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Consumption taxation to finance pension payments

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Non-technical summary

Research Question

Budget-neutral reductions of the social security contributions financed by higher consumption taxation to foster economic performance and international competitiveness range high on the political agenda within many, especially European, economies. A lot of economic analyses indeed report positive macroeconomic effects of such a tax shift. However, implications for holdings of net foreign assets and distributional aspects are addressed little in the literature.

Contribution

In this paper, we use an overlapping-generations-augmented two-region general equilibrium framework with search frictions on the labour market to assess such a tax shift. Especially the overlapping generations structure allows for effects not present in standard representative agent models.

Results

As in the literature, the tax reform partially shifts the tax burden from domestic to foreign producers and lowers marginal costs of domestic production. Thereby, it generates positive domestic macroeconomic effects. The tax reform also generates a policy-induced increase in consumption costs and partially postpones a household's tax burden to retirement. This leads to higher savings and increases domestic assets as households prepare for the cost increase. Along the transition path, however, this makes retirees and households close to retirement worse off. Moreover, the increase in domestic net foreign assets implies that consumption of foreign households eventually falls, which stands in contrast to what is commonly found in models without an endogenous savings motive. The rise in interest payments foreign economies have to pay can exceed the positive demand spillovers such that positive effects on foreign consumption eventually turn negative.

Nichttechnische Zusammenfassung

Fragestellung

Eine Reduktion von Sozialversicherungsbeiträgen, budgetneutral finanziert durch höhere Konsumbesteuerung, steht auf der Agenda von vielen Volkswirtschaften. Die akademische Literatur attestiert einer solchen Steuerverlagerung positive gesamtwirtschaftliche Effekte. Was in der Literatur allerdings weniger Beachtung findet, sind verteilungspolitische Implikationen und die Auswirkungen auf die Nettoauslandsvermögenspositionen jener Maßnahmen.

Beitrag

Wir nutzen ein zwei Regionen umfassendes, dynamisches allgemeines Gleichgewichtsmodell, das wir um einen Arbeitsmarkt mit Suchfriktionen und eine Lebenszyklusstruktur erweitern, um eine solche Steuerreform zu analysieren. Insbesondere das aus der Lebenszyklusstruktur resultierende endogene Sparmotiv führt zu (verteilungspolitischen) Effekten, die in herkömmlichen Modellen mit repräsentativen Agenten nicht zu finden sind.

Ergebnisse

Wie der Großteil der Literatur finden auch wir, dass die angesprochene Steuerreform einen Teil der heimischen Steuerlast auf ausländische Produzenten überwälzt. Dadurch senkt sie die heimischen Produktionskosten, erhöht die Wettbewerbsfähigkeit, und ruft positive gesamtwirtschaftliche Effekte hervor. Allerdings führt die Reform zu einem politikinduzierten Anstieg der Konsumkosten. Um sich darauf vorzubereiten, erhöhen Haushalte ihre Sparanstrengungen und die gesamtwirtschaftlichen heimischen Ersparnisse steigen. Die Situation von Haushalten, die sich bei der Steuerreform in oder kurz vor der Rentenbezugsphase befinden, verschlechtert sich jedoch. Sie können nicht mehr in ausreichendem Maße auf den Kostenanstieg reagieren. Darüber hinaus führt der Anstieg des heimischen Nettoauslandsvermögens zu einem Sinken der Konsummöglichkeiten ausländischer Haushalte, was so in Modellen ohne endogenes Sparmotiv nicht zu finden ist. Durch die gestiegenen heimischen Nettoauslandsvermögen muss das Ausland höhere Zinszahlungen an das Inland leisten, was gesamtwirtschaftlich gesehen die positiven Nachfrage-Spillover überkompensiert.

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Consumption Taxation to Finance Pension Payments*

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Abstract

This paper assesses how a permanent shift from financing a public pay-as-you-go pension by direct (labour income) taxation towards financing it by indirect (consumption) taxation affects the economy and welfare. To this end, we use an overlapping-generations-augmented two-region general equilibrium framework with search frictions on the labour market. The analysed tax reform partially shifts the tax burden from domestic to foreign producers and lowers marginal costs of domestic production and generates positive domestic macroeconomic effects. In addition, the partial postponement of a household's tax burden to retirement leads to higher savings and increases domestic assets. However, for some time after implementation of the tax reform, the policy-induced increase in consumption costs makes retirees and households close to retirement worse off. Moreover, the increase in domestic net foreign assets implies that consumption of foreign households eventually falls, which stands in contrast to what is commonly found in models without an endogenous savings motive.

Keywords: Fiscal devaluation, OLG models, Pension system, Optimal taxation

JEL classification: E24, E62, H21, H55, J26

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1 Introduction

In an ever more globally integrated world, a major task of government is to increase the competitiveness of its economy. One important tool to improve competitiveness directly is to optimize the composition of its tax revenues. A prominent example for tax optimization is a budget-neutral shift away from direct (labour income) to indirect (consumption) taxation also known as fiscal devaluation.[1] The European Commission, the IMF, and the OECD frequently suggest such a policy for several EU member states, see European Commission (2013, 2014, 2015, 2016), IMF (2014), OECD (2012, 2015). In the light of increased financing needs due to an ageing population, some governments discuss the stabilization of social security (especially pension) contributions through higher consumption tax rates.

In this paper, we quantitatively characterize the macroeconomic effects of a shift from a labour income tax to a consumption tax. Specifically, we develop a quantitative two-region general-equilibrium model with search frictions in the labour market. The model is augmented with overlapping generations that endogenously decide about consumption, savings and labour supply. It also includes a government that runs a mandatory pay-as-you-go pension system. We employ this model to quantify the aggregate and distributional effects of a restructuring of the pension system's financing structure. An analysis in general equilibrium makes sense because tax shifts not only have direct but also indirect effects. Search frictions help to match stylized labour market facts quite well, especially for European economies (see Maffezzoli, 2001), and an overlapping generations structure is needed to address financing the pension system. Moreover, as discussed in the literature review below, this endogenizes the savings decision and affects the international transmission of policy reforms.

In our analysis, two features of the shift from direct to indirect taxation are crucial to address the macroeconomic effects. First, the shift reduces domestic labour costs relative to the foreign region. Thereby, it favours exports, reduces imports and increases domestic employment and income. In a standard representative agent model, the proposed tax shift improves domestic output, consumption, employment and welfare. Because of positive demand spillovers, the same holds for the foreign economy in a representative agent economy (despite the deterioration in international competitiveness). We challenge the latter finding in our framework, and also show that welfare in the domestic economy may not increase for everyone.

Second, the shift postpones the tax burden of households to later in life. The life cycle structure of households embeds an old-age provision savings motive, which allows for effects not present in standard representative agent models. Lower labour taxes increase net labour income during the working age. A rise in consumption tax rates increases consumption costs at all stages of the life cycle. From a life-cycle perspective, the individual tax burden is postponed to later in life. Utility maximizing consumption smoothing com-

[1] Strictly speaking, fiscal devaluation may not be the right term to be used here. Farhi, Gopinath, and Itskhoki (2014) provide a formal analysis of fiscal devaluations in a New Keynesian open economy DSGE model. They find that an intended nominal devaluation can be robustly replicated with a small set of fiscal instruments: lower labour income financed by higher consumption taxes. Hence, fiscal devaluation is a sequence of taxes that replicates a sequence of nominal exchange rates while leaving the labour tax wedge constant (see also Kaufmann, 2019). However, the literature has agreed to also term permanent tax shifts as described in this paper fiscal devaluation.

pels households to increase their savings. On the aggregate level, this eventually leads to higher (domestic and net foreign) assets, capital income, and consumption in the domestic region. The increase in savings is not present in a representative agent model.

The policy-induced increase in consumption costs, and the resulting need for domestic households to increase savings, has distributional consequences, which has important implications for the welfare analysis. As the postponement of the tax burden favours working-age households, those who (primarily) depend on transfers – such as pensioners – may lose due to higher consumption taxes and the lower gross wages caused by the lower labour tax rates. In a pure steady-state comparison, this is not the case because the tax shift improves the households' permanent income and people can adjust their savings behaviour to tackle higher consumption costs. Therefore, domestic welfare in the new steady state rises for everyone.

Along the transition path, however, individuals who are already retired or close to retirement shortly before the policy change cannot adjust their behaviour sufficiently. They are likely to lose from the reform as they have not saved enough to cope with the policy-induced cost increase and need to reduce consumption for their remaining life. In addition, higher domestic holdings of net foreign assets eventually increase interest payments that the foreign region has to pay to the domestic households. The rise in interest payments due can exceed the positive demand spillovers such that positive effects on foreign consumption eventually turn negative.

We calibrate the quantitative model to reflect Germany as the domestic region and the rest of the European Union as the foreign region.[2] We simulate a 10%-points reduction of the labour-related pension contribution rate financed by a (in the long run) 4%-points higher tax rate on consumption. This tax shift increases domestic aggregate output by almost 4% in the long run. Aggregate consumption of domestic households is 6% higher than it was in the initial steady state. The increase is, however, delayed. A fraction of the population does not benefit from higher net labour income or higher employment as they are already retired. These households have to lower consumption. Because they make up an important fraction of the aggregate consumption, consumption only starts to increase notably when most of these generations have left the population.

Domestic savings increase by more than 15% on aggregate in the long run. Some of these additional savings are required to meet higher capital demand in the home region caused by higher domestic employment. In the long run, however, domestic asset supply exceeds domestic capital demand, and a substantial amount of the increase in savings is invested abroad. Domestic net foreign assets, after a drop by 10% in the first period after the tax change, increase by 80% in the long run. As the home region makes more than 15% of the size of the total economy, significant changes in the aggregate savings in the home region influences the common capital market. The excess supply of capital reduces the global interest rate by more than 0.6 percentage points. There are positive demand spillovers to the foreign economy, and foreign output increases by roughly 1.5%. However, because the foreign economy needs to pay interest on the higher net foreign asset holdings of the home country, foreign consumption eventually falls by close to 0.5% in the new steady state. The increase in interest payments outweighs the increase in domestic output despite the fall in the world interest rate in the end.

[2] As the benchmark date for the calibration is 2015 the European Union also encompasses the United Kingdom.

Related Literature. Our paper is related to primarily two strands of the literature. First, our paper is embedded in a rich literature of optimal taxation that lead to the advance of indirect taxes, see Mankiw, Weinzierl, and Yagan (2009). In particular, substituting labour income taxes or social security contributions by consumption taxes, which are said to generate fewer distortions in the system, has extensively been discussed. Pestel and Sommer (2017) investigate the effects of such a shift on labour supply and the income distribution in Germany. Using a microsimulation model, they find a general regressive impact in the short run and a mitigated overall effect on inequality when adjusted work incentives are accounted for. Beneficial effects of such a tax shift, using the class of general equilibrium models, are also reported by Boscá, Doménech, and Ferri (2013), Gadatsch, Stähler, and Weigert (2016), Gomes, Jacquinot, and Pisani (2016), Langot, Patureau, and Sopraseuth (2014), Lipińska and von Thadden (2019) and Stähler and Thomas (2012) calibrated to France, Germany, Portugal or Spain. Engler, Ganelli, Tervala, and Voigts (2017) show that, when reducing labour taxes levied on employers, the beneficial effects may be increased which, at least for the short run, is confirmed in an analysis by Burgert and Roeger (2014). Jacquinot, Lozej, and Pisani (2018) show that, if monetary policy is accommodative, positive effects are larger. Attinasi, Prammer, Stähler, Tasso, and van Parys (2019) also compare the effects of a labour tax reduction financed by higher consumption taxes to those using other financing instruments such as lower public purchases or public employment A shift towards property taxation is discussed in Mora-Sanguinetti and Rubio (2014), Stähler (2019) and Bielecki and Stähler (2020). None of the papers mentioned above uses an overlapping generations model to analyse such a tax shift.

Second, investigating the role of life cycle saving motives related to social security reforms on macroeconomic variables in OLG models led to a sizeable literature, Attanasio, Kitao, and Violante (2007), Krueger and Ludwig (2007), Kitao (2018). We follow de la Croix, Pierrard, and Sneessens (2013) and include a search labour market which gives a meaningful role to labour taxes and social security contributions. Like our paper, one strain of this literature embeds these mechanisms in an open economy framework and investigate international effects and spillovers, e.g., Poterba (2001), Attanasio, Kitao, and Violante (2006), Börsch-Supan, Härtl, and Ludwig (2014), Schön and Stähler (2020), Devriendt and Heylen (2020). The model in our paper is closely related to Marchiori, Pierrard, and Snessens (2017) who also introduce matching frictions on the labour market.

To the best of our knowledge, we are the first to combine both strands of the literature and provide a formal analysis of the intergenerational income distribution of this policy. We confirm positive domestic effects in the long run. However, we also show that it takes time before these effects materialise and that there are losers of the reform, an issue that is often not addressed in conventional DSGE models. Moreover, it is often found that, when a region undertakes fiscal devaluation, its trading partners also benefit. This is the case, when aggregate demand in the devaluating region eventually increases sufficiently to foster demand for imported goods and, thereby, overcompensate the loss in demand induced by a reduction in international competitiveness in the non-devaluating region(s). We also identify positive demand spillovers. However, due to the endogeneity of the savings decision, this does not translate into positive consumption spillovers. In standard open-economy DSGE models (Obstfeld and Rogoff, 1995), the net foreign asset position is exogenous in steady state. Stationarity is reached by adding a friction to the

financial market that kicks in whenever the exogenously fixed reference level is missed (see, among others, Schmitt-Grohe and Uribe, 2003). This very mechanism however makes the net foreign asset position independent of structural (policy) changes. We believe that a model with an endogenous net foreign asset position, like ours, is a superior tool to analyse the international transmission of policy reforms (see also Ghironi, 2008, Di Giorgio and Nistico, 2013, and Oxborrow and Turnovsky, 2017, for a discussion).

The outline of the paper is the following. In section 2 we describe the quantitative model In section 3 we present the calibration of the model. In section 4 we show the results of the simulation of the quantitative model. In section 5 we also show the distributional effects of the analysed policies. In section 6 we conclude our findings.

2 The Quantitative Model

This section lays out a two-region general-equilibrium model that is augmented by an overlapping generations structure on the household side. The model also features frictions on the labour market following Mortensen and Pissarides (1994). It is closely related to de la Croix et al. (2013) and Marchiori et al. (2017).

In the model, the world is populated by finitely-lived households that consume and save. During their working age, they provide labour, which is immobile across regions. Thereafter, households live on pension benefits and savings. Savings are invested in domestic physical capital, which is rented to firms, shares of domestic firms, domestic government bonds and internationally traded assets. The labour market is characterized by search frictions with (exogenous) job destruction and a matching function that determines job finding and vacancy filling rates. There is only one single matching function and all vacancies can be filled by any worker.

Governments in each region finance their expenditures, including unemployment and pension benefits and government consumption, by taxing private consumption, labour income and capital interest. They can also issue debt (for which they have to pay interest in the next period) and levy lump-sum taxes.[3] In modelling international trade, we depart from Marchiori et al. (2017) by assuming that both regions trade a differentiated good that only they are specialized in producing. This allows us to explicitly focus on the terms of trade between the two regions $i \in \{A, B\}$, which we assume to represent Germany and the remaining European Union (EU, excluding Germany), respectively. When possible, we omit the regional index i for notational convenience in the following.

2.1 Demographics

In our model people live between the ages of 20 and 100 years. One time period is 5 years and we, therefore, have 16 coexisting age groups, indexed by $a \in \{0, 1, \ldots, 15\}$. Each individual belongs to a representative household, k, that entered the economy at time $t = k$.[4]

[3]Note that, because of the overlapping generations structure, lump-sum taxes are not Ricardian in our setup. Hence, using them to finance the labour tax reduction is very much akin to using consumption taxes, which we do in the main text. We show and discuss this in more detail in appendix C.

[4]Age group, a, generation, k, and time, t, are related where $t = k + a$.

The size of new generations changes over time at an exogenous rate x_t:

$$Z_{0,t} = (1 + x_t)Z_{0,t-1}, \quad \forall t > 0, \tag{1}$$

where x_t includes both fertility and migration shocks at age zero. The size of a generation, k, along its life cycle is determined by the cumulative (unconditional) survival probabilities $0 < \theta_{a,k} < 1$:

$$Z_{a,k} = \theta_{a,k} Z_{0,k}, \quad \forall a \in \{1, 2, ..., 15\}. \tag{2}$$

The total (adult) population at time t is $Z_t = \sum_{a=0}^{15} Z_{a,t}$. Demographic growth and the survival probabilities can vary over time. These changes are assumed to be exogenous.

We assume a mandatory retirement age of 65 years so that all older people (age groups $9 \leq a \leq 15$) are inactive. The working-age population is therefore given by:

$$P_{a,t} = z_{a,t} Z_{a,t}, \tag{3}$$

where $z_{a,t} = 1$ for $0 \leq a \leq 8$ and zero otherwise. Between ages 20 and 65, household members can choose to not participate in the labour market, however. Hence, they are either employed (N), unemployed (U), or do not participate in the labour market at all (E). Formally, this is given by:

$$\begin{aligned} P_{a,t} &= N_{a,t} + U_{a,t} + E_{a,t}, \\ &= [n_{a,t} + u_{a,t} + e_{a,t}] P_{a,t}, \quad 0 \leq a \leq 8 \\ \Leftrightarrow \quad 1 &= n_{a,t} + u_{a,t} + e_{a,t}, \end{aligned} \tag{4}$$

where lower case letters denote the proportion of individuals in each status.

2.2 Labour-Market Flows

We assume that unemployed workers find a vacant job via a constant return to scale matching function:

$$M_t = M(V_t, \Omega_t) \tag{5}$$

where V_t and Ω_t stand for the total number of vacancies and job seekers at the beginning of period t, respectively. It holds that

$$\Omega_t = (1 - e_{0,t})P_{0,t} + \sum_{a=1}^{8} [u_{a-1,t-1} + \chi n_{a-1,t-1}] (1 - e_{a,t}) P_{a,t}. \tag{6}$$

At the beginning of time t, all new entrants who decide to participate in the labour market, $(1 - e_{0,t})P_{0,t}$, are job seekers. Job seekers also represent the combination of past unemployment and new job separations. These job separations are determined by an exogenous job-destruction rate χ. The finding a job and of filling a vacancy probabilities are

$$p_t = \frac{M_t}{\Omega_t} \quad \text{and} \quad q_t = \frac{M_t}{V_t}. \tag{7}$$

The law of motion of employment is therefore

$$\begin{aligned} n_{a,t} &= p_t(1-e_{a,t}), && \text{for} \quad a=0; \\ &= (1-p_t)(1-e_{a,t})(1-\chi)n_{a-1,t-1} + p_t(1-e_{a,t}), && \text{for} \quad 1 \leq a \leq 8. \end{aligned} \tag{8}$$

Total employment is

$$N_t = \sum_{a=0}^{8} N_{a,t},$$

with $N_{a,t} = n_{a,t}P_{a,t}$.

2.3 Households

Each household/generation k maximizes the sum of discounted utility for all ages a at point in time $t = k + a$. There is no aggregate uncertainty, and all households have perfect foresight. Within each household, there is no individual consumption risk due to unemployment as in Andolfatto (1996) and Merz (1995). However, we introduce a role for idiosyncratic uncertainty through an imperfect annuity market. If an individual dies at the end of a period, her financial wealth is not fully redistributed among surviving agents from the same generation but partially goes to the government. Still, there are no voluntary bequests.

The household's choice variables are consumption and labour market participation, subject to the lifetime budget constraint, labour market flows and pension point accumulation (the latter described in more detail below). Lifetime utility is given by

$$\mathcal{W}_k = \max_{c_{a,k+a}, e_{a,k+a}} \sum_{a=0}^{15} \beta^a \theta_{a,k} \left\{ \log\left(c_{a,k+a}\right) + \xi_a \frac{\left(e_{a,k+a}\right)^{1-\kappa}}{1-\kappa} z_{a,k+a} \right\} Z_{0,k}, \tag{9}$$

where β is a subjective discount factor (which can represent both, pure time preference and the effect of family-size changes, implying that consumption is enjoyed differently at different ages; see Rios-Rull, 2001). The instantaneous utility function is separable in consumption and leisure (non-participation in the labour market). The utility of per capita consumption, $c_{a,k+a}$, is represented by a standard logarithmic function. The function describing the utility from leisure, $e_{a,k+a}$, is concave, $0 < \kappa < 1$. The age-specific parameter ξ_a relates leisure to consumption in utility. For readability, we substitute the notation of the point in time $k + a$ to t where possible.

The household's flow budget constraint at time t takes the following form:

$$I_{a,t} + \left(\frac{\theta_{a-1,k}}{\theta_{a,k}}\right)^{\omega} [1 + r_t^*(1-\tau_t^k)] s_{a-1,t-1} = (1+\tau_t^c) c_{a,t} + s_{a,t}, \tag{10}$$

where $\omega \in (0, 1]$ indicates how good the annuity markets are. For $\omega = 1$, there is no idiosyncratic uncertainty and annuity markets are perfect. The smaller ω gets, the lower is the distribution of savings of those who passed away within a generation.[5] Income $I_{a,t}$

[5] Imperfect annuity markets are primarily introduced to generate an inverse u-shaped consumption profile. With perfect annuity markets, consumption over the life-cycle increases steadily; see de la Croix et al. (2013) for a discussion.

includes labour income and various transfers as follows:

$$I_{a,t} = z_{a,t}\left[(1-\tau_t^w)w_t n_{a,t} + b_t^u u_{a,t}\right] + (1-z_{a,t})b_{a,t}^r - T_t. \tag{11}$$

During working age, each employed household member earns a (gross) wage w_t. Labour income is taxed at rate τ_t^w. When unemployed, the household member receives unemployment benefits $b_t^u = \rho^u w_t$, which are a fraction $\rho^u \in [0,1)$ of gross wage earning. A retired agent receives pension benefits $b_{a,t}^r = \rho^r w_t H_{a,t}/9$, where $\rho^r \in [0,1)$ is the constant pension replacement rate and $H_{a,t}$ are the pension points acquired during working life. We assume that each period, a household can acquire a maximum of one pension point if all members participate in the labour market.[6] Pension points during working life thus accumulate according to

$$H_{9,k} = \sum_{a=0}^{8}(1-e_{a,k+a}), \tag{12}$$

with $H_{a,k} = H_{9,k}$ for $a > 9$. The more household members participate in the labour market, the higher will be the pension benefits received in the retirement phase. During 9 working periods, a household can get a maximum of 9 pension points. Lump-sum taxes, T_t, are independent of age.

Consumption expenditures are taxed at rate τ_t^c, and $s_{a,t}$ is the financial wealth accumulated at time t in per-capita terms. The total return to savings is equal to one plus the risk-free international interest rate r_t^*, net of capital taxes τ_t^k, divided by the conditional survival probability $\frac{\theta_{a+1,k}}{\theta_{a,k}}$ when $\omega = 1$ and adjusted accordingly for $\omega < 1$. This financial wealth is held in the form of either shares of domestic production firms, physical capital, domestic government bonds or internationally traded assets, which we show in more formal detail later.

The optimal consumption plan must satisfy the usual Euler equation

$$\frac{c_{a+1,t+1}}{c_{a,t}} = \beta\left(\frac{\theta_{a+1,k}}{\theta_{a,k}}\right)^{1-\omega}\left[1+r_{t+1}^*(1-\tau_{t+1}^k)\right]\frac{1+\tau_t^c}{1+\tau_{t+1}^c} \tag{13}$$

The value of having an additional household member employed is, expressed recursively, as follows:

$$W_{a,t}^W = (1-\tau_t^w-\rho^u)\,w_t + (1-\chi)(1-p_{t+1})(1-e_{a+1,t+1})\beta\frac{\theta_{a+1,k}}{\theta_{a,k}}\frac{(1+\tau_t^c)c_{a,t}}{(1+\tau_{t+1}^c)c_{a+1,t+1}}W_{a+1,t+1}^W \tag{14}$$

Each period, an employed worker earns the net wage $(1-\tau_t^w)w_t$ but forgoes unemployment benefits b_t^u when participating in the labour market. If participating next period as well, indicated by $(1-e_{a+1,t+1})$, the worker obtains the continuation value if she remains employed next period, weighted by the corresponding probability for this to happen (last term of equation (14)). Discounting takes into account the survival probability. Bear in mind that, in the last working-age cohort ($a = 8$), there is no continuation value (such that the last term of equation (14) is zero for $a = 8$) as everyone who reaches retirement

[6] One could relate pension points to individual wage earnings, which especially makes sense when talking about redistribution in a heterogeneous agent framework (and which is the case in Germany, for example). For our purpose, however, a more abstract accumulation process of pension points is sufficient, and it simplifies the analysis significantly.

age no longer participates in the labour market. For everyone else, the decision of a household to have an additional member of age a at time t participate on the labour market is given through

$$\xi_a e_{a,t}^{-\kappa} = p_t \left[\frac{(1-\tau_t^w) w_t}{(1+\tau_t^c) c_{a,t}} \right] + (1-p_t) \left[\frac{p^u w_t}{(1+\tau_t^c) c_{a,t}} \right] + \sum_{j=9}^{15} \beta^{j-a} \frac{\theta_{j,k}}{\theta_{a,k}} \frac{\rho^r w_{t-a+j}}{(1+\tau_{t-a+j}^c) c_{j,t-a+j}} \quad (15)$$

where p_t is the unconditional probability of being employed (i.e., the probability that an active worker chosen at random be actually employed).

2.4 Firms

There are two productive factors, labour and capital. We assume a constant returns to scale production function in labour and capital:

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}, \quad (16)$$

where A_t stands for total factor productivity. Firms rent capital at a cost of $r_t^* + \delta$, where δ is capital depreciation, and pay a gross wage w_t to workers. We denote the employer wage tax by τ_t^f. Firms open vacancies at a cost per vacancy of ϕ_t. As the representative firm maximizes the discounted value of all the dividends (profits) distributed to its shareholders, its value function is as follows:

$$\mathcal{W}_t^F = \max_{K_t, V_t} \left\{ \underbrace{f_t^{i,i} Y_t - (r_t^* + \delta) K_t - \sum_{a=0}^{8} (1+\tau_t^f) w_t N_{a,t} - \phi_t V_t}_{=Profits,\ \Pi_t} \right\} + \frac{1}{R_{t+1}^*} \mathcal{W}_{t+1}^F, \quad (17)$$

where τ_t^f is a payroll tax that firms have to pay, subject to equation (8) with $p_t = q_t V_t / \Omega_t$, $R_t^* \equiv 1 + r_t^*(1-\tau_t^k)$ and $f_t^{i,i}$ defining the region-i consumer price index (CPI) deflated producer price of region i.[7] The first order conditions are

$$r_t^* + \delta = f_t^{i,i} \alpha A_t \left(\frac{N_t}{K_t} \right)^{1-\alpha}, \quad (18)$$

determining capital demand, and

$$\phi_t = q_t \sum_{a=0}^{8} \frac{\Omega_{a,t}}{\Omega_t} W_{a,t}^F, \quad (19)$$

[7] Shareholders belong to different age groups and have different consumption levels. However, they all have the same discount factor, given by equation (13); see de la Croix et al. (2013) for an in-depth discussion. As domestic firms sell their products at domestic producer prices, we have to include $f_t^{i,i}$ to relate everything to domestic consumer prices, which is the region-specific numeraire. Correspondingly, $f_t^{i,j}$ relates region-j consumer prices to region-i producer prices, which we will describe in more detail below.

determining vacancy postings, where

$$W_{a,t}^F = f_t^{i,i}(1-\alpha)A_t\left(\frac{K_t}{N_t}\right)^{\alpha} - \left(1+\tau_t^f\right)w_t + \frac{(1-\chi)(1-e_{a+1,t+1})}{R_{t+1}^*}\frac{\theta_{a+1,k}}{\theta_{a,k}}W_{a+1,t+1}^F, \quad (20)$$

is the value of employing an additional worker the firm.

2.5 Wages

Wages are renegotiated every period. They are determined by a standard Nash bargaining rule maximizing $\left(W_{a,t}^W\right)^{\eta}\left(W_{a,t}^F\right)^{1-\eta}$ with respect to wages, where $0 \leq \eta \leq 1$ is household bargaining power. Assuming that unemployment benefits as exogenously given from the individual worker's perspective, the resulting sharing rule is:

$$(1-\eta)W_{a,t}^W = \eta\frac{1-\tau_t^w}{1+\tau_t^f}W_{a,t}^F. \quad (21)$$

2.6 Government

The government has to finance public consumption which is a fraction, $\overline{g}$, of output, net of vacancy costs. It also has to finance expenditures for unemployment and retirement benefits, i.e.,

$$G_t = \bar{g}(Y_t - \phi_t V_t) + \rho^u w_t \sum_{a=0}^{8} u_{a,t}Z_{a,t} + \rho^r w_t \sum_{a=9}^{15}\frac{H_{a,t}}{9}Z_{a,t}. \quad (22)$$

The primary deficit is the difference between the government expenditures and its revenue consisting of tax revenues and a fraction of accidental bequests that are not redistributed because of imperfect annuities

$$\begin{aligned} D_t = G_t - \Bigg(& (\tau_t^w + \tau_t^f)\left(\sum_a w_t n_{a,t}P_{a,t}\right) + \tau_t^k r_t^*\left(\sum_a\left(\frac{\theta_{a-1,k-1}}{\theta_{a,k}}\right)^{\omega}s_{a-1,t-1}Z_{a-1,t-1}\right) \\ & +\tau_t^c C_t + T_t Z_t + (1+r_t^*)\left(\sum_a\left(\frac{\theta_{a-1,k-1}}{\theta_{a,k}}\right)\left(1-\left(\frac{\theta_{a-1,k}}{\theta_{a,k}}\right)^{\omega-1}\right)s_{a-1,t-1}Z_{a-1,t-1}\right)\Bigg), \end{aligned} \quad (23)$$

where aggregate consumption is $C_t = \sum_a c_{a,t}Z_{a,t}$.

The primary deficit drives public debt development as follows:

$$B_t = D_t + (1+r_{t-1}^*)B_{t-1}. \quad (24)$$

To guarantee a stationary behaviour of public debt, we have to assume that at least one tax rate must adjust to take care of bringing back debt to its initial or some other target value after a shock (see Mitchell, Sault, and Wallis, 2000, and Schmitt-Grohe and Uribe, 2007, for a discussion). In the analysis that follows, we assume a balanced budget rule (i.e. a constant debt level throughout the transition) which is, after a reduction in labour taxation, achieved by changing the consumption tax rate accordingly.

2.7 International Capital Markets and Trade

Let Q_t denote the total financial value of firms at time t. In our deterministic setup, the return to equities must equal the market interest rate. In other words, the value of equities must be such that, for all $t \geq 0$:

$$\frac{Q_{t+1} + \Pi_{t+1}}{Q_t} = 1 + r^*_{t+1}. \tag{25}$$

The left-hand side is the return of one unit of savings invested in equities, while the right-hand side is the return from investment in firm bonds. The aggregate stocks of capital in the two regions are as follows:

$$K^A_{t+1} + Q^A_t + B^A_t + NFA^A_t = \sum_{a=0}^{14} s^A_{a,t} Z^A_{a,t}, \tag{26}$$

$$K^B_{t+1} + Q^B_t + B^B_t + NFA^B_t = \sum_{a=0}^{14} s^B_{a,t} Z^B_{a,t}, \tag{27}$$

where NFA^i_t denotes the net foreign asset (NFA) position of region i. As international assets in the entire world must be in zero net supply, it holds that $NFA^B_t = -rer_t NFA^A_t$, where rer_t is the real exchange rate expressed as region A's CPI relative to region B's CPI. The current-account surplus of one region (or the net capital outflow from that region to the other) is given by the change in the NFA position: $CA_t = NFA_{t+1} - NFA_t$. The net foreign asset position both regions evolves according to

$$NFA_t = (1 + r^*_{t-1}) NFA_{t-1} + NX_t, \tag{28}$$

where net exports of region i are given by

$$NX^i_t = f^{i,i}_t \left(C^{i,j}_t + I^{i,j}_t + G^{i,j}_t \right) - f^{j,i}_t \left(C^{j,i}_t + I^{j,i}_t + G^{j,i}_t \right), \tag{29}$$

where $f^{j,i}_t$ is the region-i CPI-deflated producer price of products produced in region j (and sold to i) and $C^{j,i}_t$, $I^{j,i}_t$ and $G^{j,i}_t$ are products produced in region j and purchased by consumers, capital investors and the government of region i. Assuming the same preference over home and foreign goods among these agents, it holds that

$$C^{i,i}_t + I^{i,i}_t + G^{i,i}_t = \vartheta^i \left(\frac{1}{f^{i,i}_t} \right)^{1/(1-\zeta)} \left(C^i_t + I^i_t + G^i_t \right) \tag{30}$$

$$C^{j,i}_t + I^{j,i}_t + G^{j,i}_t = (1 - \vartheta^i) \left(\frac{1}{f^{j,i}_t} \right)^{1/(1-\zeta)} \left(C^i_t + I^i_t + G^i_t \right), \tag{31}$$

where ϑ^i is the home bias of region i and $1/(1-\zeta)$, with $\zeta \in (-\infty, 1)$ is the elasticity of substitution between home and foreign goods.[8] The consumer price index, which is the

[8] The underlying CES aggregator is $C^i_t = \left[\vartheta^{i\,1-\zeta}\, C^{i,i\,\zeta}_t + (1-\vartheta^i)^{1-\zeta}\, C^{j,i\,\zeta}_t \right]^{1/\zeta}$ and correspondingly for I^i_t and G^i_t.

numeraire of each region, evolves according to

$$1 = \left[\vartheta^i \; f_t^{i,i\,-\zeta/(1-\zeta)} + (1-\vartheta^i) \; f_t^{j,i\,-\zeta/(1-\zeta)}\right]^{-(1-\zeta)/\zeta}. \tag{32}$$

It must hold that $f_t^{B,A} = rer_t f_t^{A,A}$ and, correspondingly, $f_t^{A,B} = f_t^{B,B}/rer_t$. From the above description, it is clear that capital is internationally mobile (via purchases of net foreign assets) while labor is immobile (see labour-flow equations, too).

2.8 Intertemporal General Equilibrium

The intertemporal general equilibrium is formally defined as follows:

Definition 1. Given the following exogenous processes and initial conditions:

- Population growth/fertility $\{x_t\}_{t=0..+\infty}$ and survival probabilities $\{\theta_{a,k}\}_{k=0..+\infty}^{a=1..15}$,
- replacement rates $\{\rho^u, \rho^r\}$ and initial tax rates $\{\bar{\tau}^c, \bar{\tau}^k, \bar{\tau}^w, \bar{\tau}^f, T\}$,
- and initial population $\{Z_{a,-1}\}^{a=0..15}$, assets $\{s_{a,-1}\}^{a=0..14}$, and capital stocks $\bar{K}_0^A + K_0^B + Q_0^A + Q_0^B + B_0^A + B_0^B + NFA_0^A + NFA_0^B \leq \sum_{a=0}^{14} s_{a,-1}^A Z_{a,-1}^A + \sum_{a=0}^{14} s_{a,-1}^B Z_{a,-1}^B$.

An intertemporal equilibrium with perfect foresight is such that

1. consumption $\{c_{a,t}\}_{t=0..+\infty}^{a=0..15}$ and labour market participation decisions $\{e_{a,t}\}_{t=0..+\infty}^{a=0..15}$ maximize household utility (9) subject to the budget constraint (10) and (5) and (8),
2. the capital input $\{K_t\}_{t=0..+\infty}$ and posted vacancies $\{V_t\}_{t=0..+\infty}$ maximize firms' profits (17) subject to (7), (8), (16), and $K_0 = \bar{K}_0$,
3. the number of new hires $\{M_t\}_{t=0..+\infty}$, the probabilities of finding a job $\{p_t\}_{t=0..+\infty}$ and of filling a vacancy $\{q_t\}_{t=0..+\infty}$, and the employment rates $\{n_{a,t}\}_{t=0..+\infty}^{a=0..7}$ satisfy the matching technology (5), (7), and (8),
4. total population $\{Z_{a,t}\}_{t=0..+\infty}^{a=0..15}$, population of working age $\{P_{a,t}\}_{t=0..+\infty}^{a=0..8}$, and number of job seekers $\{\Omega_t\}_{t=0..+\infty}$ satisfy the population-dynamics equations (1), (2), (3), and (6),
5. unemployment $\{u_{a,t}\}_{t=0..+\infty}^{a=0..8}$ is such that the population constraint holds,
6. wages $\{w_t\}_{t=0..+\infty}$ are negotiated following the Nash bargaining rule (21),
7. government debt $\{B_t\}_{t=0..+\infty}$ follows the budget constraint (24), and government spending $\{G_t\}_{t=0..+\infty}$ follows (22),
8. at least one fiscal instrument $\{\tau_t^c, \tau_t^k, \tau_t^w, \tau_t^f, T_t\}_{t=0..+\infty}$ is set by the government to make debt stationary,
9. stock-market prices $\{Q_t\}_{t=0..+\infty}$ satisfy the arbitrage condition (25),
10. and the international interest rate $\{r_t^*\}_{t=0..+\infty}$ clears the world capital market, i.e., equations (26) and (27),

11. the real exchange rate $\{rer_t\}_{t=0..+\infty}$ and, thereby, relative prices $\{f_t^{i,j}\}_{t=0..+\infty}$ for $i, j = A, B$ adjust such that all goods markets in both regions clear: $Y_t = C_t + I_t + G_t + Q_t - Q_{t-1} + NX_t$, where $I_t = K_t - (1-\delta)K_{t-1}$.

3 Calibration

Our objective is to examine the channels by which a change in the financing structure of a PAYG pension system affects a large open economy. We calibrate the model to represent a European situation with fairly generous public pension systems. The model encompasses two regions where the domestic region is calibrated to Germany and the foreign region reflects the rest of the European Union in terms of demographic parameters and country size but, overall, the calibration is quite standard.

The model parameters fall into five categories: (i) parameters determining demographics; (ii) general technological and preference parameters; (iii) parameters specific to the frictional labour market; (iv) parameters determining taxes and transfers. (v) parameters related to international trade. In addition to this discussion, we refer the interested reader to appendix A for a summary of our calibration choices.

3.1 Demographics

We calibrate our model to a five-year frequency. In both regions individuals start their economic life at the age of 20 and stay in the labour force for 9 periods (45 years, which implies they retire at 65).[9] They can live up to 16 periods (80 years, which means they reach a maximum age of 100). The growth rate of the working-age population in the economy is set to 0%, which implies a constant population. We take the per-period survival probabilities from the Human Mortality Database. We choose the initial population sizes of Germany and the rest of the European Union such that, given the survival probabilities, the German population amounts to roughly 16% of the entire European Union.

3.2 Technology & Preferences

We assume that economies produce with a constant-returns-to-scale production function of Cobb Douglas type. The elasticity of output with respect to capital is set to the typical value of $\alpha = 0.33$. We assume no technological progress which simplifies our analysis. The instantaneous utility function is logarithmic in consumption. Interest rate change-induced wealth and substitution effects cancel each other out. The time preference rate is set to 0.9861 per year in both regions. To get a capital-output ratio equal to 2.5 on a yearly basis, the depreciation rate of capital is set at 2.5% per quarter.

Households do not leave intentional bequests. Individual consumption rises over the life cycle but starts declining at some point (i.e. it is inverse u-shaped), which we achieve by assuming imperfect annuity markets by setting $\omega = 0.75$ in both regions. The resulting steady-state (common capital market-clearing) real interest rate is 7.729% per annum.

[9] This value is consistent with the current retirement age in the majority of OECD countries.

3.3 Labour Market

The elasticity of matches with respect to vacancies ν in the constant-returns-to-scale Cobb-Douglas function is set to 0.5 as suggested by Petrongolo and Pissarides (2001).

$$M_t = \mu \cdot V_t^{1-\nu} \cdot \Omega_t^{\nu}, \tag{33}$$

Following Christoffel, Kuester, and Linzert (2009), we set the bargaining power of workers $\eta = 0.5$, which implies that, in absence of policy, the Hosios (1990) condition is fulfilled (see also Burda and Wyplosz, 1994). The job separation rate χ is set at 6% per quarter. With a vacancy filling rate of 0.7 as in Christoffel et al. (2009), we set the steady-state job finding rate to $\bar{p}^a = 0.92$ and $\bar{p}^b = 0.9$ to target aggregate unemployment rates of roughly 5% and 10% in Germany and the rest of the European Union, respectively (see Moyen, Stähler, and Winkler, 2019, for a discussion). Parameter κ is set to 0.80, which implies a Frisch elasticity of around 0.6, in line with estimated values (see Den Haan and Kaltenbrunner (2009)). Given the employment rates from Eurostat[10], the matching efficiency parameter μ, the vacancy cost ϕ and the age-specific labour disutility parameters ξ_a are then calculated to match these targets (see Table 2 and 3 in the appendix A).

3.4 Tax and Transfers

For calibrating fiscal authorities, especially for tax rates, we rely on Gadatsch, Hauzenberger, and Stähler (2016), who estimate a DSGE model with involuntary unemployment for Germany and the rest of the European Monetary Union. Government spending is set to the typical value of 20% of GDP, and government debt to 60% of GDP, which corresponds to the Maastricht target. The gross replacement rate for unemployed workers is fixed at $\rho^U = 0.35$, which is an average of short and long-term benefits based on gross wages. In line with OECD (2019), we set the general pension replacement rate to 0.519 in Germany and slightly higher in the rest of the European Union member states, to 0.635.

3.5 International trade

We set the parameter ζ to 0.33, which renders an elasticity of substitution between home and foreign goods of 1.5 (see Osbat and Corbo, 2013, Gomes, Jacquinot, and Pisani, 2012 and Gomes, Jacquinot, Mohr, and Pisani, 2013, for a discussion). We set the home bias in Germany to 0.6 to match a GDP-weighted average of domestic expenditure shares of around 60% as found in Balta and Delgado (2009). Then, we calculate the necessary home bias of the foreign economy that ensures a relative price of home and foreign goods of 1 and net exports to be zero in the initial steady state.

4 Simulation Results

The next section shows simulation results of a shift in the financing structure of the PAYG pension system. In the initial steady-state (t=0), the labour income tax rate amounts

[10] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=t2020_10&lang=eng

to roughly 30%, which also finances the pension scheme partly.[11] In period t=1 and afterwards, this labour income contribution rate is cut by 10 percentage points. Along the transition path, until a final steady state is reached, the consumption tax rate adjusts endogenously to balance the pension expenditures. It is assumed that the foreign region keeps its original pension system financing structure.

4.1 Mechanisms

Two main mechanisms drive the macroeconomic and distributional effects shown in the next section. First, fiscal devaluation reduces the relative marginal labour costs between the domestic and the foreign region. And second, the shift of households' tax burden to higher ages changes the domestic asset stock.

Fiscal Devaluation The reduction in the domestic pension contribution rate on labour income financed by an increase in consumption taxation implies a fiscal devaluation of the domestic region. Figure 1 shows the developments of domestic and foreign gross and net wages after such a tax reform. The reduction of the pension contributions levied on labour income increases the net wage income of households in the domestic region.

Figure 1: Marginal costs of labour

Notes: The figures plot tax shift induced evolution of net wage, gross wage, and employment. Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for employment rate).

In the Nash wage bargaining process, this induces the domestic households to accept lower gross wages because it is the net wage income they care about. Lower gross wages, in turn, foster employment. Higher employment somewhat increases the wage claim again due to better re-employment chances. Moreover, firms demand more capital (because higher employment augments their marginal productivity). Because gross wages fall, relative production costs fall, and relative competitiveness of domestic firms increases. Higher aggregate (labour) income, as well as relatively lower production costs, foster demand for products produced domestically and, thereby, output.

[11] In Germany, the public pension system is financed by employees and employers by parity funding. While overall analogous, there are some small differences between reducing employers' contributions to reducing employees' contributions. A detailed discussion is relegated to appendix B.

As home-country households also increase their demand for foreign goods (according to their preferences), the higher domestic income effect eventually fosters output in the foreign economy, too (see Figure 3). Demand spillovers, however, are not accompanied by a reduction in production costs. On the contrary, wages have to increase to attract additional workers in the foreign economy. Therefore, the positive employment and output effects are much smaller than they are in the home economy (see Figures 1 and 3). We discuss the effects of a simultaneous tax shift in both regions as well as the resulting implications for the international transmission in appendix D. The effects for the world aggregates are akin to those when simulating the tax shift in a closed economy.

Tax Burden Shift Figure 2 ((a) – (c)) illustrates the life cycle patterns of household consumption, income and savings variables. The hump-shaped pattern of household consumption is determined by the Euler equation. At younger ages, consumption increases as the interest rate is larger than the time preference of the households. As households become older, decreasing survival probabilities reduce optimal consumption.[12]

It is important to note that the course of consumption does not depend on the course of income over the life cycle. Only the level of consumption, not the profile, is determined by income via the lifetime budget constraint. One principle derived from maximizing lifetime utility is that households should smooth consumption over their life cycle. The income structure of households, however, is not smooth as pension income is only a fraction of working life labour income.[13] To smooth consumption over this income incontinuity, households accumulate assets during working life. These assets reach their maximum at the statutory retirement age and then start to fall. As there is no bequest motive in the model, assets of a household are fully depleted at the certain end of life.

Panels (d) – (f) of Figure 2 show the relative deviations of income, consumption and savings from the initial steady-state values after the shift in taxation. The blue solid lines show the relative deviation for households that are living their whole life in the final steady state. The level of consumption is higher for all ages. This stems from the increase in lifetime income in the domestic region due to higher net wages and an increased employment rate (the fiscal devaluation effect just described). Note that consumption of households when they are young increases more than consumption when they are old. This change in the life cycle profile is caused by a lower interest rate which will be explained below.

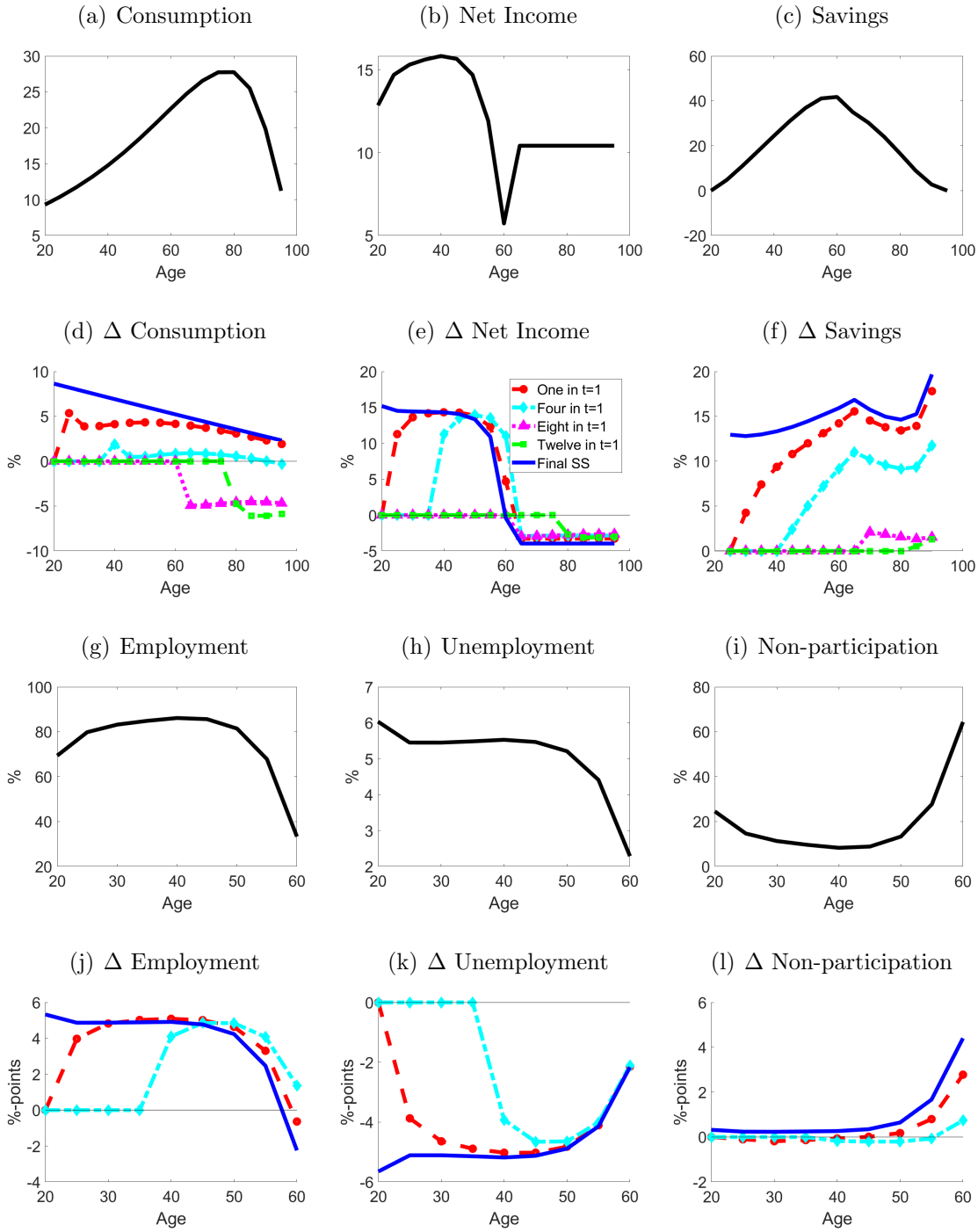
Next to the direct positive effect on labour income, the tax shift has an indirect negative effect on pension income. The pension of households is tied to the gross wage. As explained in the previous section, the tax shift leads to lower gross wages and by this decreases pension payouts.[14] A greater difference between labour and pension income and the increased lifetime income both lead to more savings to ensure the optimal consumption path. Moreover, the consumption tax rate is now higher than it was in the initial steady

[12]If the economy would include perfect annuities the increase in mortality risk would not affect consumption and the decline in higher ages would not exist.

[13]The sharp drop in income one period before the retirement age results from the targeted low employment rate. Many households in this age group retire early. For simplification, our model does not allow for early retirement and households have to rely on their savings.

[14]The higher employment rate has no effect in our model as also unemployed households accumulate pension points. The slightly lower non-participation leads to lower aggregated pensions.

Figure 2: Life Cycle Pattern



Notes: Panels (a)–(c) show absolute values of consumption, net labour & pension income, and savings, panels (g)–(i) show the rates of employment, unemployment and non-participation in the labour market over the life cycle of households in the initial steady-state. Panels (d)–(f) and panels (j)–(l) show relative deviations from the initial steady-state. Solid blue lines represent households living completely in the final steady-state. Dashed lines stand for households starting their lives in the initial steady-state and are affected by the tax shift different at ages: 25 (red), 40 (turquoise), 65 (pink) and 80 (green).

state. Therefore, households need more savings to pay for even an equal amount of consumption. The increased savings of households is reflected in higher domestic aggregate savings.

The labour income tax is paid by working-age households only while consumption taxes are also paid by retirees. In the steady-state, it only postpones the effective tax burden of households to later in their life. Along the transition path from the initial to final steady state, however, the tax shift distributes between generations. Households that are already retired when the tax shift takes place (pink and green dashed lines) do not profit from lower labour taxes and higher net wages. However, they still have to pay higher consumption taxes. To balance their lifetime budget, these households have to reduce consumption. The drop in consumption is stronger, the longer the households expect to live. Middle-aged households mildly benefit from the reform as long as the reform increases their lifetime income (turquoise line for 40 years old at the time of the reform). It is worth noting that all generations increase savings in our model.

4.2 Macroeconomic Effects

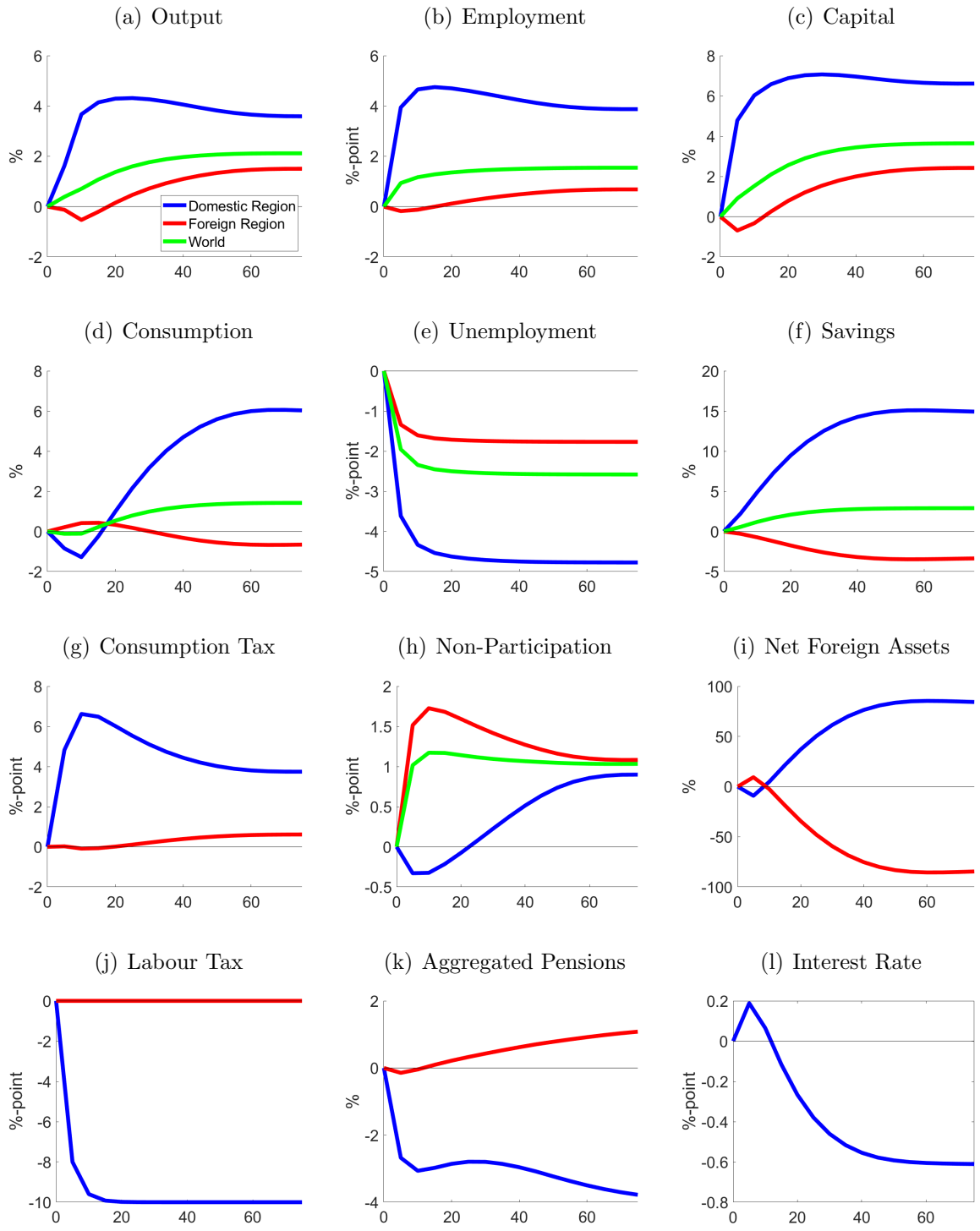
Both the fiscal devaluation and the tax burden shift affect the aggregate variables of the economy. Figure 3 shows the simulation results of the main aggregate variables when a good part of the pension contributions levied on labour supply are substituted by consumption taxes. The reduction of the labour contribution rate by 10%-points has to be financed by an increase in the consumption tax rate by an additional about 6%-points shortly after the policy is implemented. In the long run, the macroeconomic effects of the tax shift positively affect the tax base in the domestic region (especially for the capital income tax). Therefore the increase in the consumption tax rate eventually reduces to roughly 4% in the long run.[15]

As explained in the previous section, a lower domestic labour tax rate increases net wages, lowers gross wages and increases the employment rate by slightly more than 4%-points. The unemployment rate falls by slightly less than 5%-points. The difference between the employment rate and the unemployment rate stems from the somewhat lower non-participation rate of households after the tax shift. In the long run, the non-participation increases and ends even above the initial steady-state value. Higher employment increases both, output and demand for capital in the domestic region by 4% and 6%, respectively.

As already mentioned above, all households accumulate more assets which lead to a slow but constant increase of aggregated assets in the domestic region. At the final steady-state aggregated assets in the domestic region are 15% higher. Higher employment and higher assets in the domestic region eventually lead to higher aggregate consumption. The increase of aggregate consumption, however, is delayed as already retired households decrease their consumption directly after the tax shift. Only when these generations slowly leave the economy, aggregate consumptions start to rise and become 6% higher compared to the initial steady state.

[15] A back of the envelope calculation can illustrate the macroeconomic general equilibrium effect of the policy proposal: A decrease in labour tax rate from 30% to 20% would ceteris paribus result in a loss of 18% of government revenues. In a static model, this would correspond to a necessary increase in the consumption tax rate of 9%-point.

Figure 3: Aggregated Effects of a Domestic Tax Shift



Notes: This figure shows domestic tax shift induced evolution of key (macroeconomic) variables for the domestic (blue) region, the foreign (red) region, and the aggregated "world" economy (green). Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for rates).

The tax shift in the domestic region has also significant effects on the foreign region. Profit maximizing of the firms requires that due to the lower gross wages and the increased employment in the domestic region, capital is transferred from the foreign region into the domestic region on impact. This decrease of capital stock leads to slightly lower wages, employment and output in the foreign region. In the medium to long run, the increase in savings of domestic households, however, not only meets the domestic capital demand but even leads to an excess supply of assets in the domestic region. This excess supply of assets leads to two developments. First, the domestic region starts to exports its capital to the foreign region. The net foreign asset position of the domestic region increases by 80%. In the foreign region, the additional capital increases employment and output by 0.5% and 1.5%, respectively. Second, the price of capital, the interest rate, falls. In the long run, the interest rate is 0.6%-points lower than it is in the initial steady state.

The lower interest rate lowers the increase in domestic savings and even decreases the savings of the foreign region (by more than 4%). As foreign households hold fewer assets and need to pay interest to domestic households (as the home-region net foreign asset position has increased), aggregate consumption in the foreign region falls by 0.5% in the end although output in the foreign region has increased. This is a finding that is not present in a representative agent model because, in our model, the world asset market-clearing interest and savings are endogenous (and exogenous in a representative agents world).

Aggregated over both regions, the "world" output effect is positive over the simulation period, and in the final steady-state, output is almost 2% greater than it is in the initial steady state. Other macroeconomic variables such as employment, savings and consumption also increase in the long run.

5 Distributional Effect

The simulation results show that the domestic tax shift increases both utility enhancing domestic consumption and leisure (non-participation in the labour market). On aggregate, the utility of households is higher. The overlapping generation structure of our model allows us also to distinguish between generations. To evaluate the distributional effects across generations, in this section synonymously used for households, we compute the sum of certain variables over the whole life cycle. The lifetime consumption, income, non-participation, employment, and unemployment are weighted by the size of the household at each age

$$\mathcal{C}_k = \sum_{a=0}^{j^T} c_{a,k} Z_{a,k} \quad \text{and} \quad \mathcal{I}_k = \sum_{a=0}^{j^T} I_{a,k} Z_{a,k}$$

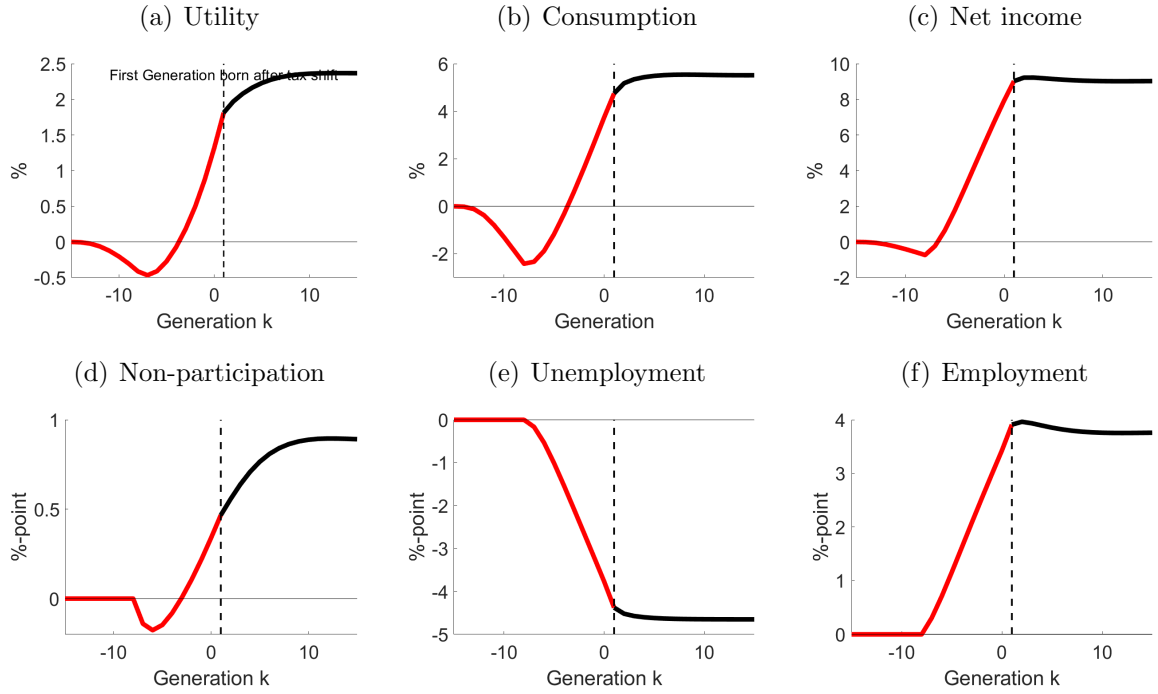
$$\mathcal{N}_k = \sum_{a=0}^{j^T} n_{a,k} Z_{a,k} \quad \text{and} \quad \mathcal{E}_k = \sum_{a=0}^{j^T} e_{a,k} Z_{a,k} \quad \text{and} \quad \mathcal{U}_k = \sum_{a=0}^{j^T} u_{a,k} Z_{a,k}$$

and lifetime utility is given by (9).

In Figure 4 we plot the difference of the lifetime variables for all generations relative to a generation that lives its whole life in the initial steady state ($k = -15$). All generations

that enter the economy after the tax shift ($k \geq 1$) are better off and lifetime utility increases further over time. For a generation that enters the economy in the final steady-state, the lifetime utility is more than 2.5% higher than for those living their whole life in the initial steady-state. For generations that are already alive at the tax shift, the advantage depends on their age. If they are 45 years or older ($-15 < k \leq -5$), they suffer a loss in their lifetime utility with the highest loss of lifetime utility of 0.5% for the generation at the age of 60 years ($k = -7$). All generations that are younger than 45 ($-4 < k < 0$) benefit from the tax shift although less than later generations.

Figure 4: Lifetime Variables



Notes: This figure shows tax shift induced evolution of households life time variables. Variables are shown in percentage deviations to a household lived its whole life in the initial steady-state (percentage point deviations for rates).

These outcomes reflect the previously stated result that households that were already retired when the tax shift happens ($-15 < k < -9$) experience a drop in their consumption. Additionally, also households that are at the end of their working life experience a drop in lifetime consumption. The first generation that consumes more than in the initial steady state is generation $k = -4$. Not retired households that are 35 and older ($-8 < k \leq 3$) also increase their participation in the labour market what negatively affect their lifetime utility. The strong increase of lifetime employment (and income), however, stems not from increased participation but from reducing unemployment. Households that are younger than 35 or enter the economy after the tax shift even reduce their participation in the labour market.

The fact that current retirees are the losers from a tax shift shapes the political implementability of the proposed reform. As long as current voters are losers while non-

voting (because not yet born) generations are winners it seems unlikely that the proposed tax shift passes legislation.

6 Conclusion

In this paper, we present a rich two-region general-equilibrium model with overlapping generations and a search labour market. We use this framework to analyse the aggregate effects when governments substitute a consumption tax to finance a pay-as-you-go pension system instead of a tax on labour income. We also evaluated the distributional effects of such a shift.

The fiscal devaluation and increased domestic savings caused by the tax shift lead to significant macroeconomic effects. Aggregate consumption of domestic households increases by up to 6% relative to the initial steady state. This increase in consumption is, however, delayed because a fraction of the population does not profit from higher net labour income or higher employment as they are already retired. These households have to decrease consumption and, because these households make up an important fraction of the aggregate consumption, aggregate consumption only starts to increase when most of these generations have left the population.

Domestic savings increases by more than 15% on aggregate in the long run. As domestic capital supply eventually exceeds domestic capital demand, a substantial amount of savings has to be invested in the foreign region. Domestic net foreign assets increase by 80% in the long run. As the home region makes more than 16% of the size of the total economy, significant changes in the aggregate savings in the home region influences the world capital market. The excess supply of capital reduces the world interest rate by 0.6%-point. The fact that foreign households need to pay interest to domestic households on these outstanding assets implies that, in the long run, aggregate consumption in the foreign region falls by 0.5% although output in the foreign region is affected positively by demand spillovers. This is a finding that is not present in a representative agent model.

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A Appendix A: Calibration Details

This appendix extends section 3 and provides some more details on the calibrated values. Based on the model structure, we distinguish between individual parameters set differently for every cohort and general parameters. To determine the population structure, we calibrate the individual survival rates for each cohort in table 1. Further, we set the parameters on how much individuals in a cohort value leisure in their utility function according to 2. Finally, table 3 defines the common parameters to calibrate the model as described in section 3.

Table 1: Survival Parameters – Human Mortality Database

Parameter	*Domestic*	*Foreign*
Age-dependent survival rate		
$\theta_{1,k}$	0.9983	0.9981
$\theta_{2,k}$	0.9947	0.9939
$\theta_{3,k}$	0.9884	0.9868
$\theta_{4,k}$	0.9785	0.9755
$\theta_{5,k}$	0.9630	0.9578
$\theta_{6,k}$	0.9382	0.9299
$\theta_{7,k}$	0.8981	0.8864
$\theta_{8,k}$	0.8346	0.8205
$\theta_{9,k}$	0.7404	0.7263
$\theta_{10,k}$	0.6128	0.6020
$\theta_{11,k}$	0.4568	0.4503
$\theta_{12,k}$	0.2864	0.2837
$\theta_{13,k}$	0.1280	0.1296
$\theta_{14,k}$	0.0294	0.0318
$\theta_{15,k}$	0.0019	0.0024

Table 2: Leisure Parameters

Parameter	*Domestic*	*Foreign*
Age-dependent leisure parameter		
ξ_0	0.7329	1.1055
ξ_1	0.4582	0.6604
ξ_2	0.3541	0.5265
ξ_3	0.2982	0.4697
ξ_4	0.2574	0.4630
ξ_5	0.2657	0.5159
ξ_6	0.3644	0.6864
Continued on next page...		

Table 2 – *...continued from previous page*

Parameter	*Domestic*	*Foreign*
ξ_7	0.6616	1.1787
ξ_8	0.7269	1.2109

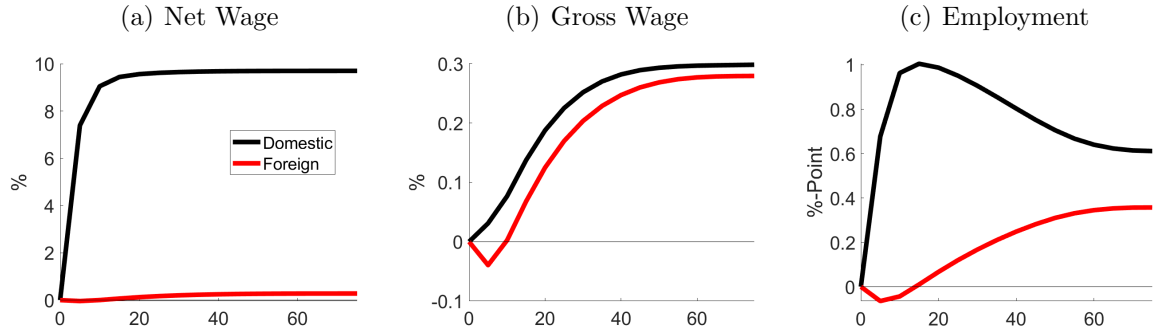
Table 3: Calibration Parameters

Parameter	*Short Description*	*Domestic*	*Foreign*
	Demographics		
j^A	Beginning of economic life (model period)	20 (0)	
j^R	Statutory retirement age (model period)	65 (9)	
j^T	Maximum age (model period)	100 (16)	
x	Population growth rate	0	
	Labour Market		
μ	Matching efficiency	0.8025	0.7937
ν	Matching elasticity	0.50	
χ	Job destruction rate (quarterly)	0.06	
ϕ	Vacancy costs	0.2410	0.2613
η	Bargaining power	0.50	
	Technology		
α	Capital share	0.33	
δ	Depreciation rate (quarterly)	0.025	
	Preferences		
β	Time preference (yearly)	0.9861	
κ	Leisure elasticity	0.80	
	Tax and Transfers		
$\overline{g}$	Government expenditures share	0.20	
$\overline{B}$	Public debt share	0.60	
τ^c	Consumption tax (initial steady state)	0.183	0.196
τ^w	Labour tax (initial steady state)	0.304	0.277
τ^f	Labour tax – employer's share	0.167	0.246
τ^k	Capital income tax	0.214	0.316
ρ^u	Unemployment replacement rate	0.350	0.350
ρ^r	Pension replacement rate	0.519	0.635
ω	Annuity imperfection	0.75	
	International Trade		
ϑ	Home bias in consumption	0.6	0.8396
ζ	Elasticity of substitution	0.33	

B Appendix B: Simulating a cut in employers' contribution rates

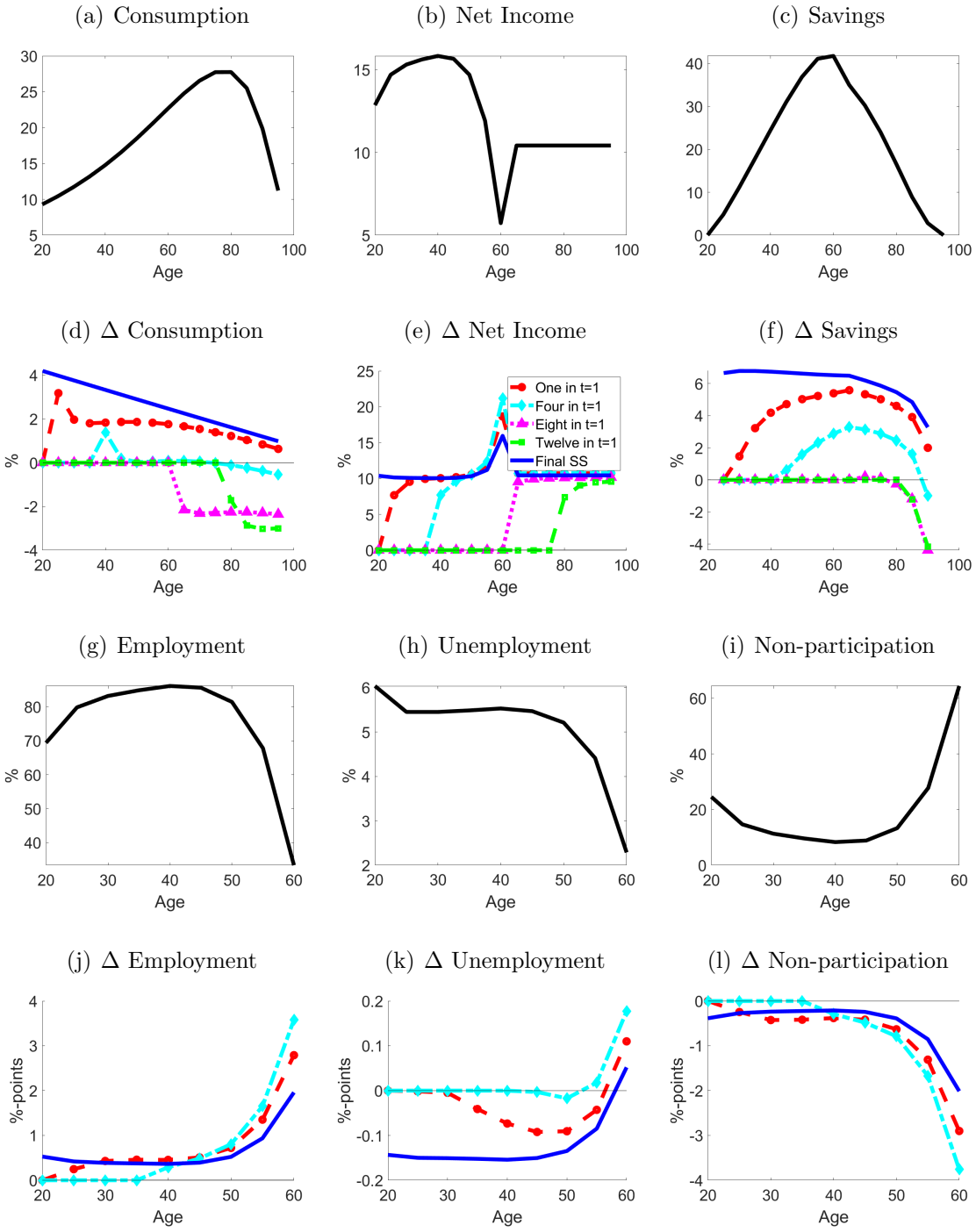
In this appendix, we show the graphs when simulating a decrease in the employer contribution rate instead of a decrease in the labour income tax rate as shown in the main text. As described there, the aggregated macroeconomic effects are analogous but smaller. The reason is the different gross wage evolution that is a result of the Nash bargaining between workers and firms. Because gross wages and, thereby, pension benefits is this simulation now increase, non-participation here falls in the end, in contrast to the simulation shown in the main text. The reason is that, now, participation pays off more as it augments pension points. The opposite was true in the simulation shown in the main text. However, aggregate effects are still very much alike (but, as said, smaller, partly also due to the reduced need to increase savings).

Figure 5: Marginal costs of labour



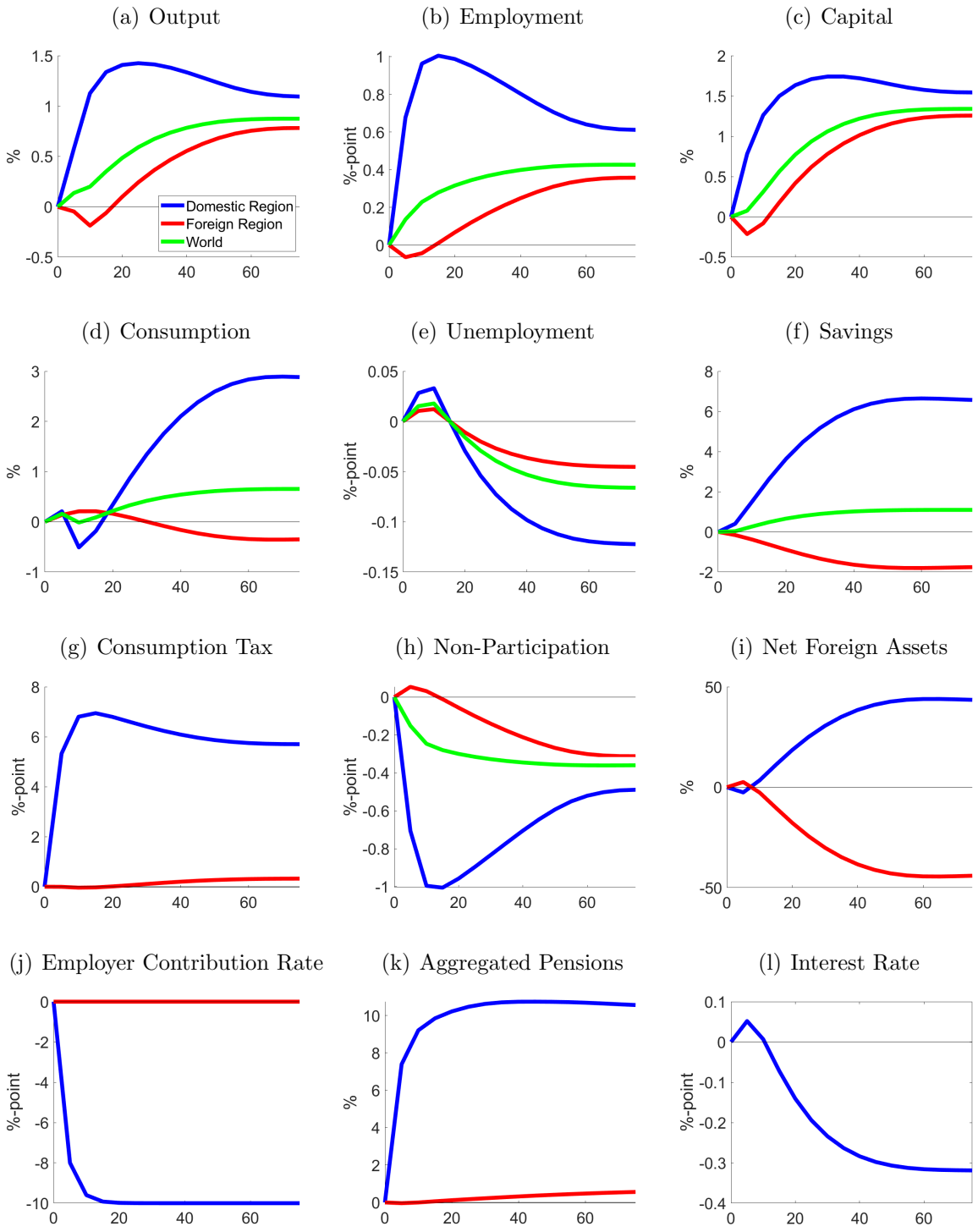
Notes: The figures plot tax shift induced evolution of net wage, gross wage, and employment. Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for employment rate).

Figure 6: Life Cycle Pattern



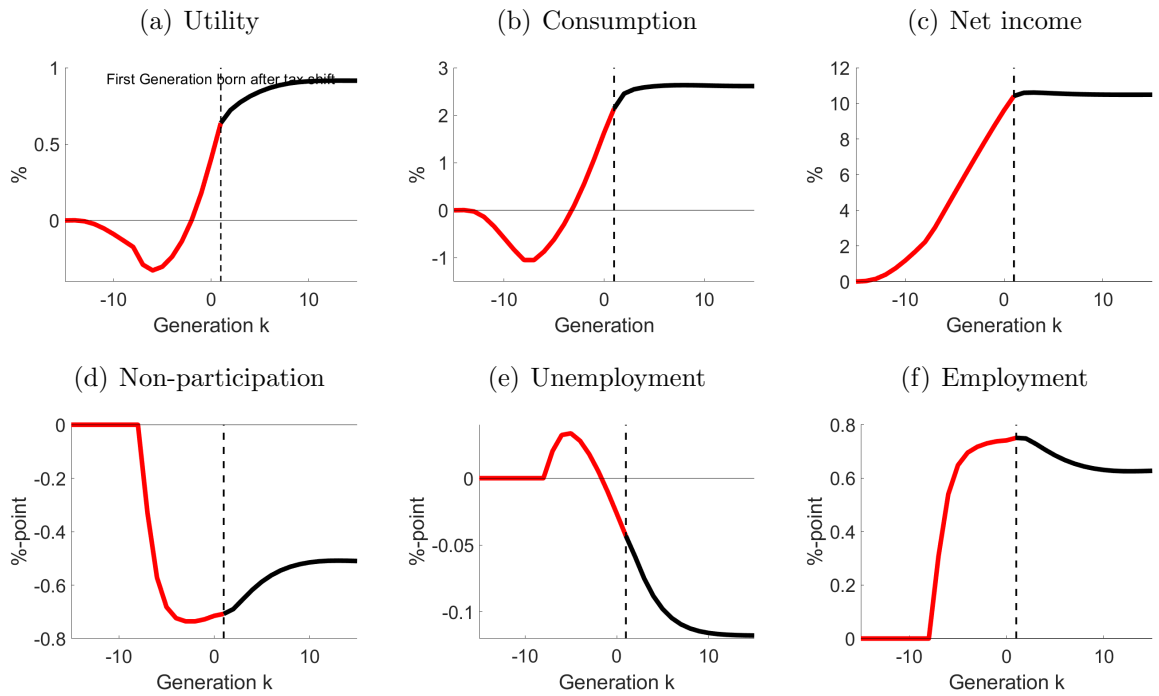
Notes: Panels (a)–(c) show absolute values of consumption, net labour & pension income, and savings, panels (g)–(i) show the rates of employment, unemployment and non-participation in the labour market over the life cycle of households in the initial steady-state. Panels (d)–(f) and panels (j)–(l) show relative deviations from the initial steady-state. Solid blue lines represent households living completely in the final steady-state. Dashed lines stand for households starting their lives in the initial steady-state and are affected by the tax shift different at ages: 25 (red), 40 (turquoise), 65 (pink) and 80 (green).

Figure 7: Aggregated Effects of a Domestic Tax Shift



Notes: This figure shows domestic tax shift induced evolution of key (macroeconomic) variables for the domestic (blue) region, the foreign (red) region, and the aggregated "world" economy (green). Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for rates).

Figure 8: Lifetime Variables



Notes: This figure shows tax shift induced evolution of households life time variables. Variables are shown in percentage deviations to a household lived its whole life in the initial steady-state (percentage point deviations for rates).

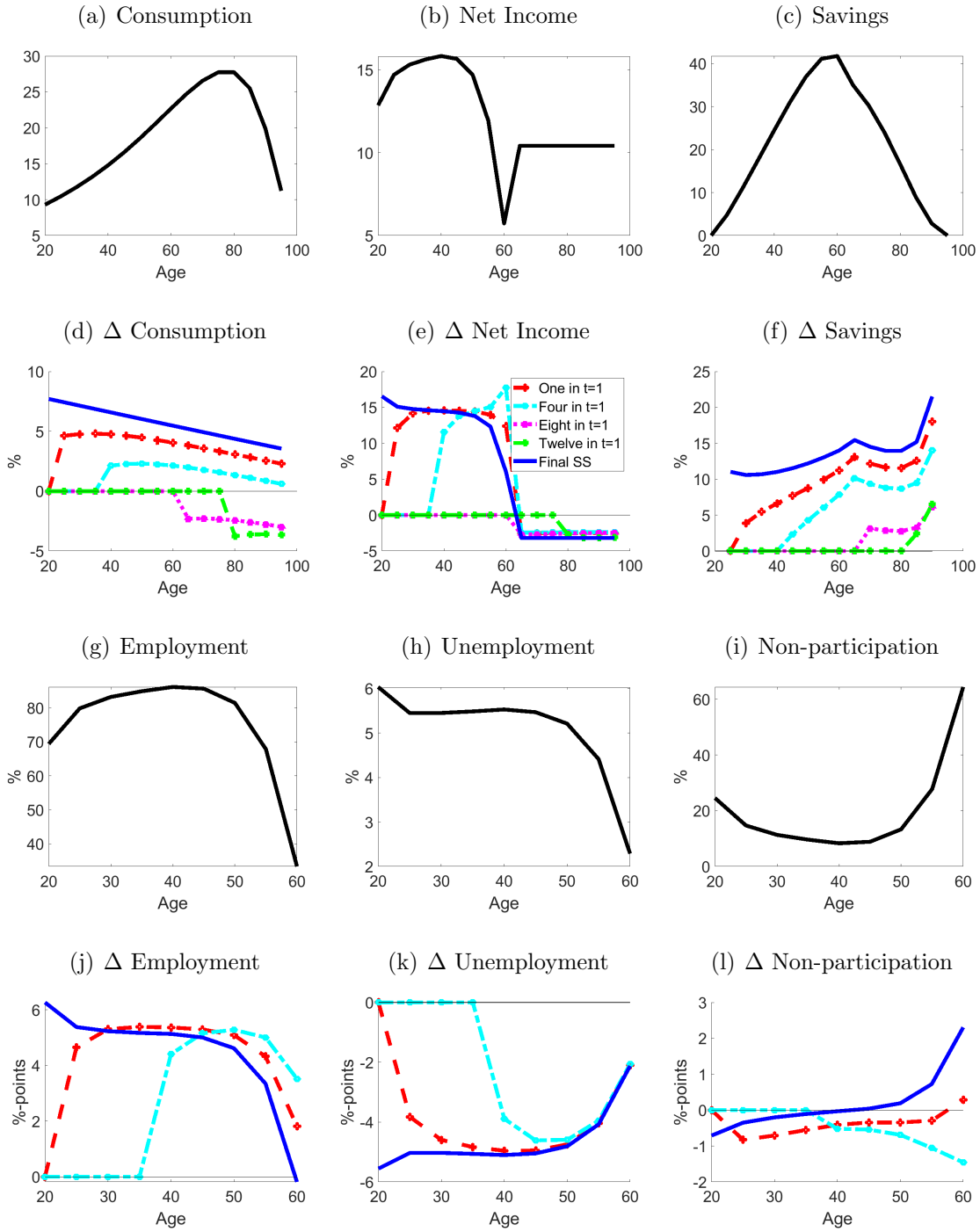
C Appendix C: Using lump-sum taxes to finance the labour tax rate reduction

In this appendix, we show the graphs when simulating a decrease in the labour income tax rate that is financed by lump-sum taxes (instead of consumption taxes). Aggregated macroeconomic and welfare effects are analogous. This is the case because lump-sum taxes are no longer fully Ricardian in our setup (due to the overlapping generations assumption and the finiteness of life, it affects the savings decision of households). However, because consumption taxes directly enter the marginal utility of consumption and the wage bargaining equations (as can be seen in the model description), while lump-sum taxes do not (they "only" reduce disposable income in the budget constraint), the use of lump-sum taxes is still slightly better than the use of consumption taxes. But these effects are of minor importance which can easily be seen by comparing (magnitudes of the effect in) the Figures below to their counterparts in the main text.

Figure 9: Marginal costs of labour

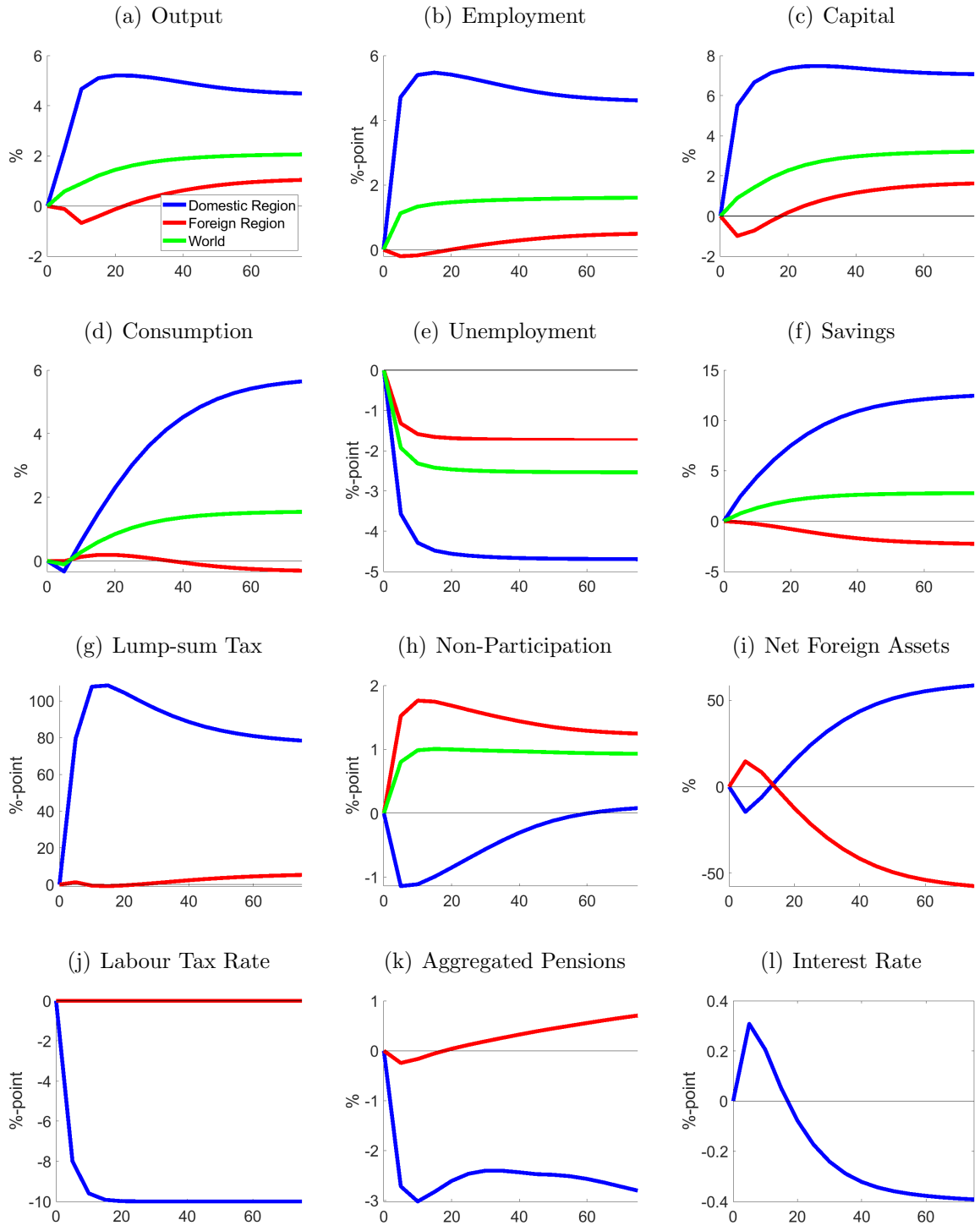
Notes: The figures plot tax shift induced evolution of net wage, gross wage, and employment. Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for employment rate).

Figure 10: Life Cycle Pattern



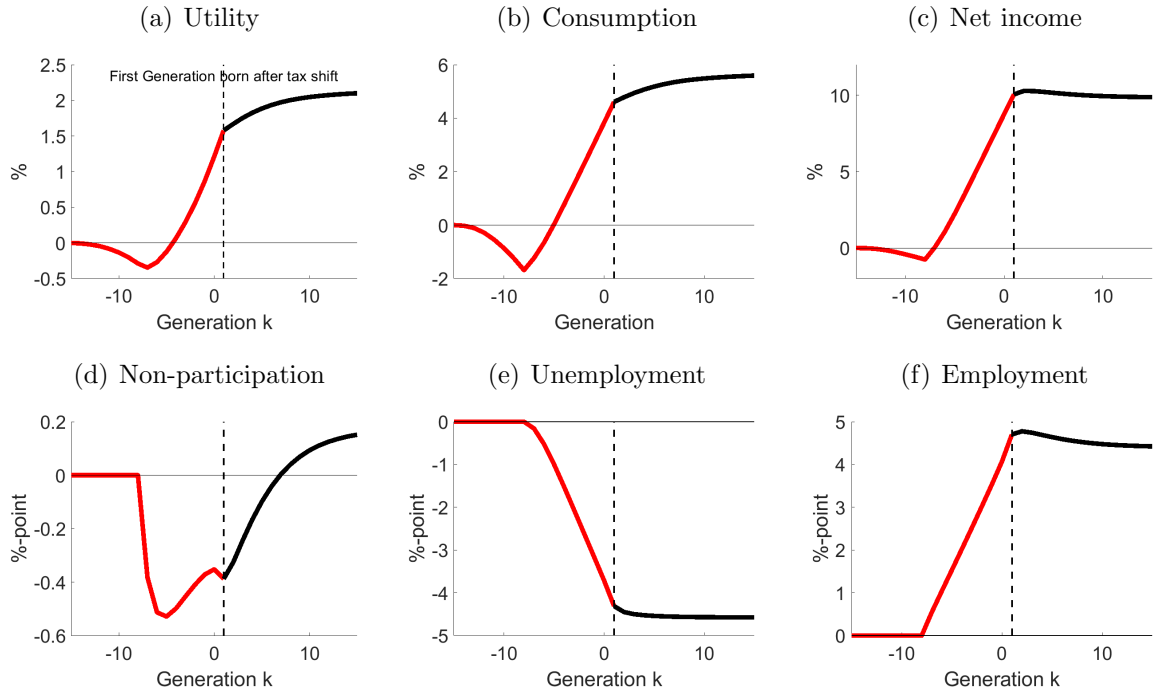
Notes: Panels (a)–(c) show absolute values of consumption, net labour & pension income, and savings, panels (g)–(i) show the rates of employment, unemployment and non-participation in the labour market over the life cycle of households in the initial steady-state. Panels (d)–(f) and panels (j)–(l) show relative deviations from the initial steady-state. Solid blue lines represent households living completely in the final steady-state. Dashed lines stand for households starting their lives in the initial steady-state and are affected by the tax shift different at ages: 25 (red), 40 (turquoise), 65 (pink) and 80 (green).

Figure 11: Aggregated Effects of a Domestic Tax Shift



Notes: This figure shows domestic tax shift induced evolution of key (macroeconomic) variables for the domestic (blue) region, the foreign (red) region, and the aggregated "world" economy (green). Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for rates).

Figure 12: Lifetime Variables



Notes: This figure shows tax shift induced evolution of households life time variables. Variables are shown in percentage deviations to a household lived its whole life in the initial steady-state (percentage point deviations for rates).

D Appendix D: Simulating a tax cut in both regions

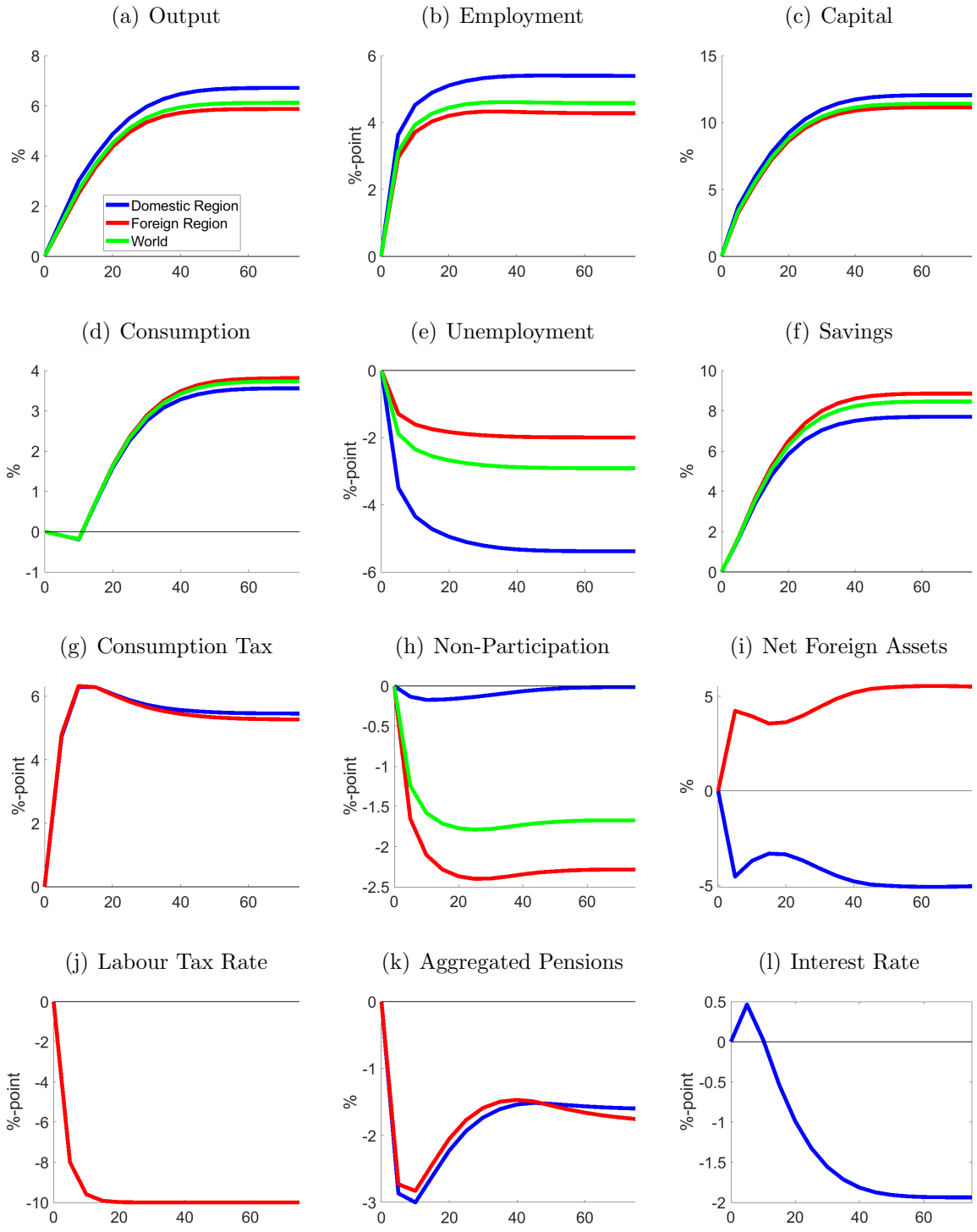
In this appendix, we discuss the effects of simulating a decrease in the labour income tax rate financed by higher consumption taxation in both regions. This is akin to a simulation in a closed economy (when focusing on the world aggregates). In Figure 13, we see that net and gross wages as well as employment in the two regions now react analogous (the small quantitative differences come from slightly different labor market parametrization; see main text). Hence, in contrast to undertaking the tax shift in one region only, there is no longer a significant improvement of labour costs and, thus, international competitiveness in one region vis-a-vis the other. This also implies that there are no longer significant movements in the net foreign asset position because savings in both regions now increase, in contrast to a tax shift in one region only (see Figure 14).

Households in both regions now increase their saving (to an analogous degree) because the incentive to save more (which is described in detail in the main text) rises in both regions. The resulting higher increase in world savings drives down the asset market-clearing world interest rate significantly more. This, in turn, fosters capital investment more. A higher capital stock increases marginal productivity of labour and also augments employment. All this implies that, in case a coordinated tax shift is undertaken, positive effects in both regions can be achieved. Relative to only undertaking it in the domestic region only (blue line), domestic output and consumption is also affected more positively. Albeit international competitiveness does not improve in this situation, the positive demand effects over-compensate the competitiveness effect in this case. This also holds when comparing world output (a proxy for a closed-economy simulation) to the domestic effects presented in the main text.

Figure 13: Marginal costs of labour

Notes: The figures plot tax shift induced evolution of net wage, gross wage, and employment. Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for employment rate).

Figure 14: Aggregated Effects of a Tax Shift in Both Regions



Notes: This figure shows domestic tax shift induced evolution of key (macroeconomic) variables for the domestic (blue) region, the foreign (red) region, and the aggregated "world" economy (green). Variables are shown in percentage deviations to the initial steady-state (percentage point deviations for rates).