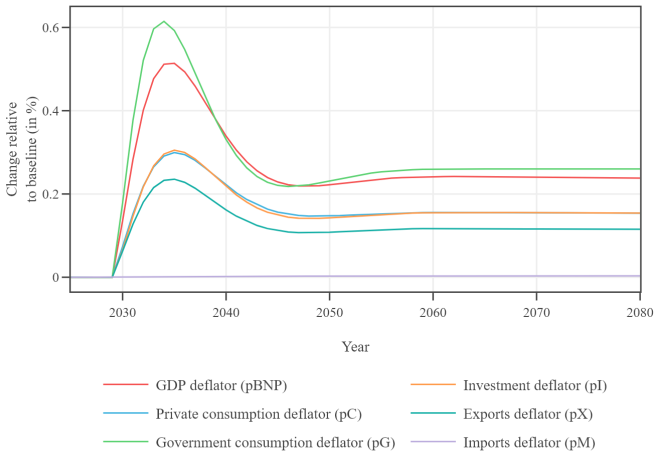
Employment



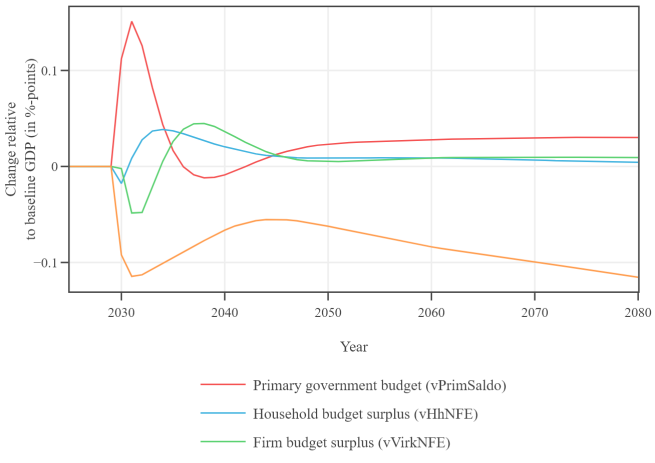
Wage



GDP deflator decomposition

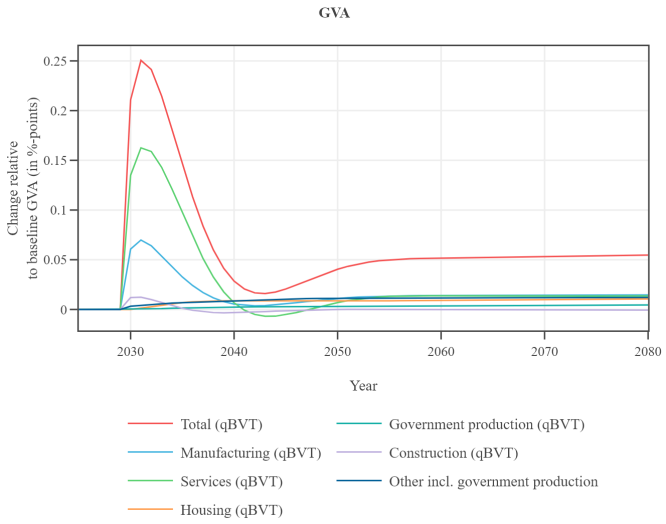


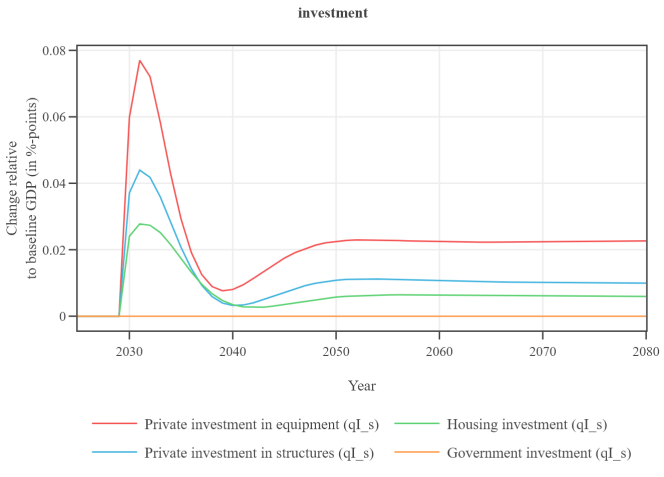
Budget surplus

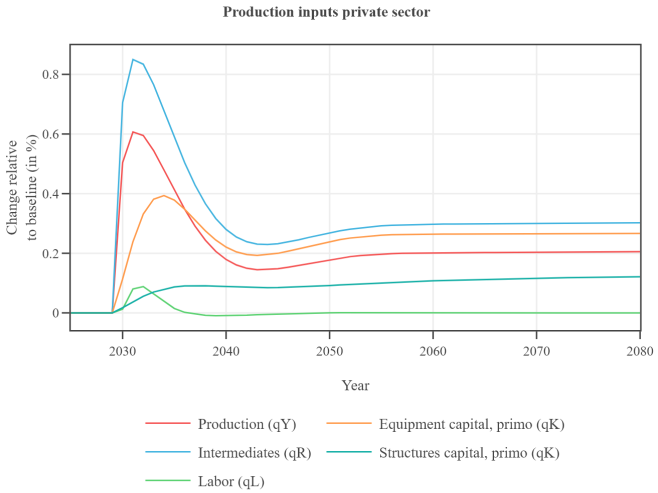


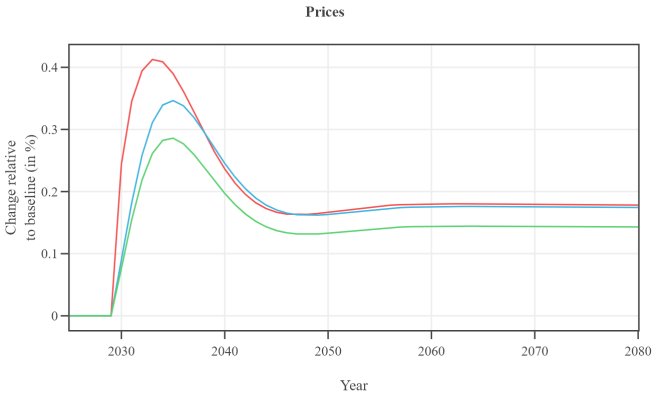
Shock Reactions in MAKRO

Permanent unfinanced demand shocks









3 Permanent unfinanced supply shocks

In this chapter, we look at unfinanced labor supply and productivity shocks. Both shocks induce lower unit costs. The labor supply shock reduces wages and increases the vacancy-filling rate, both of which reduce labor costs. The productivity shock reduces the quantity of inputs needed to produce a unit of output. These are all supply shocks, as described in the introduction. With the following mechanisms:

- Increased supply decreases prices for given demand
- Increased supply leads to lower unit costs
- Lower unit costs leads to lower output prices
- Lower output prices lead to lower demand prices
- Lower prices increase demand over time
  - Increased demand leads to increased sectoral production
  - Increased sectoral production leads to higher demand for inputs
  - Increased intermediate input demand leads to increased imports and domestic sectoral output
  - Increased capital demand leads to increased investments from imports and domestic sectoral output
  - Increased labor demand leads to increased wages, employment and labor supply
  - Increased employment and wages leads to higher household income and increased demand for private consumption and housing
  - Increased housing demand leads to increased housing prices and investments in housing
  - Increased housing prices leads to increased liquidity and demand for private consumption and housing
  - Increased production leads to higher output prices
  - Higher output prices leads to higher demand prices
  - Increased prices dampens demand over time
- There is full crowding out in the unemployment rate
- Increased supply will over time cause scale effects in exports

These mechanisms are all described in further detail in the introduction. Note that all shocks are unfinanced - see 'The reaction of the public sector' in the introduction.

3.1 Labor productivity

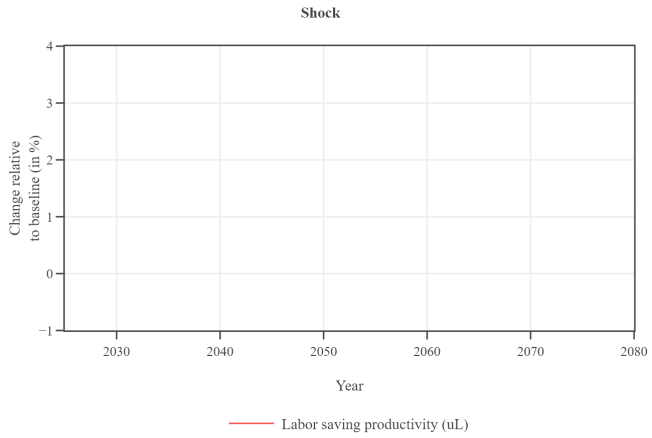
Labor productivity in all private sectors increases by 1 percent relative to the baseline.

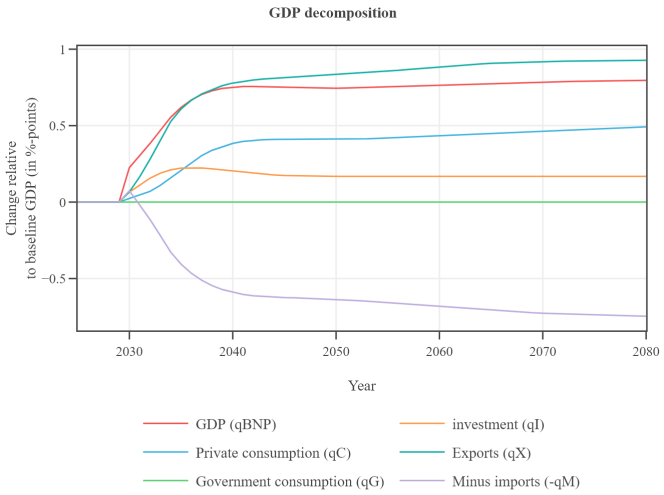
Note:

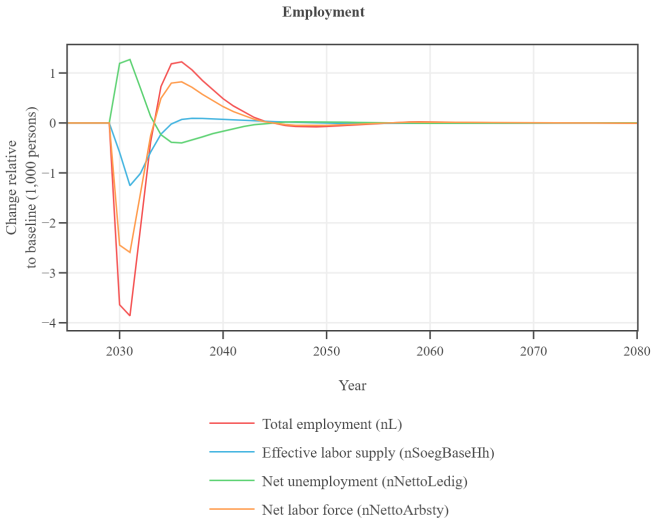
- The shock is to domestic labor productivity only - i.e. foreign demand market growth, foreign prices, and interest rates are unchanged
- Wages per hour worked increase, and real wages increase more as prices decrease
  - There is a positive effect on income, private consumption and housing investments
- There are only small net effects on employment
  - In the short run, there is less employment for given production. Increased production keeps employment relatively stable
  - In the long run, employment is unchanged as structural labor supply is unchanged
- The productivity in the public sector is unchanged - so government production and consumption is unchanged
  - Private GVA increases close to 1 percent, but total GVA and GDP less
  - The government production deflator grows as public sector wages follow private sector wages
- Scale effects in exports follow private GVA
- There is a positive effect on the government budget and fiscal sustainability

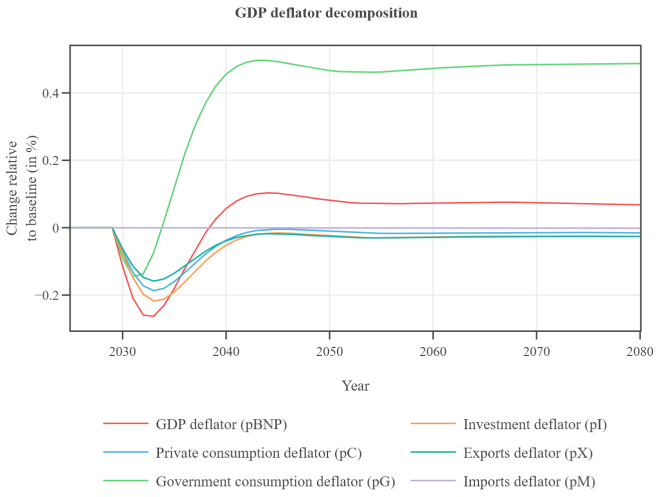
Shock Reactions in MAKRO

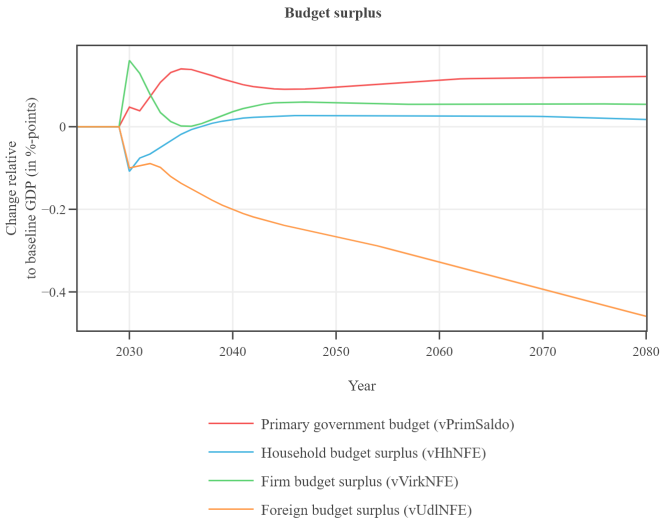
Permanent unfinanced supply shocks

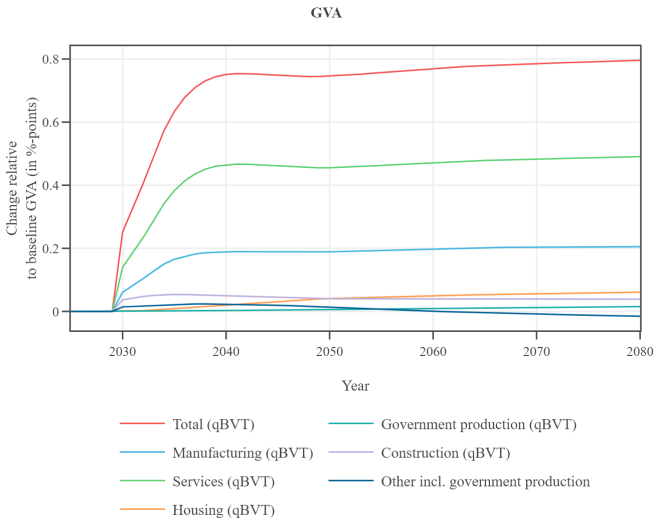


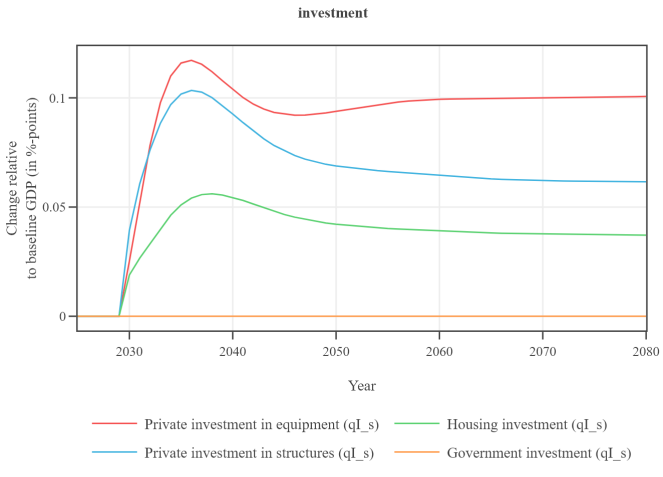


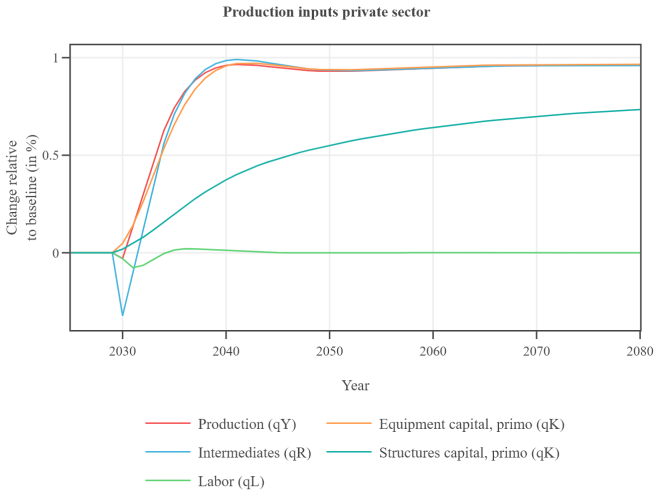


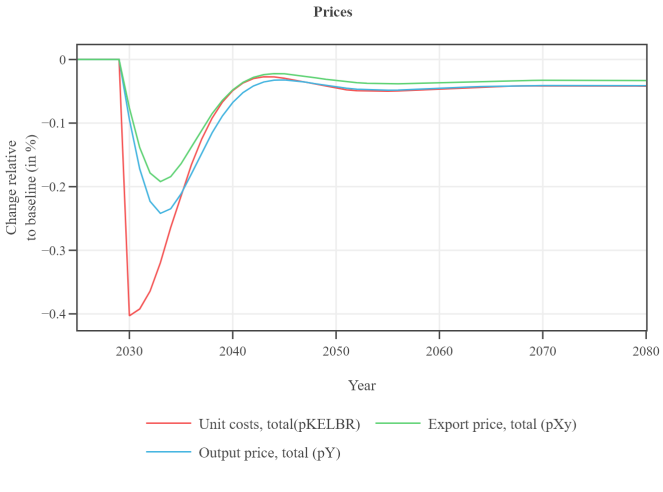





GVA
Change relative to baseline GVA (in %-points)
0.8
0.6
0.4
0.2
0
2030
2040
2050
2060
2070
2080
Year
Total (qBVT)
Government production (qBVT)
Manufacturing (qBVT)
Construction (qBVT)
Services (qBVT)
Other incl. government production
Housing (qBVT)


investment
Change relative to baseline GDP (in %-points)
0.1
0.05
0
2030
2040
2050
2060
2070
2080
Year
Private investment in equipment (qI_s)
Housing investment (qI_s)
Private investment in structures (qI_s)
Government investment (qI_s)


Production inputs private sector
Change relative to baseline (in %)
1
0.5
0
2030
2040
2050
2060
2070
2080
Year
Production (qY)
Equipment capital, primo (qK)
Intermediates (qR)
Structures capital, primo (qK)
Labor (qL)


Prices
Change relative to baseline (in %)
0
−0.1
−0.2
−0.3
−0.4
2030
2040
2050
2060
2070
2080
Year
Unit costs, total(pKELBR)
Export price, total (pXy)
Output price, total (pY)

3.2 Labor supply through participation

Labor supply is increased through participation until each age group's structural employment increases by 1 percentage point relative to the baseline.

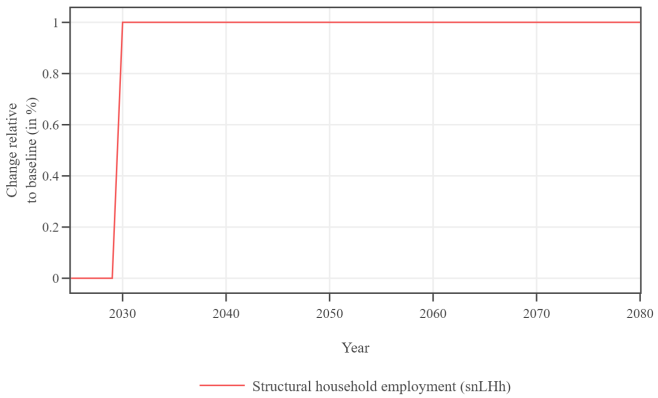
Note:

- Compared to the labor productivity shock
  - There is a negative effect from less unemployment compensation on wages.
    - This gives an extra effect that works like a negative demand shock via household income
  - It is a larger shock to effective labor supply as public sector employment is unchanged and private sector employment increases by more than 1 percent in the long run
- The shock is 'unfinanced' and labor supply increases more than labor demand for given prices. Thus, both the nominal and real wage will fall.
- There are small effects on income, private consumption and housing investments
  - Employment increases more than real wages decrease - positive effect
  - Lower unemployment and unemployment compensation decrease income
- There are small effects on investments as production increases, but lower real wages induces substitution away from capital in production
- GVA and GDP increase close to proportional with labor supply
  - A lower capital-output ratio in the sectors dampens GVA and GDP growth relative to labor supply
  - Workers finds employment in the private sector with higher GVA per worker than the public sector
- Scale effect in exports increase more than 1 percent as private employment and GVA increase more than 1 percent for given public employment and production
- Large positive effect on government budget and fiscal sustainability

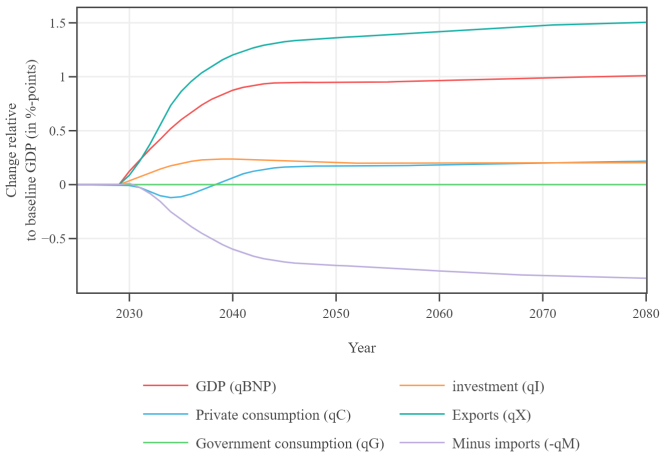
Shock Reactions in MAKRO

Permanent unfinanced supply shocks

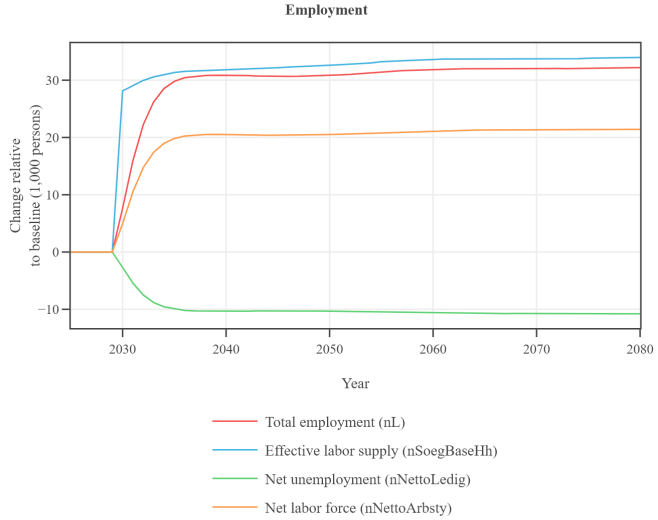
Shock



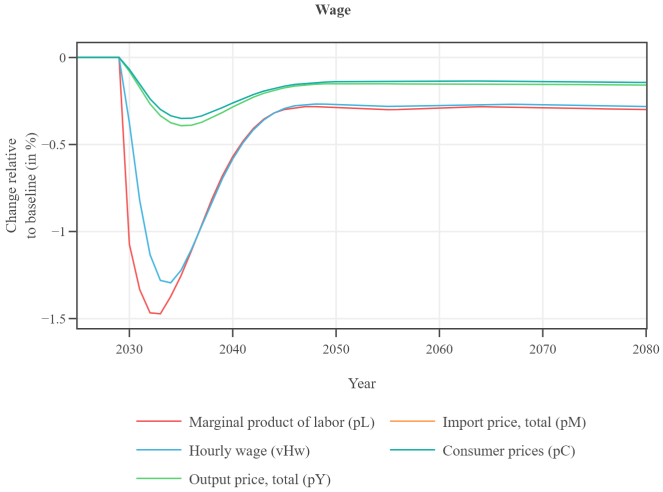
GDP decomposition



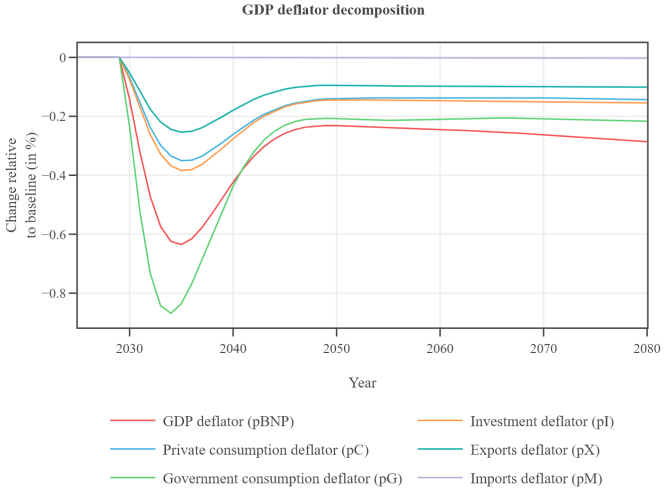
Employment



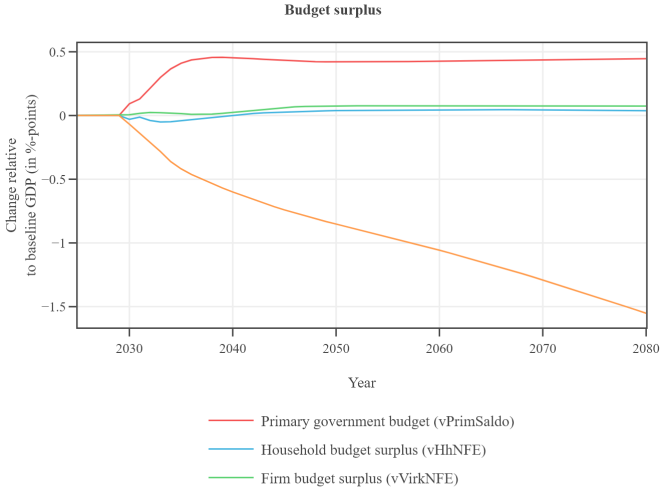
Wage



GDP deflator decomposition

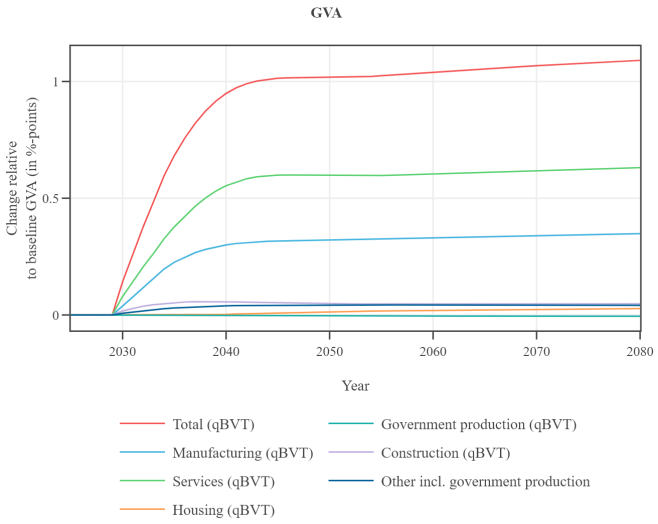


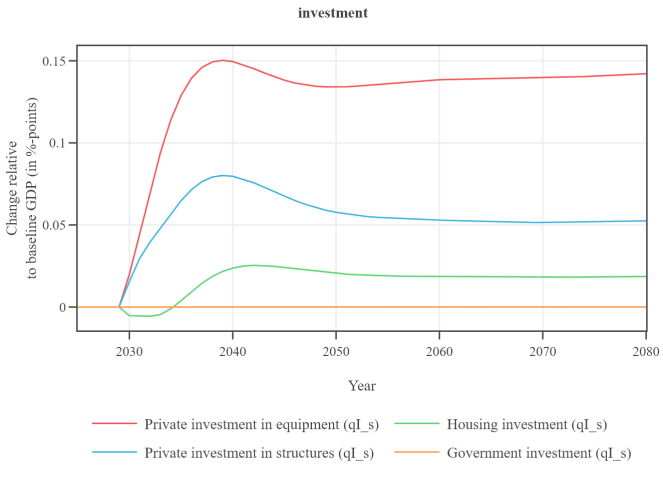
Budget surplus

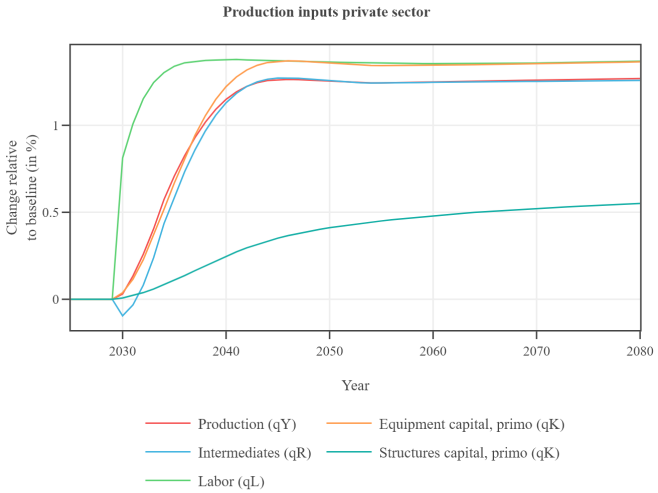


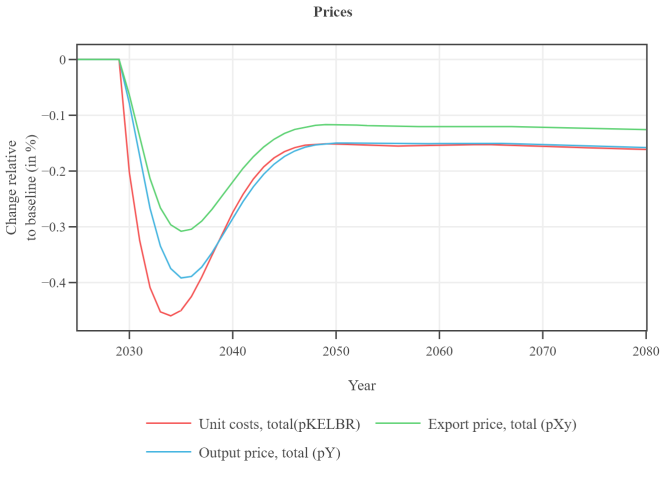
Shock Reactions in MAKRO

Permanent unfinanced supply shocks









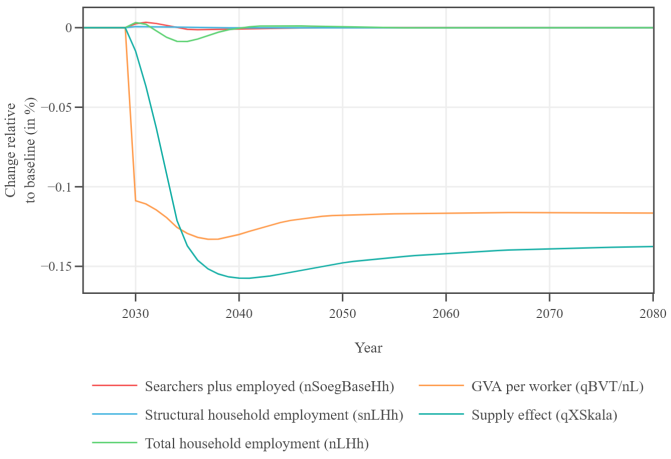
3.3 Capital productivity

Capital productivity in all private sectors increases by 1 percent relative to the baseline.

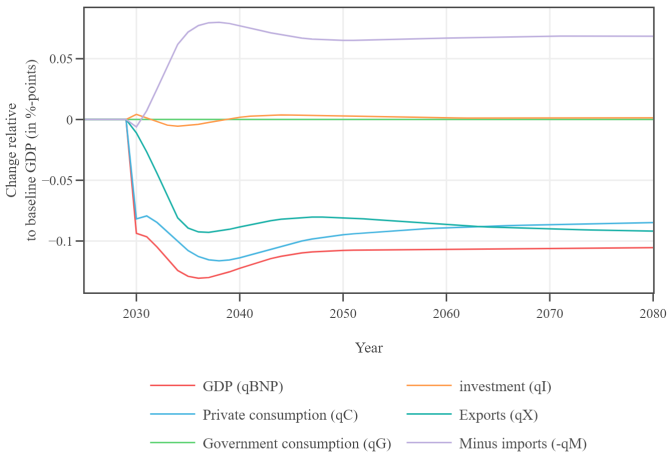
Note:

- The shock is to domestic capital productivity only - i.e. foreign demand market growth, foreign prices and interest rates are unchanged.
- Compared to the labor productivity shock:
  - There are smaller long-run effects on GVA as the non-reproducible input (effective labor) is unchanged and significantly smaller as substitution elasticities in production are small.
  - Long run price effects are positive.
- Qualitatively, most effects are as in the shock to labor productivity.
  - Wages per hour worked increase and real wages increase.
    - There is a positive effect on income, private consumption and housing investments.
  - There are small net effects on employment.
    - In the short run, less employment for given production and increased production keeps employment relative stable.
    - In the long run employment is unchanged.
  - Productivity in public sector is unchanged - so government production and consumption is unchanged.
    - Private GVA increase close to 1 percent, but total GVA and GDP less.
    - Government production deflator grows as public sector wages follow private sector wages.
  - Scale effects in exports follow private GVA.
  - There is a positive effect on government budget and fiscal sustainability.

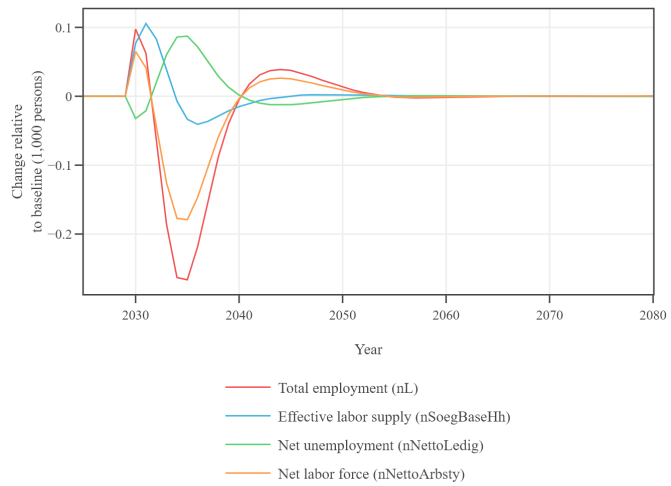
Shock



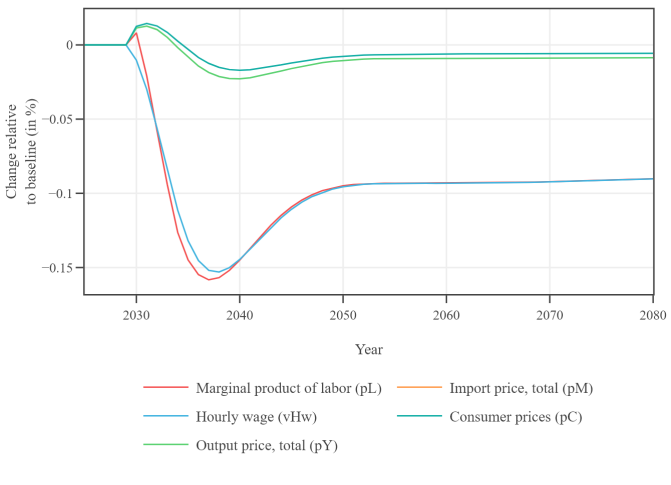
GDP decomposition



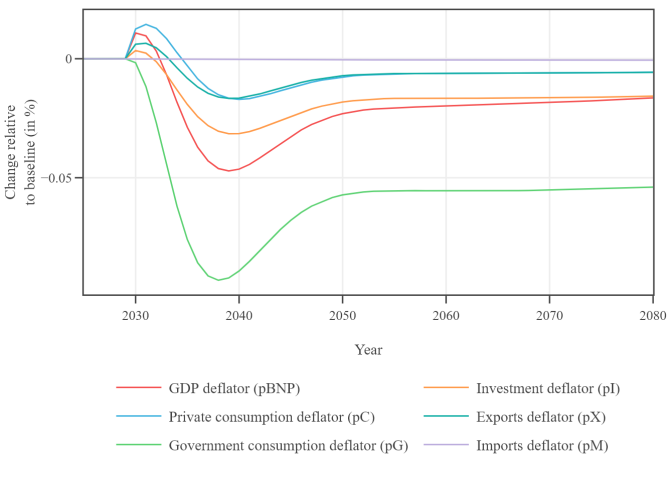
Employment



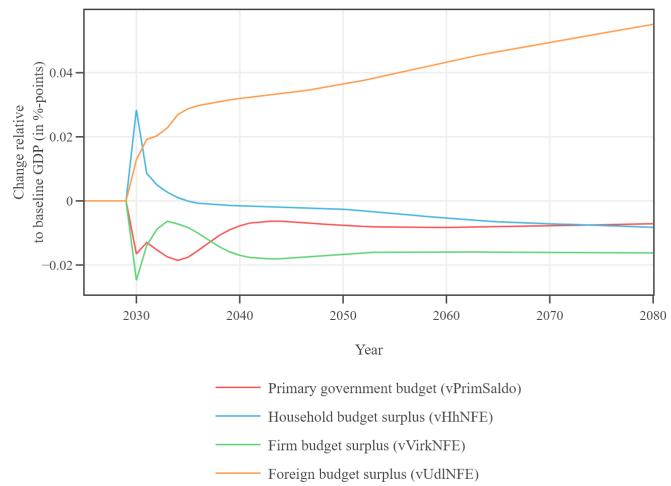
Wage

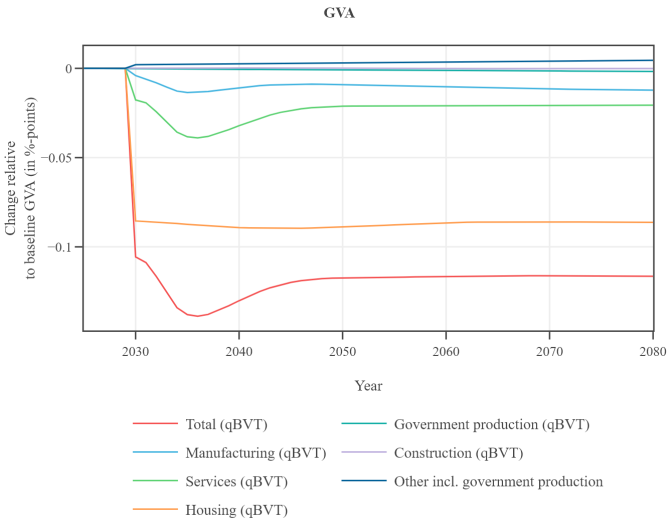


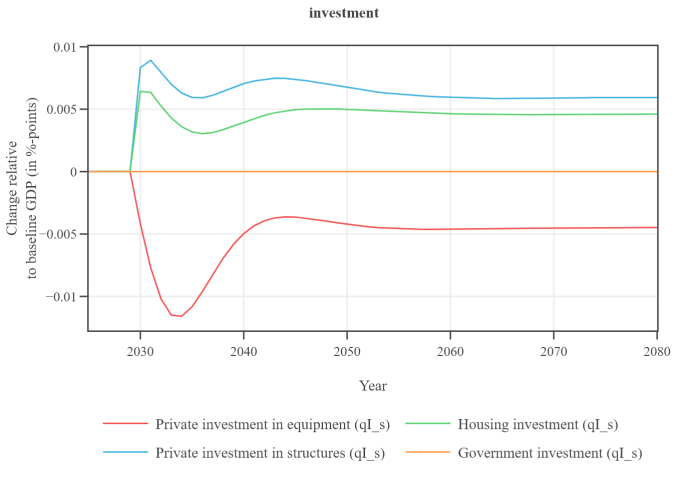
GDP deflator decomposition

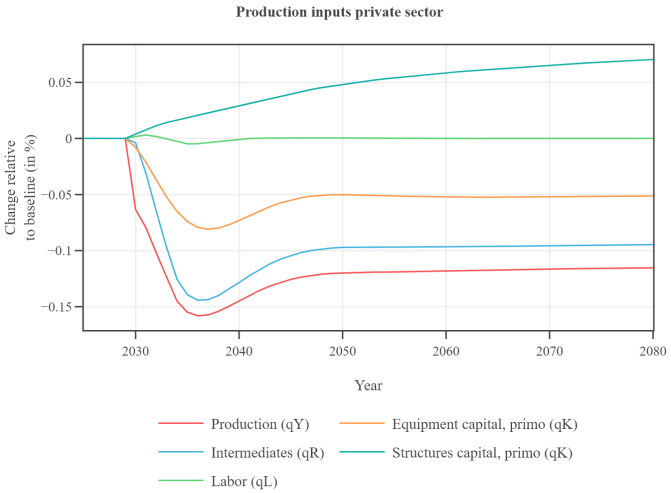


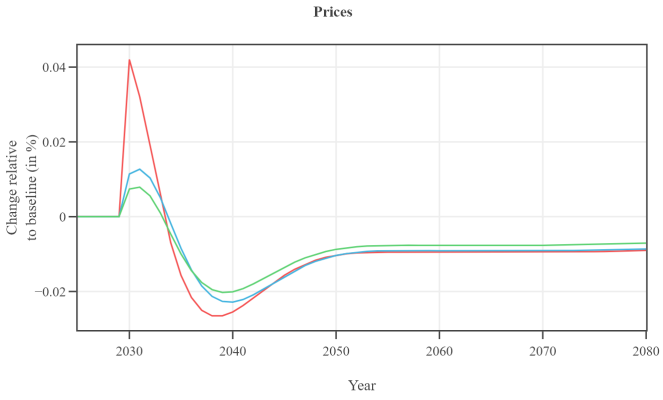
Budget surplus




GVA
Change relative to baseline GVA (in %-points)
0
−0.05
−0.1
2030
2040
2050
2060
2070
2080
Year
Total (qBVT)
Government production (qBVT)
Manufacturing (qBVT)
Construction (qBVT)
Services (qBVT)
Other incl. government production
Housing (qBVT)


investment
Change relative to baseline GDP (in %-points)
0.01
0.005
0
−0.005
−0.01
2030
2040
2050
2060
2070
2080
Year
Private investment in equipment (qI_s)
Housing investment (qI_s)
Private investment in structures (qI_s)
Government investment (qI_s)


Production inputs private sector
Change relative to baseline (in %)
0.05
0
−0.05
−0.1
−0.15
2030
2040
2050
2060
2070
2080
Year
Production (qY)
Equipment capital, primo (qK)
Intermediates (qR)
Structures capital, primo (qK)
Labor (qL)


Prices
Change relative to baseline (in %)
0.04
0.02
0
−0.02
2030
2040
2050
2060
2070
2080
Year
Unit costs, total(pKELBR)
Export price, total (pXy)
Output price, total (pY)

4 Permanent unfinanced foreign price shocks

In this chapter, we look at unfinanced shocks to foreign prices. Price shocks all have elements of a negative supply shock, as increased prices make production more expensive. They also have elements of a positive demand shock as exports increase and imports decrease for given domestic prices.

A shock to foreign prices has the following mechanisms:

- The initial shock may directly increase export competing prices (foreign prices on products that compete with domestic products internationally).
  - Thus, exports increase.
- The initial shock may directly increase import prices such that:
  - There is substitution away from imports, which increases demand for domestic goods.
  - There are higher demand prices through imported inputs, which decreases domestic demand as well as imports.
  - The sign of the net effects (from increased import prices on demand) differs for demand components.
  - There are higher intermediate input prices through imported inputs.

Higher intermediate input prices have the same properties as a negative shock to productivity.

- Higher intermediate input prices in production implies:
  - Higher unit costs in production.
  - Higher unit costs leads to higher output prices.
  - Higher output prices leads to higher demand prices.
  - Higher prices decrease demand over time.

Higher export competing prices increase domestic demand through exports. At the same time, the domestic demand effect from increased import prices can be positive through reduced imports or negative through reduced private consumption and/or investments. A positive demand shock is described in the introduction and has the following properties:

- Increased demand leads to increased sectoral production.
- Increased sectoral production leads to increased sectoral production inputs.
- Increased intermediate input inputs leads to increased imports and domestic sectoral output.
- Increased capital demand leads to increased investments from imports and domestic sectoral output.
- Increased labor demand leads to increased wages, employment and labor supply.
- Increased employment and wages leads to higher household income and increased demand for private consumption and housing.
- Increased housing demand leads to increased housing prices and investments in housing.
- Increased housing prices leads to increased liquidity and demand for private consumption and housing.

- Increased production leads to higher output prices.
- Higher output prices leads to higher demand prices.
- Increased prices dampens quantity demand over time.
- There is full crowding out in employment.

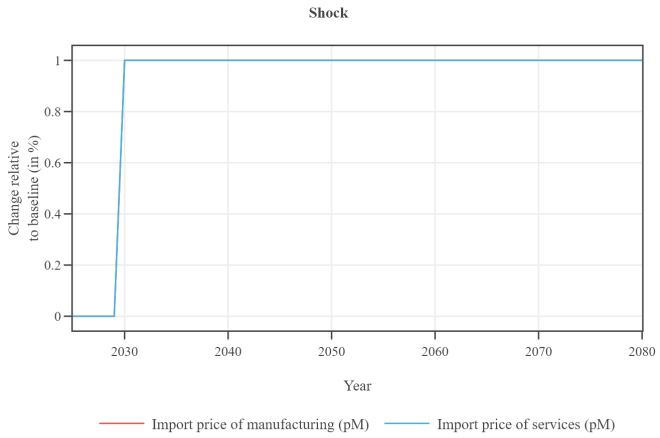
The above mechanisms are all described in further detail in the introduction. All shocks are unfinanced. All the shocks are partial from the point of view of the foreign economy, as foreign demand and interest rates are unchanged.

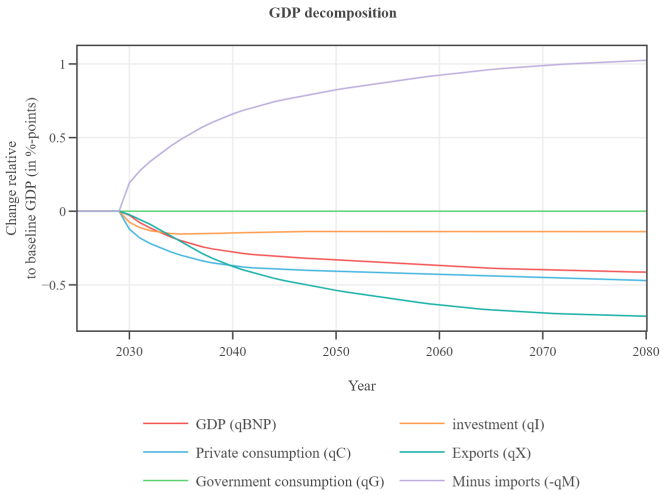
4.1 Import prices

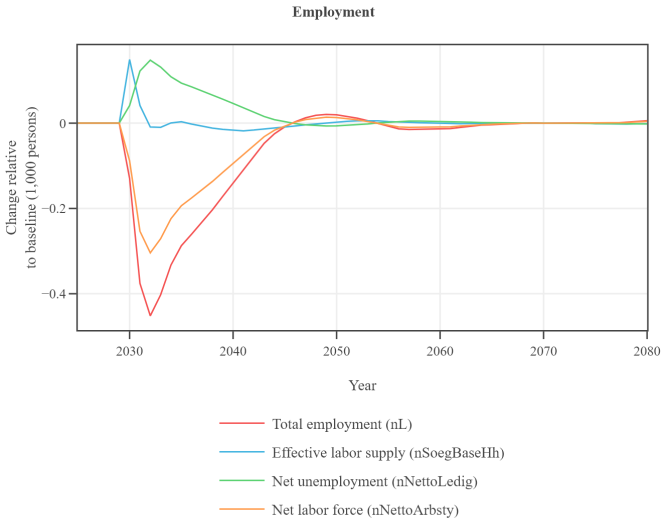
All import prices are increased by 1 percent relative to the baseline. Export competing prices are kept unchanged. This affects supply through the prices of intermediate inputs in production. Demand is affected through substitution away from imports for all relevant demand components.

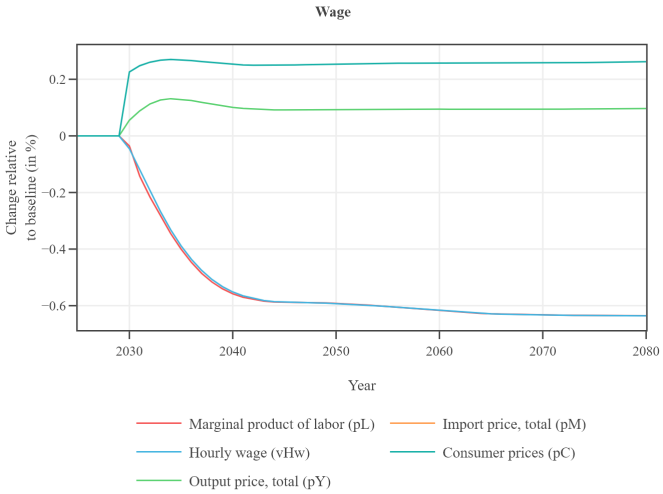
Note:

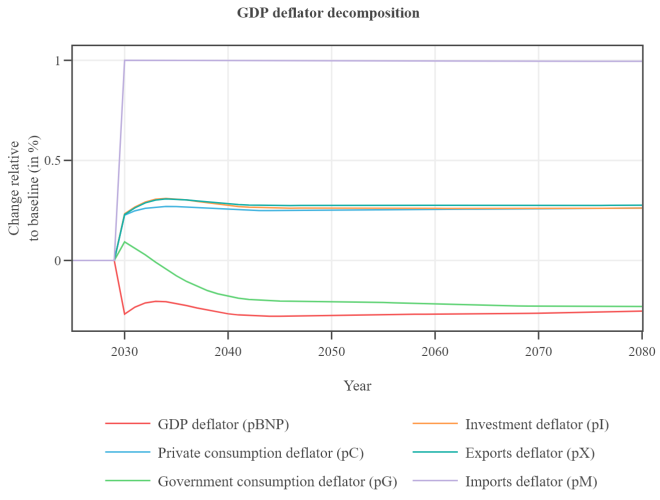
- Export competing prices are unchanged and exports decrease.
- The import share of energy at the IO-cell level is fixed.
  - Aggregate effects can be affected by sectoral composition effects - but this effect is small.
- The net effect is contractionary.
- The net effect on different prices depend on their import shares:
  - As import prices increase, but wages decrease.
  - As government consumption has a negative deflator effect.
    - Noting that government consumption has almost no direct imports.
    - And further noting that government consumption obtains the brunt of its imports from government production, which has almost no imports.
  - GDP has by construction a negative deflator, as imports are a negative part of GDP.
- There is a negative effect on the public budget and fiscal sustainability.

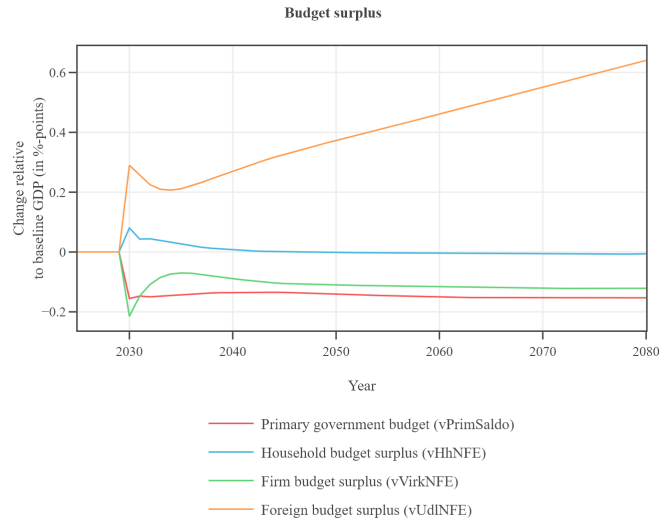

Shock
Change relative to baseline (in %)
Year
Import price of manufacturing (pM)
Import price of services (pM)


GDP decomposition
Change relative to baseline GDP (in %-points)
Year
GDP (qBNP)
investment (qI)
Private consumption (qC)
Exports (qX)
Government consumption (qG)
Minus imports (-qM)


Employment
Change relative to baseline (1,000 persons)
Year
Total employment (nL)
Effective labor supply (nSoegBaseHh)
Net unemployment (nNettoLedig)
Net labor force (nNettoArbsty)

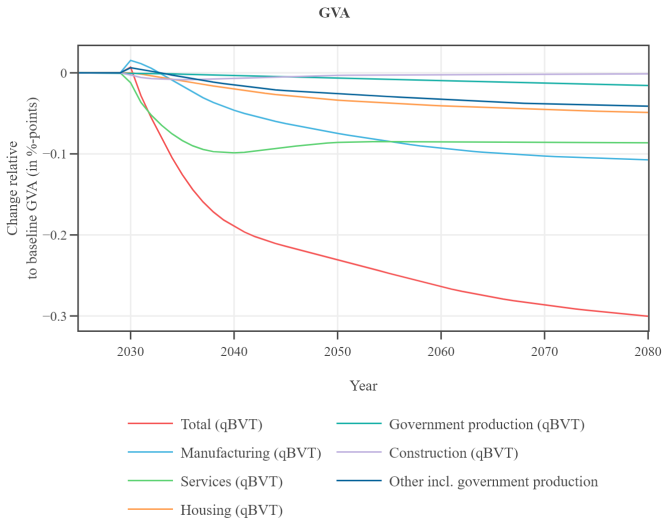

Wage
Change relative to baseline (in %)
Year
Marginal product of labor (pL)
Import price, total (pM)
Hourly wage (vHw)
Consumer prices (pC)
Output price, total (pY)

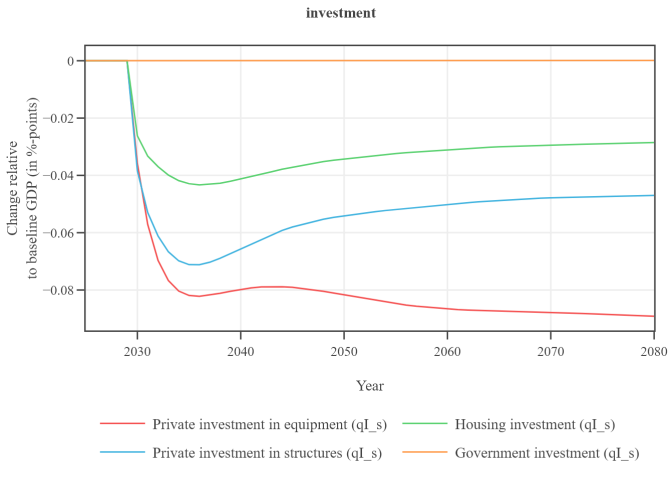

GDP deflator decomposition
Change relative to baseline (in %)
Year
GDP deflator (pBNP)
Investment deflator (pI)
Private consumption deflator (pC)
Exports deflator (pX)
Government consumption deflator (pG)
Imports deflator (pM)

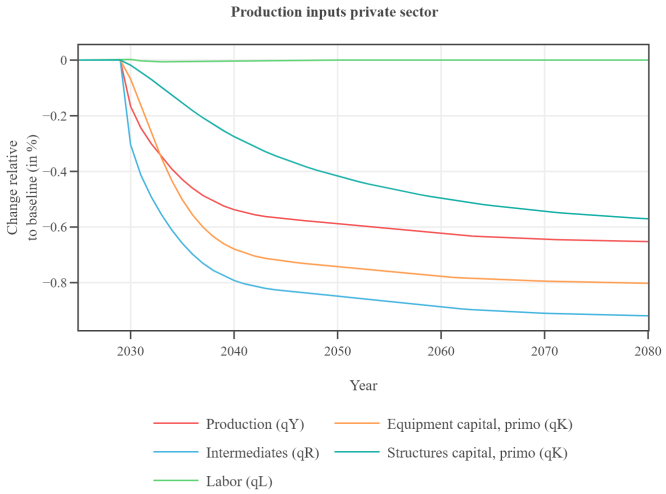

Budget surplus
Change relative to baseline GDP (in %-points)
Year
Primary government budget (vPrimSaldo)
Household budget surplus (vHhNFE)
Firm budget surplus (vVirkNFE)
Foreign budget surplus (vUdlNFE)

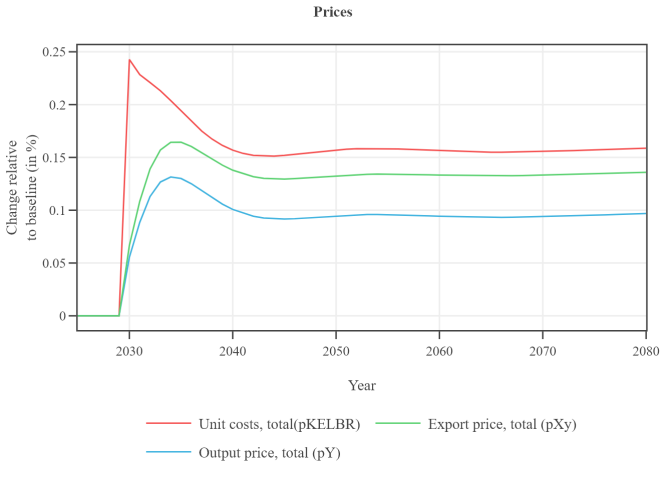
Shock Reactions in MAKRO

Permanent unfinanced foreign price shocks









4.2 Foreign prices

Foreign prices are increased by 1 percent. This shock affects supply through the prices of intermediate inputs in production and it affects demand through increased exports and substitution away from imports for given domestic prices.

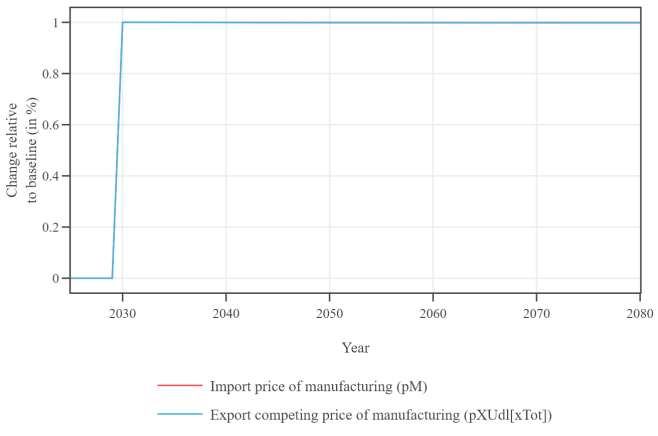
Note:

- All foreign prices increase 1 percent in the long run
- The shock is expansionary in the short run
  - Domestic prices are more rigid and net exports will increase - especially in the medium term
  - Firms expect this increase and invest in capital in the short run
- Households are net savers and their real wealth is decreased by the shock
  - Lower real wealth gives lower real returns, lower real pension income and lower real inheritance
  - Taken together, this lowers long-run real consumption
- Lower long-run demand from consumption makes wages grow with slightly less than 1 percent in the long run
  - Output prices and export prices increase by slightly less than 1 percent in the long run
  - Exports increase and import decrease in the long run - to compensate for lower private consumption
- There is a positive short run effect on the government budget.
- Long run effects on the government budget and fiscal sustainability are small.

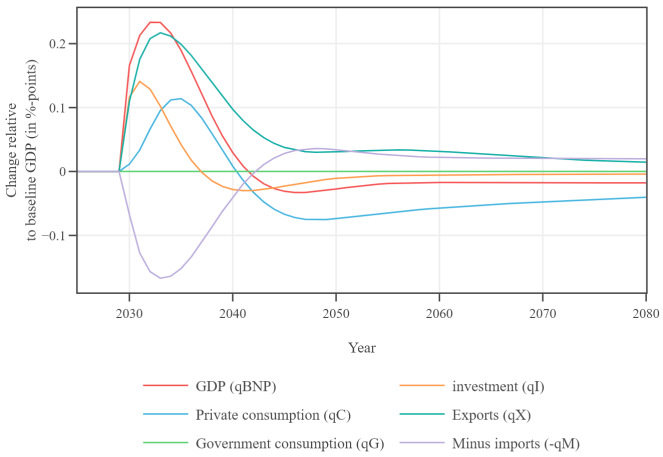
Shock Reactions in MAKRO

Permanent unfinanced foreign price shocks

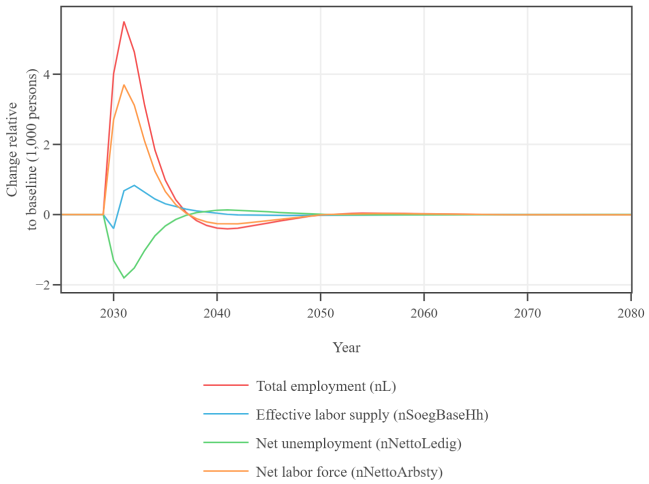
Shock



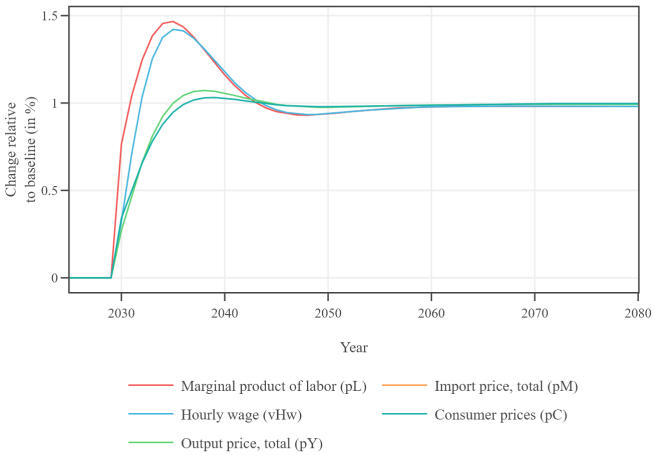
GDP decomposition



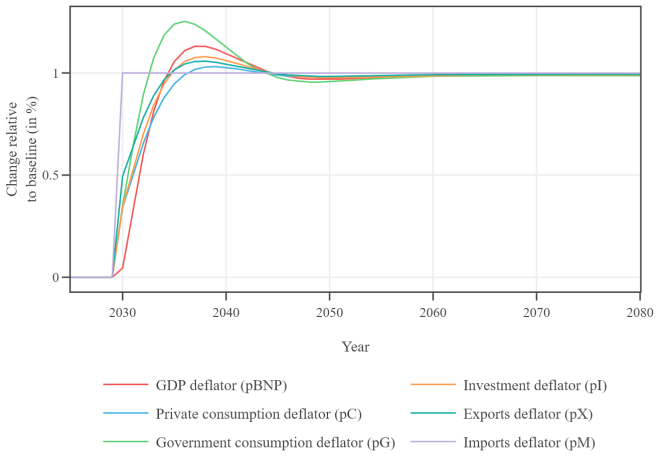
Employment



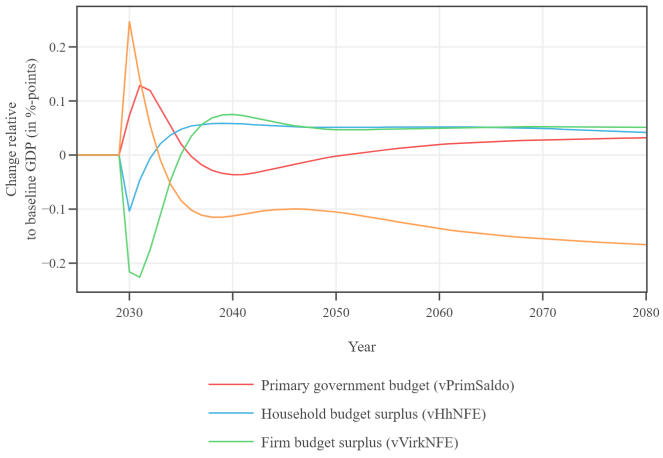
Wage



GDP deflator decomposition

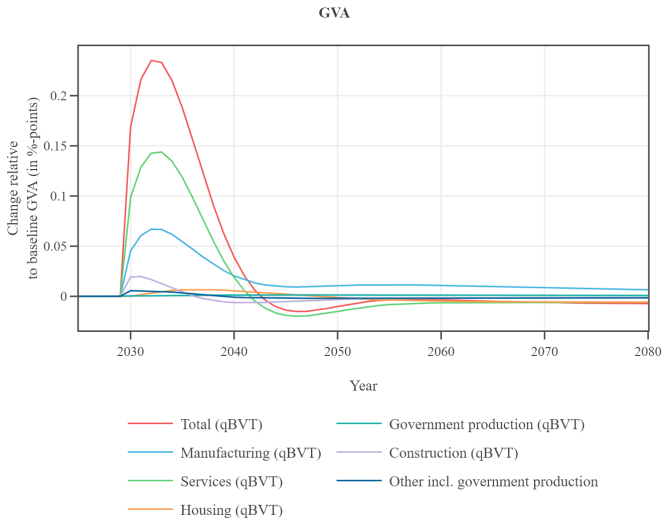


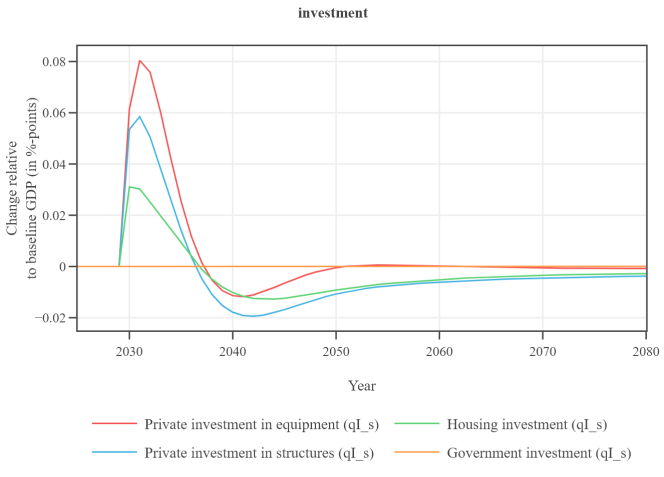
Budget surplus

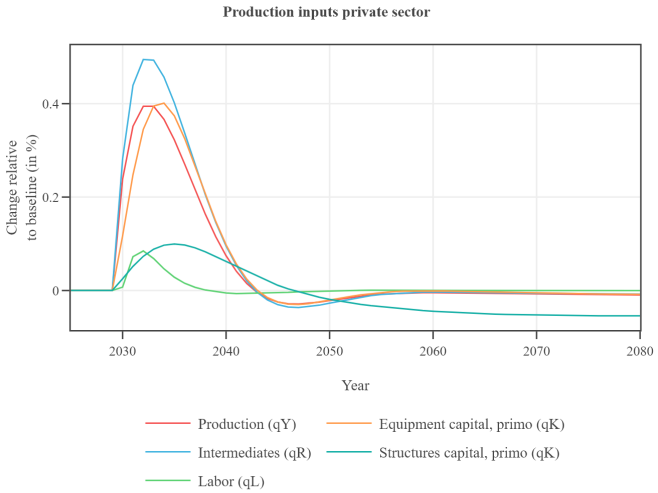


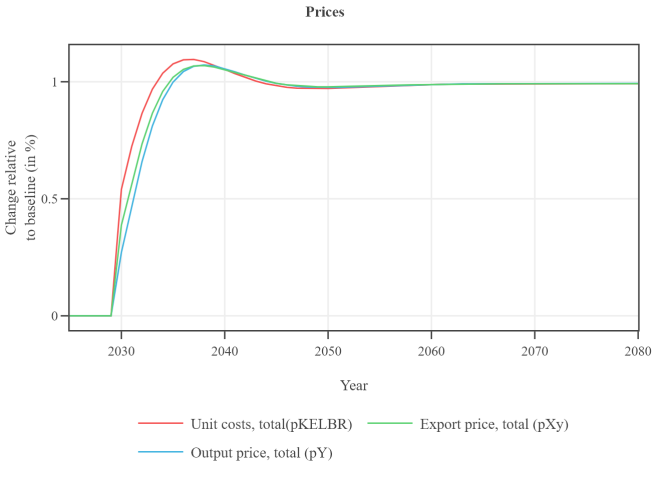
Shock Reactions in MAKRO

Permanent unfinanced foreign price shocks









5 Permanent unfinanced miscellaneous shocks

5.1 Interest rate

The ECB interest rate is increased permanently by 1 percentage point. This is a partial shock as foreign general equilibrium components are unchanged, namely foreign prices and foreign demand.

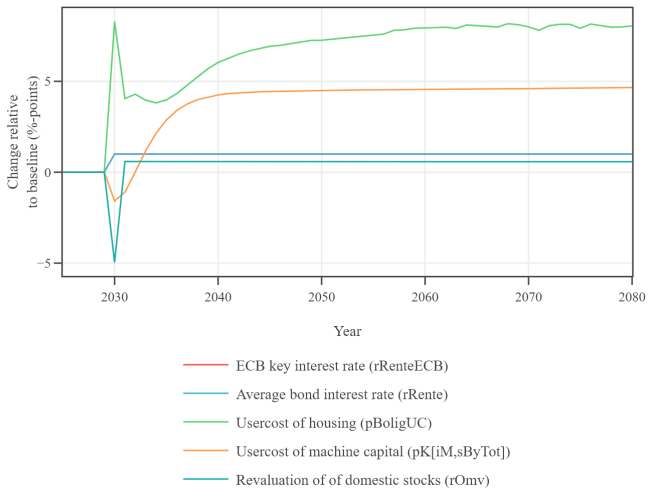
Note that:

- There is a strong negative effect on domestic stock prices in the first period
  - As a higher implied discount rate lowers the value of the firm.
  - Which in turn lowers the real pension wealth and the real wealth of the households
- The user-cost for housing increases in the long run as finance is more costly, but is in the short run strongly affected by expected changes in future housing prices due to lower housing demand due to lower household income.
- The economy will react as if hit by a negative demand shock to investments, but with a significant substitution away from capital. Thus, the negative effects on GVA and GDP will be more severe than in a direct investment shock.
- Scale effects in exports will set in as structural GVA is decreased. This will hinder crowding out in exports and increase the severity of the shock.
- There are strong negative short-run effects on the government budget due to large temporary drop in employment.
- Long-run effects on the government budget and fiscal sustainability can very well be positive as lower expenses due to lower wages and higher revenue from household and pension returns might outweigh the lower revenue from income taxes.

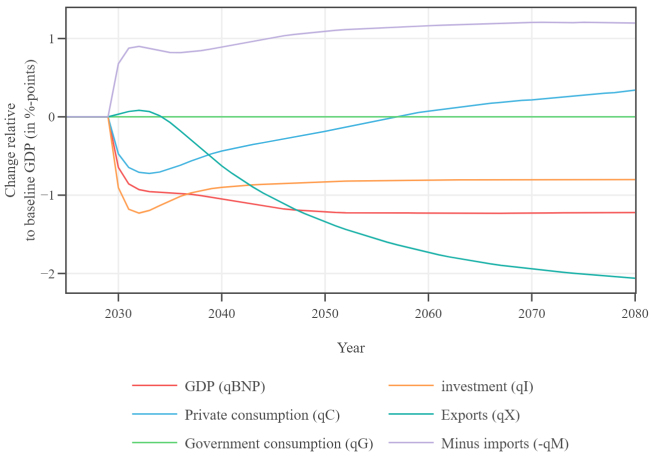
Shock Reactions in MAKRO

Permanent unfinanced miscellaneous shocks

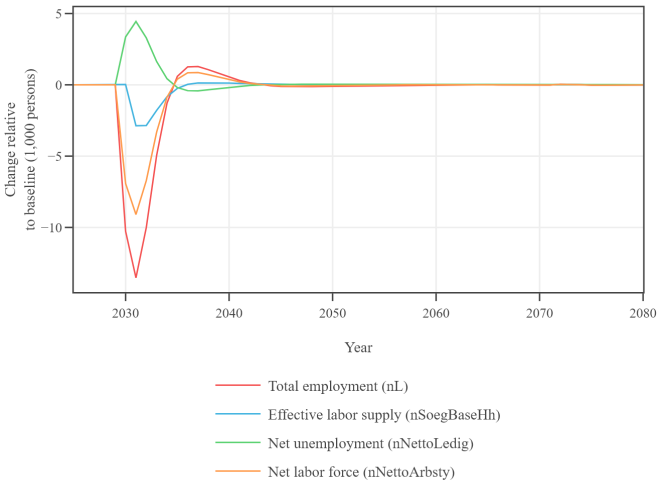
Shock



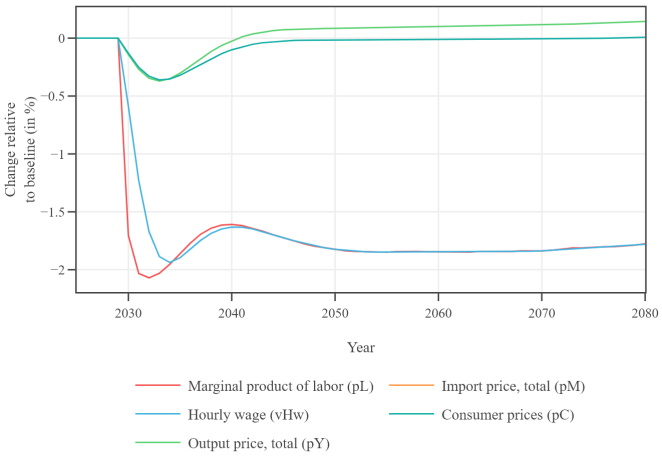
GDP decomposition



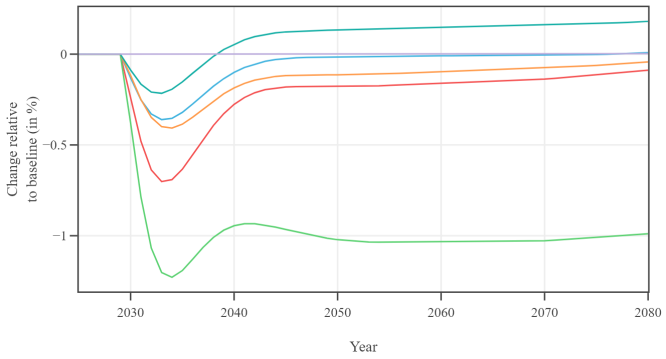
Employment



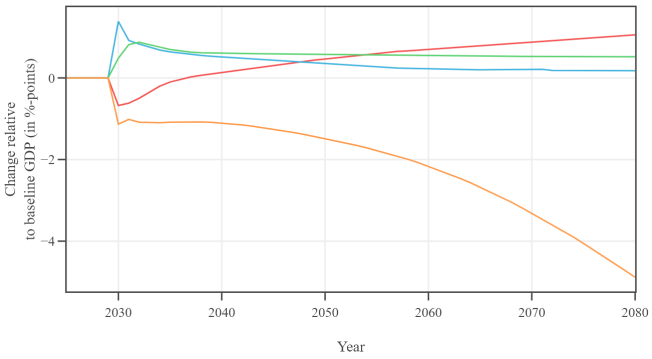
Wage

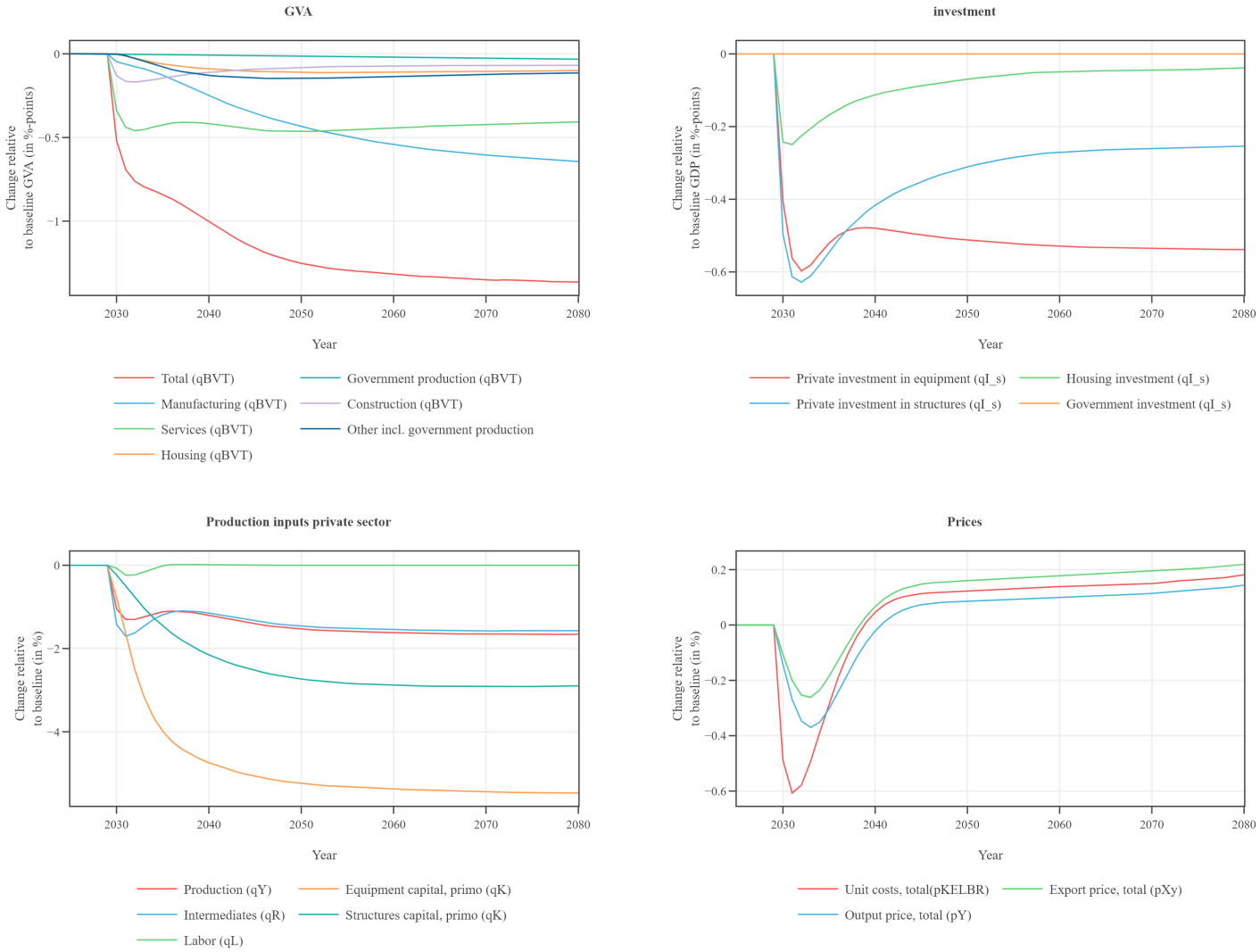


GDP deflator decomposition



Budget surplus





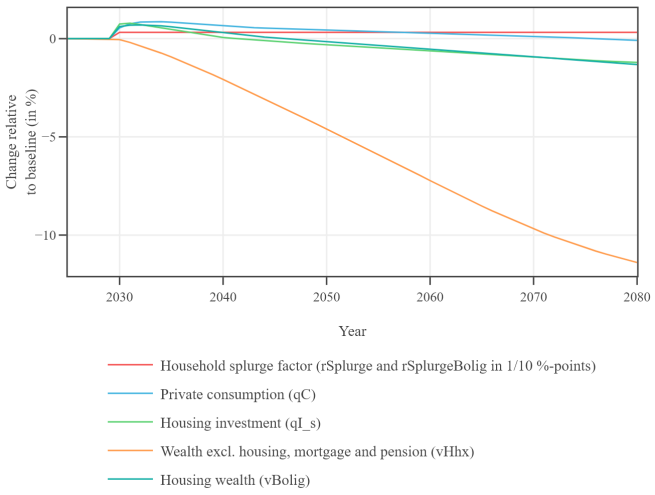
5.2 Household hand-to-mouth factor (splurge-factor)

The households' hand-to-mouth consumption shares (over durables and non-durables) are permanently increased by 1 percentage point.

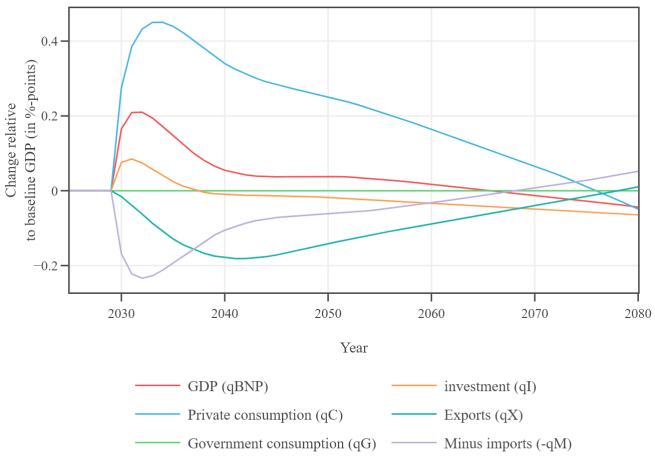
- Households now use a larger share of their liquid income on consumption.
- In the short and medium term, this works as a positive (but gradually declining) shock to private consumption and housing demand
- This sets in motion the following equilibrium responses:
  - Increased demand leads to increased production.
  - Increased sectoral production leads to increased sectoral production inputs.
  - Increased material inputs leads to increased imports and domestic sectoral output.
  - Increased capital demand leads to increased investments from imports and domestic sectoral output.
  - Increased labor demand leads to increased wages, employment and labor supply.

  - Increased employment and wages leads to higher household income and increased demand for private consumption and housing.
  - Increased housing demand leads to increased housing prices and investments in housing.
  - Increased housing prices lead to increased liquidity and demand for private consumption and housing.
  - Increased production leads to higher output prices.
  - Higher output prices lead to higher demand prices.
  - Increased demand prices dampen demand over time.
  - Full crowding out in employment.
  - Positive short run effect on government budget.
- The increased short and medium term consumption will reduce household wealth and long-run consumption.
- Even after many years (50+), the negative effect on wealth has not stabilized. This is because of slow generational effects arising from our overlapping-generations structure.
  - We do see the negative effect on consumption, but this has also not stabilized.
  - Households live many years and give inheritance - so it will stabilize very slowly.
- In the long run it works as a negative shock to private consumption and housing demand.
- There are negative long-run effect on the government budget and fiscal sustainability.

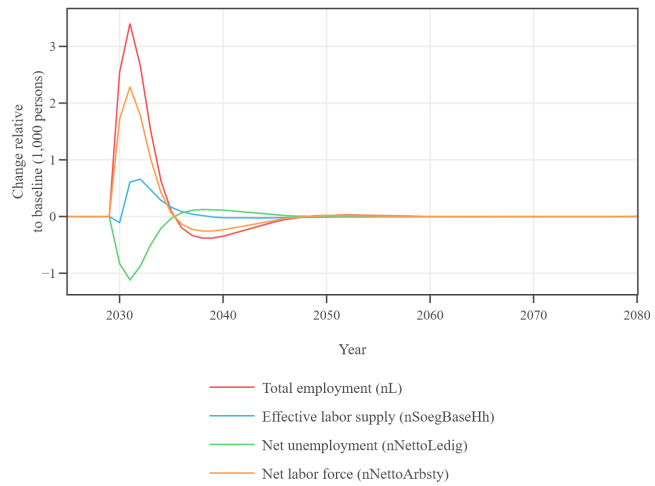
Shock



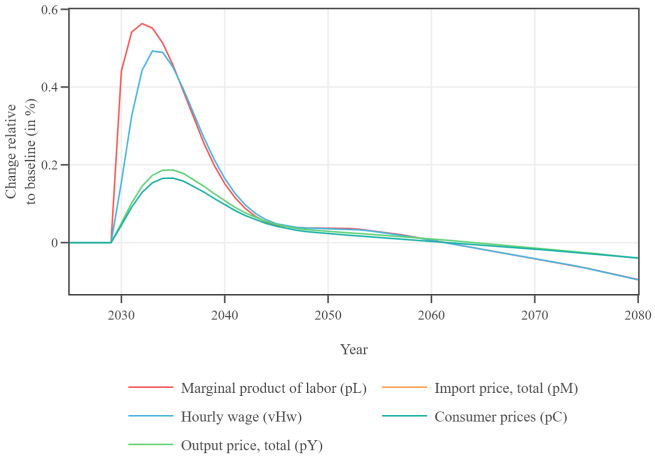
GDP decomposition



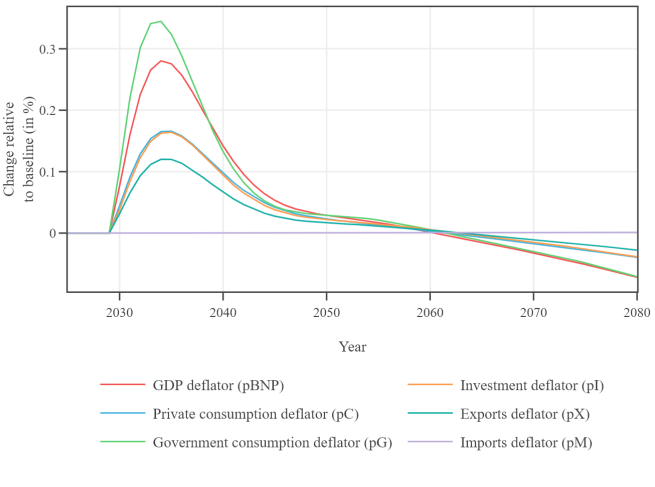
Employment



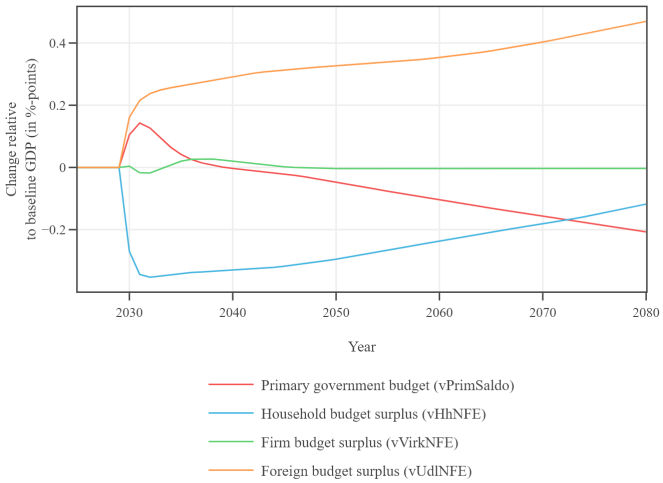
Wage

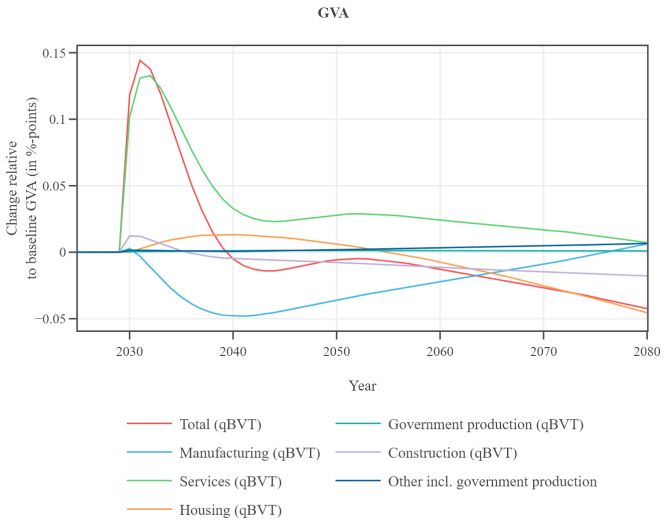


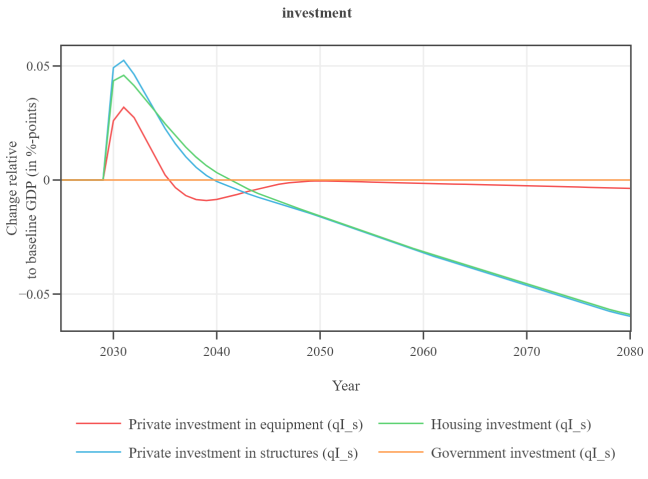
GDP deflator decomposition

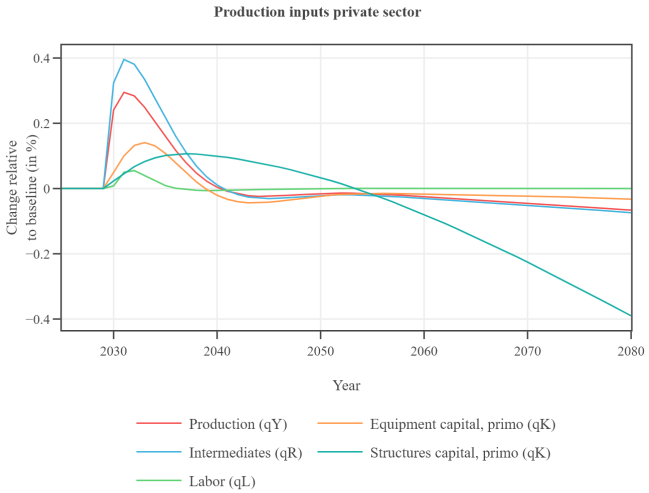


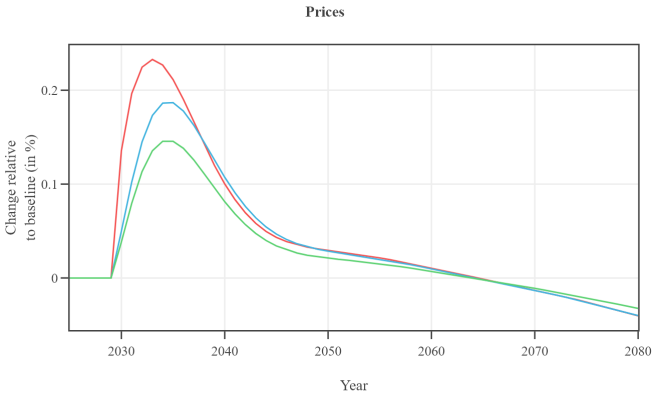
Budget surplus




GVA
Change relative to baseline GVA (in %-points)
0.15
0.1
0.05
0
−0.05
2030
2040
2050
2060
2070
2080
Year
Total (qBVT)
Manufacturing (qBVT)
Services (qBVT)
Housing (qBVT)
Government production (qBVT)
Construction (qBVT)
Other incl. government production


investment
Change relative to baseline GDP (in %-points)
0.05
0
−0.05
2030
2040
2050
2060
2070
2080
Year
Private investment in equipment (qI_s)
Private investment in structures (qI_s)
Housing investment (qI_s)
Government investment (qI_s)


Production inputs private sector
Change relative to baseline (in %)
0.4
0.2
0
−0.2
−0.4
2030
2040
2050
2060
2070
2080
Year
Production (qY)
Intermediates (qR)
Labor (qL)
Equipment capital, primo (qK)
Structures capital, primo (qK)


Prices
Change relative to baseline (in %)
0.2
0.1
0
2030
2040
2050
2060
2070
2080
Year
Unit costs, total(pKELBR)
Output price, total (pY)
Export price, total (pXy)