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Discussion Paper

Deutsche Bundesbank
No 05/2017

A model-based analysis of the macroeconomic impact of the refugee migration to Germany

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Internet http://www.bundesbank.de

ISBN 978–3–95729–346–6 (Printversion)
ISBN 978–3–95729–347–3 (Internetversion)

Non-technical summary

Research Question

Refugee migration, its repercussions, and the manner in which these two issues are being addressed remain at the forefront of political discourse in Germany to this day. This paper assesses the potential economic consequences and transmission mechanisms associated with refugee migration.

Contribution

This paper quantifies the effects of refugee migration on the German economy by simulating various scenarios with the aid of a state-of-the-art macroeconomic simulation model, the New Keynesian DSGE model *GEAR*, which is estimated for Germany, and thereby adds to the literature on the economic effects of migration by highlighting important transmission mechanisms.

Results

In summary, this paper finds that measures that cause the migrant qualification structure to closely match that of the native population over the long term do not lead to GDP and consumption losses, which seems to be a useful reference point, while a partial or total failure to close the skills gap can very well have negative economic consequences in terms of wage and consumption losses as well as higher unemployment. A failure to integrate about 800,000 migrants (equivalent to 1% of initial German population) could reduce *per capita* output and consumption by 0.43% and 0.48%, respectively, while integration measures that improve the qualification structure in Germany could even yield *per capita* output and consumption gains of 0.34% and 0.38%, respectively.

Nichttechnische Zusammenfassung

Fragestellung

Die Flüchtlingszuwanderung, ihre Konsequenzen und der Umgang mit beiden prägen noch immer die politische Diskussion in Deutschland. Dieses Papier untersucht die potenziellen wirtschaftlichen Konsequenzen und Wirkungsketten der Flüchtlingszuwanderung.

Beitrag

Das vorliegende Papier quantifiziert die Auswirkungen der Flüchtlingsmigration in Deutschland mit Hilfe eines modernen makroökonomischen Simulationsmodells, des neukeynesianischen DSGE-Modells *GEAR*, welches für Deutschland geschätzt ist. Durch das Aufzeigen wichtiger Transmissionskanäle leistet es damit einen Beitrag zur Literatur über die ökonomische Effekte von Migration.

Ergebnisse

Zusammenfassend kann festgehalten werden, dass Maßnahmen, die dazu führen, dass die Qualifikationsstruktur der Zuwanderer langfristig annähernd der der ursprünglich einheimischen Bevölkerung entspricht, was wir als Referenzpunkt definieren, zu keinen BIP- und Konsumeinbußen führen. Ein unterbleibender oder unvollständiger Aufholprozess kann durchaus mit negativen wirtschaftlichen Konsequenzen verbunden sein, bei dem auch die deutsche Bevölkerung mit Lohn- und Konsumeinbußen sowie höherer Arbeitslosigkeit konfrontiert ist. Bei unterbleibender Integration von ca. 800.000 Flüchtlingen (was 1% der ursprünglich deutschen Bevölkerung entspricht) könnten Pro-Kopf-Output und Konsum um $0,43$ bzw. $0,48$ Prozent fallen. Integrationsmaßnahmen, die die Qualifikationsstruktur in Deutschland verbessert, könnten hingegen mit Pro-Kopf-Output- und Konsumgewinnen in Höhe von $0,34$ bzw. $0,38$ Prozent einhergehen.

Bundesbank Discussion Paper No 05/2017

A Model-Based Analysis of the Macroeconomic Impact of the Refugee Migration to Germany*

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Abstract

By simulating various (labour market) integration scenarios with the aid of a New Keynesian DSGE model, this paper explores the potential economic consequences and transmission mechanisms resulting from the recent refugee migration to Germany. We find that the long-run costs and benefits for domestic agents depend critically on the skill levels migrants will obtain in the long run. A failure to integrate the about 800,000 migrants (equivalent to 1% of initial German population) could reduce *per capita* output and consumption by 0.43% and 0.48%, respectively, while integration measures that improve their qualification structure could even yield *per capita* output and consumption gains of 0.34% and 0.38%, respectively. Measures that cause the migrant qualification structure to closely match that of the native population over the long term do not lead to significant changes in GDP and consumption. Overall, our model simulations suggest that the macroeconomic impact of refugee migration is small.

Keywords: Refugee Migration, Labour Market Integration, Macroeconomics

JEL classification: F22, J61, J31, E24

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1 Introduction

Refugee migration, its repercussions, and the manner in which these two issues are being addressed remain at the forefront of political discourse in Germany to this day. While some aspects of this topic are not related to economics, it is important to assess the potential macroeconomic consequences and, thus, the potential costs and benefits for domestic agents. The present paper contributes to this topic by simulating various scenarios and their economic effects.[1] Specifically, it uses a New Keynesian three-region DSGE model (the three regions being Germany, the euro area and the rest of the world) to explore which macroeconomic effects could be triggered by refugee migration to Germany. The model simulations assume population growth of 1% of the native population. Refugees are initially solely transfer recipients for the period of one year, but are then gradually absorbed by the labour market over time.

The simulations show that the demand stimulus triggered by the migration of transfer recipients is the predominant economic impact initially, but that as time progresses, the change in supply-side conditions in the labour market comes to the fore. The population growth briefly increases aggregate output by less than 0.1% (demand stimulus). Over the longer term, the impact depends on the qualification structure which the migrants achieve in the long run. Per capita output and consumption increase/decline when migration improves/worsens the workforce qualification structure over the long term because the strength of the aggregate increase in output and consumption is then more than/less than proportional. If, over the long run, the refugees achieve the same qualification structure as natives, there are no long-term changes in output and consumption. Assuming they improve the qualification structure in the long term, per capita output and consumption might even climb by 0.34% and 0.38%, respectively, whereas per capita output and consumption are projected to decline by 0.43% and 0.48%, respectively, if all the refugees migrating to Germany (are in a position to) only perform low-skilled tasks over the long-term horizon as well.

Despite the overall increase in the labour supply, the aggregate unemployment rate will remain static over the long term if the migrant qualification structure is brought into line with that of natives. Even in the worst-case scenario – in which all the migrants remain no better than low-skilled over the long run – there is just a 0.14 percentage point increase in the aggregate unemployment rate because labour demand is raised by supply-driven cuts in real wages as well as shifts in demand towards employees with different qualifications. In this worst-case scenario, the average costs do not rise above 0.5% in terms of individual gross wage and income losses. Generally speaking, though, the more directly native employees compete with migrants, the more likely it is that they will face wage losses (including over the long term), while other groups look set to benefit. The fiscal impact of refugee migration is small.

All in all, it can be concluded that (integration) measures that cause the migrant qualification structure to closely match that of the native population over the long term do not lead to any noteworthy GDP and consumption losses while a partial or total failure

[1] The author takes the view that humanitarian considerations should, as a rule, trump economic factors, at least in a strong economy like Germany, and that is especially the case for refugee migration, a development which is mostly set in motion by catastrophic events. That notwithstanding, this paper will focus exclusively on economic effects.

to close the skills gap can very well have negative economic consequences. Of course, our model simulation has some caveats. First, when assuming a different labour market structure (such as, for example, a labour market with search frictions), the labour market transmission may be different. Second, changes in the skill composition of immigrants are assumed to happen exogenously as we do not model incentives for attaining higher education. And, third, in our model simulations, we analyse the effects of an exogenously given immigration flows ignoring the incentives of successful integration measures for those who could potentially decide to migrate to Germany. While these issues are important to be addressed in future research, our results seem to be backed by analyses which, at least partly, address the caveats mentioned above. Adda et al (2016) use a life cycle model to demonstrate that policy decisions that obstruct the integration of refugees can lead to significant welfare losses not only for the refugees themselves but also for natives, while successful integration can even yield welfare gains (see also Dustmann et al, 2016). This is also confirmed by Busch et al (2016).

The present paper adds to the debate by explicitly taking into account short, medium and long-term demand and population effects and demonstrates what should be interpreted in the debate as "stimulus" and as a structural effect of refugee migration, besides showing how short and long-term factors interact with one another. What this paper does not do, however, is provide concrete guidance on how good integration can be a success. That is a topic that should certainly be addressed by future research. For an overview of how this could be achieved, see EP (2016) and the literature discussed therein.

Other institutions, too, have sought to gauge the economic effects of the refugee migration. Many papers exploring this topic focus on the (fiscal) demand stimulus triggered by the migration of refugees, and illustrate that refugees are largely reliant on government transfers and thus trigger a corresponding government-funded demand stimulus. That stimulus is often amplified by direct increases in government consumption, since transfers are not the only items that are increased – non-financial benefits or public assistance are, too. Most papers put the resulting impulse from refugee migration for GDP growth at an annual rate of between 0.1 percentage point and 0.2 percentage point for the next three years (RWI, 2015, OECD, 2015, IfW, 2015, DIW, 2015, and Deutsche Bundesbank, 2015). The study that most closely resembles this paper in terms of the demand stimulus triggered by an increase in government expenditure was prepared by the German Council of Economic Experts (SVR, 2015). Like this paper, they, too, use a DSGE model to analyse the fiscal stimulus. The transmission mechanisms and dimensions in the present model, which a corresponding stimulus would trigger, are comparable.

One factor which has so far received less attention in the current simulations is that, besides providing somewhat short-lived stimulus for demand, refugee migration also unleashes long-term effects. That is because at least some of the migrants will probably stay in their host country, and the medium to long-term effects of migration, especially, cannot necessarily be equated with the impulse that higher fiscal expenditure can provide – particularly since the medium to long-term effects exert a much stronger impact on the labour market which simply do not exist in the case of fiscal-only stimulus. The European Commission uses its DSGE model *QUEST* to analyse a temporary population increase (EC, 2015, 2016). The population effect assumed in that model (equal to 0.4% of the native population) triggers, all other things being equal, similar short to medium-term effects to those modelled in the present simulation of the paper with regard to population

growth – that is, an increase in aggregate output and a simultaneous decline in *per capita* output. In the labour market, a rise in employment as well as a reduction in wages can be identified. The Commission does not, however, differentiate between the effects on different groups of the population, which might not be the same. The International Monetary Fund likewise analyses the effects of refugee migration using the *EUROMOD* microsimulation model by simulating two shocks, one to the size of the population, the other to government expenditure (Aiyar et al, 2016). The study finds that a small stimulus is generated at first (slightly smaller than in the DSGE analyses), but that the medium to long-term effects are extremely sensitive to the assumptions made regarding labour market integration.

Lessons learnt in this regard from earlier periods of migration are also discussed. Beyer (2016) discusses past experience of labour market integration in Germany, while Battisti et al (2015) analyse specific policy proposals in the field of integration. They find that the minimum wage in particular as well as an increase in the standard Hartz IV rates are not conducive to promoting integration. Ruist (2015) discusses the lessons learnt in Sweden, and Braun and Weber (2016) outline the situation in post-war Germany. The fact that refugee migration can influence the surge of rather more conservative to right-wing political parties, and the manner in which this occurs, are demonstrated by Dustmann et al (2016), who use Denmark as a case study. Ottaviano and Peri (2012) identify slightly positive effects on the wages of the native US population in the period from 1990 to 2006 because, first, migrants and natives constitute imperfect substitutes and, second, migrants trigger a demand stimulus. Mandelman and Zlate (2012) detect similar effects in their analysis of migration flows across the US/Mexican border. Earlier work on immigration in a DSGE context can be found in, among others, Acosta et al (2009), Barwell (2007), Chami et al (2006) and Durdu and Sayan (2010).

The remainder of this paper is structured as follows. Section 2 provides an overview of the simulation model used and describes how the simulation is designed. Section 3 presents the possible long-term effects triggered by the different scenario assumptions, while section 4 looks at the short to medium-term effects. Section 5 summarises and concludes this paper.

2 The influx of refugees to Germany: model implementation

This section begins by outlining the simulation model used before moving on to discuss the specific assumptions and model implementation.

2.1 Simulation model

We use the *GEAR* model for the following simulations, which is a standard New Keynesian DSGE model of a monetary union that consists of two regions and is embedded in the rest of the world. The baseline model is estimated for Germany, the rest of the euro area and the rest of the world with the aid of Bayesian techniques. Compared with other models in this class, the *GEAR* model comprises a complex labour market structure that is also capable of modelling involuntary unemployment, a disaggregated fiscal sector as well as

a robust representation of trade flows. More precisely, in the model, households make optimal choices regarding savings in physical capital as well as national and international assets and purchases of consumption and investment goods.[2] The latter add to the private-sector capital stock which is rented out to private firms. Household members also decide whether or not to participate in the labour market. Those who participate may find a job in the private or in the public sector or stay unemployed. Unemployment is modelled in line with Galí (2010) and Galí et al. (2011). Hence, households receive interest and wage payments, unemployment benefits and other fiscal transfers, and they pay taxes. In line with Galí et al. (2007), it is also assumed that a fraction of households does not participate in asset markets and consumes the entire income each period. Those households have become known in the literature as "rule-of-thumb" (RoT) households; we call the other type of households optimisers.

Furthermore, households enjoy some monopoly power on the labour market because different types of labor are needed in production, and these are not perfectly substitutable. Wage setting is associated with Rotemberg adjustment costs in the sense that changing nominal wages is costly for firms and for workers. This prevents wages from "perfectly" adjusting to the current economic situation which, in the end, induces potentially inefficient wage and employment fluctuations (see Ascari et al., 2011, and Ascari and Rossi, 2011, for a discussion).

On the production side, monopolistic competitors in each region produce a variety of differentiated products and sell these to the home and foreign market. We assume that there is no price discrimination between markets. Firms use labour and private capital as production inputs. Public employment and the public capital stock can be productivity-enhancing. However, the provision of these inputs is outside the control of firms and conducted by the fiscal authority. Cost minimisation determines the amount of labor and capital input demanded by each firm. Because firms enjoy monopolistic power, they are able to set their nominal price. Price setting is also associated with Rotemberg adjustment costs.

The fiscal authority purchases consumption and investment goods produced in the private sector. The latter increases the public capital stock which may, in turn, improve private-sector productivity (for example, because of better infrastructure). The government also employs public-sector workers for whom it has to pay wages. Services provided by these public-sector workers may also affect private-sector productivity positively (for example, because of better governance). Introducing immediate positive spillovers from the public to the private sector follows the idea of Baxter and King (1993), Pappa (2009), Leeper et al (2009, 2010) or D'Auria (2015). Furthermore, the fiscal authority pays unemployment benefits and other transfers to private households. It also has to pay interest on outstanding debt. Fiscal authorities finance themselves with distortionary taxes on private consumption, on labor income and on capital returns, lump-sum taxes as well as social security contributions paid by firms. They can also issue new debt. The monetary authority sets the nominal reference interest rates. In the euro area, it sets a common

[2] As we will see below, we assume that, when refugees enter Germany, they are wholly reliant on government transfers and non-financial benefits and do not have asset holdings for the period of one year. Once they enter the group of asset holding households, we assume that they enter the big household family and thus share the household's wealth in equal amounts. However, the first immigrant entering this household type needs about 8 years to do so. Before this, no immigrant will be an asset holder.

rate according to a Taylor-type rule that responds to area-wide inflation and output gap. The rest of the world is reduced to a three-equation VAR process (output, inflation and interest rate) as in Christiano et al. (2011).

In order to make this paper self-contained, we provide a detailed model description in the appendix. Besides the model modifications explained in the main text, this is basically a repetition of the model description already provided by Gadatsch et al (2016).

Since the qualification/productivity (hereinafter used synonymously) of the working population has a major bearing on the question discussed here, we extend the basic model so as to incorporate a suitably heterogeneous productivity structure in Germany – both in the original equilibrium but notably following the influx of refugees. It is assumed that the German native population can be broken down into three groups: high-productivity, medium-productivity and low-productivity employees. They account for 30%, 60% and 10% of the population, respectively, and their relative productivity is determined on the basis of the gross (hourly) wage differences in steady state. The gross hourly wage received by high-productivity households is assumed to be twice as large as that of medium-productivity households and three times larger than that of low-productivity households (see Destatis, 2016a). Unemployment within the groups, in the original long-term equilibrium, stands at 3%, 6% and 24%, respectively (see IAB, 2016a). A fourth group is added to the basic model consisting of households that do not participate in the labour market and subsist entirely on transfer payments. It is assumed, in the initial steady state, that the population share of this latter group is zero, ie that this group does not exist. The share can rise temporarily or even permanently following the influx of refugees and simply increases aggregate consumption demand.

Employees from the groups participating in the labour market constitute imperfect substitutes in the production function of firms (formally captured by a CES aggregator), with the result that firms will generally continue to have a demand for labour from those groups as long as the marginal utility of the corresponding labour input equals or exceeds the marginal production costs (ultimately real wages plus social security contributions). Imperfect substitutability between natives and immigrants may even be higher than postulated here given that immigrant workers face, among other things, language barriers (see, for example, Card, 2007, and D'Amuri et al, 2010). If we were to introduce this within-skill-group heterogeneity of natives and immigrants, the transition results presented below would be more in favour of the native population because, at least at the beginning, they would not directly compete with the immigrants. Still, the long-run results would remain the same as long as we assume that immigrant workers fully assimilate in the long run. Compared to the baseline model of Gadatsch et al (2016), the aggregate production function of the representative firm in Germany is extended to:

$$y_t^a = A_a \, y_t^{G,a} \left[K_{t-1}^a\right]^{\alpha_a} \left[\tilde{N}_t^{P,a}\right]^{1-\alpha_a} - \Omega_a, \tag{1}$$

where $\tilde{N}_t^{P,a}$ denotes a CES aggregate of different types of labour similar to Perri (2006) and Ottaviano and Peri (2012), $y_t^{G,a}$ captures the effect of public employment and capital on private-sector productivity, A_a is total factor productivity and Ω_a is a fixed cost yielding

steady-state profits to be zero.[3] The parameter $0 < \alpha_a < 1$ gives the share of private capital, K_t^a, in production. In order to simplify matters, we assume that there are only three types of employees: highly, medium- and low-skilled workers such that the CES aggregate is given by

$$\tilde{N}_t^{P,a} = \zeta^a \left(\left(\alpha_N^h \mu_t^{a,h} n_t^{P,h,a} \right)^{(1-\rho_N)} + \left(\alpha_N^m \mu_t^{a,m} n_t^{P,m,a} \right)^{(1-\rho_N)} + \left(\alpha_N^l \mu_t^{a,l} n_t^{P,l,a} \right)^{(1-\rho_N)} \right)^{1/(1-\rho_N)}, \tag{2}$$

where $\mu_t^{a,x} = \mathcal{P}_t^{a,x} / \mathcal{P}_t^a$ is the share of German highly, medium and low-productive workers, $\mathcal{P}_t^{a,x}$, with $x = h, m, l$, over total German population, $\mathcal{P}_t^a$. $n_t^{P,x,a}$ is the corresponding per-household employment level and $\rho_N = 1/v_N$, with v_N being the substitution elasticity between these worker types. ζ^a is a scaling parameter determining aggregate labour productivity, while α_N^i determines (relative) productivity between worker types.

With $r_{k,t}^a$ being the consumer price index (CPI)-deflated rental rate of capital and $(1 + \tau_t^{sc,a})\ w_t^{a,x}$ being real gross labour costs when employing a worker of type $x = l, m, h$, including CPI-deflated private-sector real wages, $w_t^{a,x}$, and the firms' social security contributions at rate $\tau_t^{sc,a}$, each firm's cost minimization problem yields

$$(1 + \tau_t^{sc,a})\, w_t^{a,x} = mc_t^a\, A_a\, (1 - \alpha_a) \left(\frac{K_{t-1}^a}{\tilde{N}_t^{P,a}} \right)^{\alpha_a} y_t^{G,a}\, \zeta^a\, \alpha_N^x \left(\frac{\tilde{N}_t^{P,a}(z)}{\alpha_N^x \mu_t^{a,x} n_t^{P,x,a}} \right)^{\rho_N} \tag{3}$$

and

$$r_{k,t}^a = mc_t^a\, A_a\, \alpha_a \left(\frac{K_{t-1}^a}{\tilde{N}_t^{P,a}} \right)^{\alpha_a - 1} y_t^{G,a}, \tag{4}$$

where mc_t^a are real marginal costs. Note that, in these equations, we already made use of the fact that marginal costs and, hence, the capital-to-labour ratio are common to all firms in equilibrium.

The household sector is analogous to the one presented in Gadatsch et al (2016) and, therefore, its presentation is relegated to the appendix. However, given that we now have three different household types participating in the labour market in Germany, whereas Gadatsch et al (2016) assume only two, we need to extend the household sector by an additional group. As in Gadatsch et al (2016), we assume that only highly-skilled households behave Ricardian (ie they save and borrow), while all other household types are assumed to be RoT households. Given an analogous household sector, labour supply decisions are also analogous. However, we no longer assume that there is a union that sets one economy-wide average wage but allow for type-specific wages as indicated in equation (3). This implies that, while the general modelling of the wage setting is analogous, it is now undertaken at the household level (see appendix for details). Total population in Germany is defined as

$$\mathcal{P}_t^a = \mathcal{P}_t^{a,h} + \mathcal{P}_t^{a,m} + \mathcal{P}_t^{a,l}, \tag{5}$$

[3] Note that $y_t^{G,a} = \zeta_a \left(K_t^{G,a} \right)^{\eta^{K^G,a}} \left(N_t^{G,a} \right)^{\eta^{N^G,a}}$ denotes the impact of public-sector employees and the public capital stock on private production, where $\eta^{K^G,a}$ determines the relevance of public capital in the private-sector productivity function and $\eta^{N^G,a}$ the relevance of public employment, while $\zeta_a > 0$ is a scaling parameter; see also Gadatsch et al (2016) for a more in-depth discussion.

where $\mathcal{P}_t^{a,x} = \bar{\mathcal{P}}^{a,x} + \epsilon_t^{pop,x}$, the bar indicating steady-state (ie long-run equilibrium) levels, and $\epsilon_t^{pop,x}$ is a population shock specified in the following section.

2.2 Simulation design

When simulating refugee migration, a distinction must be made between short, medium and long-term migration. Specifically, this means that assumptions first need be made as to the number of refugees currently migrating to Germany who will stay there permanently. To capture the immigrant influx, the simulation makes the stylised assumption that the population in the model grows by 1% (ie that around 800,000 people) at date $t = 0$. Assumptions also need to be made concerning the migrants' qualification levels (ie which productivity group they should be assigned to). The baseline scenario assumes that the migrants' average labour productivity will not differ *in the long run* from that of the native average workforce of the German population: the 1% population growth is thus split into high-, medium- and low-productivity employees to match the composition of the native workforce. We do, however, test the robustness of our assumptions to demonstrate the differences that occur if all the migrants become/remain (i) high-productivity, (ii) medium-productivity or (iii) low-productivity employees. In terms of our model simulations, this implies that, for the *long run*, we assume $\bar{\mathcal{P}}_{new}^{a,x} = 1.01 \cdot \bar{\mathcal{P}}_{old}^{a,x}$ in the baseline scenario, whereas $\bar{\mathcal{P}}_{new}^{a,x}$ increases in line with the numbers presented in Table 1 in the other scenarios.

While the assumptions presented above reflect the long-term situation used to calculated the new long-term equilibrium, we also need to make assumptions regarding the short to medium-term developments. Specifically, this means defining scenarios for the timescale of refugee migration, for the incidence of refugees who initially migrate to Germany and then leave the country again (either voluntarily or due to deportation) and for the pace of integration.

For simplicity's sake, we assume that, at a certain point in time, refugees equal in number to 1% of the native German population migrate to Germany and also stay there for the long term. This assumption allows us to analyse the economic transmission mechanisms in isolation, free from the distorting impact of additional migration and emigration flows. We assume, for the purpose of our simulation, that migrant refugees are wholly reliant on government transfers and non-financial benefits for the period of one year and that they do not participate in the labour market, in an effort to model the average time of just under one year that it takes to process an asylum request. Once the refugees have been granted asylum (all migrants in the baseline scenario), they can be integrated into the labour market in principle. However, we assume that not all migrants immediately begin looking for work, but that they do so at an annual rate of 0.125 and that they first join the group of low-productivity employees. It is assumed that, following a period of four years following immigration, employment (through "learning by doing") and vocational training will have caused a certain percentage of the refugees to become as productive each quarter as the average native medium-productivity employee (again at an annual rate of 0.125). Later on, a further percentage of individuals from this pool is assumed to become as productive as the average native high-productivity employee, with the result that the ratio of high and medium-productivity employees to low-productivity employees in the steady state does not shift in the baseline scenario. These assumptions presume

that the adjustment process in the population structure will last 60 years in total (ie that the qualification structure of the 1% population growth will need 60 years to match that originally found in the native population; Figures 1 and A.1 in section 4 and the appendix, respectively, plot the implied population developments). The assumed transition rates imply that a refugee who manages to reach the highest qualification group spends an average of eight years in each group and that $\epsilon_t^{pop,x}$ is chosen accordingly.[4] Owing to the inherent ridigities in the model, adjustment of other macro aggregates will take longer.

In addition to the assumptions made regarding refugee migration itself, we also need to make assumptions regarding the resulting fiscal implications. All in all, we initially assume that annual fiscal expenditure comes to 0.6% of GDP for migration at a rate equal to 1% of the native population (see German Federal Statistical Office, Destatis, 2016, for the cost assumptions used and their composition; the increase in staff costs is assumed to be caused by a corresponding increase in staffing levels). This expenditure includes direct transfers to asylum seekers (20%), an increase in social security and other non-financial benefits (70%) as well as a rise in refugee support staff costs (10%). As a next step, these data can be used to calculate transfers, government consumption and staff costs per refugee, which come in at around 1,250 Euro per month (the latest estimates put this figure at 1,000 Euro, but that does not detract from the general thrust of the analysis). The gradual absorption of refugees by the labour market reduces the aggregate expenditure, since it is paid only per capita as long as refugees have not joined the labour market and is discontinued altogether once they have. The individuals concerned then receive transfers equal to the "standard" transfers for their respective qualification group. In other words, if it is assumed that further expenditure on integration measures remains necessary even after refugees have joined Germany's labour market, which may not be unlikely, the present simulation would understate the corresponding costs and should be regarded as a lower bound.

It is assumed that these costs are not immediately financed but that over the long term, they will have funding that comes into play after four years in the form of a non-distortionary lump-sum tax that is payable (only) by non-liquidity-constrained – forward-looking and well-qualified – households, this funding acting to bring the debt ratio back to the starting level in the long run and then keeping it at a constant level. Although no such tax exists in the real world, it is a useful tool for modelling consolidation in model simulations (see also Attinasi et al, 2016 for a more detailed discussion). In effect, this assumption can prevent the emergence of additional distortions that are not triggered

[4]The transition rates are indeed chosen ad hoc due to the lack of reliable data. Recent findings of the German Institute for Employment Research however suggests that, while indeed being lower qualified than the average native German on average, refugees coming to Germany may not be too different from native German population in terms of their ideals and educational prospects (IAB, 2016b). Bönke and Neidhöfer (2016) show that, at least in the second generation, past (Italian) immigrants who came to Germany did not face worse educational prospects than their German counterparts, whereas Hatton (2013) provides evidence that refugees integrate more slowly than other immigrants. On the other hand, Aslund and Rooth (2007) suggest that good labour market conditions and low unemployment rates – as we currently observe in Germany – should speed up labour market integration. Hence, assuming 60 years for the refugee generation(s) to adjust to the German one does not seem to be overly implausible. Nevertheless, in an appendix, we will also show the transition dynamics if all the migrants become/remain (i) high-productivity, (ii) medium-productivity or (iii) low-productivity employees as a robustness analysis. In these cases, $\epsilon_t^{pop,x}$ is chosen such that the corresponding long-run equilibrium is reached. We concentrate only on the baseline scenario in the main text.

by migration itself. Thus, using this tax as a fiscal instrument would allow the effects shown to be attributed solely to the assumed population growth and government spending increase. The simulation results presented later in this paper show the long-term change in the lump-sum tax needed to stabilise the debt level. A positive value denotes a fiscal burden, while a negative value stands for relief. In principle, it can be said that in the case of a fiscal burden and the use of a distortionary fiscal instrument – distortionary labour income taxes, for example – the effects on macro aggregates outlined below will be more negative depending on the increase in the degree of distortion triggered by the instrument used. The opposite holds true in the case of relief. In the long run, aggregate government consumption and investment expenditure expands in line with the 1% population growth, thereby leaving the respective government *per capita* expenditure at a constant level.

3 Refugee migration in Germany: the possible long-term effects

Table 1 gives an overview of the above-described long-term population growth in Germany as well as its assumed distribution among the various categories. It also shows the population percentage of highly-skilled, medium-skilled and unskilled households resulting from the above-described assumptions in the new steady state. It is obvious that, in the baseline scenario, this does not differ from the original steady state. In all the other scenarios, the percentage share of those into which the immigrants are classified increases in line with the assumptions, while the other percentage shares decline.

Table 1: Long-term increase of the various population categories

Scenario:	Baseline	Highly-skilled	Medium-skilled	Unskilled
Increase of...				
...total population	1.00	1.00	1.00	1.00
...highly-skilled	1.00	3.33	0.00	0.00
...medium-skilled	1.00	0.00	1.67	0.00
...unskilled	1.00	0.00	0.00	10.00
Population shares of...				
...highly-skilled	30.00	30.69	29.70	29.70
...medium-skilled	60.00	59.41	60.40	59.41
...unskilled	10.00	9.90	9.90	10.89

Note: Table shows long-term population growth in Germany by scenario and skill group as percentage growth rate and the new long-run population shares by skill groups after the assumed immigration inflow in per cent.

Table 2: Long-term effects for selected macrovariables

Scenario:	Baseline	Highly-skilled	Medium-skilled	Unskilled
Macro aggregates				
Aggregate GDP	0.94	1.34	0.79	0.57
Aggregate consumption	0.93	1.39	0.76	0.51
...of highly-skilled	0.93	1.49	0.71	0.48
...medium-skilled	0.92	0.59	1.19	0.27
...unskilled	0.92	0.59	0.36	5.16
Aggregate investment	0.92	1.42	0.74	0.47
Primary deficit ratio	0.01	-0.06	0.03	0.07
Aggregate profits	0.95	1.27	0.83	0.65
Per capita macro aggregates				
Per capita output	-0.06	0.34	-0.21	-0.43
Per capita consumption	-0.07	0.38	-0.24	-0.48
...of highly-skilled	-0.07	-1.78	0.71	0.48
...medium-skilled	-0.08	0.59	-0.47	0.27
...unskilled	-0.08	0.59	0.36	-4.40
Per capita investment (per optimiser)	-0.08	-1.85	0.74	0.47
Per capita investment (per total pop.)	-0.08	0.41	-0.26	-0.52
Per capita net lump-sum tax	0.20	-0.04	0.30	0.43
Per capita profits (per optimiser)	-0.05	-1.99	0.83	0.65

Note: Table shows percentage (point) changes of new long-run steady-state values of selected macrovariables relative to initial steady state. The primary deficit ratio is expressed in percentage point deviations excluding changes in lump-sum taxes as described in the main text.

Table 2 shows the long-term effects of refugee migration on selected macroeconomic variables. Overall, it should be noted that the population growth of 1% of the original domestic population boosts gross domestic product (GDP). GDP growth is smaller (larger) than 1% if the immigrant refugees' level of productivity lies below (above) the average level of productivity of the original domestic population. In the baseline scenario, GDP growth is slightly below the growth in population, which is explained by the relative increase in the German population's percentage share of the world's total population. As a result, GDP *per capita* falls slightly in the baseline scenario, although we feel that this is

more in the area of uncertainty and not the central outcome of the simulation and should therefore not be overinterpreted.

From the point of view of the model, this latter effect can be explained as follows. The increase in population in Germany means that, with a given export demand for German goods, *per capita* export demand falls *ceteris paribus*. This can be interpreted as an "exogenous" demand shock (especially with regard to demand from the rest of the world, since demand *per capita* there is given exogenously). To partly compensate for this, German firms lower their prices, resulting in a fall in the relative price of German goods. In the long run, however, this increases the relative costs of capital for German firms, as households in the old and new steady state demand a given (in the end, parameter-fixed) real rate of interest in order to invest in capital. Relatively speaking, a given long-term real rate of interest measured by the price of the bundle of goods thus increases businesses' capital costs.[5] This leads to firms reducing their capital input, which (in relative terms) results in slight losses of output. Ultimately, this is due to the fact that Germany's population weight in the world has been increased exogenously. In a closed economy (or given corresponding population growth at home and abroad) this effect would be non-existent, resulting in the *per capita* variables remaining unchanged. How momentous this price effect is in reality and whether it can be compensated for by alternative modelling of firm entries and exits (as in, for example, Alessandria and Choi, 2007, or Ghironi and Melitz, 2005) or possibly changes in product market regulation (as in, for example, Cavallari, 2010) is something that cannot be examined in the present analysis. This could, however, be a component of future research on the macroeconomic effects of refugee migration.

It is intuitively obvious that the GDP effect is all the greater, the more skilled the immigrants are. If all the refugees are/remain low-skilled workers, GDP increases by no more than just under 0.6%, whereas the increase is all the higher, the more skills they acquire. The negative effects on GDP *per capita* are then also commensurately smaller (or more positive) depending on how much better the long-term skills level of the refugees is/becomes.

In all cases, there is an increase in aggregate private consumption in Germany after the refugee migration in the long term. However, the increase in consumption mostly slightly lags the increase in GDP, resulting in aggregate consumption *per capita* being somewhat reduced as a rule – with the exception of the scenario in which it is assumed that refugee migration has a positive impact on the structure of productivity in Germany in the long term. Differing reactions of individual private consumption occur, however, within the various categories (of highly-skilled, medium-skilled and unskilled households). If all the immigrants become highly skilled over the long term, the *per capita* consumption of the highly-skilled category decreases, while the medium-skilled and unskilled households increase their *per capita* consumption. The converse applies if all the refugees become medium-skilled or remain unskilled over the long term. In the baseline scenario, all households are faced with slight falls in per capita consumption. This can be explained

[5] In order to not consume today but to invest in capital (or assets), households want to be compensated for this consumption-utility loss by higher expected consumption-utility tomorrow. The latter is, in the end, given by their discount factor $\beta \in (0, 1)$, which is a fixed parameter, and which determines the real interest rate to be $1/\beta - 1$ in steady state. Lower selling prices in the new steady state, however, relatively increase capital costs of firms as β is fixed.

primarily by the restrained growth in total per capita gross wages and salaries (which runs roughly in parallel with per capita GDP) as well as the above-described slightly reduced input of capital (see also Table 3).

Thus, households' consumption adjustments are primarily determined by the labour market developments described in detail below (see also Table 3). Generally, it is possible to state at this stage already that the individual labour income of each of the types of household falls (rises) if the category turns out to be larger (smaller) once the immigrants have become fully integrated.

Besides labour income, a part for highly-skilled/optimising households is also played by the earnings performance as well as the tax burden (as described in section 2.2, expressed as a change in the lump-sum tax only levied on this type of household). The aggregate corporate profits distributed only to these households grow roughly in line with GDP. This means that the average *per capita* profit distribution falls (increases) if the percentage population growth in this segment is above (below) the increase in aggregate profits. If all the refugees become highly skilled, this percentage share of the population grows substantially more strongly than the profits (see also Table 1), and the relevant per capita earnings of the highly-skilled households decline. In the baseline scenario, there are no significant gains/losses in earnings, whereas the *per capita* profits show an increase in the last two scenarios.

The state of public finances (ie the primary deficit ratio - calculated excluding the lump-sum tax) deteriorates slightly, especially in the scenarios with lower-skilled immigration because there is a decline in *per capita* income tax, consumption tax and capital gains tax revenues in real terms, while real spending *per capita* (deflated by domestic prices) remain largely constant.[6] The fiscal situation improves only in the scenario in which the immigrants are all highly skilled in the long term; this can be attributed to the increase in the tax assessment bases in real terms – which more than offsets the rise in spending – and, to a lesser extent, to the denominator effect (rising GDP *per capita*). A slightly higher primary deficit can be translated into a hike in the *per capita* lump-sum tax that is levied only on the highly-skilled households. This *per capita* increase is *ceteris paribus* all the smaller, the larger the number of people among whom it can be spread; this is especially relevant in those scenarios in which refugees also become highly-skilled/optimising households over the long term (see Table 2).

In summary, the *per capita* consumption of highly-skilled households increases in those scenarios in which these households benefit from the increases in profits as well as gross wages and salaries that more than offset the hike in tax, ie the scenarios in which the immigrant refugees become only medium or low-skilled even in the long term. If all refugees become highly-skilled households in the long term, both the lower *per capita*

[6] In the baseline scenarios, the deficit ratio, the interest expenditure ratio and the primary deficit ratio are (approximately) unchanged in the long term, since it is assumed that the debt ratio is stabilised and unchanged compared with the situation taken as a starting point and the long-term interest and growth conditions are (almost) unchanged. The change in the primary deficit ratios shown in Table 2 is calculated excluding the change in lump-sum tax. The table shows how the primary deficit ratio changes without a policy change due to the assumed population growth. To compensate for this, a corresponding cut or hike in the lump-sum tax is required, since the deficit ratio – as mentioned – ultimately remains unchanged. A negative value in Table 2 means that the primary deficit ratio has fallen (fiscal growth is more positive) and, to that extent, the per capita taxes can be lowered taking into account the real tax payments on government debt. The opposite holds for a positive value.

profit distributions and the lower *per capita* level of employment with simultaneously lower wages (see Table 3) are high enough to more than offset the slight cut in the lump-sum tax. In this case, the *per capita* consumption of highly-skilled households also declines, which remains the case to a lesser extent in the baseline scenario.

Table 3 shows the long-term labour market trends triggered by refugee immigration given various scenarios.

Table 3: Long-term labour market trends

Scenario:	Baseline	Highly-skilled	Medium-skilled	Unskilled
Unemployment rate (total)	0.00	-0.04	0.00	0.14
...of highly-skilled	0.00	0.00	0.00	0.00
...medium-skilled	0.00	0.00	0.00	0.00
...unskilled	0.00	0.00	0.00	0.00
Wages (total)	-0.08	0.34	-0.25	-0.34
...of highly-skilled	-0.08	-1.08	0.37	0.28
...medium-skilled	-0.08	0.59	0-.47	0.27
...unskilled	-0.08	0.59	0.36	-4.40
Aggregate employment (total)	1.00	1.07	0.99	0.82
...of highly-skilled	1.00	3.39	-0.03	-0.02
...medium-skilled	1.00	0.00	1.67	0.00
...unskilled	1.00	0.00	0.00	10.00
Per capita employment (total)	0.00	0.07	-0.01	-0.18
...of highly-skilled	0.00	0.05	-0.03	-0.02
...medium-skilled	0.00	0.00	0.00	0.00
...unskilled	0.00	0.00	0.00	0.00
Gross wages and salaries (total)	0.92	1.42	0.74	0.47
...of highly-skilled	0.92	2.28	0.35	0.26
...medium-skilled	0.92	0.59	1.19	0.27
...unskilled	0.92	0.59	0.36	5.17
Gross wages and salaries (per household)	-0.08	0.41	-0.26	-0.52
...of highly-skilled	-0.08	-1.02	0.35	0.26
...medium-skilled	-0.08	0.59	-0.47	0.27
...unskilled	-0.08	0.59	0.36	-4.40

Note: Table shows percentage (point) changes of new long-run steady-state values of selected labour market variables relative to initial steady state taking. By taking into account changes in domestic prices, wage changes are related to real wages.

Population growth increases the aggregate supply of labour. Owing to the overall rise

in macroeconomic output and the capital stock, the aggregate demand for labour also rises at the same time. In the aggregate of the baseline scenario, the increases in supply and demand cancel each other out, causing the aggregate unemployment rate to remain constant. If only permanently low-skilled households immigrate, the aggregate unemployment rate goes up slightly, which is due to the fact that the immigrating refugees remain in a category that is characterised by an above-average unemployment rate, and therefore the aggregate unemployment rate rises. The category-specific – individual – ratios remain constant in all the scenarios. Category-specific *per capita* employment remains virtually unchanged as well, with the category-specific aggregate change in employment developing in line with the percentage category-specific change in population (see also Table 1).

The *per capita* employment and unemployment rates are held constant in the new long-term equilibrium by adjusting the long-term wages. Generally speaking, an increase in the potential labour force lowers wage claims, with the decline in the baseline scenario being the result of marginally lower output *per capita* (which is to be qualified as described above, however). Here, redistributions among the categories may occur if there is immigration into a specific category. If, for example, all immigrants become highly-skilled, wages will fall in this segment of the labour market, yet rise in the other segments. Much the same applies to long-term immigration into the medium and unskilled segment. Since immigrants move into all the categories in the baseline scenario, wages show an equally slight fall in all the categories in this case. Growth of the household-specific sum of gross wages and gross salaries derives in the baseline scenario from wage changes resulting from wage negotiations, not from changes in employment. For the aggregate, the respective increase in population then also has to be taken into account. These wage changes are primarily responsible for the changes in consumption shown in Table 2.

In summary, this means that individual employees are generally affected (more) negatively by population growth with regard to wage losses if they are in direct competition with the immigrants. The other categories, on the other hand, gain slightly.[7]

4 Refugee migration in Germany: the possible short to medium-term effects

The text below sets out the short to medium term macroeconomic effects that are incurred if, in addition to the permanent change in demographics described in the previous section, account is also taken of the migration-induced time shifts in Germany's demographic structure and the resulting fiscal demand effects (in the shape of a temporary deficit-increasing rise in government spending) as outlined in section 2.2. In each case, an overview is provided of developments over the first ten years. The adjustment path towards the new long-term equilibrium detailed above which spans a period of around 60 years is presented in its entirety in the annex. We focus on the baseline scenario in the main text, while the graphs for the other scenarios are relegated to the appendix, too. As we can see, the general findings discussed in the main text go through except that, of course, the new long-run steady state discussed in the previous section will be reached correspondingly.

[7] This does not hold entirely, however, if two categories of employees are easily substitutable. In this case, the effects would be distributed more equally among both categories.

Figure 1 shows the population growth that may be expected to arise from the assumptions described in section 2.2 for the first ten years following the influx of migrants, assuming that the country's long-term demographic structure does not change in terms of people's skills (as assumed in the long-term baseline scenario). As alternative scenarios, simulations are made of what will happen if i) the demographic structure of the new steady state occurs immediately (dashed red line) and if ii) no long-term population increase occurs but there is nevertheless an initial rise in government spending (a pure stimulus simulation; green dotted line that is not distinguishable in Figure 1 as it is obscured by the zero/blue line in the bottom right-hand panel). Scenario ii) accordingly illustrates how the economy would have evolved in the absence of long-term migration but with a fiscal stimulus of the magnitude of initial migration-induced spending.

Figure 1: Population growth over the first 10 years

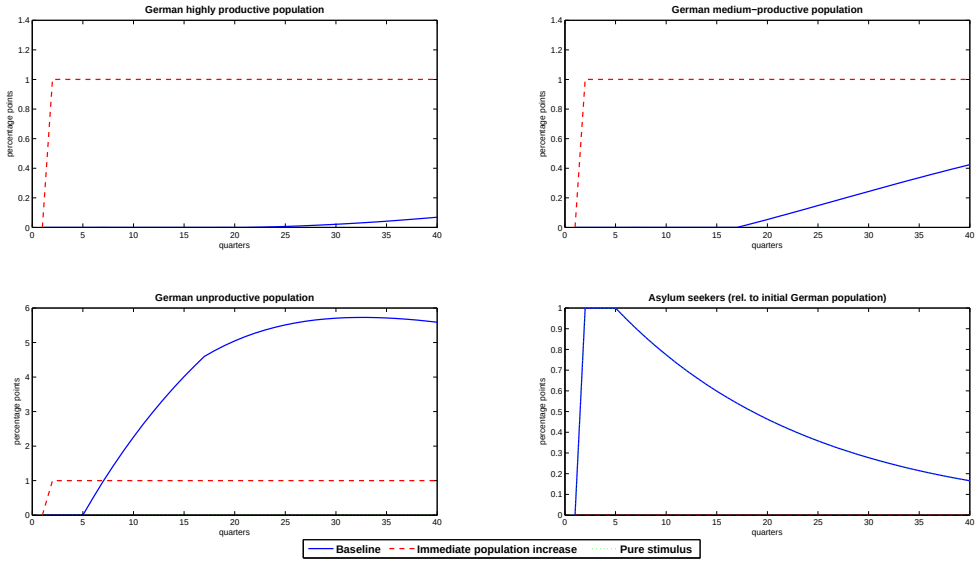


Figure 2 shows the development of selected macrovariables that results from the growth in population and its underlying structure. The refugee migration triggers an aggregate increase in demand (=stimulus),[8] because the population rises immediately and the assumption is made that all immigrants consume the total volume of received transfers in the course of the first year and that government consumption (exogenously assumed) is raised.[9] This causes aggregate GDP to increase, rising the most strongly (and, ultimately, persistently) if it is assumed that the final state of Germany's demographic structure (in

[8]The simulation envisaged by the German Council of Economic Experts (SVR, 2015) that is mentioned in the introduction assumes that exogenously determined government spending and transfers rise for a period of three years before then returning to their original level according to the estimated fiscal rules. The pure stimulus simulation presented here is broadly similar, except that the strength and trajectory of the stimulus have been adapted to match the other scenarios.

[9]In the scenario in which refugees possess the same skills as the native population from the outset, no direct demand stimulus is generated, as section 2.2 makes clear.

line with the qualifications acquired in the end) sets in immediately. In the baseline scenario, in which refugees start out as transfer recipients before gradually migrating to the labour market, the initial increase is roughly equal in size to that seen in the pure fiscal stimulus simulation and slowly grows alongside the corresponding demographic shift (see Figure 1) to reach the new equilibrium level described in the preceding section. In the case of the pure stimulus simulation, the stimulus dissipates and GDP consequently returns to its original level. In the baseline simulation, GDP per capita first increases before then falling as the labour force expands, initially in terms of a growing number of low-skilled workers. Over time it then reverts to its starting level as the pattern adapts to the original qualification structure (see also section 3 as well as Figure A.2 in the annex). Since the population in the pure stimulus simulation remains the same, GDP and per capita GDP move in the same direction here.

Developments in the labour market are depicted in Figure 3. In the case of the stimulus simulation, the effects are as one would expect. The need to raise production pushes up labour input and brings unemployment down, causing wages to rise. As the stimulus dissipates, the system returns to equilibrium. However, wages respond fairly sluggishly on account of the wage adjustment costs. In the simulation entailing a permanent increase in the size of the population and the immediate onset of the original demographic structure, the unemployment rate rises because the labour supply is "suddenly" broadened. The average *per capita* length of employment decreases because more individuals are out of work, causing wages to fall (comparatively rapidly) during the adjustment process, leading to higher demand for labour. However, owing to wage adjustment costs, it takes more than 5 years (20 quarters) for the labour market to return to a state of equilibrium.

The baseline scenario set out in section 2.2 in which refugees successively migrate to the labour market then amounts to a blend of the two scenarios described earlier. At first, it is the stimulus effect that dominates (to a slight degree), but this is subsequently supplanted by the effect of population growth. The initial wage effects are weaker here than in the pure stimulus simulation as wage negotiations, in particular, are conducted in a forward-looking manner and the economic actors anticipate population growth (as well as the new long-term equilibrium). In the case of highly and medium-skilled households, no wage losses occur along the entire transition path because refugees do not compete with these households until the increase in GDP has reached a level that prohibits employers from any longer threatening to do away with these employees' jobs during the wage negotiation process in a significant manner as they are dependent on these workers' productive labour input.

The *per capita* consumption growth of medium and low-skilled households is determined by the way in which the labour market evolves (see Figure 2 for details of consumption and Figure 3 for labour market trends). In line with wage and employment developments, *per capita* consumption of both the aforementioned groups thus goes up at first before dipping below the baseline slightly over time so as to return to its original level (see also Figure A.3 in the annex) for low-skilled employees.

Figure 2: Macro developments over the first 10 years

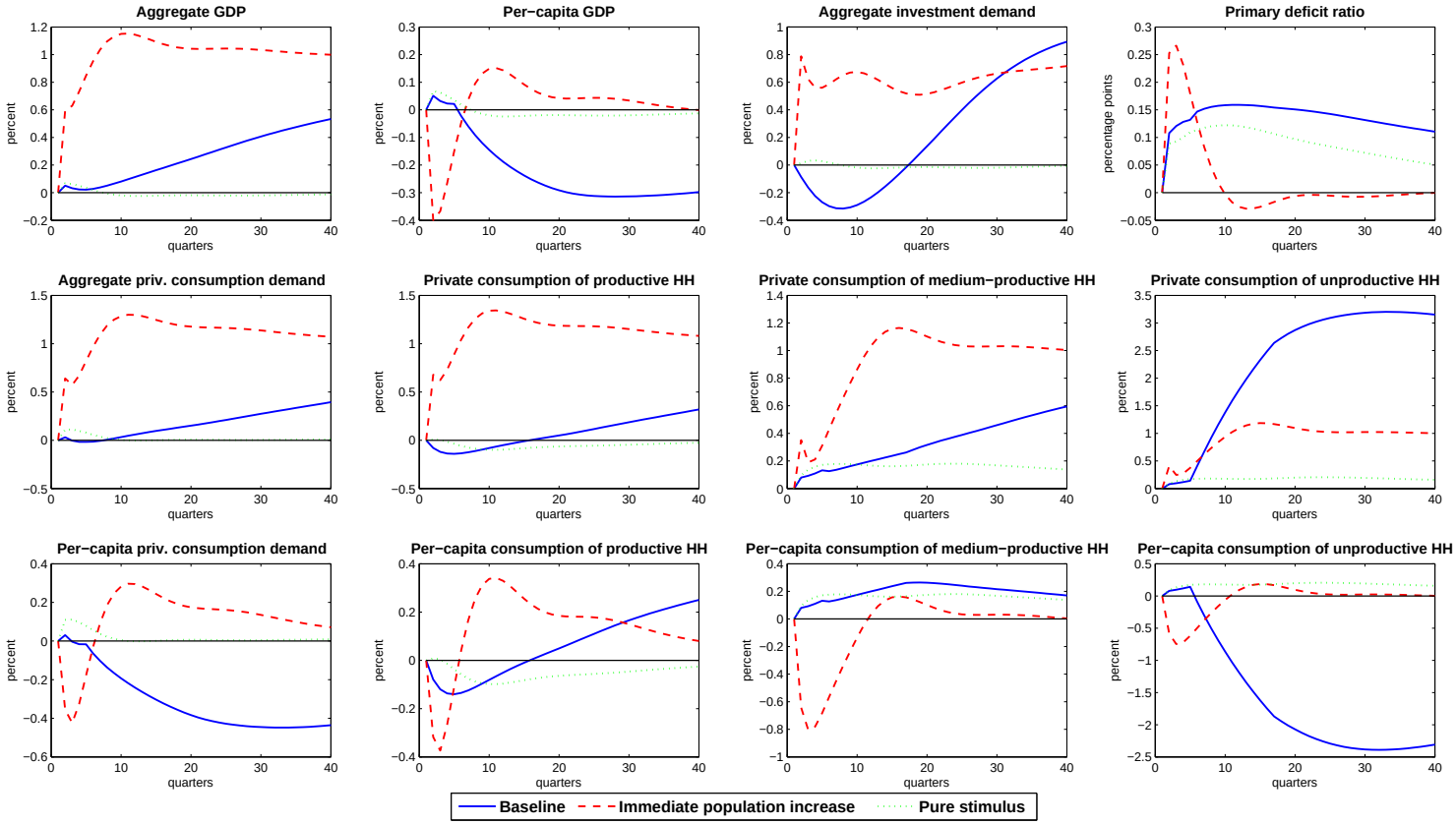
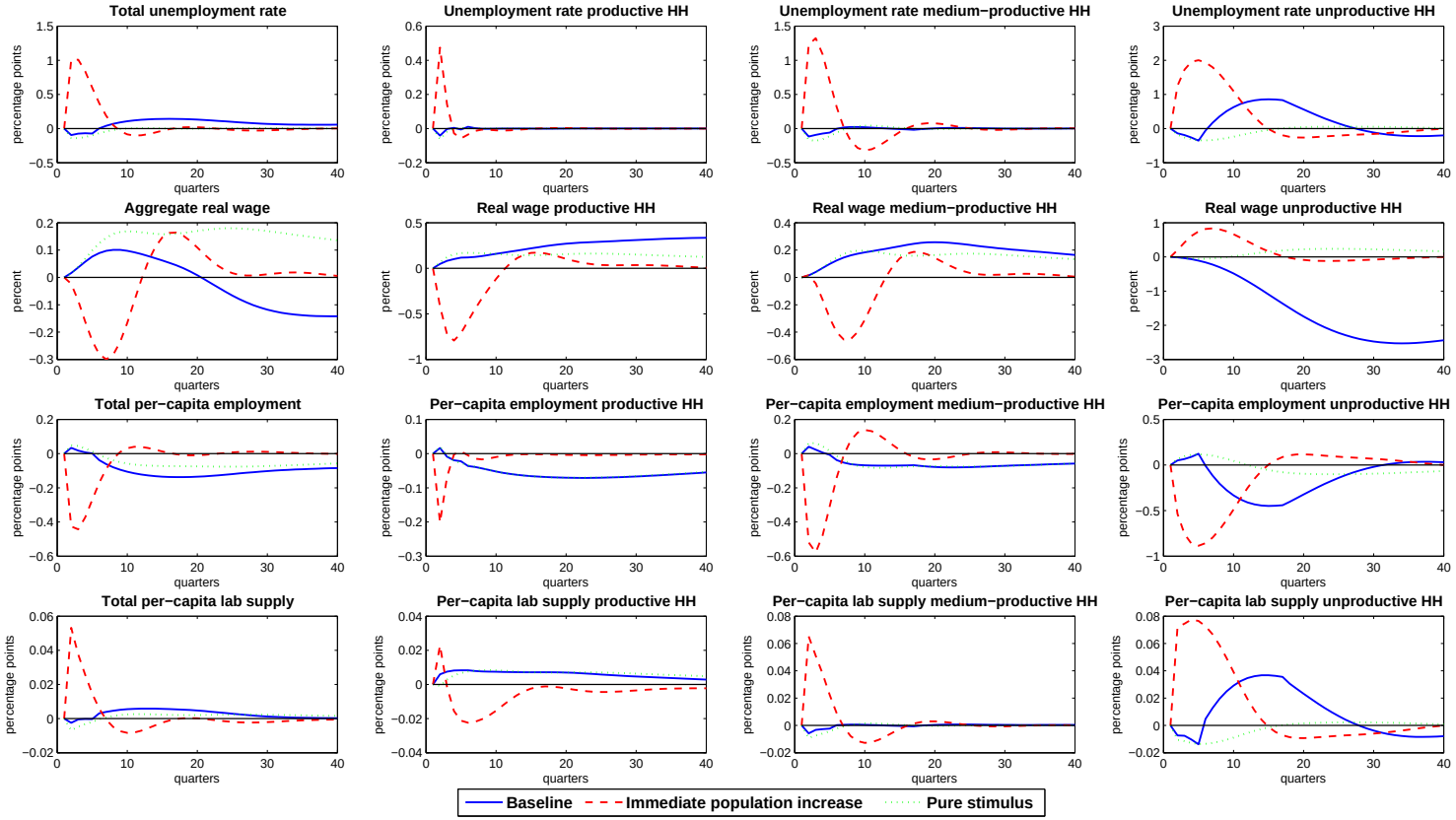


Figure 3: Labour market developments over the first 10 years



In the case of both these groups aggregate consumption is more than offset in the medium term by the accompanying population increase. Aside from the relevance of direct wage developments, highly-skilled/optimising households also anticipate the long-term loss of income that results from a slightly reduced employment rate together with lower wages and from lower per capita profit distributions alongside higher lump-sum taxes (in each case in the new steady state; see section 3) and are already scaling back their consumption accordingly in line with the permanent income hypothesis. The *per capita* consumption of these households only rises when wages themselves rise by a significant enough margin. When calculating aggregate consumption, it is also necessary to consider the corresponding demographics of the group in question. Aggregate macroeconomic consumption increases immediately because, for one thing, the short-term consumption losses incurred by highly-skilled households is more than offset by increased consumption on the part of medium-skilled and unskilled households, and for another, additional private consumption demand is generated by households that previously did not exist. Since these households are, however, (low-income) transfer recipients whose level of consumption is therefore below average – and destined to remain so on account of the assumed demographic trend – *per capita* private consumption demand initially declines in the baseline scenario before rising again (the consumption demand of transfer recipients is not explicitly shown as per capita consumption of this group is fixed to transfers).

5 Conclusions

Refugee migration, its repercussions, and the manner in which these two issues are being addressed remain at the forefront of political discourse in Germany to this day. While some aspects of this topic are not related to economics, it is important to assess the potential macroeconomic consequences and, thus, the potential costs and benefits for domestic agents. This paper adds to the literature by simulating various scenarios and their economic impacts with the aid of a New Keynesian DSGE model.

In summary, this paper finds that measures that cause the migrant qualification structure to closely match that of the native population over the long term do not lead to GDP and consumption losses, yet partial or total failure to close the skills gap can very well have negative economic consequences. A failure to integrate migrants could reduce *per capita* output and consumption by 0.38% and 0.43%, respectively, while integration measures that improve the qualification structure in Germany could even yield *per capita* output and consumption gains of 0.32% and 0.38%, respectively.

The present paper adds to the debate by explicitly taking into account short and long-term effects and identifying what should be interpreted in the debate as "stimulus" and as a structural effect of refugee migration, besides showing how short and long-term factors interact with one another. However, it is not providing concrete guidance on how good integration can be a success. This, however, is a topic that should be addressed further by future research.

Appendix

In this appendix, we fill first show the adjustments over the entire transition path in the baseline scenario before showing transitional dynamics if refugees remain i) low-skilled, ii) become only medium-skilled or iii) all become highly skilled. Then, we will focus on the model description and calibration.

A.1 Developments via entire adjustment path in baseline scenario

In this section of the appendix, we show the entire transition path of the baseline scenario from the old to the new steady state after refugee migration. The figures are analogous to Figures 1 to 3 in the main text, and so is their description.

Figure A.1: Population growth via adjustment path

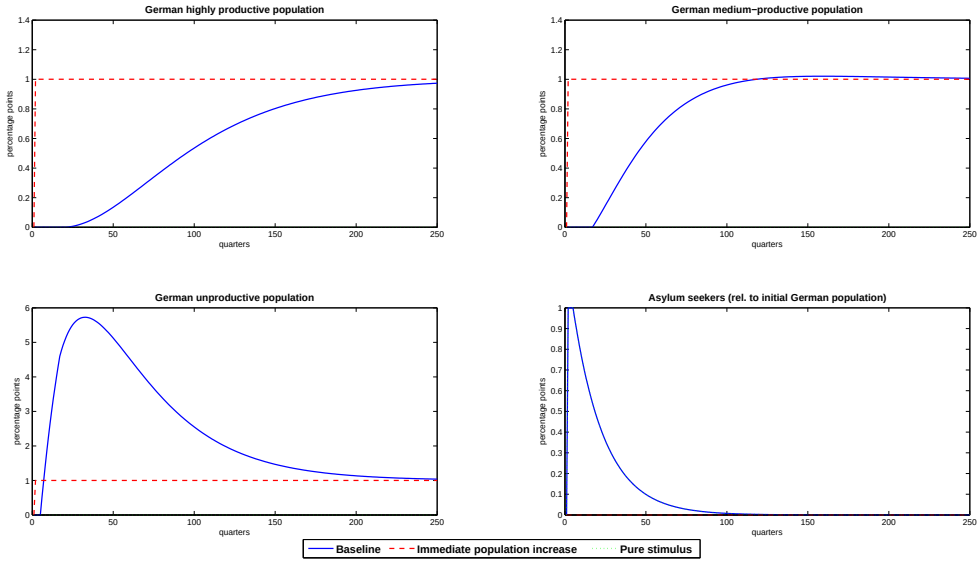


Figure A.2: Macro developments via adjustment path

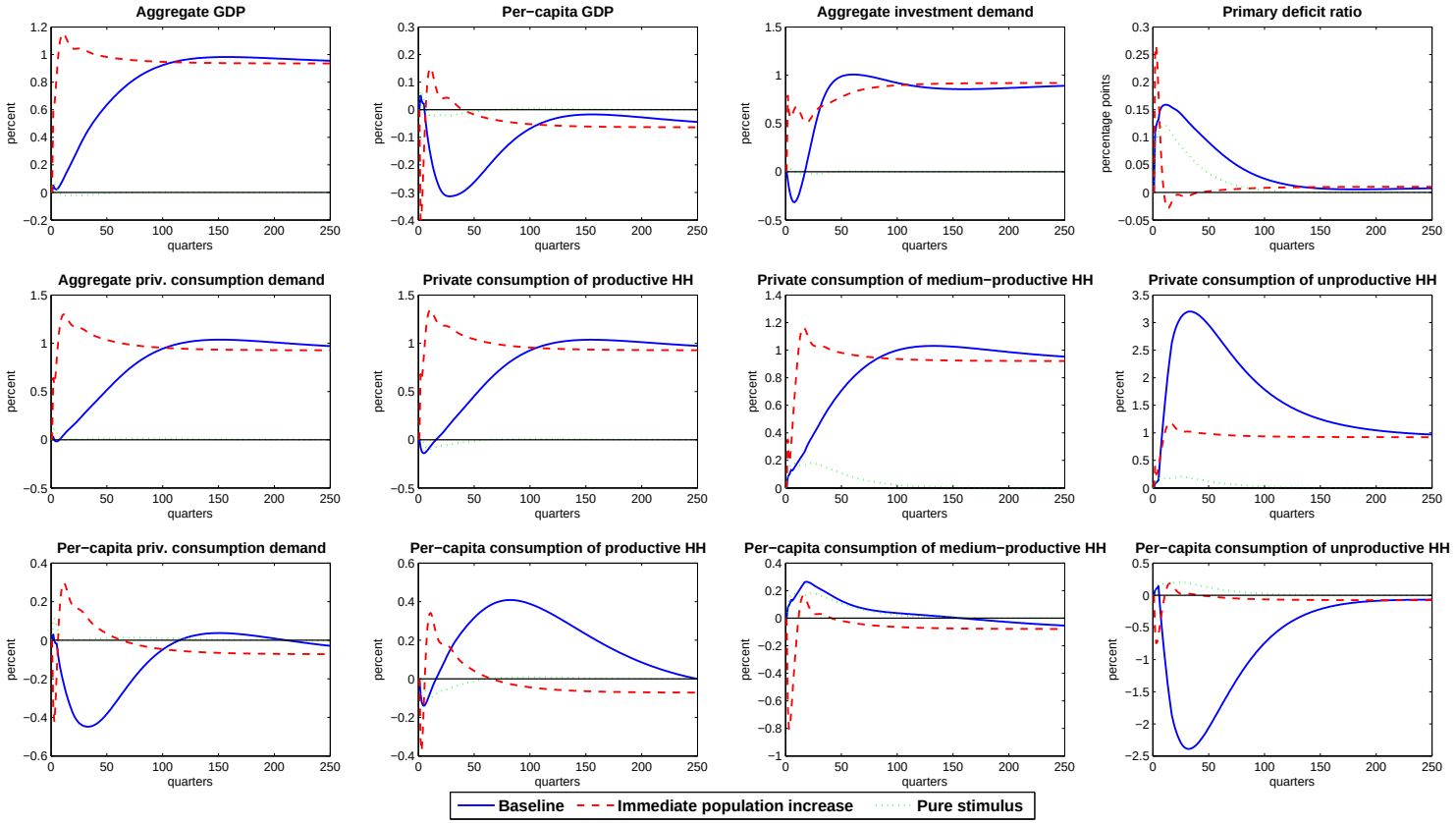
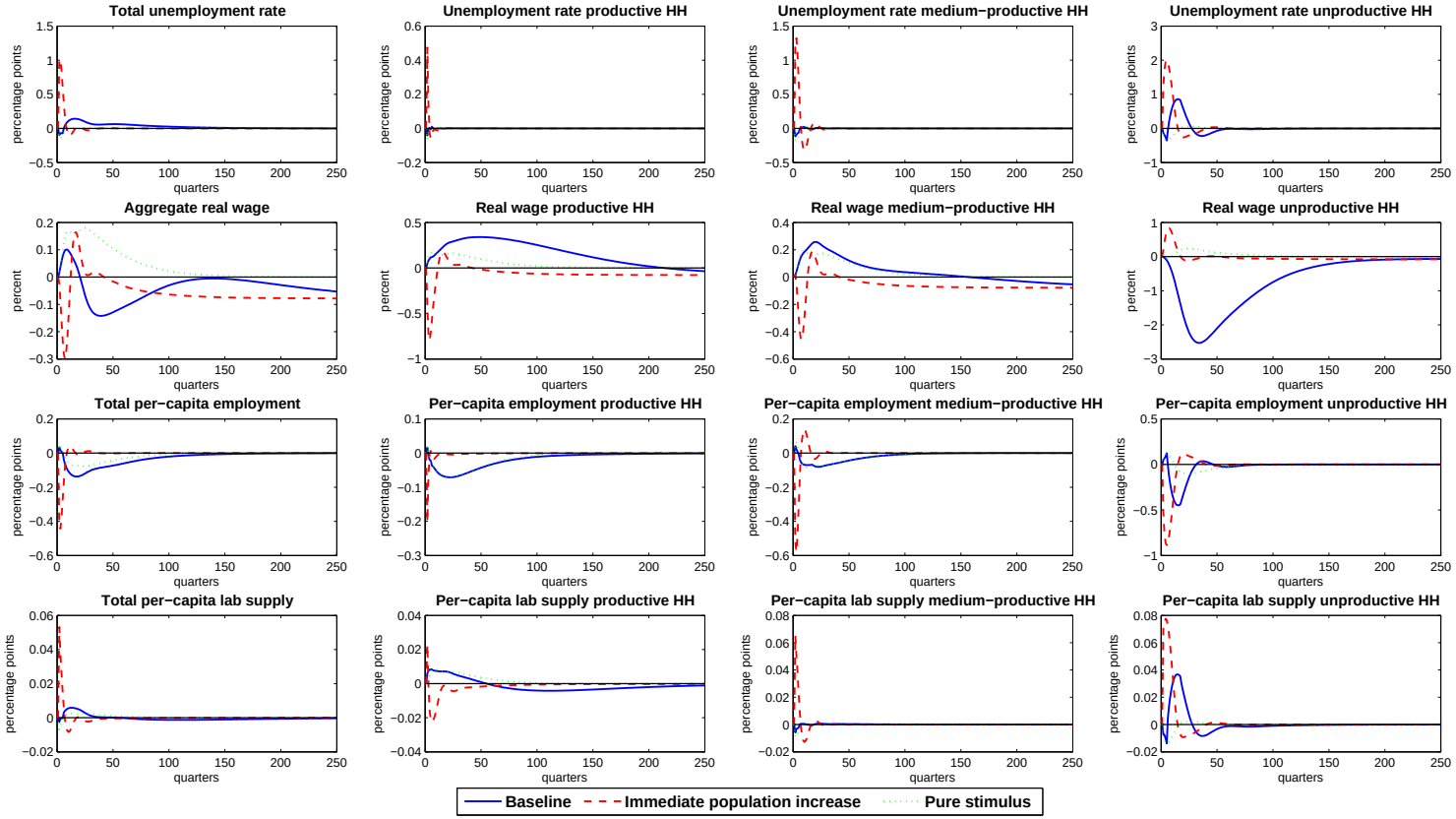


Figure A.3: Labour market developments via adjustment path



A.2 Transition if all immigrants remain low-skilled

Figure A.4: Population growth over the first 10 years

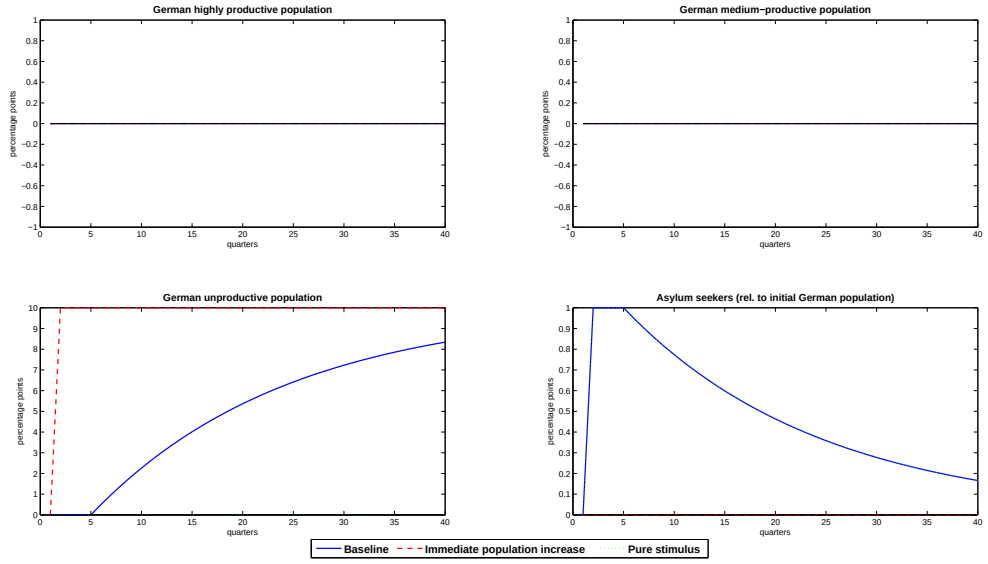


Figure A.5: Population growth via adjustment path

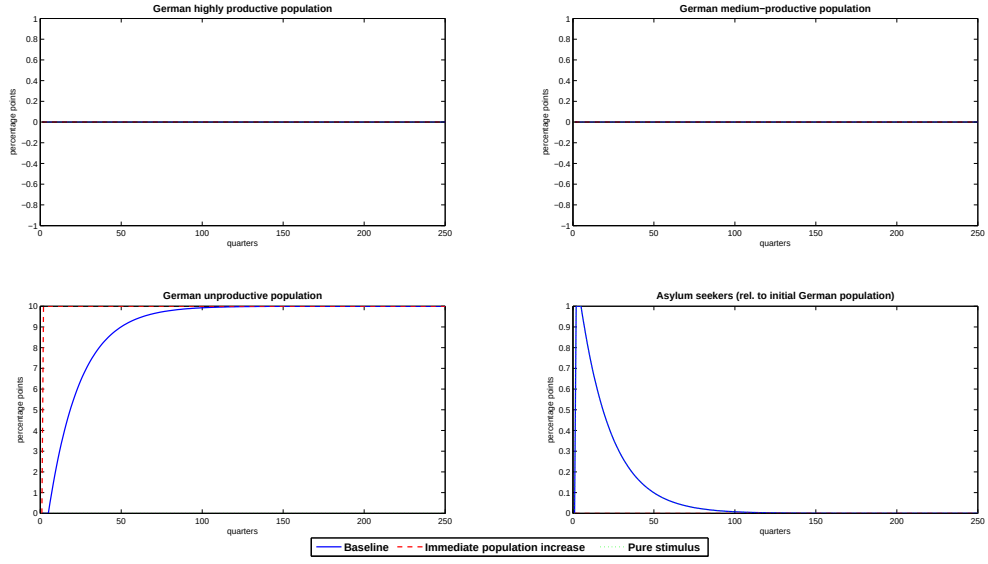


Figure A.6: Macro developments over the first 10 years

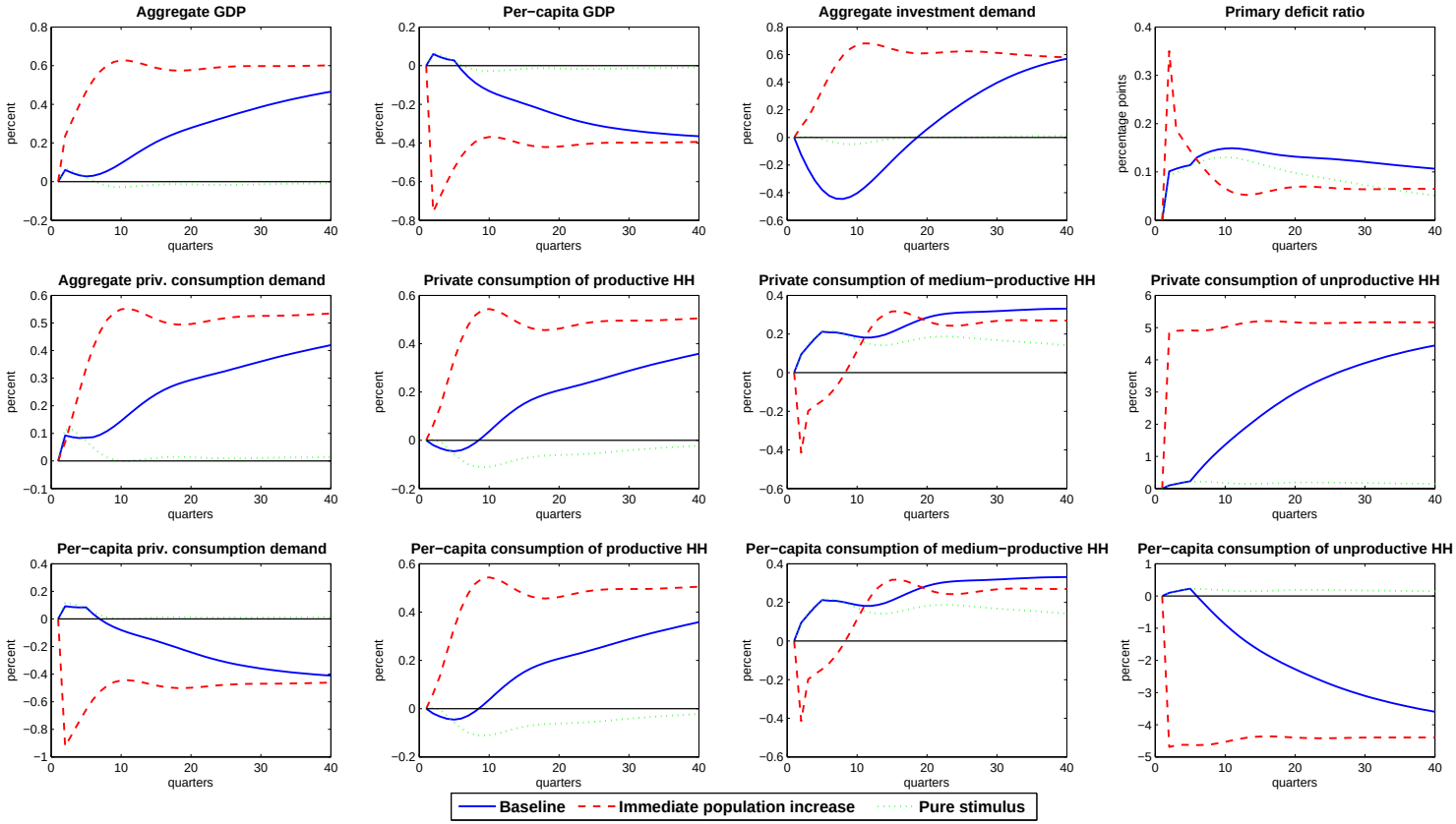


Figure A.7: Macro developments via adjustment path

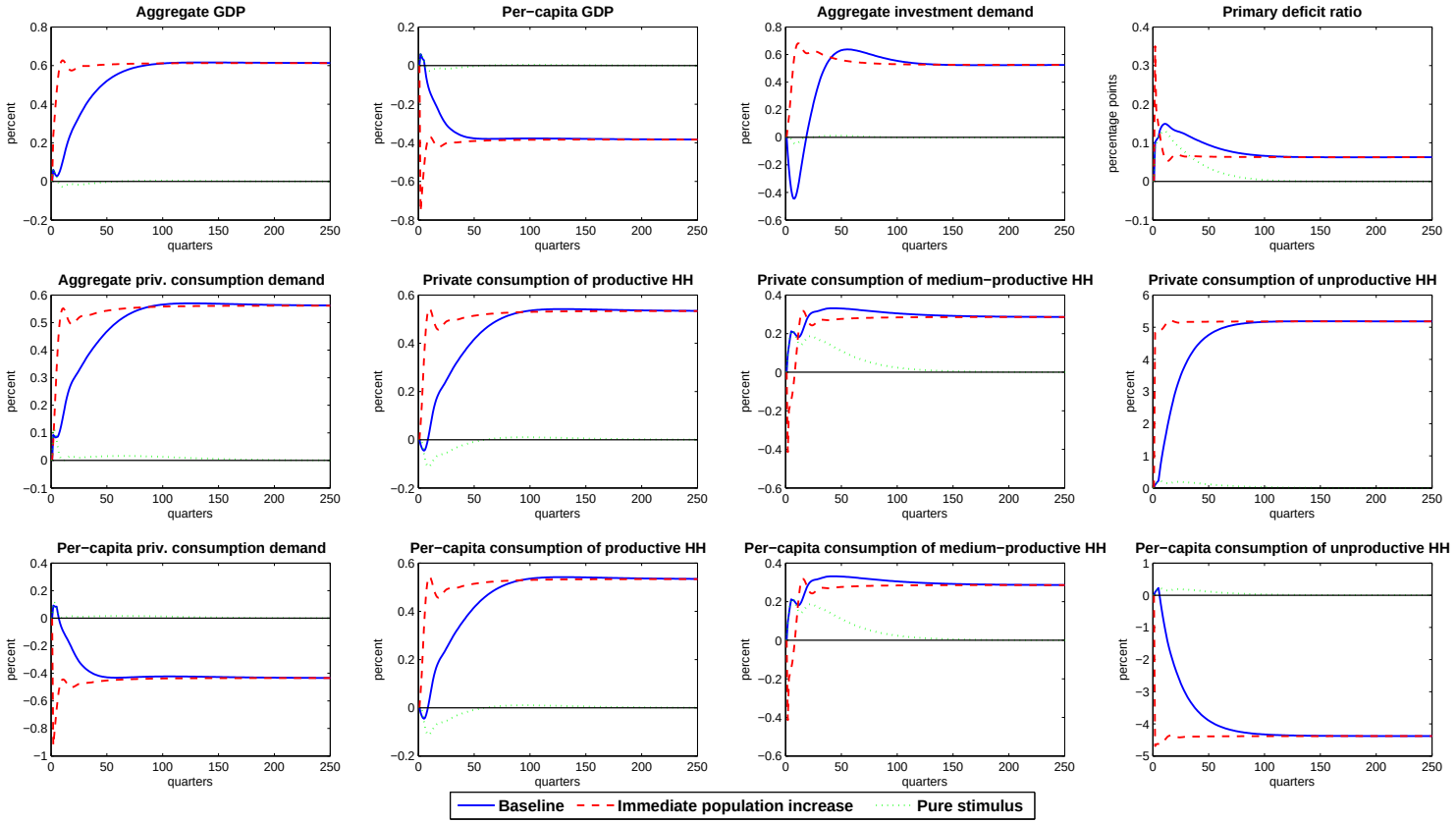


Figure A.8: Labour market developments over the first 10 years

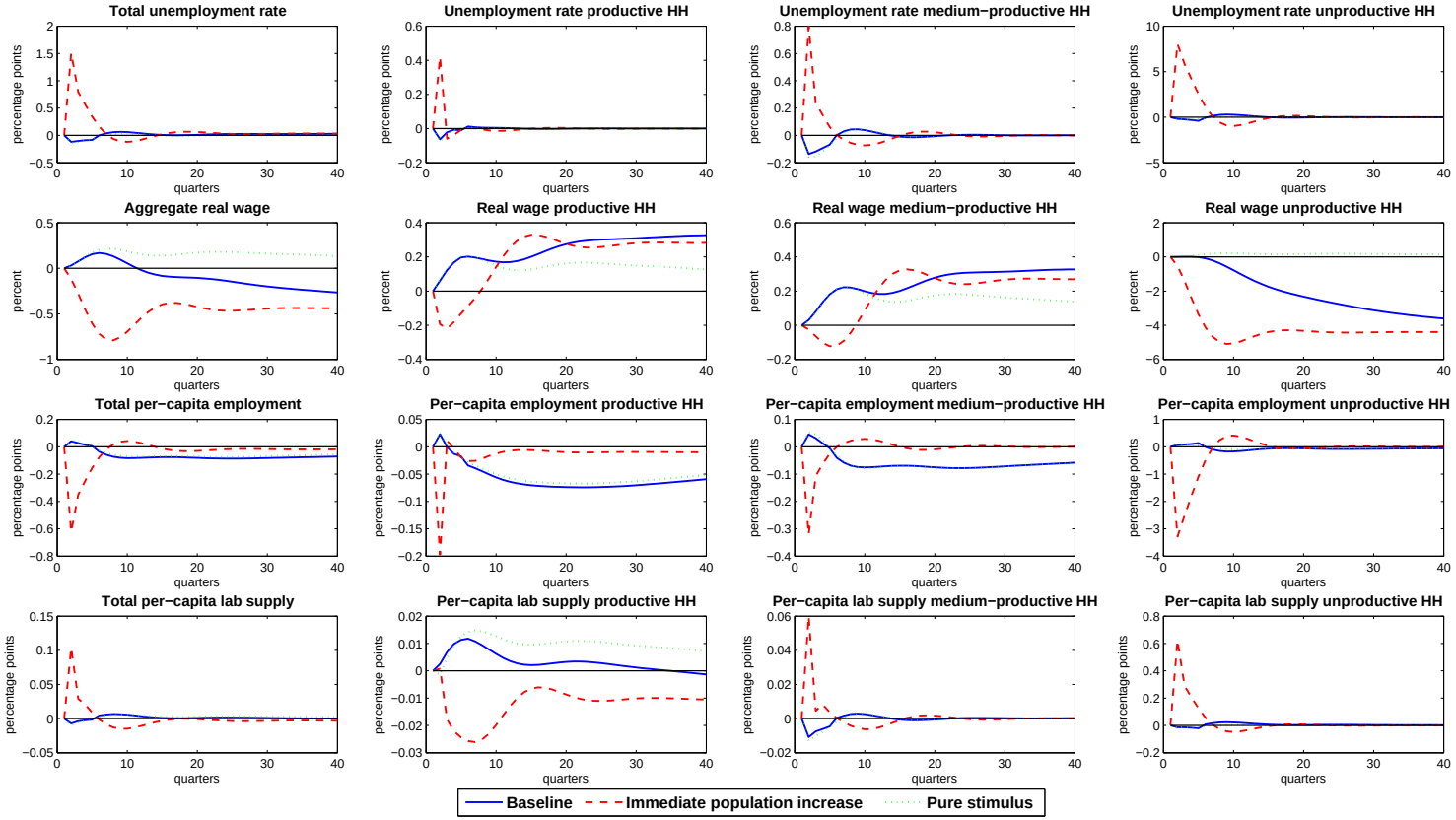
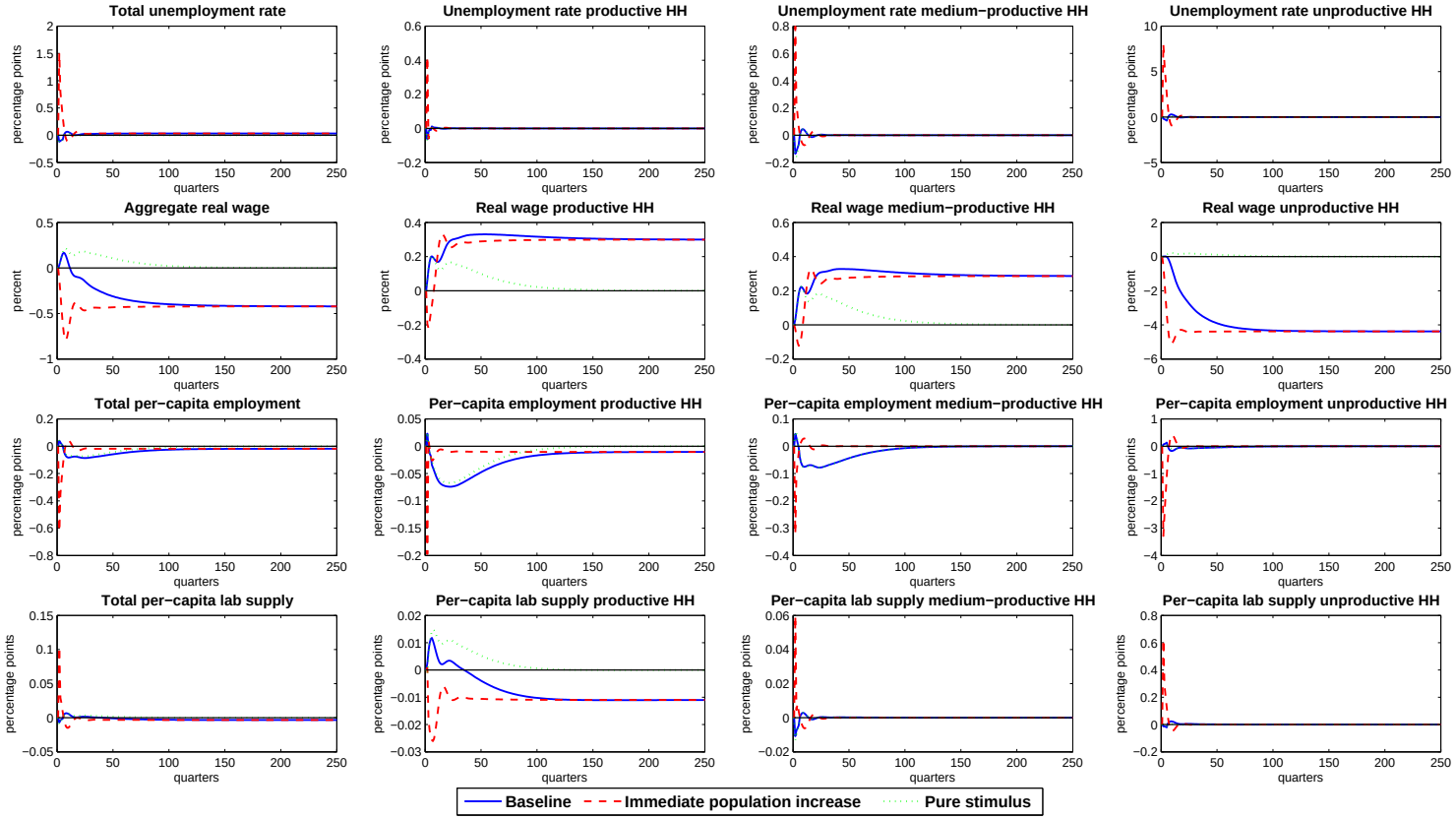


Figure A.9: Labour market developments via adjustment path



A.3 Transition if all immigrants become medium-skilled

Figure A.10: Population growth over the first 10 years

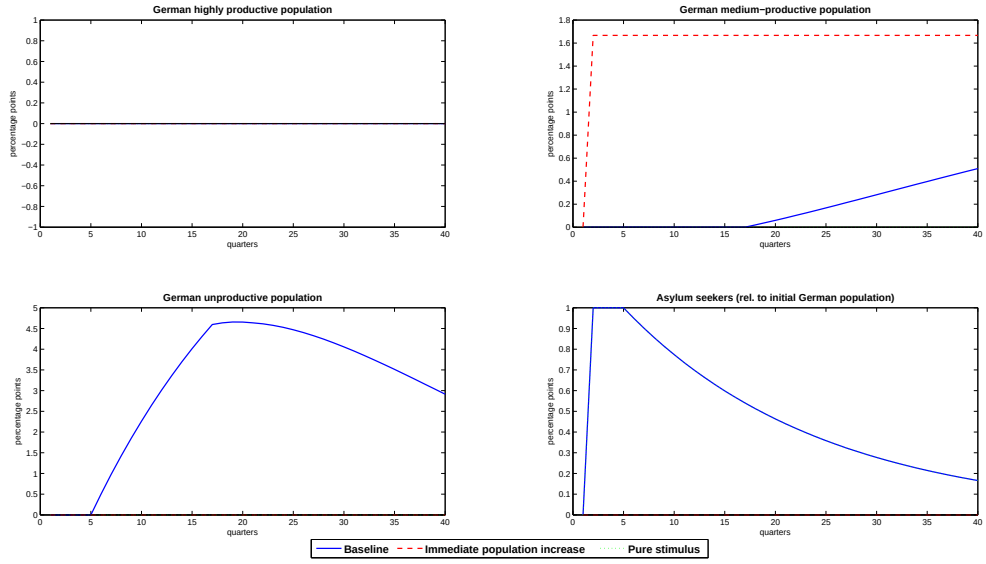


Figure A.11: Population growth via adjustment path

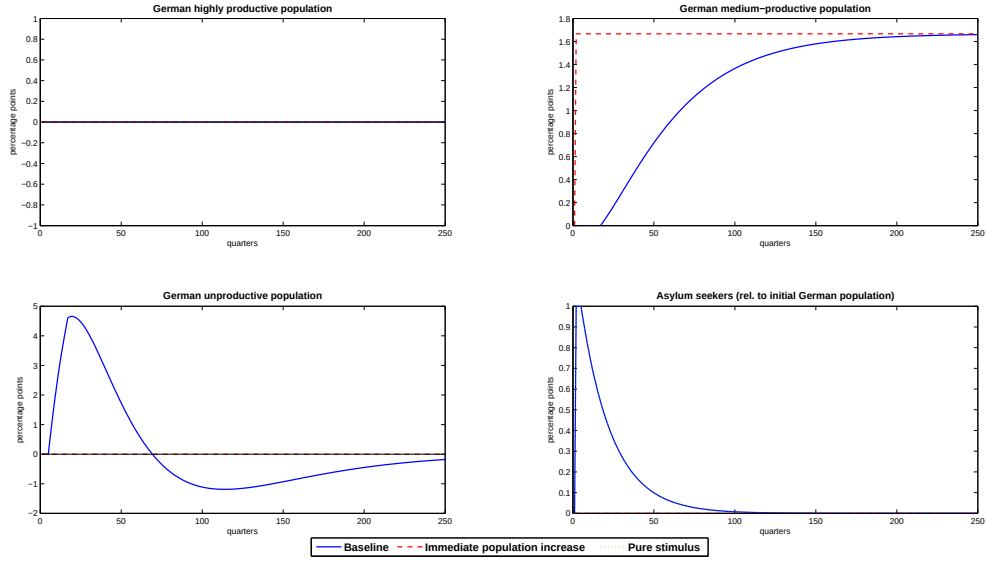


Figure A.12: Macro developments over the first 10 years

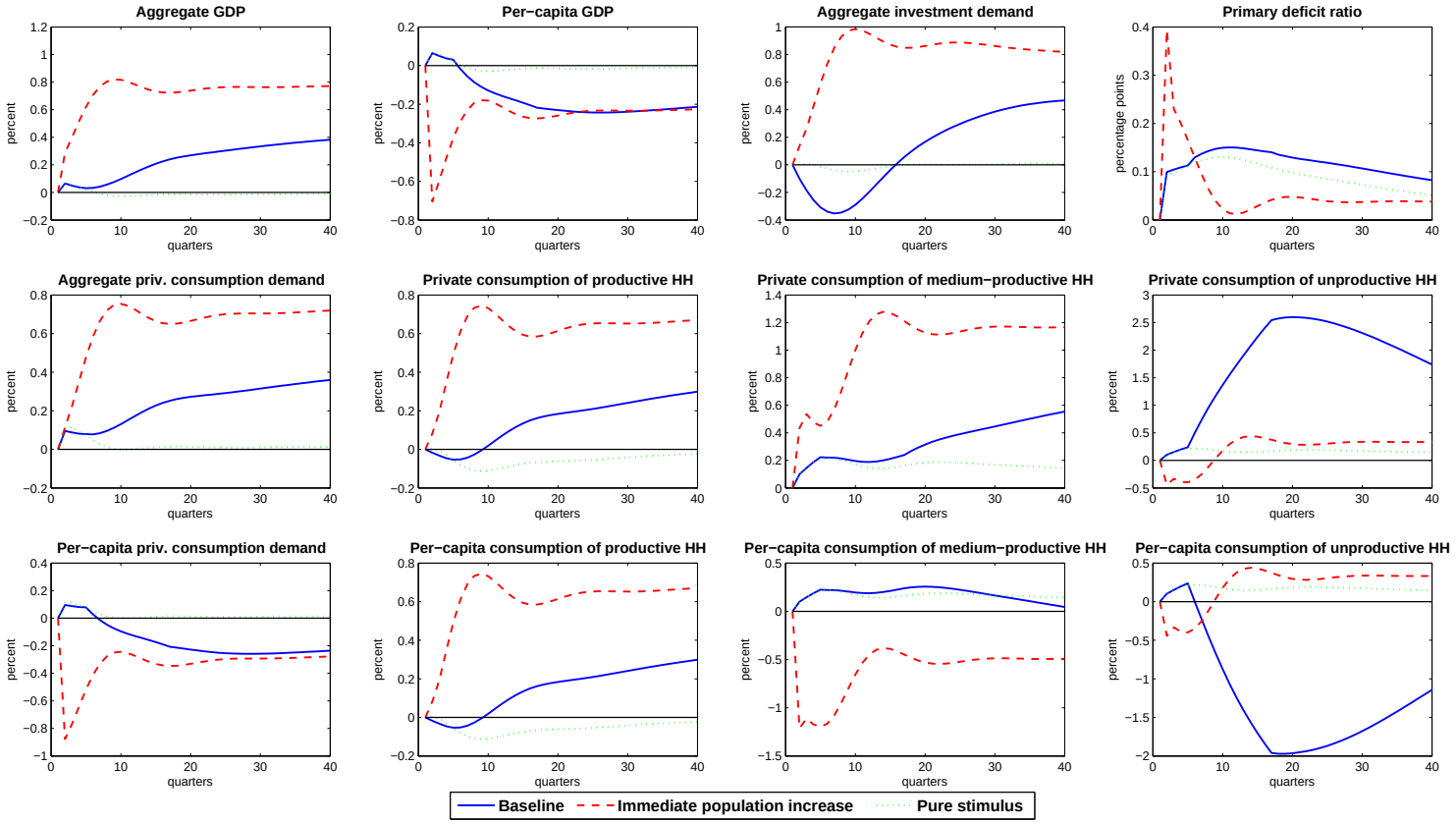


Figure A.13: Macro developments via adjustment path

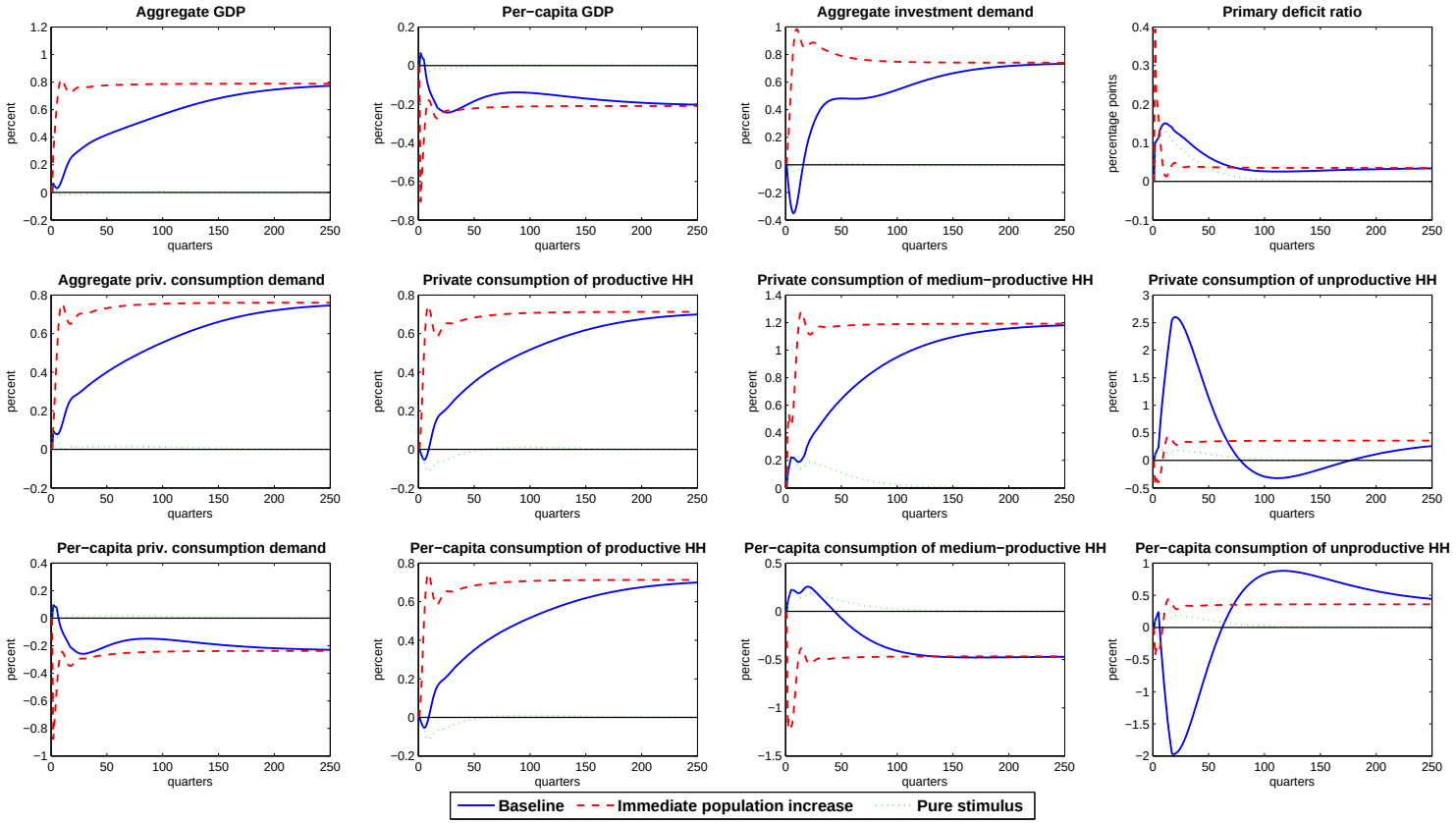


Figure A.14: Labour market developments over the first 10 years

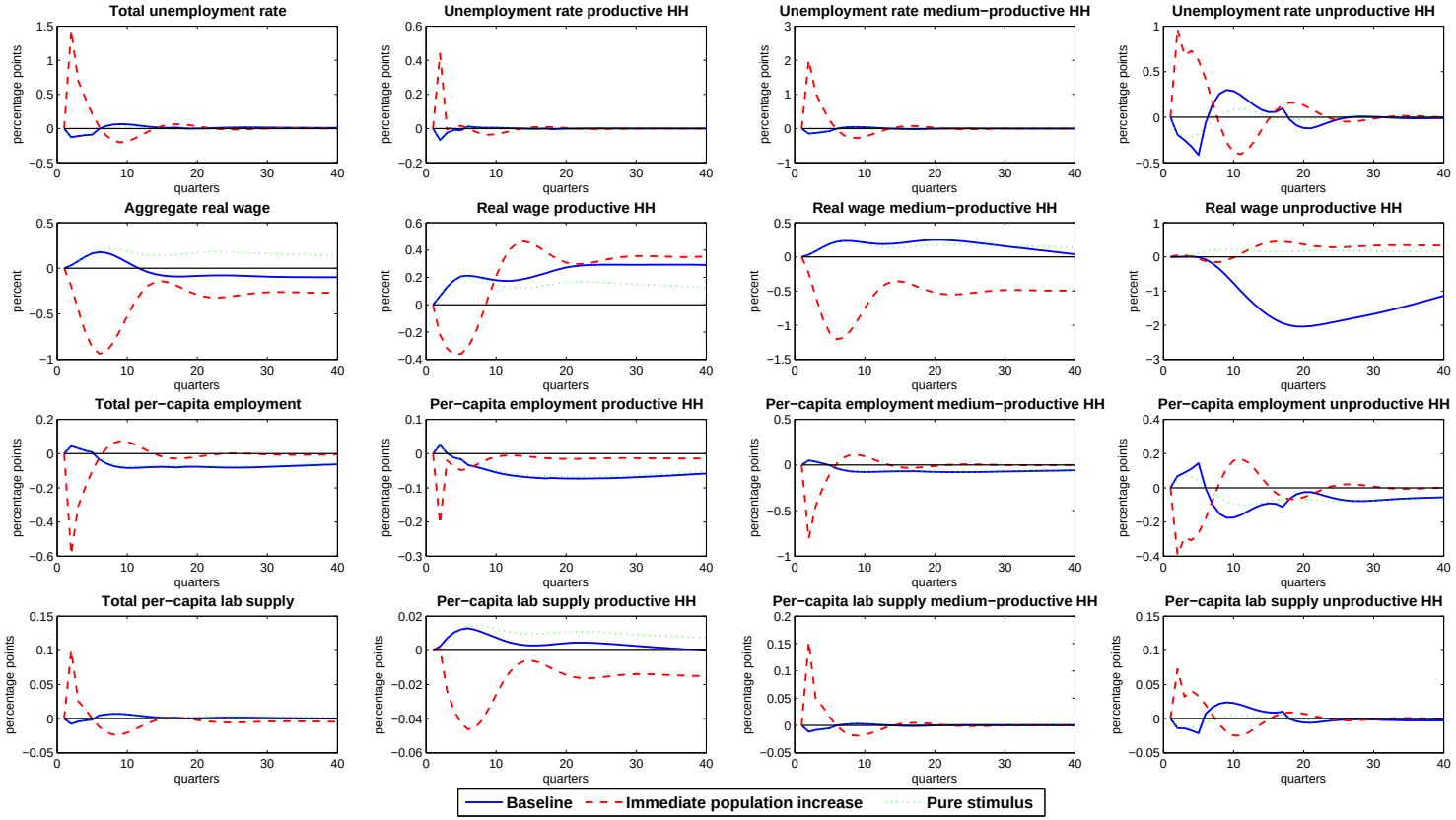
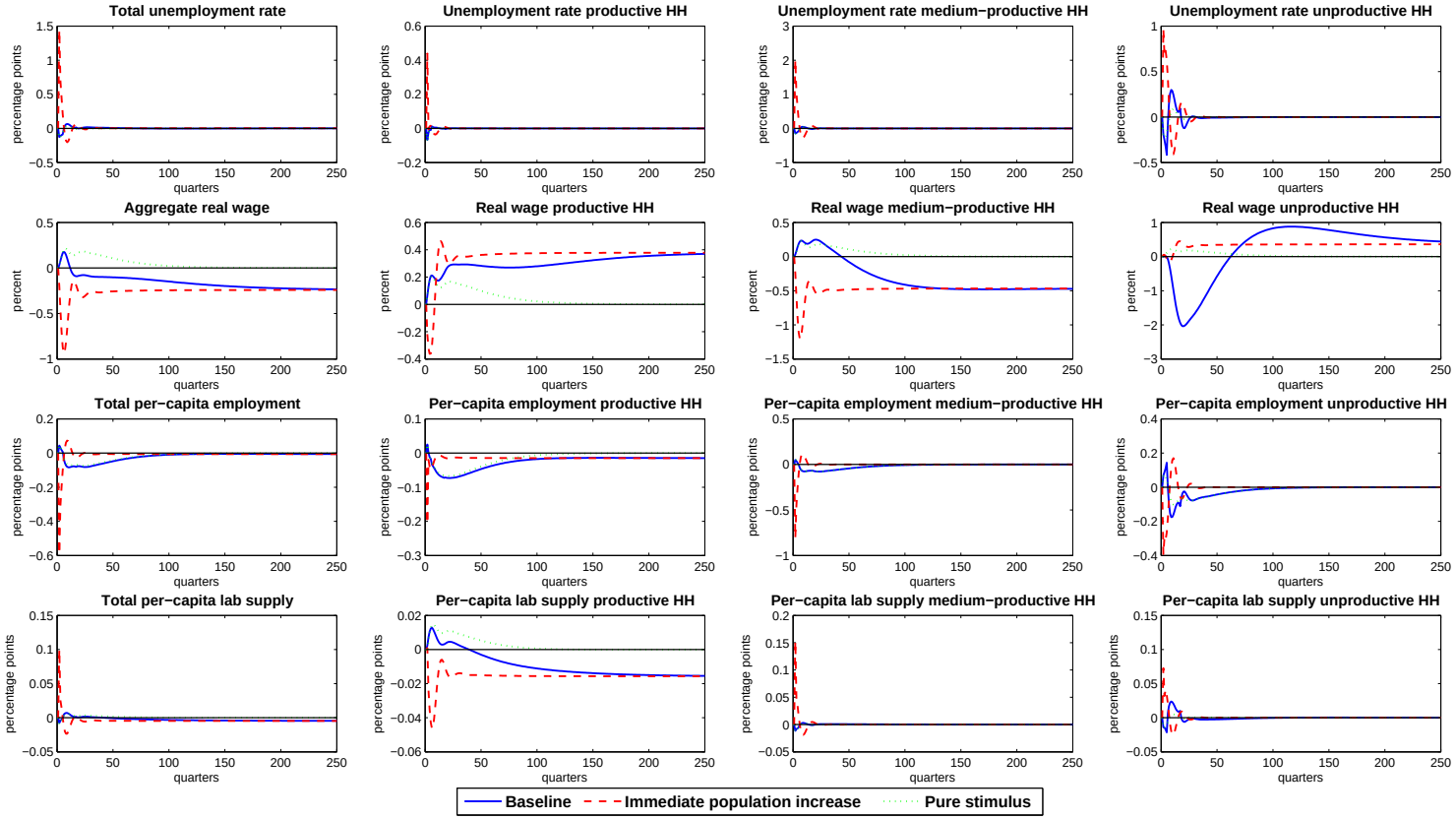


Figure A.15: Labour market developments via adjustment path



A.4 Transition if all immigrants become highly skilled

Figure A.16: Population growth over the first 10 years

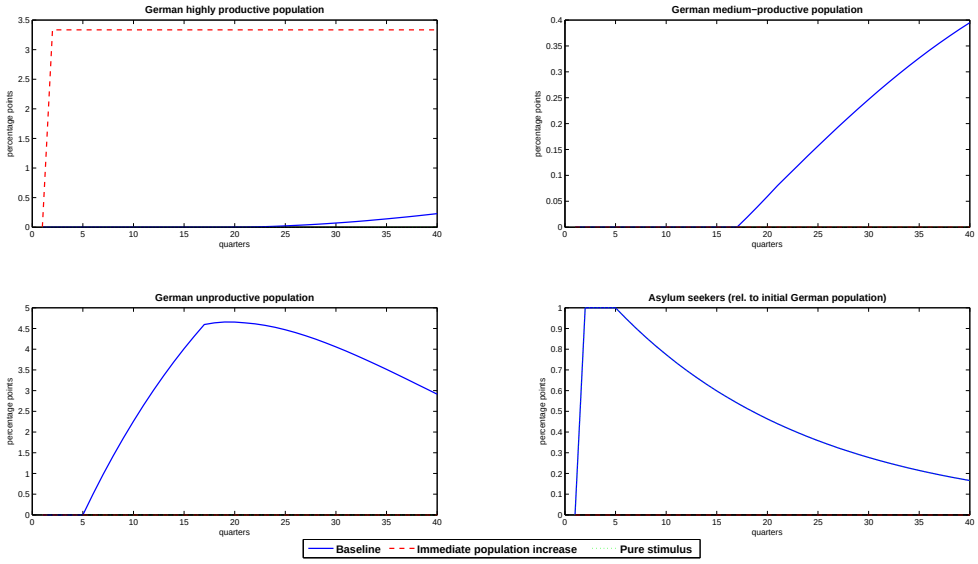


Figure A.17: Population growth via adjustment path

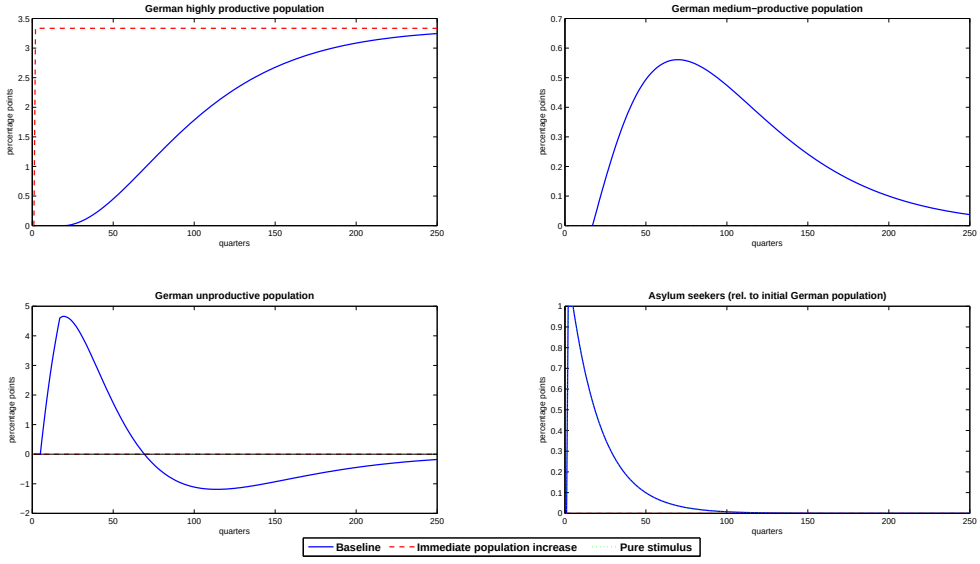


Figure A.18: Macro developments over the first 10 years

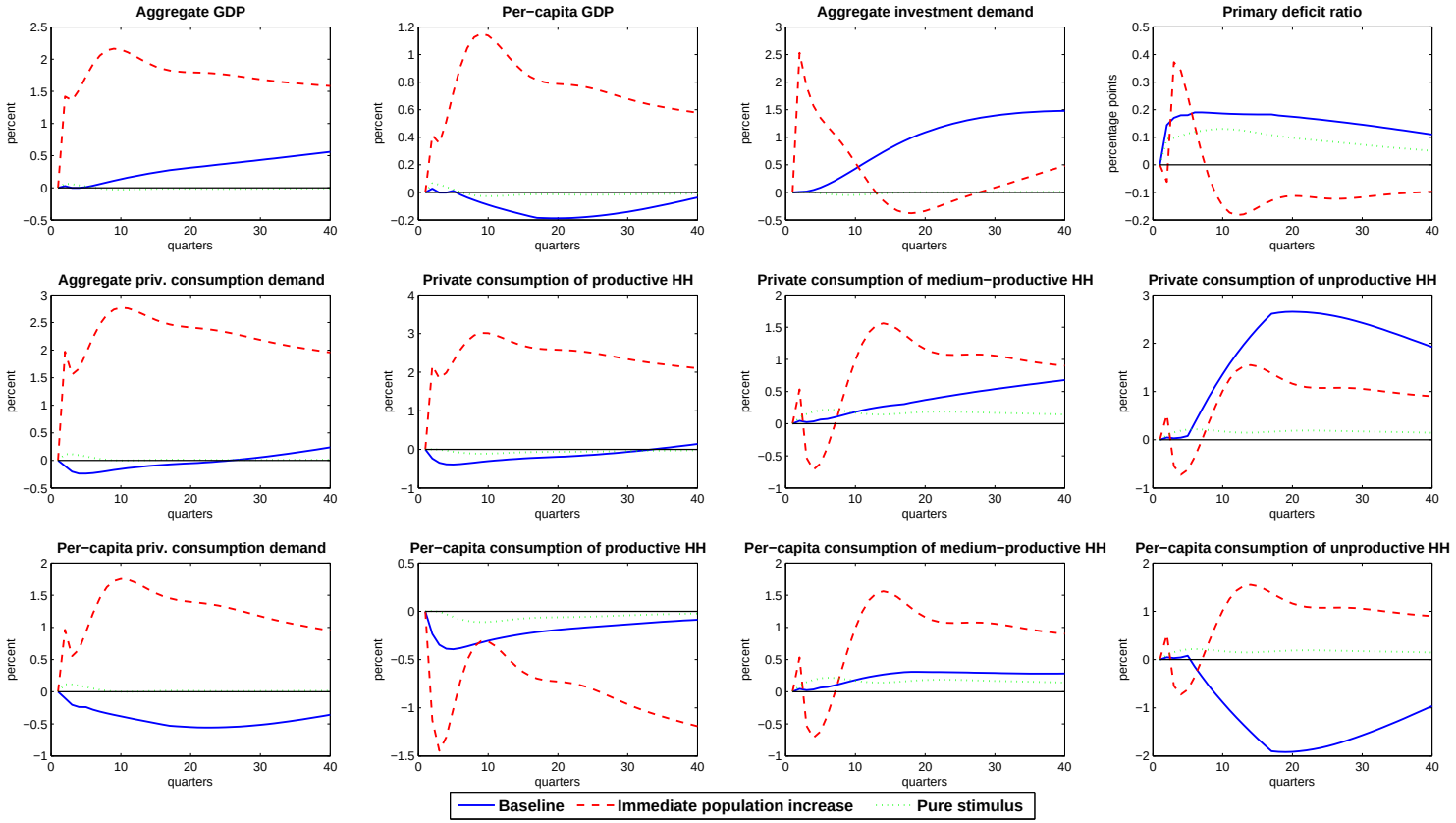


Figure A.19: Macro developments via adjustment path

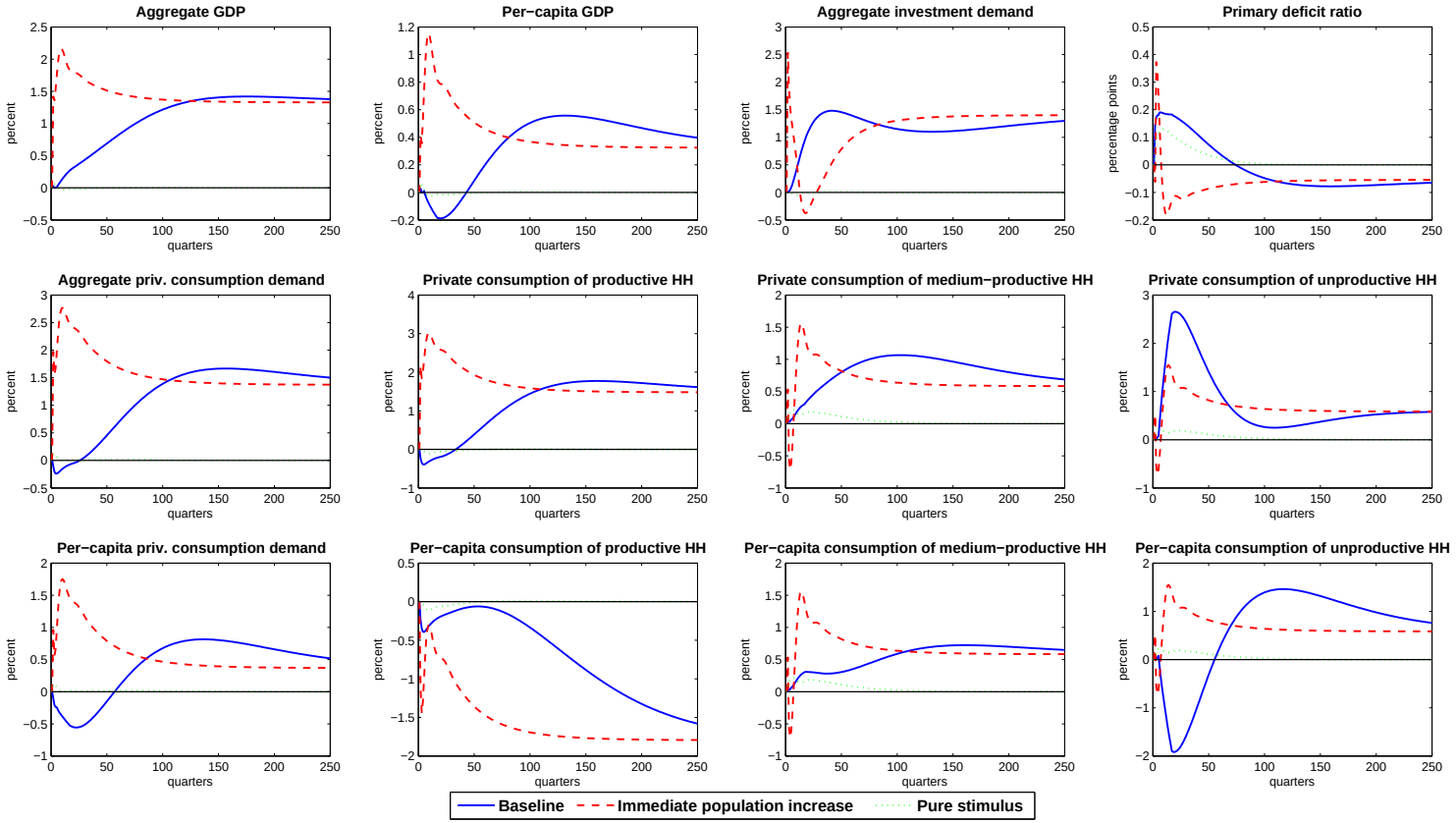


Figure A.20: Labour market developments over the first 10 years

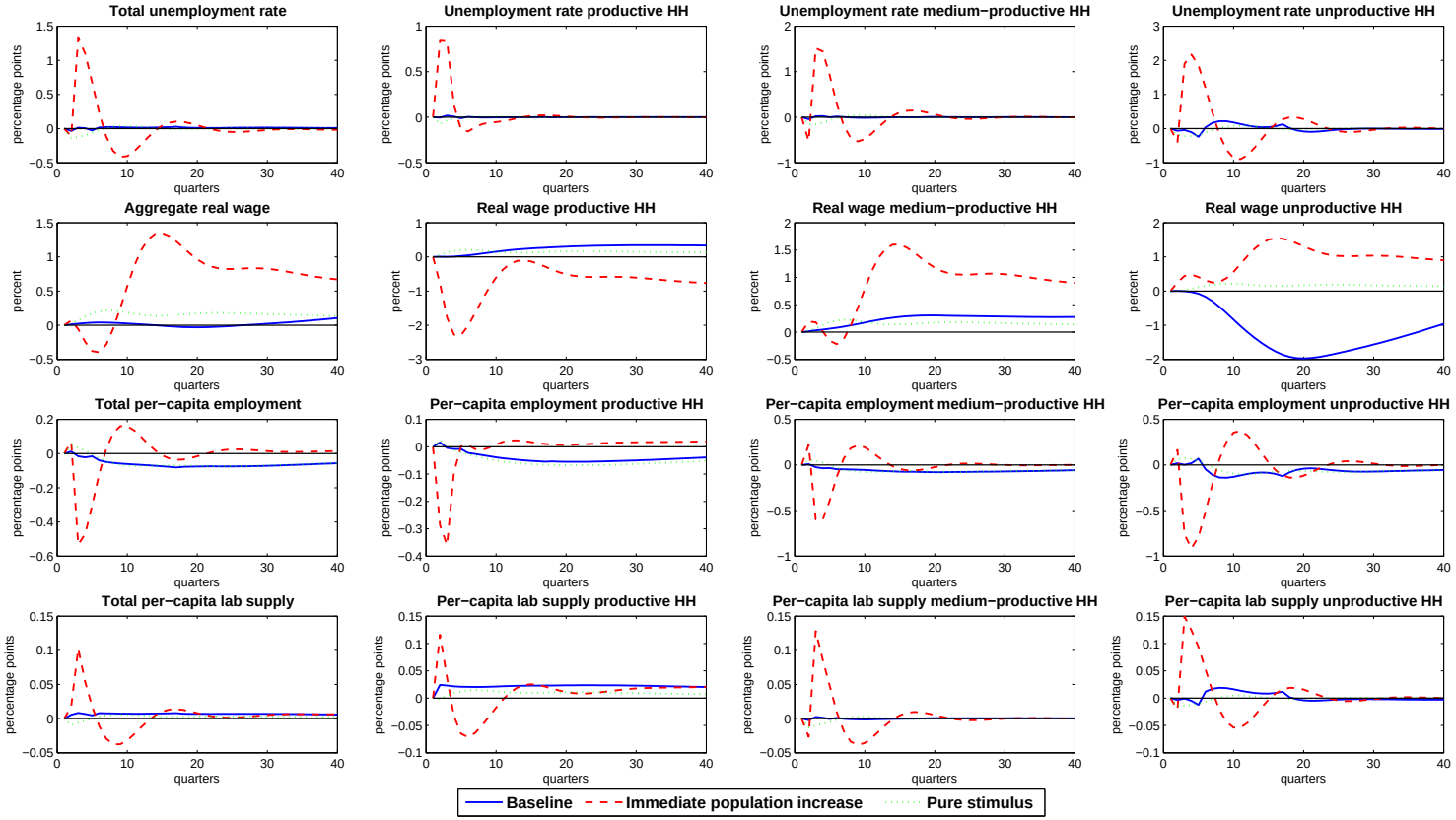
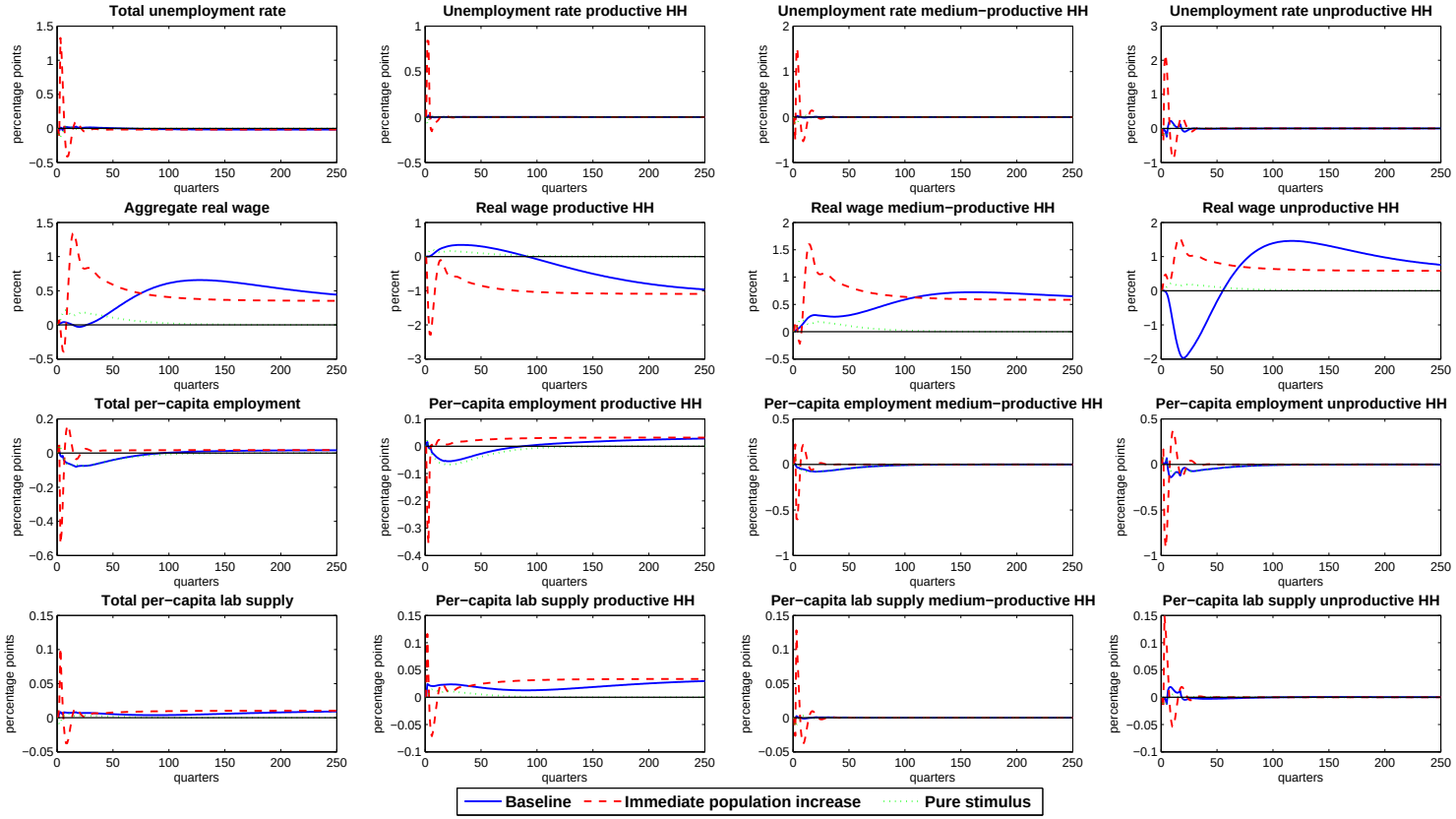


Figure A.21: Labour market developments via adjustment path



B.1 Model description and calibration

In this section, we provide a more detailed description of the model, which is, in principle, a shortened repetition of the model description provided by Gadatsch et al (2016) including the modifications necessary for the simulations in the present paper. Note that we omit the description of shocks because they are not relevant for the analysis at hand.

We assume that the world consists of three regions, two of them member of the European Monetary Union (EMU). The third region, representing the rest of the world, is modelled as a three-equation VAR. Without loss of generality, we index country-a agents in the interval $[0, \mathcal{P}_t^a]$, where $\bar{\mathcal{P}}^a = 1$ in the initial steady state, country-b agents in $[0, \mathcal{P}^b]$ and country-c agents in $[0, \mathcal{P}^c]$. Hence, $\mathcal{P}^j$, with $j = b, c$, is the initial steady-state size of country j relative to country a. We will continue by presenting the necessary equations for country a(=Germany), where our model modifications come in.

Firms: In each country, there is a measure-$\mathcal{P}_t^i$, with $i = a, b, c$, continuum of firms in the final goods sector. Firms are owned by optimising households. Each final goods producer purchases a variety of differentiated intermediate goods, bundles these and sells them to the final consumer under perfect competition. The producer price index (PPI) of goods produced in country i and sold in j is defined as $P_t^{i,j}$. We assume that the law of one price holds across regions, so firms in country a set their price $P_t^{a,a}$ for all markets. Multiplying with the nominal exchange rate, then, yields the price of country-a goods charged in the other countries, that is $P_t^{b,a} = S_t^{b,a} P_t^{a,a}$ and $P_t^{c,a} = S_t^{c,a} P_t^{a,a}$, where the nominal exchange rate $S_t^{j,a}$ is defined as country j currency per unit of country-a currency. Clearly, $S_t^{j,a}$ is one within the monetary union. The maximization problem of the representative final goods firm reads

$$\max_{\{\tilde{y}_t^a(z):z\in[0,\mathcal{P}_t^a]\}} P_t^{a,a} Y_t^a - \int_0^{\mathcal{P}_t^a} P_t^{a,a}(z)\tilde{y}_t^a(z)dz, \tag{B.1}$$

where $Y_t^a = \left(\int_0^{\mathcal{P}_t^a} \tilde{y}_t^a(z)^{(\theta_a-1)/\theta_a} dz\right)^{\theta_a/(\theta_a-1)}$ is the production function, $\tilde{y}_t^a(z)$ his demand for each differentiated input good z and $P_t^{a,a}(z)$ the price of each input. θ_a is the elasticity of substitution between differentiated goods. The first-order condition of the maximization problem yields $\tilde{y}_t^a(z) = \left(P_t^{a,a}(z)/P_t^{a,a}\right)^{-\theta_a} Y_t^a$, which implies that the PPI of country a is given by $P_t^{a,a} = \left(\int_0^{\mathcal{P}_t^a} P_t^{a,a}(z)^{1-\theta_{a,t}} dz\right)^{1/(1-\theta_a)}$.

Private intermediate goods firms on the continuum $z \in [0, \mathcal{P}_t^a]$ operate as monopolistic competitors in the product market. Each firm produces its intermediate good variety with the Cobb-Douglas production function presented in the main text, equation (1). Note that, here, we deviate from the original model provided in Gadatsch et al (2016). Taking into account that the capital-to-labour ratio is common to all firms in equilibrium, this yields equations (3) and (4) of the main text, from which we can also derive real marginal costs mc_t^a.

Each intermediate goods producer sets its own price $P_t^{a,a}(z)$ to maximize intertemporal profits: the difference between revenues and production as well as Rotemberg price adjustment costs, the latter indicated by a cost parameter γ_a. The maximization problem

in CPI-terms can be stated as

$$\max_{\{P^{a,a}_{t+s}(z):z\in[0,\mathcal{P}^a_t]\}} E_t \sum_{s=0}^{\infty} \beta_a^s \frac{\lambda^a_{h,t+s}}{\lambda^a_{h,t}} \left[\left(\frac{P^{a,a}_{t+s}(z)}{P^a_{t+s}} - mc^a_{t+s} \right) y^a_{t+s}(z) - adj_t^{P,a} Y^a_{t+s} \right] \tag{B.2}$$

subject to

$$adj_t^{P,a} = \frac{\gamma_a}{2} \left(\frac{P^{a,a}_{t+s}(z)}{\left(\pi^{a,a}{}_{t+s-1}\right)^{\xi_a} \left(\bar{\pi}^{a,a}\right)^{1-\xi_a} P^{a,a}_{t+s-1}(z)} - 1 \right)^2 \frac{P^{a,a}_{t+s}}{P^a_{t+s}}$$

and $y^a_t(z) = \tilde{y}^a_t(z) = \left(P^{a,a}_t(z)/P^{a,a}_t\right)^{-\theta_a} Y^a_t$. The parameter $\xi_a \in [0,1]$ determines the magnitude of price indexation on past inflation, $\pi^{a,a}{}_{t-1}$, or steady-state inflation, $\bar{\pi}^{a,a}$. Because optimisers own firms the intertemporal discount factor of a firm includes only the marginal utility of optimising, highly-skilled households, $\lambda^a_{h,t}$.

Households: As mentioned in the main text, we assume that the economy is populated by three types of representative households: highly, medium- and low-productive households, indexed by $x = h, m, l$. Only highly-skilled households save and borrow, such that the remaining population is assumed to be liquidity constrained as in Gali et al (2007). The corresponding population shares $\mu^{a,x}_t$ are given in the main text. Furthermore, following Gali et al (2011), household members are represented by the unit square and indexed by a pair $(\mathfrak{h}_x, \mathfrak{j}_x) \in [0,1] \times [0,1]$. Household members differ in the type of labour service they are specialized in, $\mathfrak{h}_x \in [0,1]$, and by their personal disutility of work, $\mathfrak{j}_x \in [0,1]$. The latter is given by $\kappa^w_{a,x} \cdot \mathfrak{j}_x^{\varphi_a}$ if employed and zero otherwise. $\kappa^w_{a,x} > 0$ is an exogenous labour disutility scaling parameter. $\varphi_a > 0$ determines the shape of the distribution of work disutilities across individual household members. Values not indexed by x are common across household types. Assuming that the utility of household members positively depends on consumption and that there is full risk sharing of consumption within a household as, for instance, in Andolfatto (1996), the utility of household-type x can be written as $E_t \sum_{s=0}^{\infty} \beta_a^s U\left(C^a_{x,t+s}, n^a_{x,t+s}(\mathfrak{h}_x)\right)$ with

$$\begin{aligned} U(\cdot) &= \left[\frac{\left(C^a_{x,t+s} - h_a \bar{C}^a_{x,t+s-1}\right)^{1-\sigma_a} - 1}{1-\sigma_a} - \kappa^w_{a,x} \int_0^1 \int_0^{n^a_{x,t+s}(\mathfrak{h}_x)} \mathfrak{j}_x^{\varphi_a} d\mathfrak{j} d\mathfrak{h}_x \right] \\ &= \left[\frac{\left(C^a_{x,t+s} - h_a \bar{C}^a_{x,t+s-1}\right)^{1-\sigma_a} - 1}{1-\sigma_a} - \kappa^w_{a,x} \int_0^1 \frac{n^a_{x,t+s}(\mathfrak{h}_x)^{1+\varphi_a}}{1+\varphi_a} d\mathfrak{h}_x \right], \end{aligned} \tag{B.3}$$

where $0 < \beta_a < 1$ is a subjective discount factor, $C^a_{x,t}$ is household type x-specific private consumption, and $h_a \in [0,1]$ is an external habit persistence parameter based on type-specific aggregate consumption of the previous period, $\bar{C}^a_{x,t-1}$. σ_a governs the elasticity of intertemporal substitution. $n^a_{x,t}(\mathfrak{h}_x) \in [0,1]$ denotes the household type x-specific employment rate in period t among workers specialized in labour-type $\mathfrak{h}_x$. Consumption of private goods, $C^a_{x,t}$, is a composite of goods produced at home and abroad. In country a, household type-x consumption aggregator is given by

$$C^a_{x,t} = \left[(n^a_a)^{\frac{1}{\eta_a}} \left(C^{a,a}_{x,t}\right)^{\frac{\eta_a-1}{\eta_a}} + (n^a_b)^{\frac{1}{\eta_a}} \left(C^{a,b}_{x,t}\right)^{\frac{\eta_a-1}{\eta_a}} + (n^a_c)^{\frac{1}{\eta_a}} \left(C^{a,c}_{x,t}\right)^{\frac{\eta_a-1}{\eta_a}} \right]^{\frac{\eta_a}{\eta_a-1}}, \tag{B.4}$$

where n_i^a, with $i = a, b, c$, are the weights of goods in the consumption bundle according to their origin, implying $n_a^a + n_b^a + n_c^a = 1$, and η_a is the elasticity of substitution between these goods. $C_{x,t}^{i,j}$, with $i, j = a, b, c$, is a good consumed by households of type x in region i which is produced in region j. To derive the CPI of country a, P_t^a, we note that total spending on consumption goods must obey $P_t^a C_{x,t}^a = P_t^{a,a} C_{x,t}^{a,a} + P_t^{a,b} C_{x,t}^{a,b} + P_t^{a,c} C_{x,t}^{a,c}$, where $P_t^{i,j}$ is the PPI described in the previous section.

Nominal consumption expenditures of households amount to $(1 + \tau_t^{c,a})\ P_t^a\ C_{x,t}^a$, where $\tau_t^{c,a}$ is the consumption tax rate. Income of liquidity-constrained households is given by net wage income from employment in the private and the public sector, $n_t^{P,x,a}$ and $n_t^{G,x,a}$, paying nominal gross wages $W_t^{a,x}$ and $W_t^{G,a,x}$, with $x = m, l$ which are both taxed by the rate $\tau_t^{w,a}$. Note that, in contrast to Gadatsch et al (2016), we now index employment and wages by x as we no longer assume that wage bargaining and uniform employment distribution are undertaken by *one* economy-wide union but that they are determined at the household level. Unemployed household members receive nominal unemployment benefits $P_t^a \cdot UB^{a,x}$. Those members who decided to participate in the labor market, $L_{x,t}^a$, but who did not find a job are unemployed, i.e. $U_{x,t}^a = L_{x,t}^a - n_t^{a,x}$, are unemployed. Taken together, and noting that liquidity-constrained consumers spend their entire income each period, their budget constraint in real CPI-terms becomes

$$(1 + \tau_t^{c,a})\, C_{x,t}^a = (1 - \tau_t^{w,a}) \left(w_t^{a,x}\, n_t^{P,x,a} + w_t^{G,x,a} N_t^{G,x,a} \right) + UB^{a,x} \left(L_{x,t}^a - n_t^{x,a} \right). \tag{B.5}$$

Analogously, the budget constraint for optimising highly skilled households in real terms is given by

$$\begin{aligned}
&(1 + \tau_t^{c,a})\, C_{h,t}^a + I_{h,t}^a + B_{h,t}^{a,a} + \sum_{j=b,c} S_t^{a,j} B_{h,t}^{a,j} + B_{h,t}^{G,a} + T_{h,t}^a \\
&= (1 - \tau_t^{w,a}) \left(w_t^{a,h} n_t^{P,h,a} + w_t^{G,h,a}, n_t^{G,h,a} \right) + UB^{a,h} \left(L_{h,t}^a - n_t^{h,a} \right) \\
&+ \frac{\left(1 + i_{t-1}^a\right)}{\pi_t^a} + B_{h,t-1}^{a,a} + \frac{\left(1 + i_{t-1}^{a,b}\right)}{\pi_t^a} B_{h,t-1}^{a,b} \\
&+ S_t^{a,c} \frac{\left(1 + i_{t-1}^{a,c}\right)}{\pi_t^a} B_{h,t-1}^{a,c} + \frac{\left(1 + i_{t-1}^{G,a}\right)}{\pi_t^a} B_{h,t-1}^{G,a} \\
&+ \left(1 - \tau_t^{k,a}\right) r_{k,t}^a k_{h,t-1}^a + \tau_t^{k,a} \delta_a k_{h,t-1}^a + D_{h,t}^a,
\end{aligned} \tag{B.6}$$

where we have to take into account that optimizers save and borrow. $B_{h,t}^{i,j}$ are private bonds purchased in country i issued by country j, $B_t^{G,a}$ is a government bond issued by the fiscal authority in country a, which is held by domestic households only, and $I_{h,t}^a$ are purchases of investment goods, which is an aggregator analog to private consumption (see equation (B.4) above). $\pi_t^a = P_t^a / P_{t-1}^a$ is CPI inflation. In addition to the wage and transfer income, optimisers also receive interest on their bond holdings, at rates $i_t^{a,j}$ for private and $i_t^{G,a}$ for government bonds. Furthermore, optimizers receive a return, $r_{k,t}^a$, on their capital, $k_{h,t}^a$ and pay lump-sum taxes $T_{h,t}^a$. Capital depreciates at rate δ_a and the government taxes capital gains net of depreciation at rate $\tau_t^{k,a}$. $D_{h,t}^a$ are the profits of

firms. The law-of-motion for capital is given by

$$k^a_{h,t} = (1-\delta_a)k^a_{h,t-1} + \left(I^a_{h,t} - I^a_{h,t}\frac{\psi^i_a}{2}\left(\frac{I^a_{h,t}}{I^a_{h,t-1}} - 1\right)^2 \right) \tag{B.7}$$

which states that today's capital stock equals yesterday's capital stock net of depreciation plus new investments net of investment adjustment costs, $\psi^i_a/2\left(I^a_{h,t}/I^a_{h,t-1} - 1\right)^2$.

Labour demand and supply: Turning to labour demand, we have to differentiate between private and public sector demand. As in Forni et al (2009), we assume that labour demand in the public sector gets uniformly allocated among household types, where the public sector sets $n^{G,a}_t = n^{G,x,a}_t$. Consistent with OECD data we assume that, in steady state, type-specific public sector wages include a markup, mg^a, on type-specific private sector wages.

In the private sector, a perfectly competitive agency buys the differentiated individual labor services supplied by households, transforms them into a homogenous but still type-specific composite of labor input, $n^{P,x,a}_t$, and sells that to intermediate goods producers, who demand different labour types according to equations (2) and (3). Hence, labour agencies solve for each variety of labor service, $\mathfrak{h}$,

$$\max_{n^{P,x,a}_t(\mathfrak{h}):\mathfrak{h}\in[0,\mathcal{P}^a_t]} n^{P,x,a}_t = \left(\int_0^{\mathcal{P}^a_t} \left(N^{P,x,a}_t(\mathfrak{h}) \right)^{(\theta^w_{a,x}-1)/\theta^w_{a,x}} d\mathfrak{h} \right)^{\theta^w_{a,x}/(\theta^w_{a,x}-1)} \tag{B.8}$$

subject to a given level of the type-specific wage bill $\int_0^{\mathcal{P}^a_t} W^{a,x}_t(\mathfrak{h})\, n^{P,x,a}_t(\mathfrak{h}) d\mathfrak{h} = \overline{WB}^a_t$. The solution of this problem is the standard private-sector labor demand for each variety. $\theta^w_{a,x}$ is the type-specific labour substitution.

Taking labour market conditions (i.e. wages and employment) as given, any household member specialised in type $\mathfrak{h}_x$ labor will find it optimal to participate in the labour market if and only if utility from working exceeds his or her disutility. When defining the marginal member for which this condition holds with equality as $L^a_{x,t}$ and noting that $\mathfrak{j}_x \in [0,1]$, $L^a_{x,t}$ can be seen as the labour supply of household-type x; see Gali et al (2011) for a more detailed discussion. Hence, the labor supply decision of households can be summarized as

$$\lambda^a_{x,t}\left[(1-\tau^{w,a}_t)\left(w^{a,x}_t n^{P,x,a}_t + w^{G,x,a}_t n^{G,x,a}_t\right) + UB^{x,a}\left(L^a_{x,t} - n^{x,a}_t\right)\right] = N^{x,a}_t \kappa^w_{x,a}\left(L^a_{x,t}\right)^{\varphi_a}, \tag{B.9}$$

where $\lambda^a_{x,t}$ is the corresponding marginal utility of consumption.

Wage setting: In contrast to Gadatsch et al (2016), we no longer assume that there is a utilitarian union that sets an economy-wide wage but that households will undertake their wage setting themselves. This implies that, for each household type $x = h, m, l$, there will be a different wage. But, within each household type, there will be no wage differential. Besides this, wage setting is modelled analogously. Hence, a household maximises income of its members by optimally choosing nominal wages $W^{a,x}_t(\mathfrak{h})$, taking into account the disutility of work and the effects on labour supply and demand. Furthermore, wage setting is due to Rotemberg adjustment costs, indicated by the parameter γ^w_a. Formally, each union maximizes with respect to $W^{a,x}_{t+s}(\mathfrak{h})$, $n^{P,x,a}_{t+s}(\mathfrak{h})$ and $L^{x,a}_{t+s}(\mathfrak{h}) : \mathfrak{h} \in [0,1]$

the expected utility

$$E_t \sum_{s=0}^{\infty} \beta_a^s \left\{ \left[\lambda_{t+s}^{x,a} \left((1-\tau_{t+s}^{w,a}) \left(\frac{W_{t+s}^{a,x}(\mathfrak{h})}{P_{t+s}^a} n_{t+s}^{P,x,a}(\mathfrak{h}) + \frac{W_{t+s}^{G,x,a}(\mathfrak{h})}{P_{t+s}^a} n_{t+s}^{G,x,a}(\mathfrak{h}) \right) \right. \right. \\ \left. \left. + UB^{a,x} \left(L_{t+s}^{x,a}(\mathfrak{h}) - n_{t+s}^{x,a}(\mathfrak{h}) \right) - adj_t^{W,x,a} \right) - \kappa_{a,x}^w \frac{N_{t+s}^{x,a}(\mathfrak{h})^{1+\varphi_a}}{1+\varphi_a} \right] \right\}, \tag{B.10}$$

subject to (B.9), labour demand resulting from (B.8) and $n_t^{x,a} = n_t^{P,x,a} + n_t^{G,x,a}$. The wage adjustment costs, $adj_t^{W,x,a}$, under Rotemberg are defined as

$$adj_t^{W,x,a} = \frac{\upsilon_a^w}{2} \left(\frac{W_{t+s}^{x,a}(\mathfrak{h})}{\left(\pi_{w,t+s-1}^a\right)^{\xi_a^w} \left(\bar{\pi}^a\right)^{1-\xi_a^w} W_{t+s-1}^{x,a}(\mathfrak{h})} - 1 \right)^2 \frac{W_{t+s}^a}{P_{t+s}^a}$$

in the above equation. The solution is symmetric, so that $W_t^{x,a}(\mathfrak{h}) = W_t^{x,a}$, $L_t^{x,a}(\mathfrak{h}) = L_t^{x,a}$ and $n_t^{P,x,a}(\mathfrak{h}) = N_t^{P,x,a}$ for all $\mathfrak{h}$ in equilibrium. Defining $L_t^a = \mu^h L_t^{h,a} + \mu^m L_t^{m,a} + \mu^l L_t^{l,a}$ as the total labor force, we can then define the economy-wide unemployment rate as $UR_t^a = \left(L_t^a - N_t^a\right)/L_t^a$, where $N_t^a = \mu^h n_t^{h,a} + \mu^m n_t^{m,a} + \mu^l n_t^{l,a}$. As in the case of price setting of goods, we allow for potential indexation on past wage inflation, $\pi_{w,t-1}^a$, and steady-state wage inflation, indicated by the parameter $\xi_a^w \in [0,1]$.

Policy and market clearing: Fiscal and monetary policy are model exactly the same as in Gadatsch et al (2016). Therefore, and because they are standard anyway, we omit presenting the relevant equations here. However, note that, as we now have three household types instead of two, and as we allow for group-specific wages, fiscal revenues and spending must be adjusted to take account of this. Furthermore, in the equations determining aggregate demand and international trade in goods and assets, we must allow for German population to be time-varying, ie we need to set $\mathcal{P}^a = \mathcal{P}_t^a$ wherever it appears, while $\mathcal{P}_t^a$ is defined in equation (5).

Calibration: In calibrating the model, we strongly rely on the main parameter values presented in Gadatsch et al (2016), who estimated the baseline *GEAR* model (without different skill groups and population growth) for Germany during the period 1999 to 2013. As the targets for the rest of the Euro Area (RoE) are exactly the same, we omit their presentation here, which also holds for the parameter calibration.

Table B.1: Targeted initial steady state values

Target variable for	Germany
Initial population size, $\mathcal{P}^i$	1 (2.6 for RoE)
Share of highly-skilled employees, μ^h	0.3
Share of medium-skilled employees, μ^h	0.6
Share of low-skilled employees, μ^h	0.1

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Target variable for	Germany
Fiscal policy	
Labour income taxes, τ^w	0.304
Capital taxes, τ^k	0.214
Consumption taxes, τ^c	0.183
SSC (employers), τ^{sc}	0.167
Public purchases ratio, $\frac{C^G}{GDP}$	0.111
Public investment ratio, $\frac{I^G}{GDP}$	0.017
Public employment ratio, $\frac{N^G}{N}$	0.228
Transfers (incl. UB benefits) ratio, $\frac{TR+(L-N)UB}{GDP}$	0.190
Replacement ratio, $\frac{UB}{w(1-\tau^w)}$	0.351
Public markup, mg	0.030
Government debt ratio (annualised), $\frac{B^G}{GDP}$	0.6
Monetary policy	
Inflation rate (quarterly), π	0.0045
Interest rate (quarterly), i	0.00475
Labor and goods market	
Unemployment rate (highly skilled), UR^h	0.033
Unemployment rate (medium skilled), UR^m	0.073
Unemployment rate (medium skilled), UR^l	0.218
Wage markup (highly/low skilled), $w^{a,h}/w^{a,l}$	3.000
Wage markup (highly/medium skilled), $w^{a,h}/w^{a,m}$	2.000
Price markup (over marginal costs)	0.333
International sector	
Relative prices and real exchange rates	1
Net foreign assets	0
Import share vis-a-vis Ger or RoE, $\frac{C^{i,j}+I^{i,j}}{GDP^i}$	0.130
Import share vis-a-vis RoW, $\frac{C^{i,c}+I^{I,c}}{GDP^i}$	0.244

Note: Table shows target values that the initial steady state of the model is supposed to replicate. They are based on Gadatsch et al (2016). For the unemployment rates, we deviate from the original paper as we are aiming at capturing the group-specific unemployment rates given by IAB (2016a) as described in section 2.1. Furthermore, we target group-specific wage differentials to match those also described in section 2.1 (see Destatis, 2016a), which allows us to obtain the values for α_N^i presented in Table B.2.

As in Gadatsch et al (2016) we will first set some target values which the initial steady state of the model is supposed to reflect. These target values are based on EMU data described in more detail in Gadatsch et al (2016) and they are summarised in Table

B.1. As Gadatsch et al (2016), we also target a net foreign asset position of zero and a real exchange rate of one in the initial steady state, which allows us to obtain the the consumption/investment preferences for domestically produced and foreign goods, n_j^i, in the private consumption/investment baskets. We also normalise German GDP to one and set GDP in the rest of the Euro Area to 0.871 in order to capture per capita GDP differences observed in the data. Furthermore, we assume that the economies comply with the Maastricht criteria in the long run and set the debt-to-GDP ratio to 60%.

The parameter values are standard values from the literature or taken from estimates in Gadatsch et al (2016). A detailed description on the parameter choice – at least those that we are able to set autonomously – can be found there. However, note that, as the model used in the present paper entails some modifications, we need to derive some of the parameter values "endogenously" to have our model match the targeted steady state. Table B.2 summarises our parameter choice, pointing out those parameters that deviate from those in Gadatsch et al (2016).[10]

Table B.2: Calibrated parameters

Target variable for	Germany
Preferences	
Intertemporal elasticity of substitution , σ	1
Discount factor, β	0.9985
Parameter influencing Frisch elasticity, φ	15
Habit formation, h	0.4940
Substitution elasticity between home and foreign goods, η	0.9790
Labour disutility of highly-skilled^e, κ_h^w	1003
Labour disutility of medium-skilled^e, κ_m^w	8266
Labour disutility of low-skilled^e, κ_l^w	8541
Technology	
Capital share, α	0.33
Rate of depreciation (private), δ	0.015
Rate of depreciation (public), δ^G	0.015
Public sector productivity shifter, ζ	1.22
Subs. Elasticity: intermediate goods, θ	4
Subs. Elasticity: different highly-skilled types of labour^e, θ_h^w	5.509
Subs. Elasticity: different medium-skilled types of labour^e, θ_m^w	7.648
Subs. Elasticity: different low-skilled types of labour^e, θ_l^w	3.849
Subs. Elasticity: different labour skills, ρ_N	0.5
Productivity of highly-skilled^e, α_N^h	1.0000
Productivity of medium-skilled^e, α_N^m	0.4879
Productivity of low-skilled^e, α_N^l	0.0348

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[10]Furthermore, remember that, as described in section 2.2, we only use lump-sum taxes as the debt-stabilising instrument. Hence, we assume all the other feedback parameters in the fiscal rules to be zero. We also need to increase φ (slightly) to 15 in order to guarantee stationarity in the model.

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Target variable for	Germany
International sector	
Risk premium parameter, ϕ	0.01
Frictions	
Investment adj. costs, υ	4.951
Price adj. costs, υ^p	69.811
Wage adj. costs, υ^w	61.801
Price indexation, ξ	0.351
Wage indexation, ξ^w	0.507
Elasticity pub. inv. w.r.t. output, η^{Kg}	0.084
Elasticity pub. emp. w.r.t. output, η^{Ng}	0.074

Note: Table shows calibrated parameter values. They are standard values from the literature or taken from estimates in Gadatsch et al (2016). Those that we had to endogenously calculate in order for our modified model to replicate the steady state indicated by Table B.1 are marked by an ^{e}. While one may expect the parameter ρ_N to have significant effects on the results, it can be shown that its influence is on the outcome only minor, especially in the long run. However, wage differentials between skill groups decrease when substitutability increases, especially along the transition (results can be send upon request).

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