Hanne Albig, Marius Clemens, Ferdinand Fichtner, Stefan Gebauer, Simon Junker, Konstantin Kholodilin

Increasing Inequality Reduces Long-term Growth

German Economic Analysis Using a Macroeconomic Structural Model

good society – social democracy
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PRELIMINARY REMARKS

There has been intense discussion of the effects of increasing wealth and income inequality on economic development for some years now. For example, the German Council of Economic Experts (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung) and many German economists highlight what they perceive as efficiency gains arising from economic inequality and thus do not expect negative growth effects from an increasingly unequal income and wealth distribution. In contrast, international organisations such as the IMF and the OECD, as well as many foreign economists point to the negative consequences of rising economic inequality for the general development of the economy.

Against this background the Friedrich-Ebert-Stiftung commissioned the Deutsche Institut für Wirtschaftsforschung (DIW) to conduct a simulation study. The aim was to develop a structural macroeconometric model capable of depicting the various transmission channels between income inequality and economic growth in Germany in a quantitatively plausible and theoretically consistent framework and, building on that, to analyse whether rising income inequality Germany experienced in recent decades has had a negative impact on economic growth. If this is so, then the case for immediate policy action would be clear. The authors find that the increasing income inequality in Germany in recent years has had a negative effect on economic growth. GDP would be higher today if inequality in the income distribution had not risen since the early 1990s.

The authors identify a lack of investment in education and training which dampens long-term productivity growth, as well as the evolution of current private consumption and future savings as particularly adverse effects of increasing income inequality. These are all economic variables that are of key importance for assessing overall economic prosperity and quality of life. At the same time, according to the findings of the study, the increasing income inequality has contributed substantially to Germany's current account surpluses. Since the global financial and economic crisis it has been evident that these imbalances are extremely problematic for financial stability and growth in Europe and a globalised world.

Overall, the propositions and findings from the structural macroeconometric model and the simulation confirm the claims of more recent international empirical studies on the relationship between economic inequality and economic development. If high, stable and sustainable economic growth is to be attained, Germany, in common with other economies, will have no choice but to try to reduce its now high economic inequality.

The present study appears within the framework of the FES-wide project "Good Society – Social Democracy #2017plus", at the heart of which lies the rising economic inequality that has been a central topic of economics and politics at least since the publication of Thomas Piketty's Capital in the Twenty-First Century, together with all the related economic and social problems. Several studies published in recent months show how economic inequality has developed in Germany, what that means for people's lives and which political solutions lend themselves to reducing economic inequality. We hope that all our readers find it interesting.

MARKUS SCHREYER
Department of Economic and Social Policy
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SUMMARY

The study presented here examines the effects of changes in income distribution on economic developments. To this end we develop a macroeconometric model capable of depicting the main transmission channels between the income distribution and economic growth discussed in the literature in a quantitatively plausible and theoretically consistent framework. In the short run, rising income inequality raises productivity because the stronger effects of personal efforts on relative individual income provide an incentive to engage in more productive work ("incentive channel"). In the long run, however, elevated social inequality exerts a negative effect on productivity because those earning low incomes invest less in longer or better education or training since they do not have the money to afford it ("human capital channel"). Finally, the model takes account of the fact that low earners are simply unable to save a large part of their income; consequently, a redistribution in favour of higher income earners raises the savings rate and thus suppresses consumer demand ("savings rate channel"). Our model, estimated using German data from 1991 to 2015, confirms the channels derived in the literature. Specifically, the coefficients in the various equations in which income distribution is included as an explanatory variable, have the expected signs.

The effects of a gradual increase in income inequality are simulated by a two-point increase in the Gini coefficient over a period of ten years. In the short run, the savings rate channel in particular dampens GDP. With a delay of about ten years the incentive channel overcompensates the abating effects of the increased savings formation on private consumption. Simultaneously, the human capital channel starts to dampen economic growth. In the long run it dominates the overall effects so that after twenty-five years real GDP lies markedly below its comparative value in a scenario without an increase in inequality – by around 50 billion euros. The growth rate is cumulatively around 1.5 percentage points or half of one tenth of a percentage point per year lower than in the case of unchanged income distribution. The results of the model thus confirm the findings of a large part of the literature that inequality weakens the economy and economic growth. In comparison with other studies, which derive their results using international data, however, the effects are somewhat weaker.

Counterfactual simulations for the German economy show that the rise in inequality between 1991 and 2015 is likely to have markedly suppressed economic development. If income inequality measured in terms of the Gini coefficient of net household income had remained at its 1991 level, German GDP in 2015 would have been 40 billion euros higher than was in fact the case. The results of the model also suggest that the growth of the German economy since reunification in 1990 has been a good half of a tenth of a percentage point per year lower than it would have been in the case of an unchanged income distribution. The findings presented here, however, should be treated with caution because the model equations are fraught with uncertainties. In addition, it has to be taken into account that income distribution is modelled as a purely exogenous variable.

Despite the abovementioned limitations the results elaborated here allow us to draw some conclusions relevant to economic policy. Changes in the income distribution affect economic growth only with a significant delay. For example, growth in Germany in the coming years is likely – despite fairly modest recent changes in income distribution measured in terms of the Gini coefficient of net household income – to remain subdued by the substantial increase in inequality that has been observed in the past decade. The simulations indicate that, in quantitative terms, the most significant mechanism by which inequality affects economic growth is the human capital channel, whose delayed impact is considerable. Against this background, policy measures that are capable of improving equal opportunities and removing barriers in the education and training system are all the more important.

The results presented here also indicate that the change in income distribution observed in Germany was also accompanied by a rise in the trade balance; in particular, imports are likely to have been kept down by lower domestic demand due to inequality. This finding is relevant not only against the background of the debate on imbalances in the Economic and Monetary Union (EMU), but also demonstrates that the focus of the discussion on the macroeconomic consequences of increasing income inequality is wrongly placed on the negative impact on GDP. The latter is diminished by a growing positive trade balance running counter to the domestic economic slowdown. With regard to general prosperity and living standards in Germany private consumption should be the benchmark. Due to the rise in inequality this is likely to be substantially and persistently lower.

1

INTRODUCTION

Political and public debate in Germany has for some time seen growing discussion of the connection between increasing income inequality and economic growth. This discussion was instigated by a number of international empirical studies (OECD 2015; Ostry et al. 2014) that found indications of a negative link between more income divergence, on one hand, and development of the economy, on the other.

From a theoretical standpoint the macroeconomic effects of inequality are ambiguous. The economic literature has identified a number of channels through which changes in wealth and income distribution can affect overall economic development. In this context, there are theoretical and empirical arguments both for negative and positive effects of increasing inequality on economic growth. While, generally speaking, most arguments mentioned in the literature point to negative growth effects attributable to inequality, the individual channels cannot be weighed against one another conclusively in the absence of a consistent and cohesive model framework. To this end a structural macroeconomic model is needed that enables us to depict important mechanisms in a consistent system and on this basis to weigh up – also quantitatively – the various channels.

The present report describes the development of such a model and its adaptation to the economic situation in Germany. Simulation studies using the model illustrate the effects of changes in income distribution on overall economic development in Germany.[1]

1 The report presented here concentrates on the effects of inequality of income distribution. Changes in the distribution of wealth are not included, first and foremost because data availability is somewhat restricted in this respect. See Bagchi and Svejnar (2015) for a theoretical and empirical discussion of the effects of wealth inequality on economic growth.

2

RELATIONSHIP BETWEEN INCOME INEQUALITY AND GROWTH: OVERVIEW OF THE LITERATURE

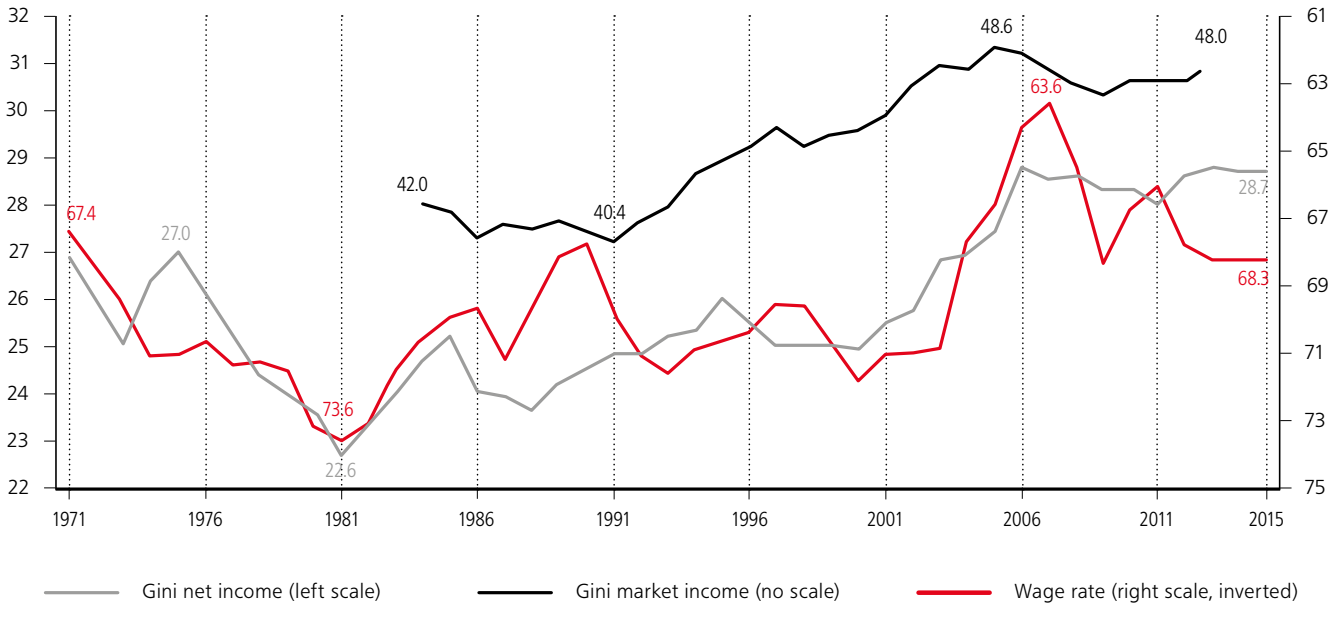
A number of channels have been identified in the literature by which changes in income distribution can exert an effect on overall economic development and, in particular, on economic growth.[2] By and large, most of these channels can be classified as mechanisms either on the supply or on the demand side of GDP. In accordance with this conceptual structure, in this section we outline the channels discussed in the literature with regard to the connection between changes in income distribution and economic growth.

First of all, a fundamental distinction has to be drawn between personal and functional income distribution. Functional income distribution describes the allocation of total income in the economy to labour and capital as factors of production or to the kinds of functional income, namely wages and profits. In general, this distribution is captured by the wage and profit rates.[3] Personal income distribution, by contrast, describes the distribution of aggregate income to persons or groups (for example, households); further distinctions can be made between distribution of market incomes and distribution of net incomes, after taking into account the effects of the tax and transfer system. A more unequal income distribution –

2 See OECD (2015), pp. 60ff for an overview.

3 The wage rate puts aggregate employee compensation in relation to total national income; the profit rate puts corporate and investment income in relation to total national income.

Figure 1
Wage rate and Gini coefficients of household income and market income in comparison



Source: See Annex, Socioeconomic Panel.

for example, as indicated by a rising Gini coefficient[4] – thus depicts a relative deterioration of the income situation of those on low incomes.

There is a connection between the two ways of looking at income distribution: those whose income derives primarily from profits or capital gains are substantially overrepresented in the upper income group, while employees belong overwhelmingly to the middle and lower income groups. This gives rise to the empirical finding that a falling wage rate tends to go hand in hand with higher personal income inequality (SVR 2012: Section 560ff). This connection is also discernible in the German data over time (see Figure 1).

In what follows, the present study refers to the personal distribution of household income because we can expect it to provide most explanatory power with regard to the overall economic effects of changes in income distribution. Wealth distribution, by analogy with personal income distribution, concerns the allocation of wealth to persons or groups. Wealth is thus generally more unequally distributed than net income (OECD 2015: 34).

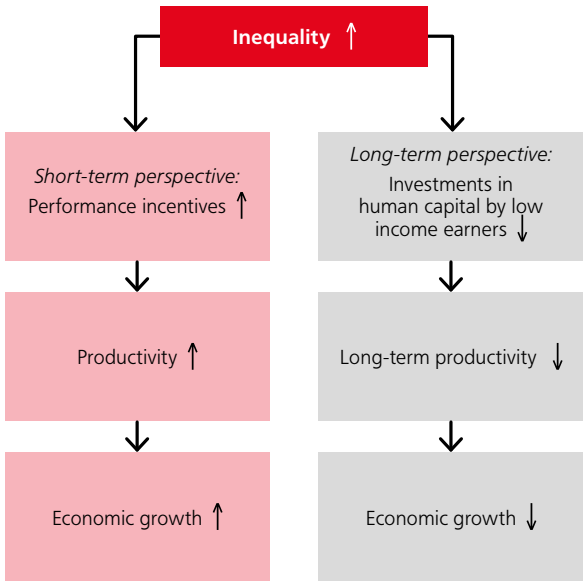
2.1 SUPPLY SIDE: INEQUALITY AND PRODUCTIVITY

On the supply side, the literature refers in particular to the connection between inequality and productivity. In this context, by and large, two channels between changes in income distribution and overall economic development are discussed (see Figure 2), whose influence on economic growth depends decisively on the time horizon under investigation.

In the short run, increasing income inequality[5] can create performance incentives because, in principle, low earners will be more inclined to opt for more demanding activities, which are likely to bring an improvement in their income situation. It is also conceivable that individuals will work more efficiently and thus generate more output because they hope for a higher reward by stepping up their performance (Baumol 2007; Hoeller et al. 2012). Overall, in this way rising inequality could lead to higher productivity and thus contribute to more vigorous growth of the economy (Voitchovsky 2005).

However, above a critical threshold the positive effect of inequality could go into reverse: in a situation of substantial income inequality, low earners, who feel themselves to be inappropriately paid, could simply reduce their efforts due to frustration about the perceived lack of fairness (Voitchovsky 2005; Cohn et al. 2014). Akerlof and Yellen's "fair wage-effort" hypothesis comes into play at this point: workers reduce their effort if their wage lies below what they consider appropriate.

Figure 2
Productivity as a channel of influence



Source: Authors' presentation.

According to theoretical studies, performance incentives linked to rising inequality could additionally affect human capital investments of low-income earners (Mirrlees 1971; Rebelo 1991). However, an empirical confirmation of this hypothesis is lacking. Indeed, empirical findings indicate a negative relationship between rising inequality and the level of human capital in the population.

In the long run this establishes a link between inequality and productivity: when inequality rises in a society low earners spend a larger proportion of their incomes on consumption in order to meet the needs of daily life. Their budget restrictions also prevent them from investing more in longer or better education and training; this can have a negative effect on economic growth (Barro 2000; Stiglitz 2012a; Fratzscher 2016).

If it is not possible to invest in human capital from their own resources, households at the lower end of the income pyramid could try to compensate it by taking out loans; under the assumption of perfect capital markets, a redistribution between low and high earners would thus not affect the development of human capital across the economy. This assumption is scarcely in tune with reality, however; instead low earners encounter credit restrictions due to their lower creditworthiness. This leads to higher interest costs that make it unattractive for potentially productive borrowers with low assets to invest in their own education or training by going into debt. This is also reflected in the fact that children from low income households have less access to good schools and a university education (Stiglitz 2012b). This results in an inefficient allocation of human capital and, over the long term, in lower productivity and lower growth. The empirical importance of this channel has often been confirmed (Galor/Zeira 1993; Becker 1993; Perotti 1996; Benabou 1996; Deininger/Squire 1998; Aghion et al. 1999; Barro 2000; Lloyd-Ellis 2003; OECD 2015).[6]

4 The Gini coefficient is based on the Lorenz curve and its values range between 0 and 1. A value of 0 indicates total income equality, in the sense that each household would receive the same income, while a value of 1 would indicate that a single household receives all income.

5 Here and in what follows the channels are presented on the example of increasing inequality, in other words, a change in distribution in favour of recipients of higher incomes. To be sure, however, the connections are also valid in the other direction, with reversed sign.

Thus, counteracting effects arise for the productivity channel that depend on the time horizon in question: in the short and medium run, rising inequality tends to give rise to productivity increases due to more performance incentives; in the long run, however, under-investment in human capital has a negative effect on productivity growth.

2.2 DEMAND SIDE: INEQUALITY AND THE SAVINGS RATE

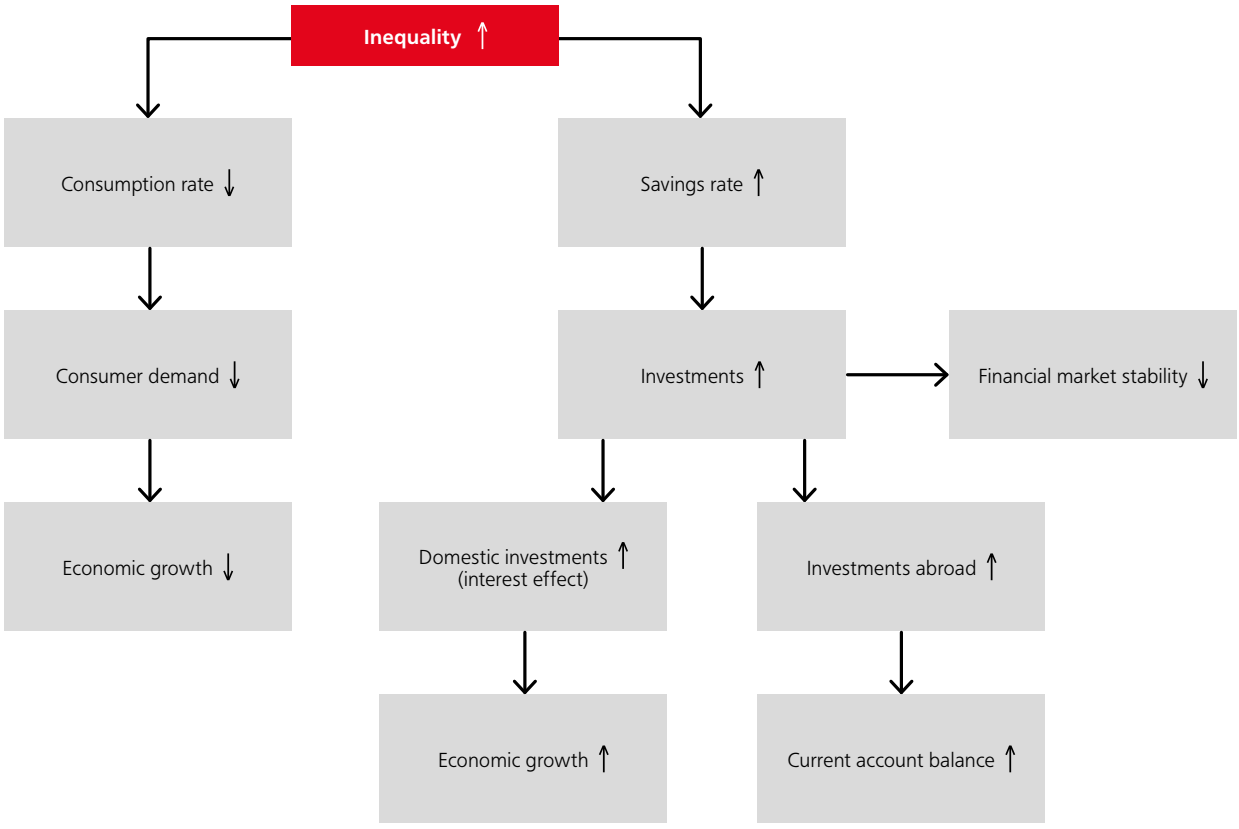
On the demand side, a change in the income distribution, in particular due to savings and consumption behaviour, can also affect economic growth (see Figure 3). The savings rate channel has the following effect in the short run (Halter et al. 2014): if inequality in a society increases, this is likely to result in a falling rate of consumption in the economy or a rising savings rate, because low earners have a comparatively strong propensity to consume and are made worse off (or more numerous) by changes in income distribution (Kaldor 1957; Dynan et al. 2004; Fichtner et al. 2012).

A falling consumption rate – that is, falling consumption demand relative to aggregate income – affects the domestic market, but also the economy's demand for imports. Domestically, weaker private consumption directly dampens economic growth (Li/Zou 2004). In order to compensate for their loss of purchasing power, lower income groups can try to continue to borrow to finance their consumption, as a result of which the aggregate savings rate would fall again. However, given the already mentioned borrowing constraints due to imperfect capital markets this is not likely to fully compensate for the rising savings rate associated with rising inequality and could also result in overindebtedness of private households (Behringer et al. 2014; Stiglitz 2012a; Fratzscher 2016).

Rising savings are likely, however, due to falling interest rates, to lead to an increase in domestic investment activity and in this way to result, in the short run, in rising demand, as well as in an accelerated increase in the capital stock – and thus lead to an expansion of production possibilities (Banerjee 2004). At the same time, however, effects on financial market stability are possible because the wealthy, who now have additional financial resources, seek profitable investment or speculative opportunities. This can contribute to falling lending standards if they fail to find sufficient safe and profitable investment possibilities and thus lead to financial market instabilities (Kumhof et al. 2013). If rising savings cannot be invested domestically in accordance with investors' desires they can move abroad, leading to rising current account surpluses.

6 The relationship between inequality and education, of course, also operates in the other direction (UNCTAD 2012) because a better education leads to a higher income level. This implies, across generations, that the income situation of the parents is a key determinant of their children's education and thus influences their future incomes and consumption possibilities (Dabla-Norris et al. 2015; Becker 1993; OECD 2015).

Figure 3
Savings rate as a channel of influence



Source: Authors' presentation.

3

A MACROECONOMIC STRUCTURAL MODEL FOR ANALYSING THE EFFECTS OF CHANGES IN INCOME DISTRIBUTION

In this section we describe a structural model that is suitable for depicting the channels of influence presented in Section 2 (see Annex B for the technical details). Such a model must, on the one hand, be comprehensive enough to reflect the most important macroeconomic mechanisms and, on the other hand, not be too complex, so that empirical estimates remain robust. In particular, income inequality is assumed to be exogenous and any endogenous feedback effects of overall economic development on personal income distribution will not be taken into account. The macroeconomic causes of inequality are thus deliberately left out of account. Furthermore, financial market linkages are modelled only selectively.[7] The model is based on the system of national accounts and is formulated and estimated on a quarterly basis.[8]

The long-run development of an economy is determined by its potential output. This depends on demographic tendencies, the development of the capital stock and productivity, and indicates what level of production in the economy would be achieved in the case of normal capacity utilisation of the production factors. The potential output in the model is defined as product of the trend total factor productivity (TFP), and of structural developments of the volume of labour and the capital stock. The production process which combines these factors of production is described by means of a Cobb-Douglas function.[9] Trend TFP is influenced – besides investments in other assets[10] – by the development of the population's human capital, which in turn depends on income distribution. The estimation of the model confirms the previous observations on the human capital channel (see Section 2.1), that human capital – and thus productivity – stands in a negative relationship with income inequality. The structural volume of labour is given by the demographically determined potential labour force – taking into account structural unemployment and the participation rate – and trend working time. The capital stock is determined by gross investment and depreciation.

The actual level of production in the economy depends, by contrast, on the fluctuating capacity utilisation of factors of production over the business cycle. This leads to deviations from the trend in productivity and in the volume of labour and thus to deviations of supply-side GDP from the economy's potential output. Thus, among other things, the model takes into account that productivity is also directly – not only in the trend – influenced by inequality. The estimated model confirms the earlier observations with regard to the incentive channel (see Section 2.1), that in the short run productivity can increase with inequality. A rise in inequality leads directly to rising productivity and hence to real GDP exceeding potential output. If companies observe such enhanced productivity over a longer period they will first increase working time, and later also employment in order to benefit in this way from higher productivity.[11] However, both higher productivity as well as rising working time and falling unemployment give rise, over time, to substantial wage and overall price increases.[12] This reduces demand and leads companies to adjust productivity, working time, and employment to counteract it, so that the economy gradually converges towards its potential path.

On the demand side, price-adjusted GDP is the sum of net exports, private and public consumption, and investment. Exports follow the development of international markets, meaning that they react to foreign demand, and price com-

7 Not modelling financial market aspects means that, in particular the effects of inequality on financial market instability (Kumhof et al. 2013) have to be left out of account.

8 The estimation is based on data from the first quarter of 1991 to the fourth quarter of 2015. Data sources are listed in Annex A.

9 The Cobb-Douglas production function describes a production technology where the input factors are interchangeable to a limited extent, but production cannot take place completely without either of the two factors.

10 Investments in other assets within the meaning of the national accounts include in particular investments in intellectual property, such as research and development expenditures.

11 Employment is also influenced by the proportion of transfers in disposable income of private households in order to take into account the fact that rising transfers can make job search less attractive.

12 Development in prices is described by a Phillips curve, according to which overutilisation of production capacity or low inventories lead to price rises.

petitiveness. Import growth is determined by domestic demand – that is, private consumption and investments – and by exports. Furthermore, the relative price of import goods plays a role; a relative rise in import prices has a negative effect on import demand because domestic households and companies substitute foreign goods with domestically produced goods.

After taking into account the savings rate, private consumption is positively related to private households' disposable income (wages and salaries, self-employment and investment income, as well as transfer income). The savings rate is thus determined, among other things, by the income distribution; the positive coefficient of inequality in the estimated equation for the savings rate thus reflects the savings rate channel described in Section 2.2, according to which an increase in inequality raises aggregate savings and, inversely, lowers private consumption in the short run. Because companies cannot adapt their production plans so rapidly, this lower demand initially leads to an increase in inventories; only over time can companies react, on the one hand, with price cuts, and, on the other hand, by reducing production in order to bring supply and demand back into balance.

Investments are accounted for in the model through their components, i.e. investment in machinery and various forms of construction, as well as investment in intellectual property. Besides aggregate demand, to which investments are positively related, the relationship to the long-term real interest rate – that is, the inflation-adjusted long-term nominal interest rate – is taken into account. Since interest rate payments represent a major part of financing costs, their increase leads to companies investing less. Long-term interest rates, in turn, are influenced, on the one hand, by short-term interest rates, and, on the other hand, by savings. If savings increase in relation to financing needs for investment projects then interest rates fall. The short-term interest rates are determined by monetary policy conditions and follow the interest rate rule proposed by Taylor (1993). The other policy conditions are assumed to be exogenous in the underlying model. This applies in particular to public consumption spending, as well as to public investment.

4

SIMULATION RESULTS

In what follows, the macroeconomic model is used to simulate the effects of a changing income distribution. First, a stylised increase in income inequality of two Gini points over a period of ten years is evaluated. Then the model is used to analyse counterfactually what macroeconomic dynamics in Germany would have occurred if income inequality had remained unchanged since 1991. Both analyses provide important findings concerning the channels through which changing income inequality affects the short- and long-run development of an economy. In contrast to previous analyses of the macroeconomic effects of changes in income distribution the model used here allows a detailed and quantitative analysis of the mechanisms involved and a consistent presentation with regard to the macroeconomic variables concerned.

In this context it is to be noted, as an initial restriction, that the model is primarily based on linear equations. This methodological simplification harbours the danger that the model does not always adequately reflect more complex relationships observed in reality. Empirically, Kuznets (1955) already found empirically that the influence of economic growth on income distribution follows a hump-shaped curve. Conversely, for example, Benhabib (2003) or Banerjee and Duflo (2003) show that the influence of the income distribution on economic growth is not linear, but can be described by a hump-shaped curve. However, these findings were obtained in cross-sectional studies including a multitude of heterogeneous economies, where a considerably larger bandwidth of income distributions flows into the calculations than in the model presented here, which is based exclusively on German data.

It should be noted, however, that there is considerable quantitative uncertainty with regard to the relationships depicted in the model; this is because there is statistical uncertainty concerning income distribution in Germany and the Gini index used for calculating the model.[13] Furthermore, different measures of distribution can produce deviating results. In order to test the robustness of the findings, alternative indicators of income distribution are also used (see Section 4.2). Even in the case of perfect information concerning income distribution the results would be fragile, at least in quantitative terms. In certain respects, the equations that characterise the model explain historic economic developments only rather imprecisely; the simulation results are also influenced by the form of the equations in the model, which sometimes cannot be derived unambiguously from theory. Against this background the quantitative results presented here are to be interpreted cautiously.

4.1 EFFECTS OF CHANGES OF INCOME DISTRIBUTION AS MEASURED BY THE GINI COEFFICIENT

4.1.1 IMPULSE-RESPONSE FUNCTIONS

Income inequality is not constant, but subject to considerable fluctuations (see also Figure 1). Furthermore, the three channels that we have identified operate in different directions, so arriving at a clear explanation of the effects of changing income inequality is a very complex matter. Thus, the relationships between income distribution and macroeconomic development are first presented on the basis of a stylised baseline scenario. In this scenario the German economy grows over the long term at a rate of 1½ per cent. The consumer price inflation rate lies at just under two per cent and income distribution remains constant with a Gini coefficient of 28.7 points.

In deviation to this baseline scenario, an exogenous increase in income inequality ("inequality shock") is assumed, with the Gini coefficient gradually rising by two points over ten years to a value of 30.7 (see Figure 5). The effects of this increase are presented in the form of impulse-response functions. The time paths, thus, show the deviation of macroeconomic development from the trajectory that it would have followed in the case of constant income distribution.

Effects of Inequality on Real GDP

The overall effect on real GDP of the increase in inequality by two Gini points is negative (see Figure 4). Twenty-five years

13 See also Voitchovsky (2005), Heinemann (2008).

after the shock it is around 50 billion euros lower than in the baseline scenario. The cumulative growth rate over this period thus lies around 1.5 percentage points lower than in the case of unchanged income inequality.[14]

Concerning the economic policy implications, however, the effects on GDP growth are not the only important factor. Rather we need to understand the processes that influence this outcome. With the help of the macroeconomic model the analysis is thus extended in two respects. First, the impulse-response functions of GDP are presented separately according to the individual channels of influence. Second, the time path of the output and expenditure components can be invoked to explain GDP development, so that a macroeconomic cause-effect profile can be derived.

Figure 4 presents the individual contributions of the channels of influence in form of a column diagram. It reflects the contributions made by the savings, incentive, and human capital channels to the overall response of real GDP (dark grey line) to the shock.

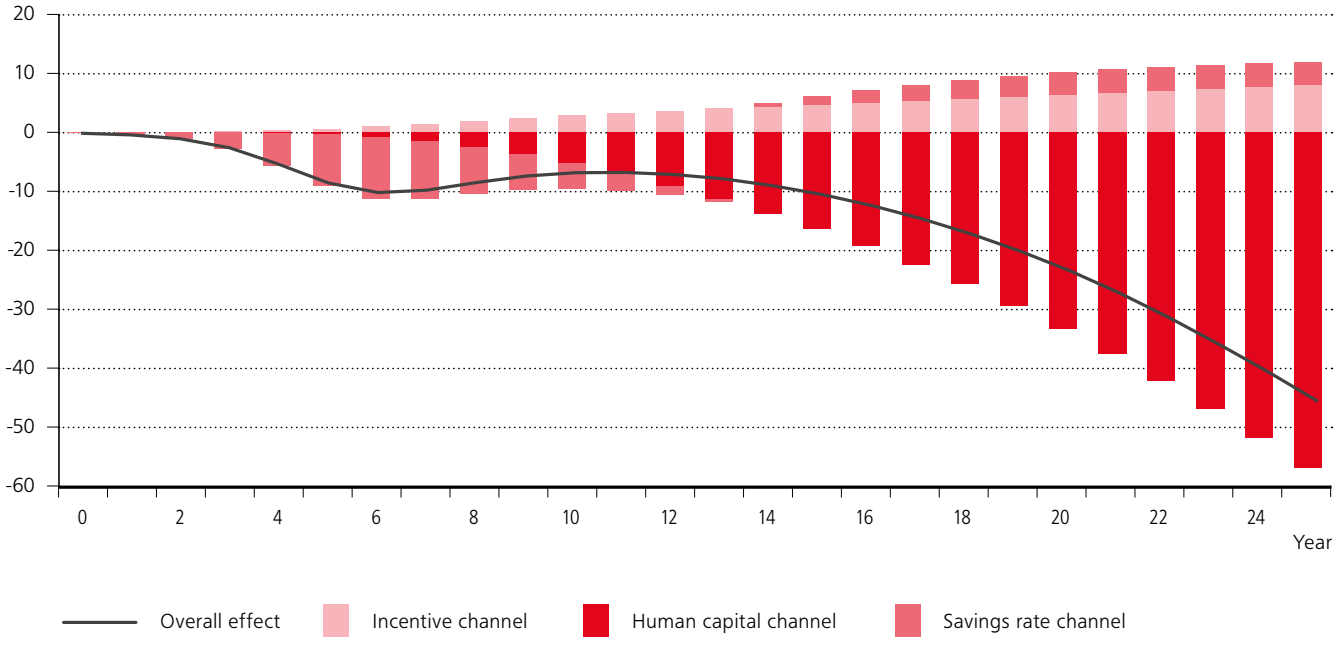
It is evident that the savings rate channel (medium red) leads first and foremost to an intertemporal shift in consumption. In the first years of the rise of income inequality, real GDP is influenced negatively through the savings rate channel. Its impact becomes smaller over time until, in the medium run, it changes sign and becomes positive, also reflecting the fact that the falling interest rates due to enhanced savings formation favour investment activity. At the end of the simulation period the contribution of the savings rate channel is small. Whether the savings rate channel exert positive or negative overall effects on the growth rate of real GDP as a result of rising inequality is thus a question of temporal perspective.

Although the incentive channel (light red) is uniformly positive after a rise in income inequality, its effects are comparatively modest. First of all, the incentive channel improves the economy's competitiveness as a result of rising productivity because wages do not rise to a comparable degree and companies thus have scope for price cuts. This boosts exports in particular, but also investment.

The human capital channel (dark red) makes a distinctly negative contribution to the development of real GDP in the simulation period. The reason for this is that higher income inequality reduces investment in education and training. It takes, however, at least a decade before the productivity-diminishing effects of the resulting reduction in accumulation of human capital are felt. Companies lose international competitiveness – because wages do not fall to the same degree as productivity – and invest less, so that, all in all, exports and GDP fall substantially.

14 The effects of a rise in income inequality on real GDP specified here are lower than in other studies (Ostry et al. 2014; OECD 2015). Taking as a basis the 1 percentage point fall in the income Gini assumed by the OECD (2015) then our model identifies cumulative effects on real GDP growth over a twenty-five-year period of just over 1 percentage point and thus lies below the 3 percentage points estimated by the OECD for a country cross-section. This appears to reflect the lower effect of income inequality on economic growth in high income countries also addressed by the German Council of Economic Experts (SVR 2015: Box 17), because the results presented here are based solely on the estimate of the situation in the German economy.

Figure 4
Impulse responses of real GDP (billion euros) as a result of an increase in income inequality of two Gini points



Source: Authors' presentation.

Effects of Inequality on Other Macroeconomic Variables

In the analysis of the impulse-response functions for individual components of the demand and supply sides (see Figure 5) it turns out that the different channels of influence affect the relevant components very differently. The trajectory of consumption and, to a lesser extent, also that of imports is decisively explained by the savings rate channel. Exports and investments in turn are determined more strongly by changes in productivity and, as a consequence, by the human capital or incentive channels.

Private consumption: The reason for the strong contribution of the savings rate channel to real private consumption is that the real disposable income relevant for consumption is barely affected by rising inequality initially, whereas the savings rate rises substantially. This leads directly to falling consumption. The resulting fall in aggregate demand also depresses investment and is accompanied by a negative output gap. As a result, companies adjust their prices. This price reduction counteracts falling consumer demand and stabilises it, although at a lower level. In the long run, the fall in private consumption is exacerbated by the depletion of human capital, falling productivity and again rising consumer prices.

Gross fixed capital formation: Real gross fixed capital formation initially falls as a consequence of the consumption-driven fall in demand. However, because of capacity underutilisation the central bank lowers the short-term interest rate substantially; additionally, savings increase. Both lead to the real interest rate falling – despite the decline in prices – and in the following years this stimulates investment demand, so that the long-term effect on investment activity arising from the savings rate channel is slightly positive. However, the human capital channel substantially lowers investment demand with a delay of around ten years. This is connected to the fact that the lower human capital accumulation caused by higher income inequality reduces productivity and makes investment less profitable. By contrast, the incentive channel exerts a positive stimulus on investment, since it in itself raises productivity, but cannot compensate for the negative effects.

Exports: In the case of real exports, the savings rate and incentive channels have a positive effect. This is due to the development of relative export and import prices (terms of trade): price cuts as a consequence of a negative output gap lead to rising price competitiveness. Domestically produced goods become more affordable to foreign consumers, so demand tends to rise. However, in due course exports, too, are affected by the loss of productivity resulting from declining human capital because wages fall to a lesser extent than productivity over the long term and thus international competitiveness declines.

Imports: Imports also decline as a consequence of weak domestic consumption and investment demand, as well as weaker exports. Due to the fall in domestic prices initially caused by the savings rate channel, domestic firms (assuming unchanged import prices) have to purchase inputs and raw materials at comparatively higher prices on world markets. The savings rate channel thus has a negative effect on imports. Although the productivity-boosting effects of the incentive channel lead to rising imports in the wake of higher investments, they are substantially overcompensated by the productivity-suppressing human capital channel. All in all, imports fall as a result of rising income inequality.

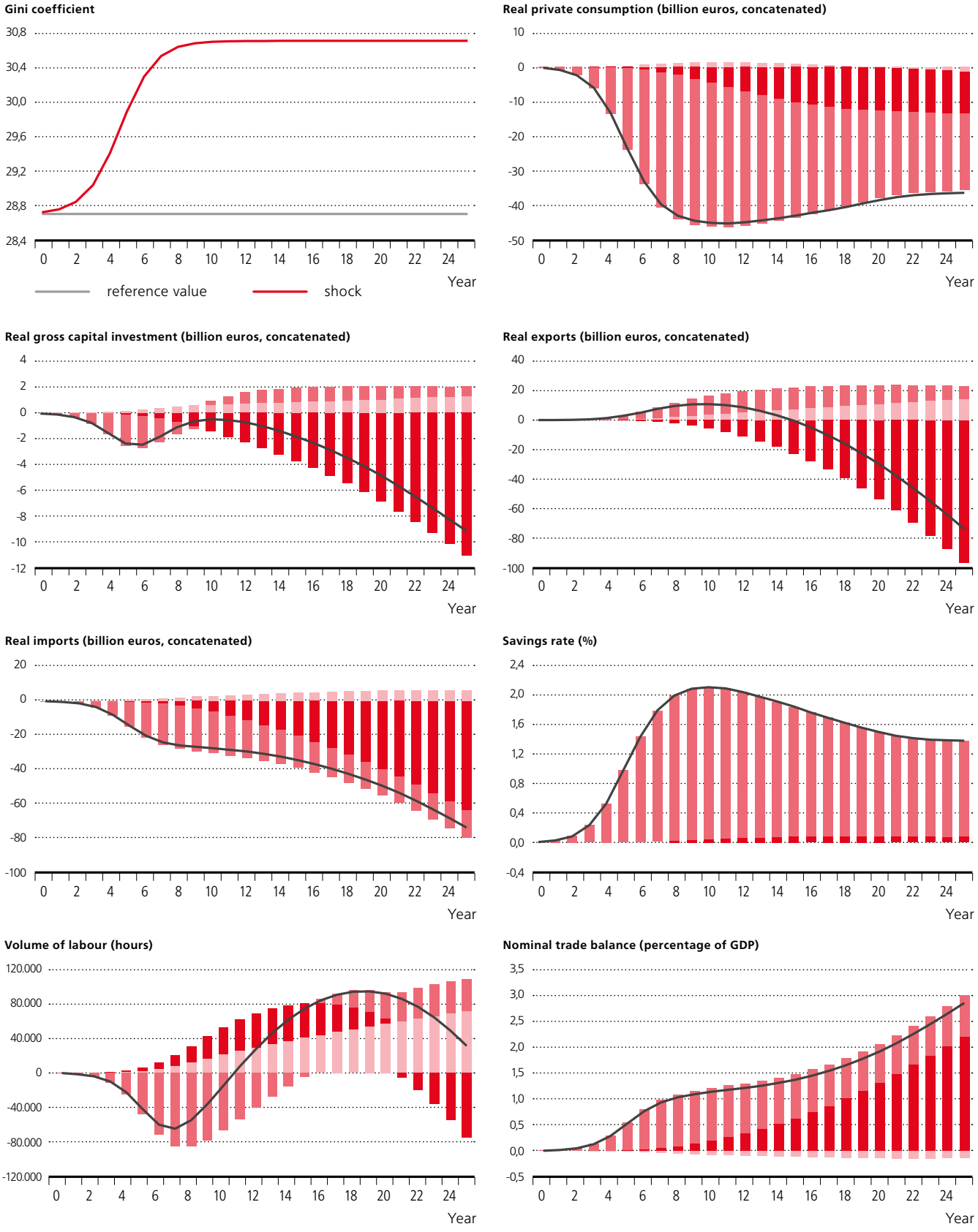
Trade balance: The developments of imports and exports and of the corresponding price deflators are transmitted to the nominal trade balance, which is presented here as a share of nominal GDP. The savings rate channel affects exports and imports asymmetrically because of relative price changes and increases the trade balance. The incentive and human capital channels affect both components in the same direction. While the positive effects of the incentive channel on the two components of the trade balance almost balance out, the negative effect of the human capital channel on nominal imports is substantially higher than in the case of nominal exports, because the quantitative decrease is partly offset by price rises. Because of weak productivity developments unit labour costs rise substantially and this is passed on by firms to customers both at home and abroad.

Production side: Initially, the human capital channel has a positive effect on the labour volume: because firms try to compensate for the falling qualifications of employees by expanding employment and extending working time, the volume of labour rises temporarily. In the long run labour volume falls because wages do not entirely follow productivity. The savings rate channel affects the volume of labour through an initially falling and later rising aggregate demand. The incentive channel has a persistently positive effect. It leads firms to extend working time substantially in order to benefit from the higher productivity.

Intertemporal welfare prospects: Overall, there appears to be a negative relationship between income inequality and aggregate production. The negative relationship is underlined when one observes that the relative level of real GDP at the end of the simulation period is not the only relevant factor, but that a lower GDP in intermediate years adversely affects prosperity, even if the gap between the simulation and the reference scenario has closed by the end of the simulation period. Following this logic, the results presented here indicate that the intertemporal welfare effect of a rising income inequality is markedly negative.[15]

15 This applies even more strongly if, as is usual in economic models, one takes consumption as the key welfare benchmark.

Figure 5
Impulse responses of selected expenditure and output components as a result of an increase in income inequality (Gini coefficient)



Source: Author's presentation.

4.1.2 HISTORICAL DECOMPOSITION

In what follows the model enables us to analyse, within the framework of a historical decomposition, what aggregate developments might have been expected in Germany if the income distribution measured in terms of the Gini coefficient of net household income had remained at its 1991 level; in 1991 the income Gini stood at 24.8 points and thus almost 4 points below its value in 2015 (see Figure 1).

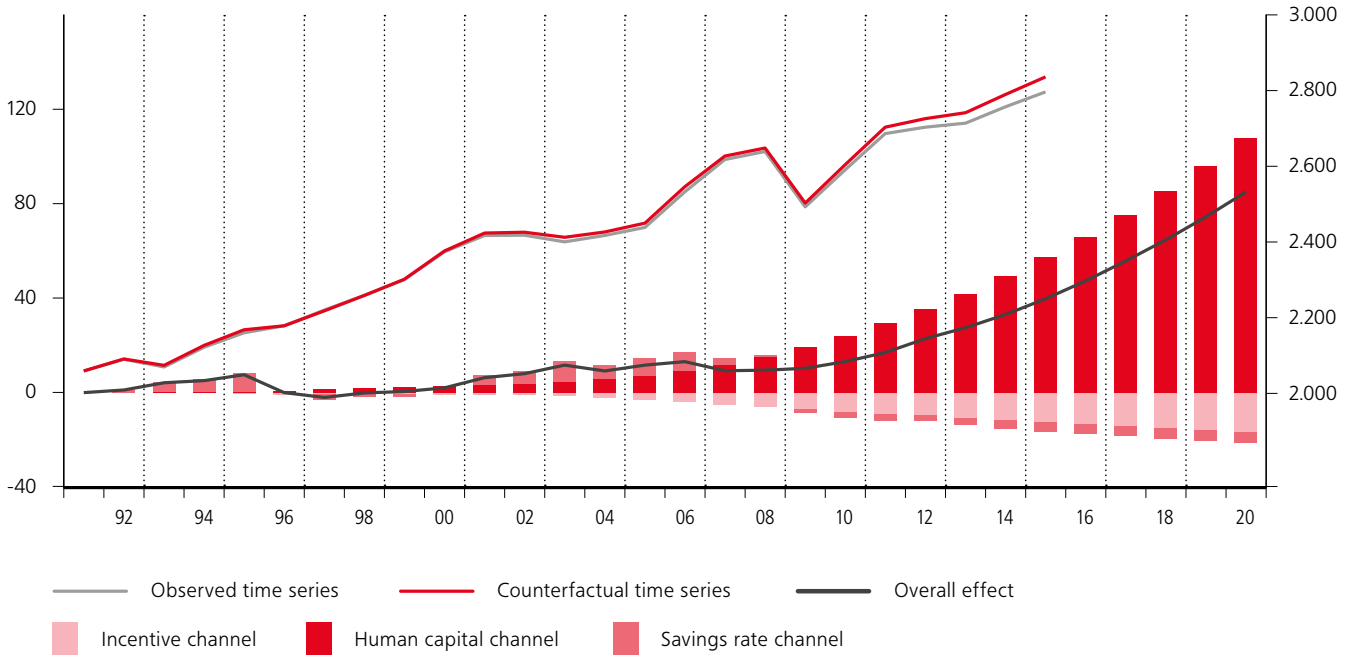
It appears that real GDP in Germany in the observed period would have risen much more strongly than was in reality the case if the income distribution had remained constant (see Figure 6).[16] Overall GDP in 2015 would have been 40 billion euros higher if the Gini coefficient had remained constant since 1991. This corresponds cumulatively to an approximately two per cent higher growth rate over the period as a whole.

However, actual GDP up to 2010 deviates only marginally from its counterfactual value. This is due to the fact that the Gini index rose primarily from the year 2000 onwards. Because the human capital channel, which is particularly relevant for the quantitative growth of GDP, exerts its effects with a delay of around a decade, a much lower aggregate production (than in the estimate for a scenario with a rise in inequality) would have been observable only for the current decade. Despite the fact that the Gini coefficient remained stable for a number of years, this means that in the current and coming years the effects related to the rise in income inequality continue and the production level falls.

A look at the components of the demand and supply side (Figure 7), however, shows that rising inequality in Germany has probably influenced macroeconomic developments from an earlier period on. The savings rate would have remained significantly – by more than two percentage points – lower than its actual value after the turn of the millennium; consequently, average annual private consumption would have been higher by around 50 billion euros from the year 2000 on if the Gini coefficient had remained at its 1991 value. This higher level of consumption in the counterfactual scenario is not reflected in GDP for long, however, because imports would also have been much higher from the year 2000 onwards than was observed in reality. Exports, by contrast, deviate substantially from their actual course only from 2010 onwards. They are largely affected by the delayed effects of the human capital channel; in the case of lower inequality more would have been invested in education or training and thus productivity would have been higher. This would have had a positive influence on competitiveness. For the trade balance, however, there would have been a dampening effect because nominal imports are increased more than exports by lower inequality. In other words, the results of the model suggest that, because of the increased inequality the German balance of trade was up to three percentage points higher from the year 2000 onwards than would otherwise have been expected.

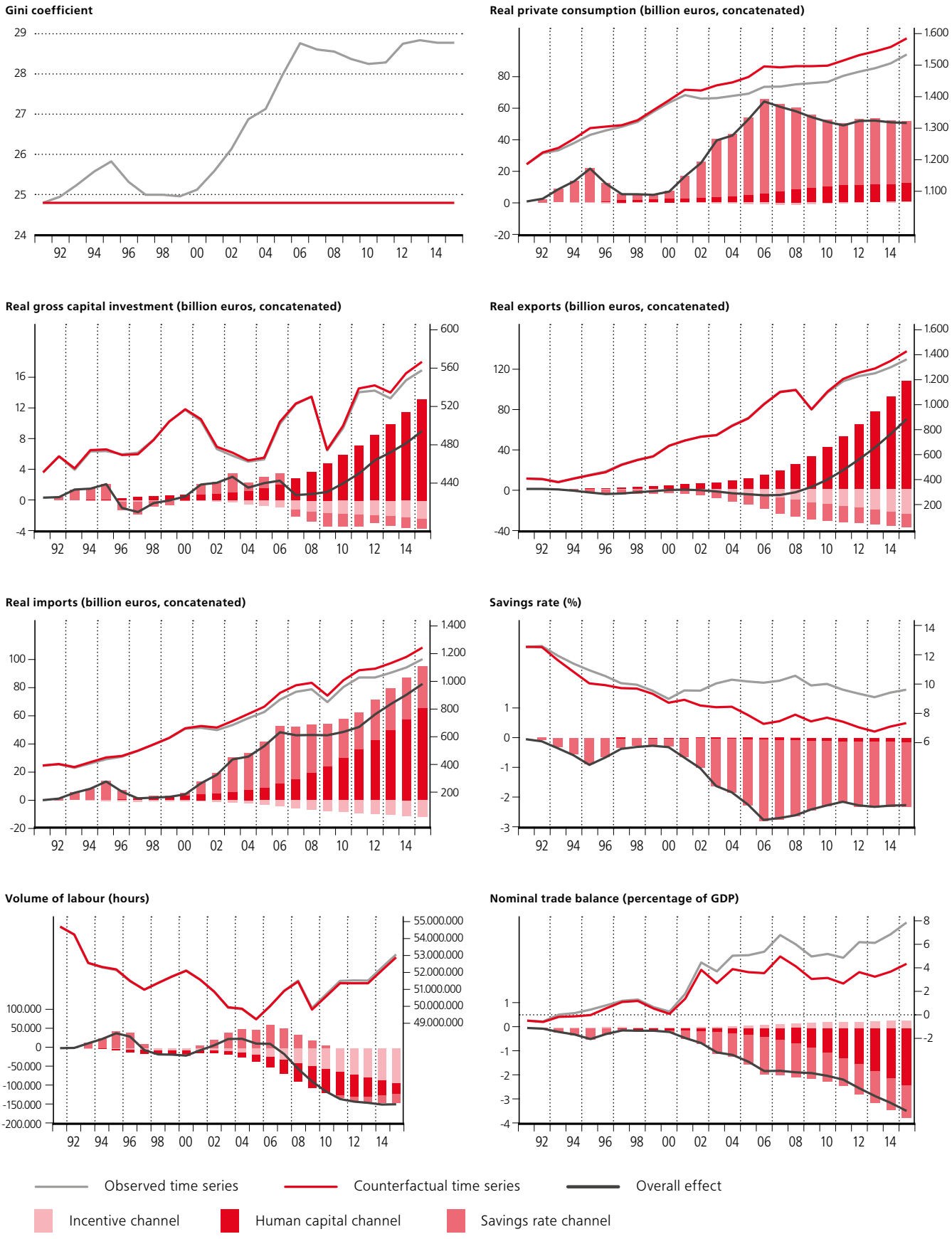
16 In the upper part of the figure the actual time series for GDP (grey), as well as its simulated – counterfactual – development (red) is presented (right-hand scale). The difference between the two time series is given by the interaction of the different channels, via which the changing income distribution affects GDP. It is presented, magnified, in the lower part of the figure in the form of the dark green line, together with the respective contribution of the three channels (left-hand scale).

Figure 6
Real GDP (billion euros) – counterfactual simulation and contribution of the individual channels



Source: Authors' presentation.

Figure 7
Output and expenditure components of GDP – counterfactual simulation



Source: Authors' presentation.

4.2 ALTERNATIVE MEASURES OF CHANGES IN INCOME DISTRIBUTION

In all simulations hitherto the Gini coefficient of net household income was used as indicator of income inequality. For the purpose of a sensitivity analysis, in what follows the model is calculated and simulated on the basis of alternative measures of income distribution. As such we use a Theil index of net household income and the income share of the highest-earning decile (top 10 per cent of earners) (see Figure 8).[17]

In Section 4.1.1 a gradual increase of two Gini points over a ten-year period was modelled. For the comparative simulations we simulate the effects of a change to the alternative distribution measures that correspond to the two-point Gini increase relative to the change in the respective series between 1991 and 2015. For the Theil index, this implies an increase of somewhat more than two points, for the top-earning decile an increase of just under one and a half points over the ten-year period.

The comparison shows that the response of real GDP to an increase in income inequality is qualitatively very similar for all measures (see Figure 9). The relative significance of the separate channels varies only slightly; for example, the savings rate channel has more significance in the calculations on the basis of the Gini coefficient than where alternative measures are used. This could reflect the fact that the Gini coefficient places more weight on the middle of the distribution, while in particular the top 10 per cent of incomes by definition weighs the tails of the distribution more highly.[18]

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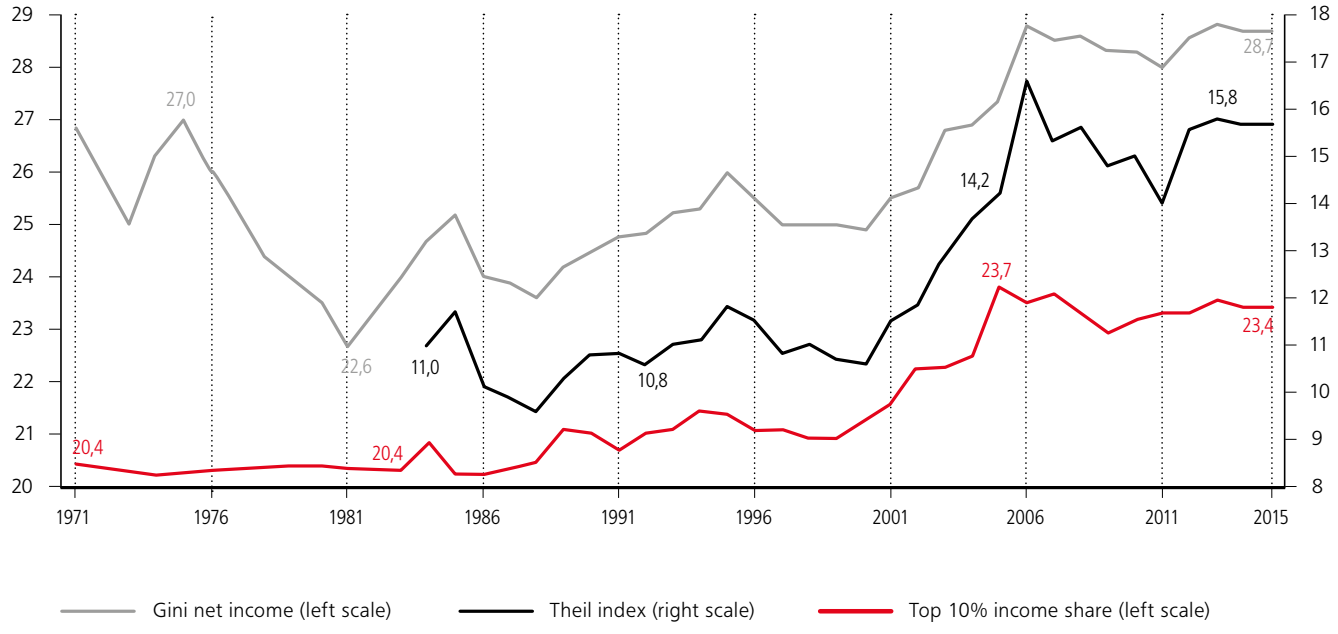
17 The Theil index – like the Gini index – takes a value of zero when all incomes are equally distributed, but in the case of increasing inequality it can also take values larger than one. The main difference from the Gini coefficient is that the Theil index can be disaggregated into individual subpopulations. For a presentation of various distribution measures see Heinemann (2008).

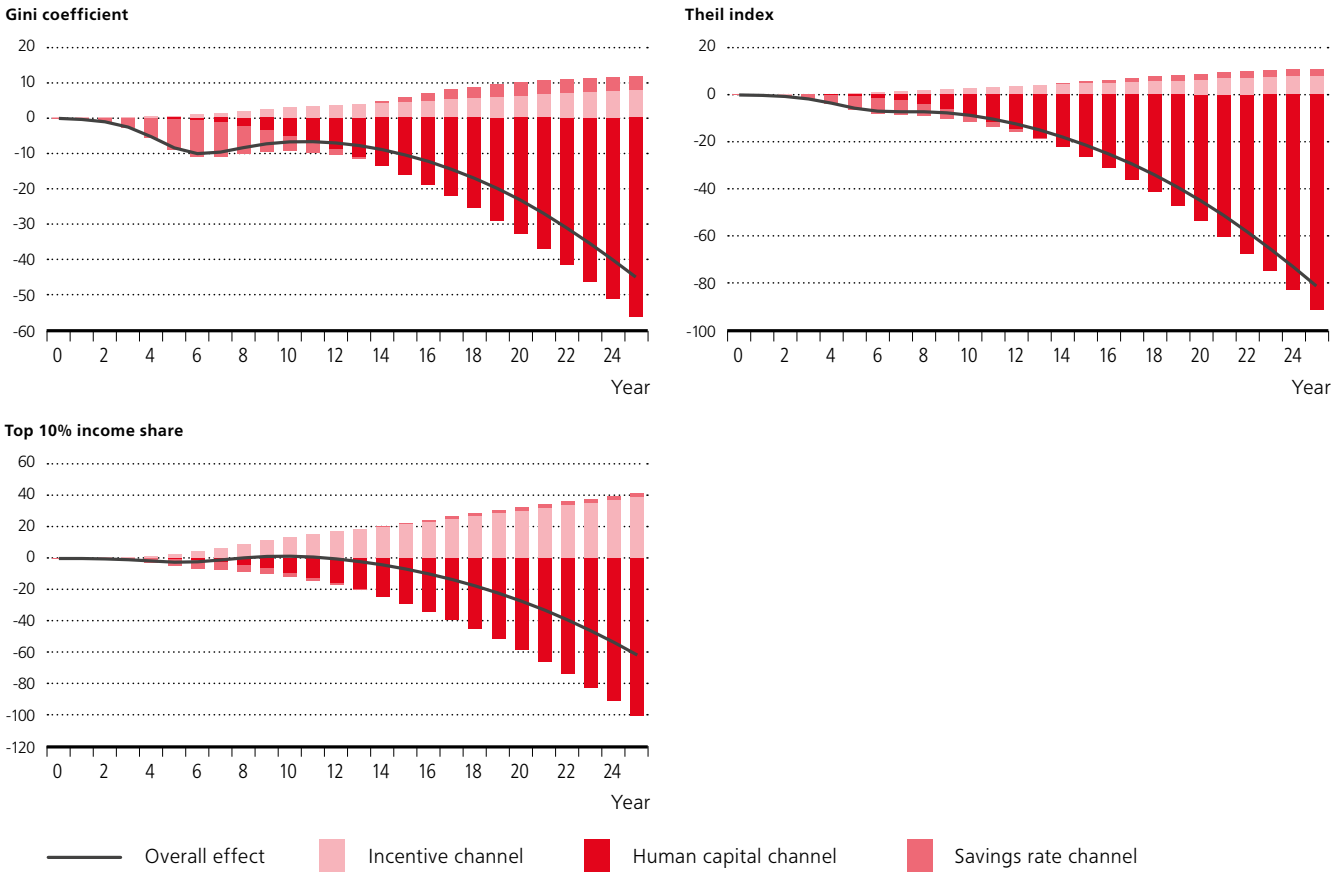
18 The quantitative results elude a comparative interpretation. An increase in the incomes of the top 10 per cent could, for example, also go hand in hand with a lower Gini coefficient if the distribution of incomes of the poorest population groups became less unequal at the same time.

Figure 8
Alternative measures of income distribution



Source: See Annex.

Figure 9
Impulse responses of real GDP (billion euros) as a result of an increase in alternative measures of inequality



Source: Authors' presentation.

5

SUMMARY AND IMPLICATIONS FOR ECONOMIC POLICY

The study presented here examines the effects of changes in income distribution on macroeconomic development. For this purpose a macroeconomic model is developed that is suitable for depicting the main channels discussed in the literature that link income distribution and economic growth in a quantitatively plausible and theoretically consistent framework.

Taking the literature discussed in Section 2 as a starting point, the model takes account, on the one hand, of the relationship between income distribution and productivity. In this context, a distinction has to be drawn between the short-run incentive channel and the long-run human capital channel. Following the incentive channel, rising income inequality in the economy can boost productivity because, due to the strengthened effects of personal effort on the relative individual income position, there is an incentive to work more productively. In the long run, following the human capital channel, higher societal inequality can have a negative effect on productivity because low earners are able to invest less in longer or better education or training because of lack of financial resources.

On the other hand, the model takes into account, by means of the savings rate channel, the relationship between income distribution and savings formation in the economy, which is derived from the fact that low earners can save a lower portion of their incomes and thus a redistribution in favour of high earners directly raises the savings rate and thus dampens consumer demand. In the medium term, however, this can exert a positive effect on the business cycle and on growth because interest rates in the economy are likely to fall as a result of the rising savings formation and thus create a favourable investment environment.

The empirical estimation of the model on the basis of German data from 1991 to 2015 confirms the channels derived from the literature. Specifically, the coefficients in the various equations, in which income distribution is deployed as explanatory variable, show the expected signs. On the basis of the estimated model the relative significance of the individual channels for the overall effect of changes in income distribution on macroeconomic developments can thus be assessed.

The effect of a gradual increase in income inequality by two Gini points over a period of ten years is simulated. It appears that in the short run in particular the savings rate channel has a dampening effect on GDP. With a delay of around ten years the incentive channel overcompensates for the declining effect of increased savings formation on private consumption. At the same time, the human capital channel increasingly gains in importance. In the long term it dominates the overall effect, so that after twenty-five years real GDP lies substantially – by around 50 billion euros – below its comparative value in a scenario without an increase in inequality. The growth rate cumulatively lies around one and a half percentage points or around half of one-tenth of a percentage point per year lower than in the case of unchanged income distribution. The results of the model thus confirm the findings of a large part of the literature that inequality has a dampening effect on the business cycle and economic growth; in comparison with other studies, which derive their results on the basis of international data (for example, Ostry et al. 2014; OECD 2015), the results here are somewhat weaker.

The model also shows that the increase in inequality has different effects on the various expenditure aggregates of GDP. In particular, private consumption is discernibly dampened; at its peak, it stands at around 45 billion euros or 2.5 per cent and at the end of the simulation period still 1.5 per cent below its respective comparative value. Here in particular the savings rate channel has a negative effect, which leads to higher savings formation and thus, under otherwise similar conditions, to lower consumer demand. In the case of investments and exports it is primarily the human capital channel that puts on the brakes, because the lower level of skills and qualifications in the economy dampens productivity; this makes investments less profitable and lowers competitiveness on export markets because wages do not keep pace with productivity on the way down.

All in all, at the end of the simulation period after 25 years real gross fixed capital formation is just under 10 billion euros or just under 1.5 per cent below its comparative value and exports around 70 billion euros or just under 2.5 per cent below. Imports fall by more than exports due to weak domestic demand. They stand around 75 billion euros or 2.5 per cent below their comparative value. As a consequence, the trade surplus increases; the effect is strengthened by rising export prices, which counteract the decrease in export volumes.

Counterfactual simulations of the model for the German economy show that the rise in inequality between 1991 and 2015 is likely to have substantially subdued economic development. If income inequality measured in terms of the Gini coefficient for net household income had remained at its 1991 level, German GDP would have been 40 billion euros higher in 2015 than was in fact the case. The model results thus suggest that annual average growth of the German economy since German reunification has been a good half a tenth of a percentage point lower than if income distribution had remained the same. The effects of the marked rise in inequality, especially over the past fifteen years, have become particularly discernible above all because the negative effect of the quantitatively important human capital channel on macroeconomic development emerges only with some delay. Despite the stability of income distribution in recent years it is likely, according to the simulation results, that in the coming years it will cause further reduced growth rates.

However, the results presented here need to be interpreted with some caution. Although the coefficients of inequality in the corresponding estimated equations are mostly significant, so that the effects of inequality on productivity and the savings rate are likely to be robust with regard to their direction, the model equations are elsewhere subject to considerable uncertainties, which also make the quantitative extent of the effects of changes in the income distribution on macroeconomic development uncertain. With regard to the choice of statistical measure for income distribution the results prove to be fairly robust in qualitative terms. In the study presented here, besides the results discussed in detail on the basis of the Gini coefficient, additional simulations based on the Theil index and on the income share of the highest income decile are documented. In all model specifications, the savings rate channel proves to be effective predominantly in the short term (negatively) and – in particular in the long term – the most pronounced (negative) effect is due to the human capital channel, so that, all in all, GDP is noticeably dampened by rising inequality, especially in the long term. In quantitative terms, however, the findings differ considerably depending on the underlying measure of inequality.

In evaluating the results it must also be taken into account that within the framework of the model the income distribution is modelled as a purely exogenous variable. The exogeneity assumption for the income distribution is likely to be econometrically appropriate in the equations estimated here; from a theoretical perspective, for example, a contemporary relationship between aggregate productivity and income distribution is not plausible, and reverse causality can even be ruled out for the delayed effect of income distribution on human capital. However, the fact that we did not model the feedback effects that the macroeconomic developments could have had on income distribution makes the interpretation of the results more difficult. For example, in the simulations presented here an increase in inequality gives rise to a shift in the functional income distribution from wage to profit income; thus the wage share falls. This is likely to tend to entail a change in personal income distribution to the detriment of low earners (not taken into account in the model) (see Figure 2). The original increase in inequality could thus result in a further shift in income to the benefit of high earners, which in turn would give rise to further macroeconomic adjustment processes. This could in itself lead to an underestimation of the effects of inequality on macroeconomic development on the basis of the model.

Despite the abovementioned limitations the results elaborated here permit us to draw some important economic policy conclusions. It should be noted, first of all, that changes in income distribution affect economic growth only after a pronounced delay. For example, growth in Germany – despite the recent fairly modest changes in income distribution measured in terms of the Gini coefficient of household income – is likely to be subdued both for the time being and in the coming years by the substantial rise in inequality that has occurred in recent years. The simulations indicate that the most significant quantitative mechanism by which inequality affects economic growth is the human capital channel, whose delayed effect is considerable. Against this background, policy measures capable of improving equality of opportunity and the permeability of the education system become all the more important.

The results presented here also show that the changes in income distribution observed in Germany are likely to have led to an increase in the external trade balance; in particular, imports are likely to have been dampened due to the lower domestic demand as a consequence of inequality. This finding is relevant not only against the background of the debate on imbalances in the Economic and Monetary Union (BMWi 2015), but also makes it clear that the focus of the discussion on the macroeconomic consequences of increasing income inequality is wrongly directed towards the negative consequences of inequality on GDP. After all, the latter are alleviated by a growing positive effect on the external balance of trade counteracting domestic economic weakening. When it comes to social prosperity and living standards in Germany private consumption should be taken as the benchmark. As a result of the increase in inequality this is likely to be substantially and persistently lower.

A

APPENDIX: DATA SOURCES

- The data from Germany's National Accounts (Volkswirtschaftliche Gesamtrechnungen) were extracted from the corresponding "Fachserien" of the Federal Statistical Office (Statistisches Bundesamt, shortly Destatis), as of 24 May 2016. All data included in the model are seasonally- and calendar-adjusted; accordingly, the annual values presented here are also calendar-adjusted and may deviate marginally from the data published in annual figures of the National Accounts statistics.
- For interest rates (short-term: three-month interest rates, from 1999 Euribor; long-term: yields on debt securities outstanding; residual maturity of more than 7 years) Bundesbank data were used.
- Oil prices (Brent) and nominal exchange rates were taken from Thomson Reuters Datastream.
- For data on demographic development the year-end figures of the National Accounts population statistics of the Destatis series 12411-0005 and 12421-0002 were used.
- The dependency ratios for young (below 17 years of age) and old (over 74 years of age) people in the population and figures on foreign demand (measured in terms of world imports) come from the OECD.
- The data on human capital were taken from the Barro-Lee dataset (http:// www.barrolee.com/). Human capital is measured in terms of the proportion of the working age population with at least secondary or higher education. The series were transformed to quarterly frequency by linear interpolation for use in the model.
- Education spending data were taken from the Statistical Yearbooks of the Federal Statistical Office. They include overall spending at the national, state, and municipal level on the following areas of activity: "schools, institutions of higher education, other education", "science, research, development outside the institutions of higher education" and "cultural affairs, church affairs". The series were transformed to quarterly frequency by linear interpolation for use in the model. Education spending was carried forward from 2011 to 2015 with the average quarterly growth rates of the years from 2001 to 2011.
- The following sources were used for measures of distribution:

Gini coefficient of household net income

- 1971 to 1983: The Standardized World Income Inequality Database (http://fsolt.org/swiid/);
- 1984 to 2013: Socio-economic Panel (SOEP Item I11102xx);
- 2014 and 2015: mean of the SOEP data for 2012 and 2013.

The series were chained back on the basis of annual rates of change and linearly interpolated to quarterly frequency for use in the model, with the first quarter of each year equated to the annual average recorded in the data.

Theil index

- 1984 to 2013: Socio-economic Panel (SOEP Item I11102xx);
- 2014 and 2015: mean value of the SOEP data for 2012 and 2013.

Suitable data are not available for the period before 1984. The series were linearly interpolated to quarterly frequency for use in the model, with the first quarter of each year equated to the annual average recorded in the data.

Share of income of the top 10 per cent

- 1971 to 1983: The World Wealth and Income Database, http://www.wid. world, missing years were estimated using linear interpolation;
- 1984 to 2013: Socio-economic Panel (SOEP Item postghekxx);
- 2014 and 2015: mean value of SOEP data for 2012 and 2013.

The series were chained back on the basis of annual rates of change and linearly interpolated to quarterly frequency for use in the model, with the first quarter of each year equated to the annual average recorded in the data.

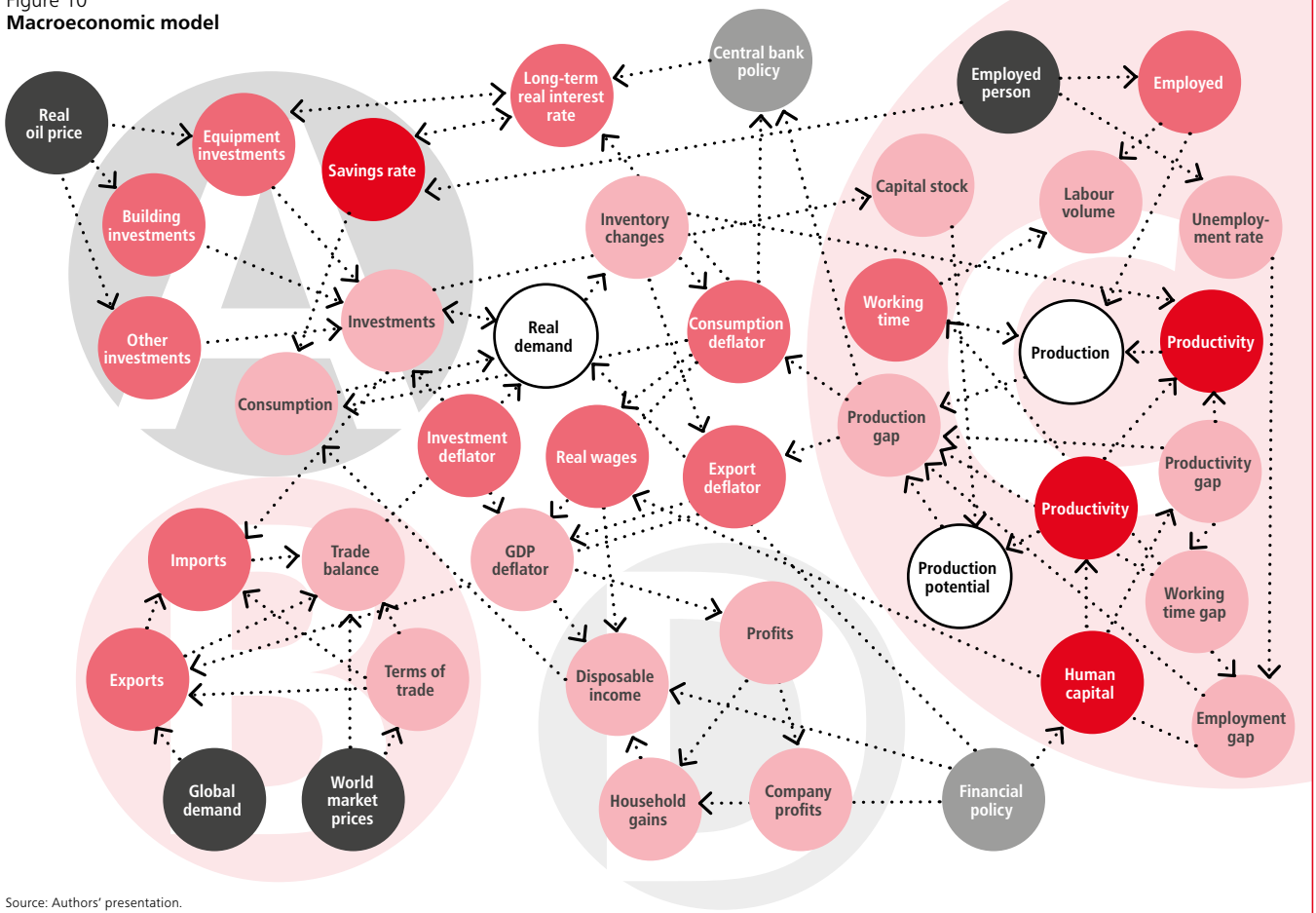
B

APPENDIX: THE MODEL

B.1 GRAPHIC PRESENTATION

Figure 10 presents an overview of the model used in this study. The main variables are real GDP on the expenditure and the production sides, as well as potential output. The identity equations describing these variables are represented in white ☐ in the model. All other values are either endogenous variables determined by behavioural equations ■ (middle red) or identities ■ (light red) or exogenous variables ■ (grey). There are also special variables, marked with different colours: variables set by monetary or fiscal policy are marked in light grey ■. Finally, the endogenous variables marked in red ■ are central to the explanation of the channels of influence of an increase in income inequality. The arrows ⋯→ indicate the direction of influence.

Figure 10
Macroeconomic model



Source: Authors' presentation.

B.2 FORMAL PRESENTATION

B.2.1 DEMAND SIDE

Real GDP from an demand-side perspective Y^D in period t corresponds to the sum of private and government consumption demand $C^P + C^G$, gross capital formation I and net exports $X - M$:[19]

(1) $$Y_t^D = C_t^P + C_t^G + I_t + X_t - M_t.$$

Real private consumption C^P – deflated with the consumption deflator P^{CP} – results from disposable income of private households DI (see Section B.2.3) minus savings, determined by the savings s:

(2) $$C_t^P = \frac{(1 - s_t) \cdot DI_t}{P_t^{CP}}.$$

The savings rate s is determined, among other things, by the income distribution (see Section B.3.2). Government consumption spending C^G is exogenously given.

Gross capital formation I arises by definition as the sum of change in inventories INV as well as gross fixed capital formation I^{GF}, for whose components separate equations were estimated using error correction specifications. For example, investment in machinery is described by:[20]

(3) $$\begin{aligned}\Delta I_t^{EQUIP} = & \underset{(-2.77)}{-0.0079} + \underset{(0.27)}{0.026} \cdot \Delta I_{t-1}^{EQUIP} + \underset{(7.97)}{2.63} \cdot \Delta Y_t + \underset{(2.09)}{0.98} \cdot \Delta Y_{t-1} - \underset{(-0.92)}{0.0042} \cdot \Delta r_t^{LONG} \\ & - \underset{(-1.87)}{0.071} \left[\ln(I_t^{EQUIP}) - \left(\underset{(-7.64)}{-7.39} + \underset{(11.35)}{1.72} \cdot \ln(Y_{t-1}) \right) \right]\end{aligned}$$

Taken into account as explanatory variables are, in particular, GDP Y – with a positive influence on investments – as well as the long-term real interest rate r^{LONG} (see Section B.2.5), with a negative impact. Similar equations were estimated for investment in construction I^{CONSTR} and other investment I^{OTHER}. The change in inventories results as a residual value between supply- and demand-side GDP.

The development of real exports X is described within the framework of an error correction equation as a function of foreign demand FD as well as changes in the terms of trade ToT – defined as the relation between the export price deflator P^X and the import price deflator P^M:

(4) $$\begin{aligned}\Delta X_t = & \underset{(-0.51)}{-0.0012} + \underset{(8.68)}{0.98} \cdot \Delta FD_t - \underset{(-1.37)}{0.34} \cdot \Delta ToT_t \\ & - \underset{(-5.03)}{0.25} \cdot \left[\ln(X)_{t-1} - \left(\underset{(-22.78)}{-2.26} + \underset{(75.70)}{0.94} \cdot \ln(FD)_{t-1} - \underset{(-6.46)}{1.59} \cdot \ln(ToT)_{t-1} \right) \right].\end{aligned}$$

If foreign demand thus rises, this implies rising exports. The same applies to a relative fall in export prices.

Real import growth is positively affected by the expansion of the expenditure components – private consumption C^P, gross fixed capital formation I^{GF} and exports X – and negatively by the change in the terms of trade ToT. An increase in the terms of trade – in other words, falling import prices in relation to export prices – thus gives rise to increasing imports. As in the case of exports the long-term relationship is taken into account in an error correction term:

(5) $$\begin{aligned}\Delta M_t = & \underset{(1.16)}{0.0023} + \underset{(2.43)}{0.52} \cdot \Delta C_t^P + \underset{(3.18)}{0.27} \cdot \Delta I_t^{GF} + \underset{(6.58)}{0.49} \cdot \Delta X_t + \underset{(1.52)}{0.12} \cdot \Delta ToT_t + \underset{(0.77)}{0.06} \cdot \Delta M_{t-1} \\ & - \underset{(-4.54)}{0.38} \cdot \left[\ln(M_{t-1}) - \left(\underset{(-4.83)}{-4.26} + \underset{(4.57)}{0.79} \cdot \ln(C_{t-1}^P) + \underset{(3.25)}{0.24} \cdot \ln(I_{t-1}^{GF}) + \underset{(24.32)}{0.69} \cdot \ln(X_{t-1}) \right) \right].\end{aligned}$$

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19 The model used here for the purpose of simplification thus only approximates the German national accounts; because real GDP is worked out for German statistical purposes on the basis of annual prices (previous year's prices) the subaggregates do not add up exactly to the total aggregate – here, for example, GDP. Cf. Nierhaus (2005: 22f) for a detailed discussion.

20 T-values are given in the parentheses below the coefficients.

B.2.2 SUPPLY SIDE

On the supply side, a production function of the Cobb-Douglas type is assumed. From a supply-side perspective GDP Y^S is thus determined by the interaction of total factor productivity *TFP*, is thus determined by the interaction of total factor productivity *K*, and the volume of labour *L*. In line with the literature, the elasticities of the production factors capital and labour are set to 0.35 and 0.65, respectively:

(6) $$Y_t^S = TFP_t \cdot K_t^{0.35} \cdot L_t^{0.65}.$$

Total factor productivity is thus determined by, among other things, income distribution (see Section B.3.1). The capital stock corresponds to the capital stock of the previous period adjusted for depreciation, plus gross fixed capital formation in the current period. The labour volume is the product of per capita working time *H* and the number of employees *EMP*.

Per capita working time is divided into trend and cyclical components. The trend component is exogenous to the model, and for the relative deviation of per capita working time from its trend H^{GAP} the equation is:

(7) $$H_t^{GAP} = \underset{(-0.60)}{-0.0026} + \underset{(2.1)}{0.21} \cdot (H_{t-1}^{GAP}) + \underset{(1.94)}{0.20} \cdot \text{avg}(TFP_{t-1,t-5}^{GAP})$$

The development of actual working time as a combination of the trend and cyclical component is thus positively influenced by the average *avg* of the productivity gap TFP^{GAP} – that is, the relative deviation of productivity from its trend – in the past five quarters. For example, firms increase working time if actual productivity rises above its trend value over a longer time period. In due course the number of employees will also rise, which is modelled in form of an error correction equation as follows:

(8) $$\begin{aligned}\Delta EMP_t = {} & \underset{(3.60)}{0.0011} + \underset{(1.07)}{0.07} \cdot \text{avg}(H_{t,t-4}^{GAP}) \\ & - \underset{(-2.34)}{0.07} \cdot \frac{TR_t}{DI_t} - \underset{(-2.48)}{0.07} \cdot \left[\ln(EMP_{t-1}) - \left(\underset{(35.94)}{8.22} + \underset{(9.92)}{0.35} \cdot \ln(Y_{t-1}^S)\right)\right]\end{aligned}$$

The positive dependence of the number of employees on the deviation of per capita working time from trend working time (H^{GAP}) takes into account a demand-side effect on the labour market: firms initially react to cyclical fluctuations in capacity utilisation by adjusting per capita working time. If working time deviates from its trend over a longer period, then the number of employees is adjusted. The negative dependence of the share of transfers *TR* in the disposable income of private households *DI* takes into consideration the reservation wage in wage negotiations, as well as the opportunity costs of the labour supply of households.[21] Thus an increase in net social benefits leads to a higher reservation wage and thus indirectly to a fall in the labour supply. The long-term negative relationship between employment and production Y^S is taken into account in an error correction term. It is assumed that the number of dependent employees EMP^{SAL} and the number of self-employed persons EMP^{SELF} follows the same dynamic.

Potential output corresponds to

(9) $$Y_t^{POT} = TFP_t^{TREND} \cdot K_t^{0.35} \cdot (L_t^{TREND})^{0.65}.$$

Trend productivity TFP^{TREND} is determined by, among other things, the income distribution (see Section B.3.1); the trend labour volume L^{TREND} is determined by exogenous assumptions in relation to trend working time, structural unemployment, the participation rate and the development of the economically active population. The capital stock is a variable endogenous to the model and determined by gross investment and depreciation.

B.2.3 INCOME SIDE

Looked at from its income side, GDP in nominal terms is the sum of depreciation and primary income, taking into account the balance of primary income with other countries. The primary income of the economy is composed of employee compensation and corporate and investment income minus subsidies on production and imports, which are set exogenously in the model. Employee compensation includes employer social contributions, which are also exogenously given, and gross wages and salaries. The latter are the product of the number of dependent employees EMP^{SAL} and per capita wage *w*, the level of which in real terms is given by the following equation:

---

21 The reservation wage corresponds to the wage rate at which workers are still just willing to supply their labour. If the wage offered by the firm lies below the reservation wage, workers will not supply their labour. Opportunity costs characterise losses of utility or income arising due to refraining from engaging in an economic activity. The opportunity costs of work not engaged in are determined by the difference between the wage and the expected wage replacement benefit.

(10) $$\ln\left(\frac{w_t}{P_t^{CP}}\right) = \underset{(-11.88)}{-3.26} + \underset{(6.16)}{0.22} \cdot \ln(TFP_t) - \underset{(1.91)}{0.06} \cdot \text{avg}(U_{t-1,t-5}^{GAP})$$

Decisive influencing factors with regard to the real per capita wage are total factor productivity *TFP* and deviations of the unemployment rate from its structural level U^{GAP}. High productivity raises the real wage, while unemployment below the structural level lowers it.

Private household disposable income

(11) $$DI_t = w_t \cdot EMP_t + \Pi_t^{HH} + TR_t$$

stems from primary income and net transfers (that is, the difference between, in particular, the monetary social benefits received by households and employees' social contributions). Primary income corresponds to employee compensation (and gross wages and salaries $w \cdot EMP$, which contain transfers *TR* in addition to employer social contributions) and the property and entrepreneurial income that goes to private households, Π^{HH}; these are incomes from self-employed work and from assets, and whose share α in private corporate and investment income is extrapolated from its average value for the past five years. Aggregate corporate and investment income Π is given by

(12) $$\Pi_t = P_t^Y \cdot Y_t - \Theta_t - w_t \cdot EMP_t,$$

where Θ_t contains depreciation, the balance of other primary income with foreign countries, taxes less subsidies on production and imports and employer social contributions. The earnings of private households Π^{HH} and of firms Π^F are given by the proportion α or $(1 - \alpha)$ in total private sector earnings

(13) $$\Pi_t^{HH} = \alpha_t(\Pi_t - \Pi_t^{GOV}) \quad \text{bzw.} \quad \Pi_t^F = (1 - \alpha_t)(\Pi_t - \Pi_t^{GOV}),$$

whereby the property and entrepreneurial income to be provided, on balance, by the government, as well as the proportion of household earnings $\alpha = 79\,\%$ are given exogenously.

B.2.4 PRICES

The GDP deflator

(14) $$P_t^Y = \frac{P_t^{CP} \cdot C_t^P + P_t^I \cdot I_t + P_t^{CG} \cdot C_t^G + P_t^X \cdot X_t - P_t^M \cdot M_t}{Y_t}$$

is determined, by definition, by the ratio between nominal and real GDP, whereby nominal GDP is the accumulated aggregate of nominal expenditure components.

The development of the deflators of the expenditure components is determined by estimated equations. The change of the deflator of private consumption

(15) $$\Delta P_t^{CP} = 0.0037 + 0.25 \cdot \Delta P_{t-1}^{CP} + 0.03 \cdot \text{avg}(Y_{t,t-4}^{GAP}) - 0.00085 \cdot \text{avg}(INV_{t,t-4}^{STOCK})$$

is modelled as a function of the aggregate stock level[22] INV^{STOCK} as well as the output gap $Y^{GAP} = 100 \cdot (Y_t^S - Y_t^{POT})/Y_t^{POT}$. Both the output gap and the stock level are hereby entered in the equation in the form of moving averages of the preceding four quarters. A lower stock level or a high utilisation of aggregate production capacities thus generate price rises, which give rise to a lowering of demand and a reversion to normal capacity utilisation (price Phillips curve).

Similar equations are estimated for the other deflators of expenditure aggregates.

22 The stock level corresponds to accumulated changes in stocks.

B.2.5 INTEREST RATES AND POLICY ENVIRONMENT

The interest rates for short-term liabilities are determined by monetary policy conditions. They are given in the model by an estimated equation

(16) $$i_t^{SHORT} = \underset{(3.65)}{1.18} + \underset{(1.42)}{0.18} \cdot Y_t^{GAP} \cdot 100 + \underset{(7.29)}{1.34} \cdot \left[\frac{P_t^{CP}}{P_{t-4}^{CP}} - 1 \right] \cdot 100$$

which follows the form proposed by Taylor (1993). The short-term nominal interest rate thus depends positively on the output gap and the inflation rate. Interest rates on long-term liabilities follow short-term interest rates, but are also influenced by a measure for excess savings in the economy:

(17) $$i_t^{LONG} = \underset{(2.42)}{1.65} + \underset{(18.60)}{0.61} \cdot \text{avg}\,(i_{t-1,t-5}^{SHORT}) - \underset{(2.28)}{0.016} \cdot (s_t \cdot DI_t - P_t^I \cdot I_t) + \underset{(2.01)}{0.47} \cdot D_t^{CRISIS}$$

Accordingly, long-term interest rates rise if domestic savings $s \cdot DI$ fall in comparison with the financing needs for investment projects $P^I \cdot I$.[23]

The other policy conditions are assumed in the underlying version of the model to be exogenous. This applies in particular to public consumption spending, as well as to public investments.

B.3 MODELLING DISTRIBUTION SHOCKS

B.3.1 DISTRIBUTION SHOCKS AND PRODUCTIVITY

Trend productivity is explained, following the literature on empirical research on growth, with human capital *HK* and investment in other fixed assets I^{OTHER} which, among other things, include research and development spending:[24]

(18) $$\ln(TFP_t^{TREND}) = \underset{(-435.80)}{-8.44} + \underset{(10.10)}{0.087} \cdot \text{avg}(\ln(HK_{t,t-8})) + \underset{(24.18)}{0.18} \cdot \text{avg}(\ln(I_{t,t-8}^{OTHER})).$$

The growth in human capital over a fifteen-year window

(19) $$\Delta^{15y} HK_t = \underset{(18.71)}{14.54} + \underset{(6.13)}{2.25} \cdot \text{avg}(\ln(g_{t,t-15y}^{EDUC})) - \underset{(-3.79)}{2.20} \cdot \text{avg}(\ln(DIST_{t,t-15y}))$$

is thus positively influenced by the average share of public education spending in GDP g^{EDUC} and negatively by average income distribution *DIST* in the time window. In this way the long-term influence of inequality on productivity, as presented in Section 2.1, is taken into account.

The percentage cyclical deviation of productivity from its trend

(20) $$TFP_t^{GAP} = \underset{(-0.16)}{-0.013} - 0.0033 \cdot INV_t^{STOCK} + \underset{8.41}{0.66} \cdot TFP_{t-1}^{GAP} - \underset{(-0.24)}{0.0029} \cdot \ln(HK_t) + \underset{(0.13)}{0.0014} \cdot \ln(I_t^{OTHER}) + \underset{(0.20)}{0.0062} \cdot \ln(DIST_t),$$

is determined by the stock level INV^{STOCK}, income distribution *DIST*, spending on other investments (I^{OTHER}), including research and development investments, as well as human capital *HK* in the economy. Productivity responds positively to rising income inequality; the estimated equation thus models the short-term incentive channel from inequality to productivity (see Section 2.1). Higher other investments, including research and development, also raise productivity in the short term. A higher stock level initially subdues productivity, before firms adjust per capita working time (equation 7) and/or the number of employees (equation 8). High human capital, finally, diminishes, according to the estimate, the deviation of productivity from its trend; overall, however, productivity rises in response to an increase in human capital, because trend productivity is positively influenced to a greater extent than the deviation is diminished (equation 18). This reflects the fact that changes in human capital do not exert their full effects on productivity in the short term.

23 D_t^{CRISIS} is a dummy for the global financial crisis and denotes the years 2008 and 2009.

24 See for example, Gust and Marquez (2004) or Belorgey et al. (2006).

B.3.2 DISTRIBUTION SHOCKS AND SAVINGS RATE

In addition, demand-side effects are also to be taken into account in the case of an increase in income inequality. As described in Section 2.2, the income-distribution-dependent savings rate *s* is central, which is modelled by

(21)
$$\ln(s_t) = \underset{(1.46)}{3.54} + \underset{(9.67)}{0.71} \cdot \ln(s_{t-1}) + \underset{(1.95)}{0.51} \cdot \ln(pop_t^{OLD}) + \underset{(2.26)}{2.21} \cdot \ln(pop_t^{YOUNG}) + \underset{(2.33)}{0.81} \cdot \ln(DIST_t) + \underset{(1.23)}{0.61} \cdot r_t^{SHORT}$$

Thus the savings rate is influenced by demographic conditions measured by the youth pop^{YOUNG} and older people's pop^{OLD} dependency ratios; if the proportion of young or old people in the population rises, the savings rate also rises.[25] Besides that, the short-term real interest rate $r^{SHORT} = i^{SHORT} - \Delta P^{CP}$ positively influences savings formation, because higher interest rates make savings formation more attractive. Finally, the income distribution *DIST* enters into the equation, whose positive coefficient confirms the above-described savings rate channel. If inequality increases, the savings rate in the economy also rises; accordingly, private consumption is dampened in accordance with equation (2). In the medium term, however, an increase in investment activity is to be expected because the higher savings lead to a fall in the domestic interest rate level (see equation 17).

25 Behind the positive relationship between the proportion of older people in the population and the savings rate there is likely to be an altruism or precautionary savings motive, in accordance with which older people make provision for themselves because of health risks or wish to leave as much as possible to their children. In cross-country studies there is generally a converse relationship, even though often it is not significant; see Schmidt-Hebbel and Serven (2000) or Rocher and Stierle (2015).

Figures

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Imprint:

Friedrich-Ebert-Stiftung
Publisher: Division of Economic and Social Policy
Godesberger Allee 149, 53175 Bonn
Fax 0228 883 9205, www.fes.de/wiso

Orders/contact: wiso-news@fes.de

ISBN: 978-3-95861-784-1

Cover photo: © Nikada/www.istockphoto.com
Design: www.stetzer.net
Printing: www.bub-bonn.de

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