Projektbericht

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A general equilibrium approach, background paper for the ECA Old-Age Insurance World Bank report

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Final Report

Study on behalf of The World Bank

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Aging and pension reform, a general equilibrium approach - background paper for the *ECA Old-Age Insurance* report - Final report

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Abstract

This document is the final report for a background paper for the *ECA Old-Age Insurance* report, using a General Equilibrium approach to analyze aging and pension reforms in two countries from the Europe and Central Asia region, Poland and Slovakia. Compared to the second interim report, this document adds analysis for some additional reforms, sensitivity analysis and policy implications.

Low fertility and increases in life expectancy lead to aging of the population. As the number of young active households is growing less rapidly (or even shrinking) than old households prone to retirement, the financing of pension systems is a challenge when these systems are based on the pay-as-you-go scheme. All developed countries rely to some extent on pay-as-you-go schemes. The basic challenge of pension financing created by population aging is common to many developed countries. The challenge confronted by countries in the ECA region may however be larger, for several reasons. In particular, high participation in informal markets decreases government revenue, adding to immediate pension financing difficulties. Using an expanded overlapping generations model with endogenous retirement decisions with formal and informal sectors, simulation predicts that aging would increase social security deficits by more than 5% of GDP by 2100. Among the various reforms considered, cuts in pension benefits are the most successful at containing the deficits if the sole goal of reforms is financial sustainability. Increases in retirement age may be preferable if additional goals are considered. Targeting a decrease in informality alone may not help to decrease the deficit in the long run because gains in revenues are offset by the increase in pension payments.

For the sake of completeness and ease of reading, some parts of the second interim report, dated 12 October 2012, have been included without any change in this final report [1].

Keywords: population aging, pension reforms, formal and informal sectors
JEL-Classification: D58, E26, H55, J11, J26, J65

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[1] Only small changes in sections 1, 2, 3 and 5 have been applied. Differences in these sections are clearly identified. There are significant changes and additions in section 6. Sections 4, 7 and 8 are new.

1 Introduction[2]

Economic development is associated with population aging, the fact that the proportion of old individuals in the society is increasing, a mechanical consequence of declining rates of fertility and increases in life expectancy. According to the United Nations (2011) demographic projections, the old-age dependency ratio, which computes the number of persons aged 65 years and above over the number of persons 15 to 64 years old, should increase from a worldwide average of 12% in 2010 to 30% in 2060. In Eastern Europe, the ratio should increase from 19% to 46% and in Central Asia from 7% to 27%. These demographic changes can have large economic consequences. Unless pension systems are reformed, there can be large financial deficits: with a dominating pay-as-you-go component, the number of young working households will be insufficient to finance the consumption of old retired households. Comparing pensions systems and planned reforms in the EU27 zone, the Economic Policy Committee and the European Commission (2012) estimate that population aging will increase pension expenditures by more than 5 percentage points of GDP in several countries between 2010 and 2060, including Slovakia. In Luxembourg, pension expenditures should rise from 9% of GDP to more than 18% of GDP.

All developed countries have to answer the same pension financing question posed by population aging. For countries in the Eastern Europe and Central Asia region however, the challenge is larger, for several reasons. These include high inherited pension expenditures, a large informal sector, high burdens of taxes and contributions. As the common challenge of population aging has been well documented and researched, we focus our discussion on countries in Eastern Europe and Central Asia (ECA[3]).

First, the transition to a market economy started with large output and employment drops. Many countries used early retirement schemes to ease the transition (Boeri and Terrell, 2002; OECD, 2003; Schneider and Burger, 2005; Chawla et al., 2007), increasing pension expenditures. As Svejnar (2002) writes, "*the promises of these systems, which are largely pay-as-you-go, are not sustainable*".

Second, the informal sector is larger in the ECA region than in other developed countries. According to estimates from Schneider et al. (2010), the average shadow economy size in the ECA region was 36.5% of official GDP in 2005, compared to 13.5% of GDP in high income OECD countries.[4] Large informal market participation reduces the base for general tax revenues and pension budgets. Increasing tax and contributions rates to compensate for the smaller base may however have the counter-productive effect of increasing the informality rate (Schneider and Enste, 2000). Taking an average of 22 empirical studies, Schneider (2012) finds that the "increase of tax and social security contribution burdens" factor explains 50% of the influence of institutional factors on shadow economies, the second factor accounting for a mere 15%. Finding the right balance between incentives for participation in the formal labor market and financing of social security is thus a difficult task (Chawla et al., 2007).

Third, current contribution and tax rates are already fairly high, by international standards (Schneider and Burger, 2005). Increasing rates to generate additional government revenue and finance public pension systems can make the informal labor market more attractive. The room for additional revenue is thus small, an additional constraint to pension reforms.

[2] Except for last two paragraphs, identical to the second interim report, dated 12 October 2012.

[3] Strictly speaking, ECA denotes the entire Europe and Central Asia region. For ease of reading, we also use the abbreviation ECA for the subsample of Eastern Europe and Central Asia.

[4] One should however note the heterogeneity within both groups. The size of the shadow economy ranges from 8.5% of GDP in 2005 for Switzerland to 27.1% for Italy or 29.9% for Mexico, while the lowest value in the ECA region is attained by the Slovak Republic with 17.6% in contrast to 26.9% for Poland or even 65.1% for Georgia.

For an in-depth analysis of aging and reform options in the ECA region we focus on two countries, Poland and Slovakia. We believe that these two countries constitute a small sample which is reasonably representative of the ECA region, as they cover different portions of the demographic and economic spectrum: one is large while the other is comparatively small, both face a significant population aging challenge, and pensions expenditure projections predict very different outcomes.

With 38 millions inhabitants, Poland is one of the 10 most populated countries in Europe while Slovakia, with less than 6 millions, is in the lower tier. Figure 1 shows that population aging in these two countries is no smaller challenge than in the rest of Europe. Demographic projections used by the Economic Policy Committee and the European Commission (2012) even predict that lower than average fertility rates and net migration flows will lead to some of the highest old-age dependency ratios in the EU27 zone in 2060 (Poland: 2nd highest; Slovakia: 4th highest).

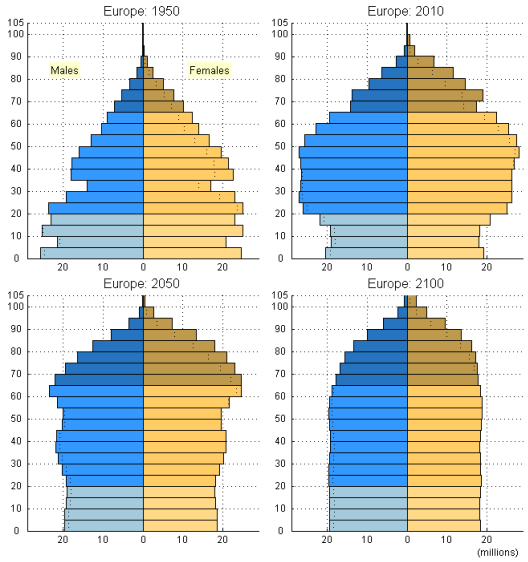
Even if Poland and Slovakia face the same demographic challenge, past and planned reforms are different and are expected to have very different economic consequences. Poland currently spends more on pensions but its pioneer 1999 reform towards a multi-pillar system is predicted to lead to a decrease in expenditures, according to projections from the Economic Policy Committee and the European Commission (2012) (11.8% of GDP in 2010 versus 9.6% in 2060). In contrast, the European Commission estimates an increase in pension expenditure for Slovakia (8.0% of GDP in 2010 versus 13.2% in 2060), which also implemented a multi-pillar system in 2004/2005. A main explanation is that the Polish PAYG system relies on notional accounting, hence benefits vary according to changes in life-expectancy also after retirement, while the latter is not true in the Slovak PAYG pillar, where benefits are calculated according to points earned during time before retirement. Differences between the two countries also take place in other dimensions of the labor market, with Poland having one of the lowest net replacement ratio (considering taxes and benefits together) and Slovakia one of the largest (Schneider and Burger, 2005).

There are several approaches to evaluate pensions financial sustainability under an aging population. The three standard methods in the literature are projections, generational accounting and overlapping generations modeling. As discussed by Jimeno et al. (2008), these methods deliver similar conclusions when no reforms are considered, but only overlapping generations models are able to capture general equilibrium effects of reforms and deliver a more accurate evaluation of the effect of reforms.

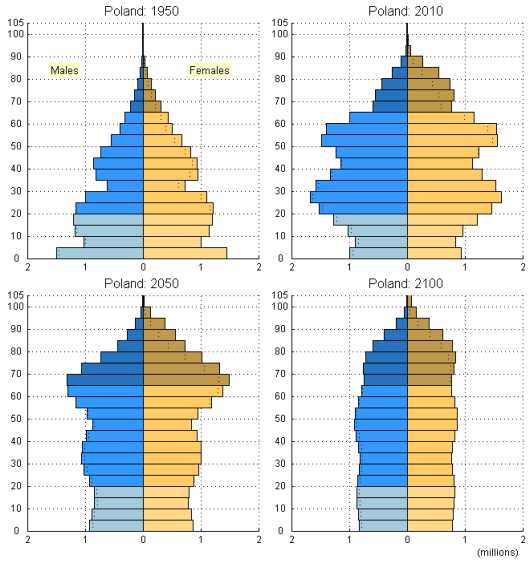
We will thus perform the analysis of the effect of aging and different pension reforms using an overlapping generations model. The critical components of the model are as follows. The overlapping generations structure needs to be fine enough to capture the long run demographic changes. Endogenous labor supply decisions need to include hours, participation and retirement decisions, as tax changes affect hours and participation decisions and pension reforms may change retirement behavior of households. Finally, given the importance of the informal sector in transition economies and the impact on pension expenditures and government revenue, the model needs to capture household decisions to participate either in the formal or in the informal market.

To the best of our knowledge, there does not exist any overlapping generations model with endogenous decisions both on retirement and on informality. We will thus expand the Berger et al. (2009) model to endogenous participation decisions in formal or informal sectors. This model is based on the probabilistic aging overlapping generations structure (Grafenhofer et al. 2007), where mortality rates are age-dependent, suitable for a fine analysis of demographic changes. It contains endogenous decisions margins along several dimensions, including hours, participation, retirement, education and search effort while unemployed. The model is already calibrated for Poland and Slovakia.

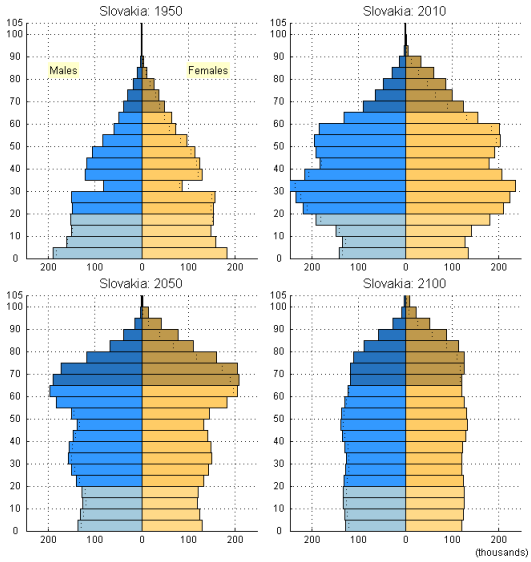
Figure 1: Projected age pyramids in Europe, Poland and Slovakia, as per United Nations (2011).



(a) Europe



(b) Poland



(c) Slovakia

The extension to informality features several components of prominent theoretical analysis in the field. As Fugazza and Jacques (2004), we assume that goods produced in the formal and in the informal sector can not be distinguished. Differences between sectors will thus lie in production and we will assume that the production technology in the informal sector is simple so that no capital is required, consistent with Ihrig and Moe (2004) and Amaral and Quintin (2006). Neither workers nor firms in the informal sector pay any taxes. Because goods are indistinguishable for the consumer, we follow Bird and Smart (2012) in assuming that an informal sector producer charges the same price as the after-tax price of a formal sector producer. Informal sector producers will thus be able to keep the VAT for themselves. As Galiani and Weinschelbaum (2012), we assume that households have a different tolerance for working in the formal sector, where regulation is constraining behavior. Households choose to work in the formal or informal sector depending on this unique tolerance level, social security benefits they would gain by participating in the formal market and taxes they avoid by participating in the informal market. In line with Fortin et al. (1997) and Albrecht et al. (2009), unemployed households may find home production or welfare benefits more attractive than joining either of the formal or informal labor markets.

The resulting overlapping generations model with endogenous retirement and informal market participation decisions is appropriate for the analysis of the effect of population aging on macroeconomic outcomes and public finances. It allows to compare taxation and pension policy reforms taking into account behavioral responses from households. For instance, it can quantify the net effect of decreases in the rate of social security contributions, which on the one hand reduce pension financing for a given contribution base, but on the other hand increase the incentive for formal market participation and so increase the contribution base.

Simulations confirm the challenge posed by population aging on the financing of social security, deficits growing by more than 5 percentage points of GDP in constant population terms until 2100. They also show that population aging alone, without any reforms, reduces the rate of informality by as much as 30% and that informality alone is not a cause for social security deficit. From the various reforms considered, reductions in pension benefits are the most efficient reforms to cut the social security deficit due to aging, if the sole goal of reforms is financial sustainability. Increases in the retirement age may be preferable if one trades-off financial sustainability, reduction in informality, prevention of old-age poverty and high output per capita.

The next section presents a simple overlapping generations models with endogenous retirement and informality participation. Section 3 summarizes the additional structure of the full scale model used for aging and pension reform analysis. Section 5 summarizes the calibration approach. Section 6 presents and discusses the result of the analysis. Section 7 derives some policy implications. The last section concludes.

2 A simple model with retirement and informality[5]

We start by a detailed presentation of the overlapping generations model with endogenous retirement and informality decisions, a scientific novelty. For ease of understanding and to isolate the crucial novel features, we keep the model simple. A complete and more realistic model will be used for demographic and policy evaluation, presented in section 3.

[5]Contents essentially identical to the revised first interim report, dated 14 August 2012. Some clarifications have been added in subsections 2.2 and 2.4.

2.1 Overview

For simplicity we consider the Diamond-Samuelson overlapping generations structure with 2 generations and no uncertainty. All households from the first generation (the *young*) decide to participate in a labor market or not; if they decide to participate, they then decide to join the formal or the informal labor market. Households from the second generation (the *old*) choose their retirement date; before retiring, they choose to work in the formal or the informal market. The young also decide how much to consume in the first period and how much to save for the second period. When young, non-participants receive welfare benefits. When old, retirees receive a pension, with a formal market earning related part and a flat anti-poverty part.[6] Old households who always chose to work in the informal labor market thus only receive the flat pension.

From a modeling perspective, the retirement decision when old is equivalent to the participation decision when young, which helps to keep the model simple: a low participation when old is interpreted as early retirement. One can think for instance of periods covering 30 years. If individuals start their working life in average at age 20, a participation rate in the second period of 0.4 would correspond to retirement at age 62.

Government gets revenue from labor income taxes and consumption taxes and uses it to finance own consumption, welfare benefits and pay-as-you-go pensions. For simplicity we assume that government has no debt.

We assume that the economy is small and takes the interest rate as given.

We do not focus on demographic changes at this stage, so that we can assume constant population and certainty in life duration[7]. In the complete model, uncertainty in life duration will be introduced as well as age-dependent mortality rates, to better capture demographic changes and population aging in particular, most relevant for pension reform analysis. Other realistic features of labor markets and public finance will be introduced in the full scale model, such as labor supply along the intensive margin, productivity growth, unemployment, heterogeneity in skills, public debt, incentives for postponed retirement and capital income taxes. Details will be provided in section 3.

2.2 Specifying informality

If they decide to participate in any labor market, households then decide whether to join the formal or the informal labor market. This second decision will depend on characteristics of the informal labor market and regulation. The basic difference between the informal and the formal sector is that agents in the informal sector operate outside regulation. Since it does not capture underreporting, the model includes informal economies but not shadow economies[8].

More specifically, the particular features of the model related to informal labor markets are as follows (when relevant, we refer to similar theoretical analyzes):

[6] The pension system of neither the Slovak Republic nor Poland features a purely flat anti-poverty part. This part will nevertheless be useful in the calibration to match total pension expenditure and capture non-linearities in the the pension system. We return to this question in section 3.

[7] Uncertain life duration is more realistic. A Blanchard (1985) OLG structure is appropriate when there is no retirement. Richer OLG structures are needed for both retirement (whether exogenous or endogenous decisions) and uncertainty in life duration. Since our focus is simplicity and the interplay of retirement and informality, we prefer to opt for certain life duration and a Diamond-Samuelson structure.

[8] Calibration could but does not have to rely on shadow economy output estimates. As will be explained in appendix A.3, we will not rely on such estimates.

- Production in the informal market is simple, requires no capital, uses a linear technology (with productivity growing at the same rate as in the formal market; Ihrig and Moe, 2004; Amaral and Quintin, 2006)
- Labor supply in the informal market is unobserved and constant (no labor income taxes are paid)
- Government can not distinguish between non-participants and informal labor market participants
- In particular, informal labor market participants pay no labor income taxes and can claim non-participant welfare and anti-poverty pension benefits
- Goods produced in the formal and informal markets can not be distinguished and are perfect substitutes for households (Fugazza and Jacques, 2004) but informal market producers prefer to sell to households (for immediate consumption) rather than firms (for investment), to minimize the risk of being discovered by the government
- Informal sector participants sell their goods to households in the same market as formal goods producers, and goods being indistinguishable, receive and keep consumption taxes[9] (Bird and Smart, 2012)
- There is no black market bank so capital income from informal labor market participants is also taxed (via source taxation)
- Working in the formal labor market generates net disutility compared to participating in the informal market. On one hand these costs can be motivated as psychological cost of compliance with regulations. See for example Galiani and Weinschelbaum, 2012. On the other hand one could think of disutility of not conforming to social norms or actual costs of being caught and punished when working informally. The model will not distinguish between these forms of disutility and always address both forms jointly as net disutility. Hence, whether the net disutility is captured on the formal or informal side is a matter of presentation.

2.3 Household behavior

We denote with an index $a = 1$ variables relating to the first period of the life of a household (young), and $a = 2$ for the second period (old). Decision variables are:

- C_t^a: how much to consume
- $\delta_t^a \in [0, 1]$: participation probability in any labor market
- When $a = 2$: δ_t^a defines the retirement age
- $\zeta_t^a \in [0, 1]$: in case of participation, probability of joining the formal labor market

We assume that working in the formal labor market sector produces net disutility (which could in principle be positive or negative).

[9] This implies that a VAT increase could increase informality as it would become more attractive in comparison to formal work. Section 4 will provide a more extensive discussion of this and other modeling choices.

The household maximization problem in the first period (young, born at time t) is then:

$$V_t^1 = \max_{C_t^1, \delta_t^1, \zeta_t^1} \quad u\left(Q_t^1\right) + \beta V^2(A_{t+1}^1, P_{t+1}^1)$$

with

$$\begin{aligned}
Q_t^1 &= C_t^1 - \bar{\varphi}_t^1 \\
\bar{\varphi}_t^1 &= \varphi_P(\delta_t^1) + \delta_t^1 \varphi_F(\zeta_t^1) \\
A_{t+1}^1 &= R_{t+1}\left(y_t^1 - (1+\tau_c)C_t^1\right) \\
y_t^1 &= \delta_t^1 \zeta_t^1 (1-\tau_w) w^1 l^1 + (1-\delta_t^1) z^1 + \delta_t^1 (1-\zeta_t^1)(z^1 + (1+\tau_c) y_{inf}^1) \\
P_{t+1}^1 &= \delta_t^1 \zeta_t^1 m\, w^1 l^1
\end{aligned}$$

where u is the instantaneous utility of consumption, $\beta < 1$ represents the time discounting preference, A_{t+1}^1 are assets at the end of the period, P_{t+1}^1 are (notional) pension rights accumulated when working in the formal market, $\bar{\varphi}_t^1$ is the total disutility of working expressed in goods consumption terms, φ_P is the disutility of participation, φ_F is the net disutility of working in the formal market, $R_{t+1} = 1 + r_{t+1}$ is the given gross interest rate, y_t^1 is the average income in period 1, w^1 is the wage rate in the formal sector, l^1 are labor hours in the formal labor market, z^1 are welfare benefits for non-participants, y_{inf}^1 is the output from the informal sector with linear production technology (constant labor, no capital) and m is a pension right accumulation factor.

The household maximization problem in the second period (old) for the same household is:

$$V^2(A_{t+1}^1, P_{t+1}^1) = \max_{C_{t+1}^2, \delta_{t+1}^2, \zeta_{t+1}^2} \quad u\left(Q_{t+1}^2\right)$$

with

$$\begin{aligned}
Q_{t+1}^2 &= C_{t+1}^2 - \bar{\varphi}_{t+1}^2 \\
\bar{\varphi}_{t+1}^2 &= \varphi_P(\delta_{t+1}^2) + \delta_{t+1}^2 \varphi_F(\zeta_{t+1}^2) \\
0 &= R_{t+2}\left(A_{t+1}^1 + y_{t+1}^2 - (1+\tau_c)C_{t+1}^2\right) \\
y_{t+1}^2 &= \delta_{t+1}^2 \zeta_{t+1}^2 (1-\tau_w) w^2 l^2 + (1-\delta_{t+1}^2) P_{t+1,net}^2 + \delta_{t+1}^2 (1-\zeta_{t+1}^2)(P_{t+1,net}^2 + (1+\tau_c) y_{inf}^2) \\
P_{t+1}^2 &= R_{t+1}^P P_{t+1}^1 + \delta_{t+1}^2 \zeta_{t+1}^2 m\, w^2 l^2 \\
P_{t+1,net}^2 &= \nu\, P_{t+1}^2 + P_0
\end{aligned}$$

where $P_{t+1,net}^2$ is the net pension payment, $R_{t+1}^P \leq R_{t+1}$ is a (notional) interest rate on pension rights (which capture administration costs), ν is the conversion rate of pension rights P_{t+1}^2 into monetary payments and P_0 is a anti-poverty pension (unrelated to earnings on the formal labor market). The third line only states that there is no saving at the end of the second period and that old households consume all their savings. Compared to period 1, the only difference is that welfare benefits z^1 are replaced by pension payments $P_{t+1,net}^2$. As in period 1, government can not make the difference between non-participants and black market participants, so both can collect pension payments.

2.4 Production

Goods: Goods from the formal sector and from the informal sector can not be distinguished. They are perfect substitute for households. Because of this, they are sold at the same after-tax price to households and informal market producers can keep the consumption tax proceeds. We normalize units so that the formal market producer price of the good is 1. As a consequence, the budget constraint of a household is expressed in the same manner, with or without informal markets (e.g $A^1_{t+1} = R^\tau_{t+1}\left(y^1_t - (1+\tau_c)C^1_t\right)$).

We introduce the assumption that the goods from the informal market are immediately consumed by households and are not used for investment or government consumption, hence private consumption equals production ($\sum_a C^a_{inf} = \sum_a Y^a_{inf}$).[10] This way consumption tax revenue can be expressed in a simple way (see below). Although our single-good framework abstracts from all sorts of heterogeneities, this assumption reflects the idea of a pattern where very small firms tend to work informally and focus on consumption goods more extensively compared to big firms which are more likely to operate formally and are in addition also responsible for the production of investment goods. This could be motivated by an asymmetric information setting where buyers cannot distinguish sellers and their goods, while the sellers have a preference for selling their goods only to households, e.g. as there is a lower chance that illegal transactions are detected by authorities. The chance of detection is however not explicitly modeled.

Note that informal sector producers can sell their good on the market and decide to save some of their income. The assumption does not mean that informal sector producers consume all what *they* produce. Being an informal market participant is a production characteristic of households, not a consumption characteristic.

We denote by Y_f the aggregate output from the formal market (the official GDP), Y_{inf} the aggregate output from the informal market and $Y = Y_f + Y_{inf}$ the total output.

Formal market: Production in the formal market is identical to standard overlapping generations models. Firms take formal market labor supply $L_f = \sum_a \delta^a \zeta^a N^a l^a$ as given and define investment level I to maximize firm value, facing quadratic capital adjustment costs J.

More specifically, production uses capital K and labor L_f using a Cobb-Douglas technology, $Y_f = K^\alpha (L_f)^{1-\alpha}$. Following Hayashi (1982), we assume that changes in capital is a costly operation for firms, and use a quadratic specification for adjustment costs $J = K(I/K - \delta)^2$, where δ is the capital depreciation rate. The capital law of motion is $K_{t+1} = (1-\delta)K_t + I_t$. Because the labor market is perfect, the after-tax wage $(1-\tau_w)w$ equals the marginal product of labor. Firms take factor prices and labor supply as given and define investment I to maximize firm value V, defined in a recursive fashion:

$$V(K_t) = \max_{\{I_s\}_{s=t,t+1,\dots}} Y_f\left(K_t, (L_f)_t\right) - w_t\left(L_f\right)_t - I_t - J_t(K_t, I_t) + \frac{1}{R_{t+1}} V(K_{t+1})$$

This expression states that investments decision maximize the current period profits with the discounted next present value of the firm in the next period.

Informal market: Labor supply on the informal market is unobserved and is assumed to be constant: taxes are not perceived so they do not have the direct influence that they have on

[10] Empirical estimates of the size of shadow economies lead to a weighted mean of 36.5% of official GDP in Europe and Central Asia according to Schneider et al. (2010). As informality is part but not all of the shadow economy, activity related to informality should thus be no larger than 36.5% of GDP. Assuming that the output of the informal sector is entirely consumed is thus realistic.

working hours in the formal market. Production y^a_{inf} uses a linear technology, with no capital and constant labor supply (which we normalize to 1). Firms in the informal market can have any size. When firms have size one, being an informal worker is equivalent to self-employement without paying labor income taxes but collecting welfare benefits . Because productivity and labor supply in the informal market are not observed, we do not decompose y^a_{inf} into its production factors (e.g. y^a_{inf} = productivity $\times$ labor supply)[11].

Even though production factors are not observed (and not handled in the model), y^a_{inf} plays a role in the model, as it defines the value of participating in the informal labor market.

The aggregate output from the informal market Y_{inf} is simply:

$$Y_{inf} = \sum_a Y^a_{inf} = \sum_a \delta^a_t (1 - \zeta^a_t) N^a_t y^a_{inf}$$

2.5 Government

We assume that the government can not observe informal market activity. In particular, the government can not make the difference between non-participation and informal labor market participation. As a result, both non-participants and informal market participants can claim the same welfare benefits z^1 when young. When retired, households who occasionally did not participate in the labor market and households who occasionally participated in the informal market, or both, can make claims on pensions in a similar fashion, with a flat part P_0 and an (formal) earnings related part. Government receives no labor income tax from informal labor market participants.

Since formal market and informal market goods can not be distinguished, government can not raise consumption tax revenue from the informal market. Informal market producers, selling goods at the same after-tax price, keep the tax revenue for themselves[12].

Compared to a model without informality, only total consumption tax revenue is different. It is equal to:

$$\tau_c \left(\sum_a N^a C^a - Y_{inf} \right) \equiv \tau_c \ (C - Y_{inf})$$

since output in the informal market equals consumption at every point in time (see above).

We assume that government balances its budget at every period (using any of the tax rates or government consumption as closing instrument), so that tax revenues equal expenditures:

$$\begin{aligned} & \tau_c \ (C - Y_{inf}) + \tau_w \left(\sum_a \delta^a \zeta^a N^a w^a l^a \right) \\ = \quad & CG + N^1 \left((1 - \delta^1) + \delta^1 (1 - \zeta^1) \right) z^1 + N^2 \left((1 - \delta^2) + \delta^2 (1 - \zeta^2) \right) P^2_{net} \end{aligned}$$

2.6 Equilibrium

We assume a small open economy which takes the international interest rate r_t as given. The goods market will not clear and the trade balance TB will vary with household decisions so that foreign assets will be accumulated. The trade balance takes into account informal market goods,

[11] In the complete model, we will assume exogenous labor productivity growth. Then, we will assume that productivity in the informal market grows at the same rate as in the formal market. As a consequence, we can detrend informal labor market variables as for the formal labor market.

[12] We also assume that savings of informal market participants are stored as for formal market participants, and earn the same after-tax returns. Informal market participants thus pay capital income taxes.

since these can not be distinguished and needs to purchased by households:

$$TB = Y - C - CG - I - J$$

Foreign assets DF keep track of accumulation in trade balance positions:

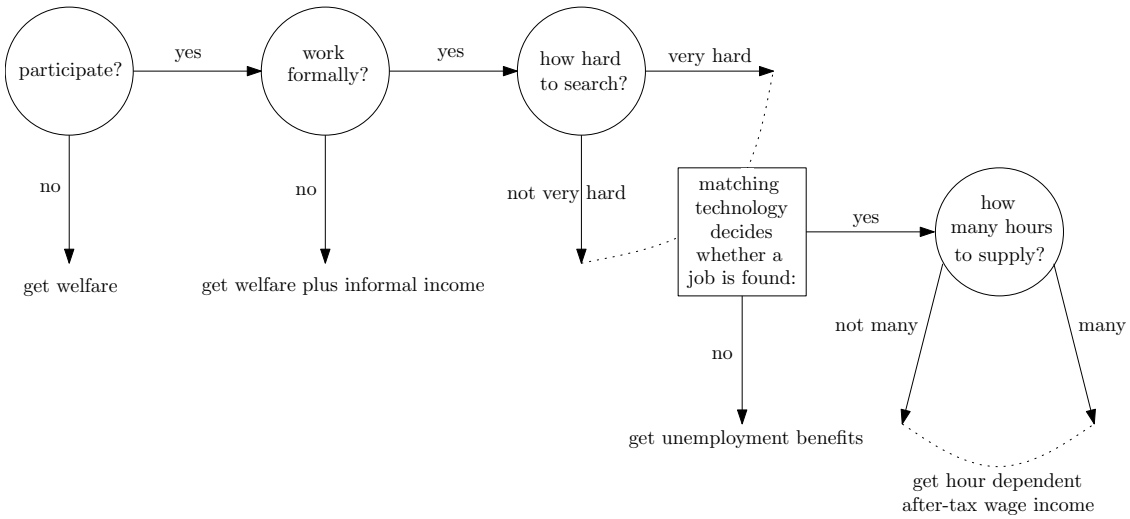
$$DF_{t+1} = R_{t+1}(DF_t + TB_t).$$

3 Full scale model for evaluations[13]

The retirement and informality model from section 2 is too simple for policy relevant analysis, as several components are missing. We will add informality to a full scale overlapping generations model in the same way it was done for the simple Diamond-Samuelson model. The existing full scale model is described in details in Berger et al. (2009) and has already been used for various policy reform analysis, including tax and pension reforms. We present the main additional characteristics of this model below and focus on the most important components for the project.

Uncertainty in life duration and age-dependent mortality rates are used, to better capture the effect of population aging. Because of a search friction, labor markets are imperfect and workers who decided to participate in the formal labor market may remain unemployed, in which case they perceive unemployment benefits. If they decide to participate in the informal markets, households are never unemployed[14]. Households take labor supply decisions along several margins, on top of participation, retirement and informality: how many hours to supply on the formal market, depending on social security contributions and labor income taxes; how many hours to search when unemployed; how much time to spend in education before entering the labor market; how many hours to invest in continuous training while working. As a result of initial education decisions, households have one of three skill levels, providing different wage levels. Figure 2 illustrates the chain of decision making of households concerning labor supply.

Figure 2: Labor market decisions in the full scale model



[13]Except for the new figure 2 and the last two paragraphs, identical to the second interim report, dated 12 October 2012.

[14]From the point of view of government and the model, unemployment in the informal sector corresponds to non-participation.

Government collects taxes on several fronts, including labor income taxes, social security contributions on workers' and firms' side, capital income taxes, firing taxes, firm profit taxes and consumption taxes. It provides different types of social insurance and benefits, such as welfare benefits, unemployment insurance, training or investment subsidies. Government also administrates a pay-as-you-go pension system and provides small or strong incentives for postponed retirement, such as more than proportional increases in pension benefits for delayed retirement. Health expenditures are assumed to be constant per capita (potentially age-dependent) and covered by the government budget.

Pensions are modeled with two parts and financed by a pay-as-you-go system. There are flat payments to retired workers, unrelated to labor market history and suitable to fight poverty in old age. There are earnings-related payments, which depend on the amount of pension rights accumulated throughout the (formal) working life. Pension rights are accrued at a rate comprised between inflation and total labor productivity growth. The rate is a policy parameter and can be different for households in age of working and households in retirement. As this parameter is important, we will refer to values in Poland and Slovakia during the reforms simulations in section 6. Households are free to save while young in order to finance more consumption after retirement than what pension payments alone allow. There are however no specific policy instruments to encourage private savings dedicated to retirement financing, so the model does not capture third-pillar pensions. We however make sure to calibrate the model so that total pension expenditures match aggregate multi-pillar data. There is no mechanism in the model to tie pension payments to demographic variables.

There are two sources of variation in labor productivity: exogenous technological progress and endogenous training decisions. Employed workers in the formal sector decide how much time to devote to work and how much time to training. The more the training, the higher the labor productivity. In a steady-state equilibrium, training decisions vary over the life-cyle but are constant in average, so that average labor supply grows at the technological progress rate. We will refer to this rate as the growth trend. Because pension rights accumulate at a rate which is (partly) indexed to total labor productivity, the growth trend plays a role in financing of pension systems.

4 Discussion of informality modeling

We now present a discussion of the implications of the modeling of informality in the simple and full scale models. As with every model, it is simpler than reality. In general, choices have been made to focus on parts of informality which are most relevant for public finances.

We start by an illustration of the effect of adding informality to existing models, discussing impacts on the labor market. We then discuss the analysis which can be done with the model, followed by a discussion of the analysis which can not be done. We also mention the impact that the modeling choices are likely to have on the results.

When adding informality, what is the impact on the (formal sector) labor market? Compared to a model without informality, wages in the (formal) labor market have one more reason to vary with households decisions, namely informality decisions. Without informality, (formal sector) wages are impacted by consumption decisions (how much to save impacts capital formation, the capital-effective labor ratio and thus the marginal product of labor), participation and hours decisions (how much effective labor is provided impacts the capital-effective labor ratio). These decisions are in turned defined by preferences and institutions. For instance, labor income taxes

reduce both participation and hours provided. With informality, wages are also impacted by sector decisions. If more households choose to participate in the formal sector, effective labor supply in the formal sector is increased, the capital-effective labor ratio declines, the marginal product of labor declines and (formal sector) wages decline. The discussion of simulation results in section 6 will illustrate the importance of this phenomenon.

We now continue with a discussion of what (new) analysis can be done with the model, once informality has been added. The model is suitable for the analysis of the relationships between informality and public policy. For instance, an increase in the pension benefits (via ν in the simple model) increases the incentive for participation in the formal labor market (ζ^a), the labor income tax base and thus government revenue. At the same time, pension expenditures increase, a direct negative impact on government budget. The overall net effect on the government budget is thus ambiguous and simulations will allow to identify and quantify it. Another example is a decrease in labor income tax rate (τ_w) or social security contributions (full scale model). It also increases the incentive for participation in the formal market, increase the tax base but the reduction in the rate has a negative effect on government revenue. Again the overall net effect on public finances is ambiguous and simulations can identify and quantify it.

Section 6 will be more specific on the policy reforms which will be considered with the full scale model.

The model however is not suitable for a detailed analysis of informality alone, in particular its production process. For instance, we can not estimate the impact of technological progress on the informality rate, as we assume that production in the informal sector uses a linear technology with effective labor and no capital, effective labor growing at the same rate as in the formal sector (at constant training decisions).

The model does not capture direct government interventions to reduce informality, such as anti-fraud controls. These interventions are costly but can influence the household decisions to join the formal or informal sector, and thus government tax revenue. Costs and benefits analysis are thus relevant. The model could be extended to capture these direct government interventions. As such however, it can not estimate their effects.

A related simplification of the model is the assumption that all informal market participants collect welfare benefits, as the government cannot make the distinction between non-participants and informal market participants. In reality, informal market participants may prefer to ignore welfare benefits, especially if governments have anti-informality fraud measures. However, we believe that the assumption that informal labor market participants will collect the flat part of pension benefits, once retired, is realistic. Our simulations may thus overestimate the welfare benefit costs of informality. Given the limited weight of welfare benefit costs in aggregate public expenditures and the fact that population aging puts pressure on pension expenditures rather than welfare benefits, we believe that the bias is small.

Since we address informal rather than shadow economies, we neglect the impact of underreporting of economic activity. We thus do not simulate the effect of public policy change on reporting of income and associated government tax revenue. A model extension would be required to perform such simulations.

The last noteworthy simplification of the informality modeling is the assumption that informal sector participants sell their products on the same market as formal sector participants; that goods of the two sectors are indistinguishable; that informal market participants can keep the consumption taxes for themselves. In reality, some of the goods from the informal market can be distinguished. For instance, whether cigarettes are purchased on the black market or not may

be clear in some cases (e.g. purchases on the street). Because there is a risk that the product is of poorer quality, consumers may pay a lower price for identified informal sector goods. Informal market producers may thus sell at a lower price than formal market producers. Depending on the calibration procedure, we may thus be giving an unjustified higher value to informal sector work, and overestimate the public finance costs of informality. Our calibration approach is based on actual earnings reports, presented in appendix A.3, and avoids this problem.

Finally, we present a limitation which is not particular to our modeling of informality, but applies to most general equilibrium analysis of public finance. General equilibrium models rest on the assumption of perfect foresight: households can anticipate the impact of their current actions on their entire future. In reality, it may not be the case. Myopia is one justification for the implementation of mandatory pension savings. We shall see in section 6.1 that population aging alone, without any reform, reduces the informality rate. The reason is the following. With a constant retirement age, having good income after retirement becomes more and more important as life expectancy increases; formal earnings-related pension payments are higher, increasing the attractiveness of formal sector participation. If households are really myopic, they will ignore the increase in life expectancy and the increased attractiveness of the formal sector. The caveat of perfect foresight however applies for decision in every labor market margin, not just formal sector participation, and is not considered to be a major setback. One should however keep it in mind.

5 Calibration[15]

In this section we summarize the calibration procedure. It is based on the calibration strategy designed and presented in the first interim report. The actual procedure is consistent with this strategy although some adjustments were made. Details are presented in appendix A.

Informality rates are taken from Koettl and Weber (2012). Because age and income classes in this paper and in the model are very similar but not identical, we establish simple correspondence rules.

We use household-level data to calibrate income in the informal sector. With one minor exception, we use the same criteria as in Koettl and Weber (2012) to identify informal workers. As earnings data is lacking for Slovakia, we partially rely on estimates for Poland for that country and verify consistency with data from another transition country. We calibrate the earnings profile and levels such that differences between informal workers are consistent with data, along age and skill dimensions, and such that the premium for working in the formal sector as opposed to the informal sector is consistent with data. The resulting weighted averages of the formal sector premiums are 1.157 for the model and 1.169 in the data for Poland and similar values for Slovakia.

Parameters of the net disutility of working in the formal sector $\varphi_F(\zeta)$ define household behavior with respect to informality, when there are policy or economic environment variations. Households may decide to increase participation in the informal sector if social security contributions are increased, for instance. Calibration will define to which extent they do, ceteris paribus. We use the empirical estimate in Koettl and Weber (2012) as calibration target. For instance, they find that a 1 percentage point increase in the so-called formalization tax rate (FTR) is associated with an average decrease of 1.1% of the probability of working in the formal sector. The study also identifies a stronger reaction of low income earners, about twice larger than the average.

[15] Identical to the revised second interim report, dated 12 October 2012.

Together with actual informality rate by age and skill class, this information deliver parameter values for $\varphi_F(\zeta)$. The calibration results in equilibrium responses of 1.6%, 1.1% and 0.7% for the low[16], medium and high skills in Slovakia and similar values for Poland.

Population aging in the model is calibrated to match the long run medium forecasts of United Nations (2011). We target the population size and the age structure, changing mortality rates and population inflow parameters. The latter comprise newborns and immigrants together. Mortality rates pin down the age structure and inflows the population size. In reality, populations do not stop growing or shrinking. Computable General Equilibrium models however need to start and finish with stationary steady-state equilibrium. Compromises thus need to be made but approximations are of good quality. The final steady state was calibrated to approximately reflect the population projections for 2100.

For parameters unrelated to informality and population aging, we use the same calibration procedure as the full-scale model without informality Berger et al. (2009). Because of informality, outcomes are different for formal sector wages, which are higher. This difference is however without any consequence as the level of wages is never interpreted, only their variations.

6 Results

This section presents and discusses the results of the simulation. We start with the effect of aging without any reform and continue with the joint effect of aging and reforms. We finish with a summary of the analysis. Appendix B is a reminder of the reform analysis goals. Tables 1 and 2 provide an overview of the cases and reforms that we consider, in accordance with the appendix.

Tables 3 and 4 collect the results for a selection of interesting cases. Appendix C contains the results for the rest of the reforms considered. Numbers in the first column present the current status. Numbers in the second column present the long run effects which approximately reflect the year 2100, taking into account population aging but without any reforms. Subsequent columns report outcomes in the various cases and reforms. For a reason that we will explain, the simulated effect of aging and reforms on informality is stronger in Slovakia than in Poland. Qualitative outcomes are however identical. We will use numbers from the Slovakia cases when discussing outcomes, because effects are more visible and for ease of reading. Comments however apply to both countries.

[16]Note that in contrast to Koettl and Weber (2012) who separately estimate effects on informality choices for the low income earners, which are defined as persons earning about one third of the average wage, the low-skill workers in the model earn about 70% of the average wage. This explains why the responsiveness was reduces accordingly.

Table 1: Cases and reforms considered

	Code	*Cases and reforms*	*Magnitude*
		Basic reforms	
r0	Aging	Pure population aging until 2100, no reforms	-
r56	Const HC	Aging, no reforms, constant human capital decisions	-
r57	Const Inf	Aging, no reforms, constant informality decisions	-
r59	Const	r57 + r57 + constant retirement decisions	-
r192	+2 years	Increase in retirement age of 2 years	2 years
r34	SSC+	Increase of social security contribution rates	3% GDP
r334	SSC-	Decrease of social security contribution rates	3% GDP
r24	Pen-	Decrease in pension benefits	3% GDP
r324	Pen+	Increase in pension benefits	3% GDP
r27	Pen flat-	Decrease in flat part of pension benefits	3% GDP
r327	Pen flat+	Increase in flat part pension benefits	3% GDP
r29	Pen Ear-	Decrease in earnings-related part of pension benefits	3% GDP
r329	Pen Ear+	Increase in earnings-related part of pension benefits	3% GDP
r101	Welfare-	Decrease in welfare benefits (non-participant income)	0.5% GDP
r106	Welfare+	Increase in welfare benefits (non-participant income)	0.5% GDP
r81	IncTax+	Increase in labor income taxes	3% GDP
r86	IncTax-	Decrease in labor income taxes	3% GDP
r91	VAT+	Increase in consumption taxes	3% GDP
r96	VAT-	Decrease in consumption taxes	3% GDP
r70	g+	Increase in exogenous productivity growth rate	20%
r71	g-	Decrease in exogenous productivity growth rate	20%
		Additional reforms	
r603	CapTax+	Increase in capital income taxes	3% GDP
r204	+4 years, HC0	Increase in retirement age of 4 years, const human capital	4 years
r199	+8 years	Increase in retirement age of 8 years	8 years
r52	W Pen Acc-	Reduction on accrual rate of pension rights, workers	-50%
r53	Pen Acc-	Reduction on accrual rate of pension rights, all	-50%

Note: all reforms take place with the same population aging as in r0; reforms magnitude in general: 3% of initial GDP; under constant human capital decisions (r56), constant informality decisions (r57) and constant human capital, informality and retirement decisions (r59), workers still continue to take training decisions in the formal sector; social security changes on firms and households (r34, r334); r199 reform ignores informality.

Table 2: Cases and reforms considered - combined reforms

	Code	*Cases and reforms*	*Magnitude*
		Combination of reforms	
r1002	Pen flat+, Welfare-	Increase in flat part pension benefits (r327) + Decrease in welfare benefits (r101)	See table 1
r1011	Pen flat+, VAT+	Increase in flat part pension benefits (r327) + Increase in consumption taxes (r91)	See table 1
r1101	+2 years, Welfare-	Increase in retirement age of 2 years (r192) + Decrease in welfare benefits (r101)	See table 1
r1021	Pen Ear-, IncTax-	Decrease in earnings-related part of pension benefits (r29) + Decrease in labor income taxes (r86)	See table 1
r1221	+2y, Pen Ear-, IncTax-	Increase in retirement age of 2 years (r192) + Decrease in earnings-related part of pension benefits (r29) + Decrease in labor income taxes (r86)	See table 1
r1301	IncTax-, VAT+	Decrease in labor income taxes (r86) + Increase in consumption taxes (r91)	See table 1
r1400	+2y, Pen Ear-, CapTax-	Increase in retirement age of 2 years (r192) + Decrease in earnings-related part of pension benefits + Decrease in capital income taxes	2 years, 1% GDP, 1% GDP
r1500	+8 years, Pen Acc-	Increase in retirement age of 8 years (r199) + 25% reduction on accrual rate of pension rights	8 years, -25%

Note: all reforms take place with the same population aging as in r0; reforms magnitude in general: 3% of initial GDP; r1400 reform only for Poland, as capital income taxes are too low in Slovakia for significant decrease; r1500 reform ignoring informality.

Table 3: Overview of selected long run simulation results for Slovakia

	2010	r0 Aging	r56 Const HC	r57 Const Inf	r59 Const	r192 + 2years	r34 SSC+	r27 Pen flat-	r29 Pen Ear-	r101 Welfare-	r91 VAT+	r70 g+
absolute numbers												
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	40.19	40.28	40.58	37.71	40.45	39.96	40.45	40.32	40.42	40.29
Effective retirement age	58.02	58.22	58.31	58.24	58.02	60.19	58.12	58.48	58.11	58.21	58.14	58.23
Unemployment rate	14.74	14.41	14.00	14.60	14.08	14.22	15.04	14.36	15.03	14.88	14.81	14.69
Employment (yearly hours per formal worker)	1786	1785	1786	1785	1787	1781	1776	1784	1776	1785	1778	1785
Effective formal employment (year hours/capita)	793	667	685	640	641	699	614	681	617	706	628	629
Low-skills population (in % of population)	9.06	9.68	9.06	9.69	9.06	9.67	9.76	9.86	9.76	9.55	9.77	9.68
Medium-skill population (in % of population)	75.18	77.23	75.18	76.29	75.18	77.14	77.61	77.09	77.58	77.10	77.59	77.51
High-skill population (in % of population)	15.76	13.09	15.76	14.03	15.76	13.19	12.62	13.05	12.67	13.35	12.64	12.81
Informality rate (in % of participants)	12.74	9.32	7.62	12.68	12.83	9.72	14.60	8.06	14.15	4.28	13.29	14.35
increase from basis in %												
Labor costs (low-skilled)	-	-3.49	-0.26	-4.82	-0.29	-5.35	-2.69	-4.04	-2.43	-13.73	-3.14	-10.07
Labor costs (medium-skilled)	-	-3.03	-0.02	-3.75	0.58	-2.81	-2.38	-3.16	-2.36	-3.02	-2.87	-9.21
Labor costs (high-skilled)	-	13.81	1.38	16.68	-1.23	15.10	15.29	14.69	15.06	14.65	15.26	6.66
Pension payment per beneficiary*	-	-1.41	1.77	-5.82	-6.13	3.11	-11.77	-37.91	-46.72	3.47	-6.80	1.54
Pension payment (low-skilled)	-	-4.37	2.75	-7.66	-3.87	1.85	-13.18	-50.65	-47.64	2.26	-9.41	-
Pension payment (medium-skilled)	-	-1.17	6.87	-6.35	-3.12	4.10	-12.46	-42.84	-46.72	3.67	-7.46	-
Pension payment (high-skilled)	-	34.47	5.56	17.87	-5.07	34.39	23.64	-6.92	-25.95	39.29	31.44	-
GDP/capita*	-	-14.52	-11.34	-18.08	-16.64	-10.49	-21.11	-13.05	-20.70	-10.33	-19.74	8.72
Informal GDP/capita*	-	-42.97	-48.46	-20.19	-18.38	-37.92	-13.36	-49.91	-15.93	-69.47	-20.84	74.82
Consumption/capita (formal goods)*	-	5.36	7.80	2.76	3.60	7.54	-3.21	1.03	-4.57	8.52	-2.04	3.95
Consumption/capita (formal & informal goods)*	-	0.02	1.60	0.23	1.18	2.52	-4.33	-4.59	-5.82	-0.08	-4.11	8.42
Government consumption/capita*	-	-56.12	-52.85	-59.04	-57.57	-45.74	-47.12	-18.71	-26.97	-52.47	-40.40	-6.97
Assets/capita*	-	33.93	35.40	35.24	36.83	34.02	32.69	39.64	40.57	31.92	36.22	10.80
in % of basis GDP												
Pension expenditure	7.10	9.19	9.46	8.77	8.81	8.99	8.25	5.74	4.98	9.64	8.71	7.52
Pension expenditure (constant population)	7.10	11.34	11.67	10.83	10.87	11.10	10.19	7.08	6.15	11.91	10.75	9.28
Social security deficit	0.08	5.08	5.08	5.01	4.97	4.45	3.29	1.45	1.46	5.11	5.16	4.40
Social security deficit (constant population)	0.08	6.27	6.27	6.19	6.14	5.50	4.06	1.79	1.80	6.31	6.37	5.44
Pension social security deficit	0.04	4.40	4.51	4.18	4.18	3.95	3.02	0.84	0.51	4.60	4.18	3.29
Pension social security deficit (const pop)	0.04	5.43	5.57	5.16	5.16	4.88	3.72	1.04	0.63	5.67	5.16	4.06

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g+ (r70) and g- (r71) scenarios compare absolute changes with pure aging scenario case (r0)

Table 4: Overview of selected long run simulation results for Poland

		r0	r56	r57	r59	r192	r34	r27	r29	r101	r91	r70
	2010	Aging	Const HC	Const Inf	Const	+ 2years	SSC+	Pen flat-	Pen Ear-	Welfare-	VAT+	g+
absolute numbers												
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	38.92	38.96	38.98	36.38	39.08	38.98	39.07	39.02	39.07	38.92
Effective retirement age	59.37	59.33	59.42	59.39	59.37	61.35	59.30	59.38	59.31	59.34	59.31	59.42
Unemployment rate	13.36	13.20	12.76	13.36	12.70	12.97	13.78	13.23	13.59	13.24	13.63	13.51
Employment (yearly hours per formal worker)	1939	1936	1936	1936	1937	1926	1925	1934	1928	1936	1928	1936
Effective formal employment (year hours/capita)	604	506	532	499	506	527	464	506	482	516	473	463
Low-skills population (in % of population)	12.03	12.24	12.03	12.29	12.03	12.26	12.28	12.34	12.26	12.17	12.29	12.18
Medium-skill population (in % of population)	66.82	69.34	66.82	68.50	66.82	69.26	70.03	69.71	69.75	69.18	70.05	69.90
High-skill population (in % of population)	21.15	18.42	21.15	19.21	21.15	18.49	17.69	17.95	17.99	18.65	17.66	17.92
Informality rate (in % of participants)	33.18	32.68	29.82	33.47	33.34	33.61	37.28	32.70	35.12	31.49	36.35	38.54
increase from basis in %												
Labor costs (low-skilled)	-	-1.73	0.36	-1.93	1.14	-1.79	-0.25	-2.19	-0.53	-2.76	-0.92	-8.60
Labor costs (medium-skilled)	-	-2.66	1.37	-4.14	2.25	-2.09	-1.98	-3.24	-2.11	-2.78	-2.61	-10.28
Labor costs (high-skilled)	-	8.81	2.82	10.51	0.97	10.27	9.60	10.10	9.40	9.07	9.91	-0.66
Pension payment per beneficiary*	-	-5.70	-1.30	-6.19	-4.14	-2.46	-11.86	-27.39	-28.86	-4.54	-9.49	6.37
Pension payment (low-skilled)	-	-2.65	0.92	-3.87	-2.05	-2.31	-7.94	-27.19	-25.25	-1.40	-5.98	-
Pension payment (medium-skilled)	-	-5.02	2.24	-5.95	-1.17	-4.00	-11.52	-29.65	-27.17	-3.97	-9.33	-
Pension payment (high-skilled)	-	11.06	2.15	5.63	-2.72	10.81	5.36	-10.19	-15.71	11.64	9.20	-
GDP/capita*	-	-14.55	-9.18	-16.07	-13.22	-10.75	-21.32	-14.88	-18.42	-13.12	-21.10	4.40
Informal GDP/capita*	-	-20.76	-23.42	-15.78	-14.32	-14.00	-10.57	-21.48	-15.62	-23.17	-12.93	35.60
Consumption/capita (formal goods)*	-	-1.31	3.06	-2.25	-0.07	0.41	-9.48	-5.64	-8.07	-0.83	-8.77	3.79
Consumption/capita (formal & informal goods)*	-	-7.26	-5.03	-6.39	-4.43	-4.00	-9.81	-10.48	-10.38	-7.66	-10.04	12.11
Government consumption/capita*	-	-65.87	-59.81	-67.89	-65.08	-53.09	-59.36	-37.28	-43.05	-61.34	-54.28	-31.84
Assets/capita*	-	9.04	10.14	9.91	11.63	9.10	9.82	17.00	17.50	8.09	11.96	13.39
in % of basis GDP												
Pension expenditure	13.16	13.96	14.57	13.86	14.17	13.46	13.06	10.73	10.54	14.13	13.41	11.94
Pension expenditure (constant population)	13.16	18.61	19.43	18.48	18.90	17.94	17.42	14.31	14.05	18.84	17.88	15.93
Social security deficit	8.04	11.25	11.49	11.26	11.39	10.46	9.29	8.03	8.09	11.31	11.15	10.20
Social security deficit (constant population)	8.04	15.00	15.32	15.01	15.19	13.95	12.38	10.71	10.79	15.08	14.86	13.60
Pension social security deficit	5.90	9.37	9.71	9.35	9.54	8.65	7.70	6.15	6.14	9.45	9.10	8.07
Pension social security deficit (const pop)	5.90	12.49	12.94	12.47	12.72	11.53	10.26	8.20	8.19	12.60	12.14	10.76

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g+ (r70) and g- (r71) scenarios compare absolute changes with pure aging scenario case (r0)

6.1 Effects of aging

Consistent with previous economic analyzes, the simulation predicts an increase in the social security deficit, driven by pension expenditures. In constant population terms, the social security budget starts from a balanced position and would reach 6.3% of GDP by 2100, while the pension budget deficit[17] would reach 5.4%. The reason is standard. Although workers spontaneously decide to retire later to finance consumption in old age, the change is small (average retirement age of 58.2 instead of 58). Due to population aging, households die less at a young age and are more likely to survive until and past the retirement age. With essentially constant retirement age, the number of contributors to the pension system increases slower (even shrinks) than the number of beneficiaries, creating a deficit.

A more striking, novel and surprising result is the reduction of the informality rate due to population aging and without any reform. The informality rate drops from 12.7% to 9.3%. Two supplementary effects explain the drop. The first effect is related to the increase in life expectancy. At constant or near constant retirement age, the longer households live, the more important the post-retirement segment of their life, the more important to have high pension benefits. Informality gives access to the flat part but not the earnings-related part of benefits. Participation in the formal sector thus become more attractive as life expectancy increases. The second effect is related to human capital. As the probability of dying young decreases, it is more beneficial for workers to train and increase productivity over the life-cycle in the formal sector: the likelihood of dying before benefits from these investments are reaped is lower. As productivity increases, wages in the formal sector increase, followed by social contributions and later pension benefits. Participation in the formal sector becomes overall more attractive.

A related finding is the shift in skill composition of the population: the share of high skills decrease from 15.8% to 13.1% of the population. Consistent with empirical evidence, we assume that high skill workers retire later and have a lower disutility of working and training[18]. Formal high skill workers have a higher incentive to train and their productivity increases more. Even though continuous training takes time away from productive work, the increase in productivity is large enough that effective hours increase. In general equilibrium and before education decisions are made, a labor supply increase for constant demand leads to a reduction in formal sector wages. Changes in wages in the constant decision case (column r59) show indeed that wages for the high skill drop by 1.2%. Before entering the labor market, young adults are then more likely to choose a medium-skill education.

Simulations keeping skill constant (column r56) further illustrate the role of human capital in informality decisions. When skills are constant, the informality rate further drops to 7.6%. High skill workers continue to train more over the life-cycle. Their productivity keeps increasing. In contrast to the general case, labor supply in the formal sector in every skill class is modified by the informality decisions alone, not by initial education decisions. In particular, formal sector

[17] We consider that social security expenditures include pensions, unemployment insurance and health insurance. Welfare benefits are included in the general budget. Social security contributions (SSC) often make not distinction between pensions, unemployment insurance and health insurance. We arbitrarily allocate SSC revenue to the various social security budgets on the basis of expenditures for illustration purposes. The difference between the social security budget deficit and the pension budget deficit is then a pure accounting artifact. The reference remains the social security budget deficit.

[18] Recall that human capital has two dimensions in the model: initial education decisions defining the skill level for the rest of life (low, medium and high), resulting in 3 different initial productivity levels; continuous training decisions over the life-cycle for further improvements in productivity.

labor supply for the medium skills is only increased by informal sector workers and there is no increase due to education decisions shifting from high to medium skill training. Compared to the general case, the positive labor supply shock is smaller and equilibrium wages for medium skills decrease less. Wages and pension payments are thus even more attractive when skills are constant than when skills vary for the medium skill workers. The informality rate for medium skill workers thus decreases more. As three quarters of the population has medium skills, the average informality rate drops further. The simulation with constant skills thus predicts that informality rate should drop significantly more (down to 7.6%) as a result of aging than in the general case (down to 9.3%). It illustrates the overestimation bias introduced by macroeconomic analysis without endogenous skill decisions: if one neglects endogenous skill decisions, one would predict a decline in informality to 7.6%, when a more complete and realistic model with endogenous skill decisions predicts a decline to 9.3% only.

Another potentially surprising finding is that informality does not lead to larger social security deficits over the long run. Simulations using constant informality (column r57) indeed show that the deficit would reach 6.19% of GDP in constant population terms, lower than the 6.27% figure of the general case with endogenous informality decisions. One could expect that informal workers are a net drag on social security finances, since they do not contribute but can claim the basic welfare benefits of non-participants. The experiments shows that this is not the case. Although they do not contribute to financing, informal participants only receive non-earnings related benefits, which are lower than average earnings-related benefits. This is a result of the strong earnings-related link present in the pension systems of Poland ans Slovakia. From a long run public finance point of view, the immediate benefit of lower informality are higher social security contributions and its price higher expenditures from larger benefits at a later stage.

Comparison of outcomes in Poland and Slovakia deliver another interesting finding, to be treated with caution. The effect of population aging on the informality rate is much smaller in Poland than in Slovakia. In the first country, the informality rate drops by 2%, in relative terms (from 33.2% to 32.6%). In the second, it drops by 36% (from 12.7% to 9.3%). This difference is mainly due to the data on informality and its impact on the calibration procedure. Reliable data on informality is difficult to gather, due to its nature. Data shows that the informality rate was on average 33% in Poland and 13% in Slovakia, in 2010. Differences across skills classes were even larger: for instance, the rate was close to 50% in Poland but below 15% in Slovakia among low-skilled households (see appendix A.1 for more). The earnings premium for formal sector participation is however similar in the two countries. Net disutility of formality is not observed but calibrated so that the model predicts the correct informality rate in 2010 (φ_F in the model presented in section 2). To reconcile premium and participation data, net disutility must be higher in Poland than in Slovakia. In formal market participation decisions, these psychological costs drive a wedge between the monetary values of formal and informal market participation. Loosely speaking, Poles have a much higher distaste for work in the formal sector than Slovaks, at comparable monetary benefits.

The net disutility function is calibrated to match 2010 informality rates and so that it predicts correct informality variations for observed policy shocks, which are small by nature (see appendix A.4 for details). When shocks are larger, such as population aging over 50 years, predictions in the variation of the informality rate are only precise if the net disutility costs are precisely calibrated. Because 2010 informality rates are so different between Poland and Slovakia, the net disutility costs are very different and the predictions for large policy shocks will be very

different[19].

The conclusion is that qualitative results are fully reliable but one should be more cautious with quantitative results on informality rates. One can safely compare informality rate outcomes across countries in qualitative terms, but should exert caution with quantitative terms. One should also be careful with quantitative predictions on the effect of a single policy or demographic shock on the informality rate. Comparison across two or more shocks in the same country can however be made both in qualitative and quantitative terms, since the bias in the net disutility calibration is identical.

6.2 Effects of basic reforms

We focus the discussion on the effect of reforms on social security deficits and the role of informality, considering more standard outcomes at the end. Opposite reforms have opposite effects. For instance, an increase in social security contributions (column r34 of table 3) increases informality while a decrease in contributions (column r334 of table 16 in appendix C) decreases informality. For this reason[20], we only discuss results in table 3.

6.2.1 Reforms and informality

Most of the reforms impact the informality rate in a way that is intuitively expected, but not all. As one could expect, the informality rate increases with higher social security contributions (column r34), higher consumption taxes (column r91) and lower earnings-related pension benefits (column r29) but decreases with lower welfare benefits (column r101) and lower flat pension benefits (column r27). The increase in informality (relative to the pure aging no-reform case, column r0) due to the increase in the effective retirement age (column r192) may be more of a surprise. The negative impact on informality that higher growth (column r70) has may also come as a surprise to some, although effects may be unclear a priori to others.

Before starting the discussion of the effects of reforms, we make a note on informality rates and formal sector employment. When all other labor supply margins are constant, an increase in informality is mechanically associated with a decrease in effective formal employment (yearly hours per capita). In tables 3 and 4, this is the case for all reforms except the increase in retirement age (column r192).

When social security contributions increases, the benefits from working in the formal sector are maintained but the price to have access to these benefits increase, making work in the informal sector more attractive. Informality then increases (14.6% compared to 9.3% in the pure aging, no-reform case). Higher consumption taxes not only decrease the incentive to provide labor in the formal sector, a standard taxation theory effect (average 1776 yearly hours per worker instead of 1785), decreasing the value of formal sector participation, but also directly increase

[19]Unreported simulations show that a larger wedge in Slovakia reduces informality rate variations, confirming the role of the net disutility of formal sector participation. When the formal sector earnings premium of the high-skilled in Slovakia is increased to the level of Poland (which increases the overall formal sector premium while keeping the informality rate in 2010 constant, thus increasing the calibrated net disutility of formal work in Slovakia), population aging reduces informality from 12.7% to 11.2%, a 14% drop which is significantly lower than the 36% drop predicted in the baseline case.

[20]The results of an overall pension benefits increase (r24) and those of a labor income tax increase (r81) are two exceptions. We do not discuss the first case because, as expected, results are intermediates between results of flat part benefits increases (r27) and earnings-related part benefits increases (r29). The r24 reform is indeed a combination of r27 and r29 reforms. We do not discuss the second case because, as expected, it has similar effects as a SSC increase (r34). Increases in labor income taxes and consumption taxes indeed have a similar impact on households labor supply decisions, with or without informality. Both decrease the attractiveness of the (formal) labor supply and consumption bundle and increase the value of outside options, be it leisure or informal work.

the value of informal sector participation. Indeed, the model assumes that informal workers sell their product on the same market as formal workers, charge the same price but do not have to transfer the consumption tax proceeds to the government. As informal workers can keep the consumption taxes for themselves, the value of informal sector participation increases even more. As a result, informality increases (13.3%). Pension benefits have two parts: a flat part, lower in value and which all households can collect, and an earning-related part, which depends on rights accumulated through formal sector participation. When the earnings-related part is decreased, the value of formal sector relative to informal sector participation decreases, so informality increases (14.2%). When the flat part is decreased, it is the opposite and informality drops (8.1%). A similar phenomenon takes place with decreases in welfare benefits. As the government can not distinguish between non-participants and informal sector participants, both can collect welfare benefits. Decreases in welfare benefits thus make both options less attractive and boost formal sector participation so that the informality rate drops (4.3%). Note that it also decreases the value of outside options for formal workers, during wage negotiations with employers. As the relative value loss is bigger for low-skilled than medium- and high-skilled, their bargaining position is most weakened, explaining why labor costs decrease most for them (14% loss).

Compared to the pure aging no-reform case, the increase in informality due to later retirement age can appear as a surprise (9.7% instead of 9.3%). Recall that one of the reason for the drop in informality due to aging alone was related to human capital: as the likelihood of dying young decreases, investing in training is more interesting, so that productivity, wages, earnings-related pension benefits and then formality increase. One could think that the benefits of training are even larger with later retirement age, since the higher productivity benefits can be reaped over a longer working period, which could make formal sector work even more attractive than informal sector work. There is however a simple mechanical counteracting effect. Informality rates are larger for older than younger workers (in Slovakia, initial weighted average formality rates by age group are 0.91, 0.92, 0.87, 0.86, 0.84, from younger to older). Retiring later thus mechanically increases the informality rate, in relative terms, undoing some of the changes due to aging and training.

A higher exogenous productivity growth (yearly 1.45% increase instead of 1.2% over the total period, 2010 to 2100) leads to an increase in informality (14.4% compared to the 9.3%, pure aging case). The simulation shows that informality becomes more interesting. The main reason is related to regulation on pension indexation. Pensions benefits are partly indexed to wage and thus productivity growth (50% in Slovakia, 20% in Poland). Rewards to work in the formal and informal sectors are however fully indexed to productivity growth. Higher growth thus makes the benefit of formal work less interesting (since pensions grow less), increasing the relative value of informal sector work. A counterfactual experiment where pension indexation for retirees is doubled, on top of higher productivity, leads to a large relative drop in informality (11.0% instead of 14.4%).

6.2.2 Reforms and social security financing

As one might expect, postponement of retirement age (column r192), increases in social security contributions (column r34), decreases in the flat part or the earnings-related part of pension benefits (columns r27 and r29), increases in exogenous productivity growth (column r70) all lead to an improvement in the financing of social security, relative to the pure aging, no reform case (column r0). In some of these cases, the magnitude of the gain may be surprising. The

fact that decreases in welfare benefits (column r101) worsen the social security deficit may be unexpected but there is a simple accounting explanation. Cuts in welfare benefits improve financial sustainability. Increases of consumption taxes (column r91) have very little effect on the deficit, slightly increasing it in Slovakia and slightly decreasing it in Poland.

Postponing the retirement age by 2 years decreases the social security deficit relative to the no reform case (4.5% of initial GDP instead of 5.1%). The decrease is however limited by the larger relative drop in wages for the low skill formal workers (5.3% drop instead of 3.5%), which decreases social security contributions revenue. The drop in wages is due to a general equilibrium effect: many low skill workers join the formal sector, resulting in a strong labor supply shock and drop in wages. The decrease is also limited by the fact that 2 years is not a large figure, compared to the 9 years increase in life expectancy between 2010 and 2100.

Increases in social security contribution rates reduce the social security deficit in a moderate fashion, while decreases in flat and earnings-related parts of pension benefits all lead to significant improvements (respectively drop from 5.1% of GDP to 3.3%, 1.5% and 1.5%). Because of the increase in the informality rate, average pensions per beneficiary drop when contributions are increased, an aggregate 0.9% of GDP saving (compared to the no reform case). In relative terms, contributions increases add up to 0.8% of GDP more revenue. Most of the gains from decreasing pension benefits come from the targeted aggregate expenditures reduction. Decreasing the flat part also improves formality, leading to extra revenue. Decreasing the earnings-related part, although it increases informality and reduce revenue, leads to a larger decrease in aggregate pension expenditures, as labor supply in the formal sector, earnings and thus pension benefits drop more.

An increase in productivity growth leads to a very modest improvement in the social security deficit (4.4% of initial GDP instead of 5.1%; 7.25% of actual GDP instead of 7.36%). With larger productivity, pensions relative to current wages decline, because pension rights grow at a slower pace than wages and productivity (partial indexation). In relative terms, aggregate pension expenditures are thus lower and social security financing improves. However, the increase in informality wipes away most of these gains, as less contributions are collected.

With lower welfare benefits, the social security deficit slightly increases (5.11% of GDP instead of 5.08%), but government consumption per capita has to decrease less (-52.5% instead of -56%). The reason is that welfare benefits are not counted as social security expenditures. The relevant measure is thus the change in government consumption per capita, which shows that lower welfare benefits improves the financial sustainability of public expenditures.

Changes in consumption taxes have a small and mixed impact on social security deficits (5.16% of GDP instead of 5.09% in Slovakia, 11.15% of GDP instead of 11.25% in Poland). Both aggregate pension expenditures and social security contributions decline because of the increase in informality, two opposite effects on the financing of the social security system which essentially cancel out. The increase in consumption taxes revenue materializes in the overall government budget but not in the social security budget, so it contains unreported additional benefits. Changes in government consumption per capita are an indirect measure of the benefit of reforms on the entire government budget. They however show that consumption taxes usually deliver more benefits on the total budget than most other reforms, but in a limited fashion (decrease of 47% compared to 56% in case of no reform) and less than pension benefit reductions (decreases of only 20%).

Comparing the various cases, one conclusion is that single dimension reforms may not be sufficient. None of the reforms considered is able to restore financial sustainability of the social

security system in a politically realistic fashion. The most effective measures are pension benefit cuts but they may weaken protection against old-age poverty too much. Moreover, cuts would have to be even larger to fully restore financial sustainability. Increases in social security contributions or consumption taxes help but are insufficient to restore financial sustainability. Welfare benefits cuts have even more limited impacts. Increases in retirement age also help but needs to be larger to restore financial sustainability. Section 6.3 will investigate the effect of larger increases in retirement age. Whatever the policy goals, it is safe to conclude that light measures will not be able to secure financing of the social security system over the long run. We will provide a more comprehensive comparison of the various reform options when discussing policy implications, in section 7.

6.2.3 Other analysis of reforms

Reforms have the standard impact on the (formal) labor market. Higher taxes and contributions (columns r34, r91) and lower benefits (columns r29, r101) decrease the attractiveness of (formal) work. Effective employment, unemployment rate and (formal) GDP variations reflect the corresponding changes in household labor supply on the formal sector.

The impact of aging and reforms on pensions per beneficiary and consumption per capita combine standard labor supply reactions in the formal sector with changes in informality rates. The combination of these reactions are sometimes nontrivial, but not always.

In almost all cases, pension payments to former high-skill workers rise more (or drop less) than payments to medium- and low-skill workers. For instance, high-skill retiree payments increase 34% (compared to the growth trend) when retirement age is increased 2 years (column r192), while they only increase 4% for medium-skill retirees and less than 2% for low-skill retirees. These relative differences are driven by the impacts on the labor market. As labor costs and wages increase more for high-skill (see subsection 6.1), the earnings-related part of pension benefits increase more for them. Cuts in earnings-related pensions (column r29) confirms the role of policy: in this case, the size of the gain of the high-skilled, relative to the low- and medium-skilled, is smaller.

Compared to some other studies, the drop in consumption per capita due to aging is limited. In some cases, there is even a gain. When there is no reform, total consumption per capita is essentially stable and consumption of formal goods per capita increases. The second finding is easy to explain, as informality drops. The first is more unusual. It comes from households behavior and a technical component of the analysis. In spite of the drop of labor supply brought by a constant retirement age and the increase in life expectancy, total consumption per capita is maintained because households change their saving behavior. They save more (34% increase in private assets in Slovakia, 9% in Poland, the difference coming from different patience parameters) to finance consumption after retirement. This increase in savings in the long run delivers more capital income, compensating the drop in labor income and allowing to maintain consumption.

One technical component of the current analysis is the government budget closure. Over the long run government debt would explode if the budget deficit increased forever. We therefore assume constant government debt, by automatic changes of one policy instrument, unrelated to any reform. In the analysis performed here, we chose to adjust government consumption to balance the government budget. Other instruments can be chosen[21]. Each have advantages and disadvantages. One benefit of using government consumption as closing instrument is that it

[21] For example, if the government budget was closed with lump-sum taxes, results would not change except that the decrease in government consumption would be shifted to private consumption.

leads to no direct distortion of households behaviors. One can isolate the impact of aging and reforms on household behavior. One drawback is that it can be unrealistic. For instance, aging leads to a drop of more than 50% of government consumption per capita.

Closing with taxes is more realistic but does not allow to isolate the effect of aging and reforms. In these cases, higher taxes generally decrease labor supply, output and thus consumption per capita. Tables 18 and 19 in appendix B provide the results of the simulations in Slovakia when the budget is closed with consumption taxes. As expected, households reduce labor supply on the formal sector (average 1755 yearly hours instead of 1785 when closing with government consumption, in the pure aging case, column r0). For the same reasons as reform r91, households increase participation in the informal market (informality increases to 25% instead of reducing to 9%). As a consequence, formal sector GDP per capita decreases more. While government consumption per capita is now stable, the reduction in labor supply reduces total consumption per capita. As a consequence of the increase in informality rates, pension expenditures decrease and so does the social security deficit. In general, closing the government budget with consumption taxes adds the effects of reform r91 to the reform considered. In particular, the informality rates are simply shifted up. In some occasions, the combination of effects is different from a simple addition. These differences however remain of second order. For instance, informality after a decrease in earnings-related pension benefits (r29) is lower than in the no reform case (r0), not higher. This comes from the fact that the relative decrease in consumption taxes impacts workers and retirees and formal sector workers compensate by increasing labor supply.

We finish this section with a discussion of the effect of exogenous productivity increases. In absolute terms, total consumption per capita reaches increases 8.4% more under large productivity increases (column r70) than under average productivity increases (r0). Similar patterns occur for consumption of formal goods, GDP per capita and pension per beneficiary, in different magnitudes. These differences takes place in spite of a larger decline in effective labor supply when growth is larger (average of 629 yearly hours per capita instead of 667) and illustrate the effect of larger productivity growth.

6.3 Effects of additional reforms

This section reports the long run results of additional reform measures as described in the last part of table 1. Tables 5 and 6 contain results for all additional reforms except large retirement age increases, which are contained in tables 7 and 8.

We start by discussing the results in tables 5 and 6.

Table 5: Overview of selected additional reform simulation results for Slovakia

	2010	r0 Aging	r603 CapTax+	r52 W Pen Acc-	r53 Pen Acc-	r192 +2 years	r1922 +2 years, HC0	r204 +4 years, HC0
absolute numbers								
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	40.29	40.31	40.34	37.71	37.62	35.04
Effective retirement age	58.02	58.22	58.23	58.22	58.20	60.19	60.26	62.22
Unemployment rate	14.74	14.41	14.37	14.52	14.57	14.22	13.83	13.78
Employment (yearly hours per formal worker)	1786	1785	1786	1783	1783	1781	1781	1784
Effective formal employment (year hours/capita)	793	667	674	657	653	699	717	742
Low-skills population (in % of population)	9.06	9.68	9.78	9.70	9.70	9.67	9.06	9.06
Medium-skill population (in % of population)	75.18	77.23	77.41	77.29	77.32	77.14	75.18	75.18
High-skill population (in % of population)	15.76	13.09	12.80	13.01	12.98	13.19	15.76	15.76
Informality rate (in % of participants)	12.74	9.32	8.59	10.30	10.67	9.72	8.05	9.45
increase from basis in %								
Labor costs (low-skilled)	-	-3.49	-4.08	-3.29	-3.29	-5.35	-2.26	-3.26
Labor costs (medium-skilled)	-	-3.03	-3.49	-2.85	-2.83	-2.81	0.12	-0.07
Labor costs (high-skilled)	-	13.81	15.73	13.94	14.08	15.10	2.98	2.40
Pension payment per beneficiary	-	-1.41	-0.41	-16.54	-21.25	3.11	6.35	8.37
Pension payment (low-skilled)	-	-4.37	-4.24	-18.90	-23.40	1.85	9.91	-
Pension payment (medium-skilled)	-	-1.17	-0.50	-16.48	-22.04	4.10	12.60	-
Pension payment (high-skilled)	-	34.47	40.77	16.07	7.34	34.39	6.15	-
GDP/capita	-	-14.52	-14.35	-15.74	-16.25	-10.49	-7.30	-4.86
Informal GDP/capita	-	-42.97	-47.61	-37.46	-35.42	-37.92	-43.63	-31.76
Consumption/capita (formal goods)	-	5.36	-3.06	2.52	1.52	7.54	9.96	8.57
Consumption/capita (formal & informal goods)	-	0.02	-7.98	-1.89	-2.56	2.52	4.05	4.12
Government consumption/capita	-	-56.12	-29.12	-44.64	-41.41	-45.74	-42.40	-34.41
Assets/capita	-	33.93	22.81	36.26	36.75	34.02	35.42	26.45
in % of basis GDP								
Pension expenditure	7.10	9.19	9.28	7.78	7.34	8.99	9.25	8.78
Pension expenditure (constant population)	7.10	11.34	11.45	9.60	9.07	11.10	11.42	10.84
Social security deficit	0.08	5.08	5.08	3.78	3.39	4.45	4.45	3.68
Social security deficit (constant population)	0.08	6.27	6.27	4.67	4.19	5.50	5.49	4.54
Pension social security deficit	0.04	4.40	4.44	3.05	2.64	3.95	4.07	3.42
Pension social security deficit (const pop)	0.04	5.43	5.48	3.76	3.26	4.88	5.02	4.22

Notes: All +4 years (r204) reforms are simulated with constant human capital for technical reasons.

Table 6: Overview of selected additional reform simulation results for Poland

		r0	r603	r52	r53	r192	r1922	r204
	2010	Aging	CapTax+	W Pen Acc-	Pen Acc-	+2 years	+2 years, HC0	+4 years, HC0
absolute numbers								
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	39.05	39.03	39.04	36.38	36.30	33.77
Effective retirement age	59.37	59.33	59.32	59.34	59.33	61.35	61.41	63.33
Unemployment rate	13.36	13.20	13.21	13.31	13.34	12.97	12.54	12.37
Employment (yearly hours per formal worker)	1939	1936	1935	1933	1932	1926	1927	1926
Effective formal employment (year hours/capita)	604	506	507	498	496	527	553	576
Low-skills population (in % of population)	12.03	12.24	12.29	12.25	12.25	12.26	12.03	12.03
Medium-skill population (in % of population)	66.82	69.34	69.86	69.47	69.50	69.26	66.82	66.82
High-skill population (in % of population)	21.15	18.42	17.85	18.29	18.25	18.49	21.15	21.15
Informality rate (in % of participants)	33.18	32.68	32.58	33.47	33.69	33.61	30.80	31.66
increase from basis in %								
Labor costs (low-skilled)	-	-1.73	-2.61	-1.18	-1.15	-1.79	0.28	0.74
Labor costs (medium-skilled)	-	-2.66	-3.80	-2.35	-2.35	-2.09	1.88	2.53
Labor costs (high-skilled)	-	8.81	10.66	8.99	9.09	10.27	4.37	3.84
Pension payment per beneficiary	-	-5.70	-5.95	-16.88	-19.94	-2.46	1.97	5.38
Pension payment (low-skilled)	-	-2.65	-2.79	-14.47	-17.27	-2.31	1.47	-
Pension payment (medium-skilled)	-	-5.02	-5.82	-15.86	-18.83	-4.00	3.46	-
Pension payment (high-skilled)	-	11.06	14.54	-0.79	-5.73	10.81	2.05	-
GDP/capita	-	-14.55	-15.21	-15.71	-16.10	-10.75	-5.26	-0.29
Informal GDP/capita	-	-20.76	-21.73	-19.22	-18.73	-14.00	-16.89	-9.50
Consumption/capita (formal goods)	-	-1.31	-7.95	-4.12	-4.98	0.41	4.81	15.12
Consumption/capita (formal & informal goods)	-	-7.26	-12.16	-8.73	-9.19	-4.00	-1.83	7.60
Government consumption/capita	-	-65.87	-47.70	-53.26	-50.06	-53.09	-46.51	-19.48
Assets/capita	-	9.04	-2.22	13.44	14.25	9.10	10.20	59.26
in % of basis GDP								
Pension expenditure	13.16	13.96	13.93	12.30	11.85	13.46	14.04	13.50
Pension expenditure (constant population)	13.16	18.61	18.57	16.41	15.80	17.94	18.72	18.00
Social security deficit	8.04	11.25	11.22	9.67	9.24	10.46	10.66	9.82
Social security deficit (constant population)	8.04	15.00	14.97	12.89	12.32	13.95	14.21	13.10
Pension social security deficit	5.90	9.37	9.34	7.77	7.34	8.65	8.95	8.18
Pension social security deficit (const pop)	5.90	12.49	12.46	10.36	9.78	11.53	11.93	10.90

Notes: All +4 years (r204) reforms are simulated with constant human capital for technical reasons.

The previous sections demonstrated how aging affects the savings decision of the individual households. The question arises how well capital income taxation (r603) performs in raising revenue to reduce the increasing fiscal gap compared to other reforms, such as raising social security contributions (r34). The direct effect is that asset accumulation is hampered and significantly

reduced compared to the pure aging benchmark (r0) in the long run. This reduces capital income and therefore long run consumption. While the effect on formal labor market decision margins is negligible there is an effect on the average informality rate. The informality rate in Slovakia is reduced while it is almost constant in Poland. This can be explained by a skill composition effect that arises in the long run. In relative terms the high skill suffer most from an increase in the capital income tax which leads to decline in the share of high skills. The average informality rate declines as high skill workers are characterized by the highest informality rates in Slovakia. As a consequence there is a shift in average from informal to formal production. The effects on the reported pension and social security deficits are negligible. This should not come as a surprise as revenue from capital income taxation affects these deficits only indirectly via changes in the social security contribution tax base. The generated revenue flows into the general budget (which is ultimately used to cover the deficit in the social security system). Comparing the endogenous changes in government consumption per capita which is used to close the general budget reveals that generated revenue is sizable, e.g. government consumption per capita has to decrease by 47.7% instead of 65.9% for Poland and by 29.1% instead of 56.1% for Slovakia.

Reducing the rate of accrual of pensions rights (columns r52, r53) has similar effects as a cut in the earnings-related part of pension benefits (column r29, tables 3 and 4). Subsection 6.2 elaborates on these effects. This is not a surprise, as these reforms are very close in nature: the first kind cuts the rate at which past pension rights accumulate in the future and the second kind cuts the conversion factor between pension rights and actual monetary payments, once retired. Magnitudes however differ, as r52 and r53 reforms are milder. Since reform r52 only reduces the accrual rate while households are in age of working, r52 impacts are smaller than r53 impacts.

The effective retirement age as well as the statutory retirement age (reference for financial incentives) were further raised by 4 years (column r204). For technical reasons, the simulation assumes constant human capital decisions. As the comparisons of the effect of a 2 years increase of the retirement age with variable and constant human capital decisions show (column r192 and r1922), impacts on the social security deficit are correctly predicted when human capital decisions are kept constant. The aging related increase in the social security deficit can be cut by about 50% for Poland and 30% for Slovakia. Hence, an increase of the effective retirement age by 4 years, which relates to approximately 40% of the increase in life expectancy during the same time period[22], is not sufficient to contain the social security and general budget deficit for given tax and contribution rates, but effective. Further increases in the retirement age would be necessary to restore the financial sustainability of the pension system, which we discuss next.

Tables 7 and 8 contain the results of further increases in the retirement age, alone or coupled with other reforms.

[22]United Nations (2011) predicts an increase in life expectancy at birth from 75.8 in 2010 to 85.3 in 2100 for Slovakia and from 76.4 to 85.6 for Poland.

Table 7: Overview of selected reforms with large retirement age increase for Slovakia

		CGE with informality			CGE without informality			
	2010	r0 Aging	r192 +2 years	r192 + r57 +2 years, Inf0	r0 Aging	r192 +2 years	r199 +8 years	r1500 +8 years, Pen Acc-
absolute numbers								
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	37.71	37.68	40.12	37.54	29.89	29.88
Effective retirement age	58.02	58.22	60.19	60.22	58.37	60.32	66.12	66.13
Unemployment rate	14.74	14.41	14.22	14.46	14.35	14.21	13.94	14.00
Employment (yearly hours per formal worker)	1786	1785	1781	1781	1784	1779	1757	1756
Effective employment (yearly hours per capita)	793	667	699	672	738	775	881	879
Low-skills population (in % of population)	9.06	9.68	9.67	9.67	9.75	9.73	9.69	9.70
Medium-skill population (in % of population)	75.18	77.23	77.14	76.14	76.24	76.13	76.34	76.35
High-skill population (in % of population)	15.76	13.09	13.19	14.19	14.01	14.13	13.97	13.95
Informality rate (in % of participants)	12.74	9.32	9.72	12.77	-	-	-	-
increase from basis in %								
Labor costs (low-skilled)	-	-3.49	-5.35	-7.25	-5.00	-7.36	-11.88	-11.81
Labor costs (medium-skilled)	-	-3.03	-2.81	-3.53	-3.50	-3.25	-1.50	-1.44
Labor costs (high-skilled)	-	13.81	15.10	17.99	15.36	17.10	29.73	29.94
Pension payment per beneficiary	-	-1.41	3.11	-1.46	-3.19	1.48	16.78	6.00
Pension payment (low-skilled)	-	-4.37	1.85	-1.86	-7.17	0.34	27.17	16.20
Pension payment (medium-skilled)	-	-1.17	4.10	-1.94	-4.53	1.26	19.99	8.52
Pension payment (high-skilled)	-	34.47	34.39	16.67	19.42	19.95	25.34	14.24
GDP/capita	-	-14.52	-10.49	-14.06	-17.50	-13.38	0.03	-0.19
Informal GDP/capita	-	-42.97	-37.92	-15.61	-	-	-	-
Consumption/capita (formal goods)	-	5.36	7.54	4.97	4.02	6.29	13.31	12.07
Consumption/capita (formal & informal goods)	-	0.02	2.52	2.70	-	-	-	-
Government consumption/capita	-	-56.12	-45.74	-48.78	-59.35	-49.09	-14.05	-7.07
Assets/capita	-	33.93	34.02	35.33	37.35	37.38	37.66	38.87
in % of basis GDP								
Pension expenditure	7.10	9.19	8.99	8.58	8.98	8.81	8.07	7.32
Pension expenditure (constant population)	7.10	11.34	11.10	10.60	11.09	10.87	9.96	9.04
Social security deficit	0.08	5.08	4.45	4.41	5.16	4.56	2.44	1.71
Social security deficit (constant population)	0.08	6.27	5.50	5.44	6.38	5.63	3.01	2.11
Pension social security deficit	0.04	4.40	3.95	3.75	4.36	3.94	2.40	1.66
Pension social security deficit (const pop)	0.04	5.43	4.88	4.63	5.38	4.86	2.96	2.04

Notes: CGE without informality results are obtained with a reduced model, where there is no distinction between formal and informal work.

Table 8: Overview of selected reforms with large retirement age increase for Poland

		CGE with informality			CGE without informality			
	2010	r0 Aging	r192 +2 years	r192 + r57 +2 years, Inf0	r0 Aging	r192 +2 years	r199 +8 years	r1500 +8 years, Pen Acc-
absolute numbers								
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	36.38	36.33	38.19	35.79	29.28	29.07
Effective retirement age	59.37	59.33	61.35	61.39	59.98	61.80	66.75	66.91
Unemployment rate	13.36	13.20	12.97	13.16	13.80	13.56	13.05	13.10
Employment (yearly hours per formal worker)	1939	1936	1926	1926	1932	1922	1897	1895
Effective employment (yearly hours per capita)	604	506	527	523	757	794	892	893
Low-skills population (in % of population)	12.03	12.24	12.26	12.30	12.42	12.42	12.42	12.43
Medium-skill population (in % of population)	66.82	69.34	69.26	68.30	68.87	68.71	68.52	68.52
High-skill population (in % of population)	21.15	18.42	18.49	19.40	18.71	18.88	19.06	19.06
Informality rate (in % of participants)	33.18	32.68	33.61	33.88	-	-	-	-
increase from basis in %								
Labor costs (low-skilled)	-	-1.73	-1.79	-2.43	-3.11	-3.33	-2.76	-2.74
Labor costs (medium-skilled)	-	-2.66	-2.09	-3.72	-4.03	-3.40	-1.31	-1.25
Labor costs (high-skilled)	-	8.81	10.27	12.21	13.56	15.50	21.77	22.13
Pension payment per beneficiary	-	-5.70	-2.46	-2.55	0.14	2.63	7.51	0.46
Pension payment (low-skilled)	-	-2.65	-2.31	-3.25	0.66	5.15	14.14	7.07
Pension payment (medium-skilled)	-	-5.02	-4.00	-4.59	-3.03	0.43	9.00	2.24
Pension payment (high-skilled)	-	11.06	10.81	5.11	12.38	12.98	14.50	6.75
GDP/capita	-	-14.55	-10.75	-11.89	-14.15	-9.76	2.82	2.91
Informal GDP/capita	-	-20.76	-14.00	-9.78	-	-	-	-
Consumption/capita (formal goods)	-	-1.31	0.41	-0.18	0.43	2.44	7.51	6.48
Consumption/capita (formal & informal goods)	-	-7.26	-4.00	-3.11	-	-	-	-
Government consumption/capita	-	-65.87	-53.09	-54.84	-68.33	-53.73	-9.00	-0.95
Assets/capita	-	9.04	9.10	9.84	11.65	11.77	11.97	14.04
in % of basis GDP								
Pension expenditure	13.16	13.96	13.46	13.43	14.50	13.93	11.94	11.07
Pension expenditure (constant population)	13.16	18.61	17.94	17.90	19.34	18.58	15.92	14.77
Social security deficit	8.04	11.25	10.46	10.51	11.77	10.87	7.92	7.05
Social security deficit (constant population)	8.04	15.00	13.95	14.01	15.70	14.49	10.56	9.39
Pension social security deficit	5.90	9.37	8.65	8.67	9.89	9.06	6.34	5.46
Pension social security deficit (const pop)	5.90	12.49	11.53	11.56	13.19	12.09	8.45	7.28

Notes: CGE without informality results are obtained with a reduced model, where there is no distinction between formal and informal work.

Results in the two tables are obtained with a model where there is no distinction between formal and informal work, for technical and resource commitments reasons[23]. With the exception of av-

[23]The complete CGE model with formal and informal work was not originally implemented to handle large

erage pension payments per beneficiary, the simulation of aging (columns r0) and 2 years increase in retirement age (columns r192, with variable and constant informality decisions, r192+r57) by the models with and without informality are reasonably comparable[24]. One can then use the model without informality as an estimate of the effect of large retirement increases, comparing changes with the no reform case r0 (rather than absolute values). Effects of an increase of 8 years of retirement (column r199) are identical to the effects of a 2 years increase (column r192), except that they are more pronounced, as expected. Subsection 6.2 explains the driving forces. The social security deficit is cut in half in Slovakia (from above 6% of GDP to 3% of GDP) and it is cut in three in Poland (from above 7.5% of GDP to less than 2.5% of GDP). The deficit reduction is larger in Poland because the accrual rate of pension rights is lower (0.2% when retired, as opposed to 0.5% in Slovakia) and because the demographic challenge is not as strong (the dependency ratio increases more between 2010 and 2100 in Slovakia). Output per capita and average pensions per beneficiary all increase at the same speed or faster than the productivity growth trend, sometimes markedly.

During the period considered, the projected increase in life expectancy is about 9 years. In spite of an increase of retirement of 8 years, the deficit is not entirely eliminated. This may come as a surprise. The explanation is that the population aging phenomenon cannot be represented only by an increase in life expectancy. It also means that the fraction of old age persons increases, in particular for countries such as Slovakia and Poland. The fraction of pensioners in Slovakia, even with an increase of 8 years of the retirement age, moves from 25% to 30% of the population.

The role played by pension indexation in the differences in outcomes between Slovakia and Poland suggests that the deficit could be further cut with only a mild decrease in the accrual rate. When the accrual rate is cut by 25%, the deficit drops from 3% to 2.1% of GDP in Slovakia (column r1500), without any significant damage to the average pension payment per beneficiary. We will discuss other combined reforms in more details in the next section.

6.4 Effects of combined reforms

Results of the reforms described in table 2 are collected in tables 9 and 10 (except reform r1500, contained in tables 7 and 8).

policy reform shocks, such as large increase in retirement age. With appropriate resources, it is possible to improve on the original implementation so that the model handles large policy shocks.

[24]Naturally, the effective employment per capita figures are very different, since they only report formal hours of work in the model with a distinction between formal and informal work. The figures should not be compared, but the variations can be compared.

Table 9: Overview of long run simulation results of combined reforms for Slovakia

	2010	r0 Aging	r1002 Pen flat+ / Welfare -	r1011 Pen flat+ / VAT+	r1101 + 2years / Welfare -	r1021 Pen Ear- / IncTax-	r1221 Pen Ear- / IncTax- / +2y	r1301 IncTax- / VAT+
absolute numbers								
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	40.71	40.80	37.72	40.28	37.65	40.25
Effective retirement age	58.02	58.22	57.92	57.85	60.19	58.25	60.24	58.27
Unemployment rate	14.74	14.41	14.93	14.86	14.71	14.27	14.05	14.08
Employment (yearly hours per formal worker)	1786	1785	1786	1779	1781	1787	1783	1789
Effective formal employment (year hours/capita)	793	667	693	616	737	681	717	691
Low-skills population (in % of population)	9.06	9.68	9.39	9.60	9.55	9.65	9.64	9.67
Medium-skill population (in % of population)	75.18	77.23	77.22	77.73	77.02	77.06	76.95	77.08
High-skill population (in % of population)	15.76	13.09	13.38	12.68	13.44	13.29	13.41	13.25
Informality rate (in % of participants)	12.74	9.32	5.36	14.33	4.95	7.88	7.91	7.06
increase from basis in %								
Labor costs (low-skilled)	-	-3.49	-13.45	-2.68	-14.49	-1.86	-3.70	-2.60
Labor costs (medium-skilled)	-	-3.03	-2.92	-2.76	-2.81	-2.39	-2.19	-2.87
Labor costs (high-skilled)	-	13.81	13.89	14.45	15.86	10.46	11.62	10.86
Pension payment per beneficiary	-	-1.41	41.83	32.09	7.92	-41.94	-39.01	1.87
Pension payment (low-skilled)	-	-4.37	48.99	37.44	7.04	-43.55	-39.73	-1.97
Pension payment (medium-skilled)	-	-1.17	46.04	35.79	8.94	-40.93	-37.27	3.00
Pension payment (high-skilled)	-	34.47	81.18	73.74	38.93	-23.27	-22.85	36.36
GDP/capita	-	-14.52	-11.71	-21.03	-6.36	-12.57	-7.96	-11.53
Informal GDP/capita	-	-42.97	-63.45	-15.45	-64.25	-51.36	-48.86	-56.14
Consumption/capita (formal goods)	-	5.36	13.36	2.74	10.58	5.66	8.60	8.52
Consumption/capita (formal & informal goods)	-	0.02	4.89	0.73	2.32	-0.63	2.26	1.38
Government consumption/capita	-	-56.12	-92.13	-79.26	-41.74	-35.26	-25.82	-51.86
Assets/capita	-	33.93	26.06	30.32	32.01	43.28	43.37	37.91
in % of basis GDP								
Pension expenditure	7.10	9.19	13.35	12.46	9.41	5.41	5.31	9.48
Pension expenditure (constant population)	7.10	11.34	16.48	15.38	11.62	6.67	6.55	11.70
Social security deficit	0.08	5.08	8.98	9.07	4.46	1.12	0.54	5.17
Social security deficit (constant population)	0.08	6.27	11.09	11.20	5.51	1.38	0.67	6.39
Pension social security deficit	0.04	4.40	8.40	8.02	4.12	0.51	0.14	4.53
Pension social security deficit (const pop)	0.04	5.43	10.36	9.90	5.09	0.64	0.18	5.60

Notes: All reforms are simulated on top of the pure aging scenario (r0)

Table 10: Overview of long run simulation results of combined reforms for Poland

	2010	r0 Aging	r1002 Pen flat+ / Welfare -	r1011 Pen flat+ / VAT+	r1101 + 2years / Welfare -	r1021 Pen Ear- / IncTax-	r1221 Pen Ear- / IncTax- / +2y	r1301 IncTax- / VAT+	r1400 Pen Ear- / CapTax- / +2y
absolute numbers									
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	39.07	39.11	36.37	39.03	36.38	39.03	37.71
Effective retirement age	59.37	59.33	59.31	59.27	61.35	59.34	61.35	59.34	60.34
Unemployment rate	13.36	13.20	13.21	13.60	13.01	12.99	12.73	13.03	13.19
Employment (yearly hours per formal worker)	1939	1936	1938	1929	1927	1938	1929	1938	1928
Effective formal employment (year hours/capita)	0	506	516	473	537	525	549	516	509
Low-skills population (in % of population)	12.03	12.24	12.07	12.20	12.18	12.21	12.23	12.24	12.23
Medium-skill population (in % of population)	66.82	69.34	68.80	69.66	69.10	68.98	68.88	69.27	69.24
High-skill population (in % of population)	21.15	18.42	19.13	18.15	18.71	18.81	18.90	18.49	18.53
Informality rate (in % of participants)	33.18	32.68	31.50	36.30	32.48	30.41	31.16	31.67	33.90
increase from basis in %									
Labor costs (low-skilled)	-	-1.73	-2.33	-0.46	-2.77	-1.09	-1.21	-1.49	-1.09
Labor costs (medium-skilled)	-	-2.66	-2.22	-2.01	-2.20	-2.24	-1.68	-2.73	-1.81
Labor costs (high-skilled)	-	8.81	7.83	8.59	10.51	7.88	9.30	8.37	9.08
Pension payment per beneficiary	-	-5.70	17.67	12.71	-1.30	-25.64	-23.09	-4.69	-12.01
Pension payment (low-skilled)	-	-2.65	23.13	18.62	-1.15	-22.40	-21.90	-1.78	-10.07
Pension payment (medium-skilled)	-	-5.02	20.65	15.40	-2.98	-23.42	-22.38	-3.82	-11.82
Pension payment (high-skilled)	-	11.06	33.07	30.68	11.34	-13.51	-13.49	12.43	0.94
GDP/capita	-	-14.55	-12.83	-20.74	-9.32	-11.20	-6.91	-13.81	-13.59
Informal GDP/capita	-	-20.76	-22.35	-12.24	-16.42	-26.14	-20.16	-23.34	-15.49
Consumption/capita (formal goods)	-	-1.31	3.61	-4.46	0.86	1.06	3.37	0.44	-0.09
Consumption/capita (formal & informal goods)	-	-7.26	-4.33	-6.84	-4.42	-7.25	-3.82	-6.83	-4.80
Government consumption/capita	-	-65.87	-90.78	-82.63	-48.43	-52.87	-40.68	-65.93	-58.92
Assets/capita	-	9.04	0.03	3.93	8.15	16.22	16.11	9.53	15.94
in % of basis GDP									
Pension expenditure	13.16	13.96	17.44	16.72	13.62	11.01	10.61	14.11	12.59
Pension expenditure (constant population)	13.16	18.61	23.25	22.29	18.15	14.67	14.15	18.81	16.78
Social security deficit	8.04	11.25	14.61	14.44	10.51	8.06	7.35	11.35	9.81
Social security deficit (constant population)	8.04	15.00	19.48	19.26	14.01	10.75	9.79	15.14	13.07
Pension social security deficit	5.90	9.37	12.76	12.41	8.72	6.24	5.60	9.44	7.94
Pension social security deficit (const pop)	5.90	12.49	17.01	16.54	11.62	8.32	7.47	12.58	10.59

Notes: All reforms are simulated on top of the pure aging scenario (r0)

Increases in the flat part of pension benefits may help to achieve the political goal of fighting poverty in old age. As seen in table 16 (column 327), informality increases. There can thus be a short term drawback in the implementation of such a policy, as social contribution resources decrease. One could thus try to curb the increase in informality with a decrease in welfare benefits (see column r101 of table 3). As shown in column r1002 of table 9, the combined reform indeed succeeds in keeping a low informality rate (as r101) while at the same time increasing the average pension payment per beneficiary (as r327). The table also shows that, in the long run, public finances will only slightly improve (while the social security deficit is essentially constant, the decrease in government consumption per capita needed to balance the budget drops to 92%, instead of 96% for reform r327). This outcome is not a surprise as the decrease in informality adds contributions but increases pension expenditures.

In the long run, a combined reform with the same political goal which is more effective in long run public finance would be to increase the flat part of pension benefits with an increase in consumption taxes (column r1011 in table 9): the average pension payment is almost as high as reform r327 but the government consumption per capita only has to drop to 80% to close the budget.

Another interesting policy mix would be an increase in the retirement age with a decrease in welfare benefits (column r1101 in table 9): the average pension payment increases 8% (while it only increased 3% with sole increase in retirement age), due to the decrease in informality (inherited from the decrease in welfare benefits), and the government consumption per capita decreases less (42% instead of 46% with sole increase in retirement age). What appears to be crucial for the definition of the policy mix are the goals of the reforms, on top of containing public finance costs.

If the focus is on stimulating formal sector work alone, equal decreases in the earnings-related part of pension benefits and in labor income taxes is of interest (column r1021). The simulation confirms the expectation, as formal work hours per capita are 681 (compared to 667 with no reform, column r0). Financing of social security improves even more than sole cuts in earnings-related pension benefits (reform r29 in tables 3 and 4), thanks to the combined cut in benefits and decrease in informality.

For further contribution to social security deficit reduction, adding increases in retirement age is interesting (column r1221). One achieves the best outcome overall in deficit reduction, going down from 5% of GDP to 0.5% of GDP, thanks to the largest amount of formal work, at 717 hours per capita. Associated are small losses in output per capita and a low informality rate. Other policies are however more successful at fighting old age poverty, as the average loss in pension payments per beneficiary is close to 40% (relative to the productivity growth trend).

Fiscal devaluations - a shift from labor income taxation to consumption taxation - is often considered an interesting policy reform to stimulate job and output growth, at least over the short run. Simulations (column r1301) show however that the policy may not be attractive over the long run: most of its outcomes are worse than the sole reduction in labor income taxes (column r86 in tables 16 and 17). For instance, the loss of output per capita is larger than 11% (relative to trend) with reform r1301, compared to a loss of less than 6% with reform r86. The reason is that larger consumption taxes increase informality (see discussion of reform r91 in subsection 6.2).

We finish with a discussion of reform r1400 for Poland, which combines an increase in retirement age, cuts in earnings-related pension benefits and a decrease in capital income taxation, to

encourage private savings[25]. As expected, private savings increases, as asset per capita grew 16% more than the productivity growth trend (compared to 9% when there is no reform, column r0). Compared to the sole increase in retirement age (column r192 in table 4), the reforms allow for a larger social security deficit reduction, to 9.8% of GDP instead of 10.5%. There is however a larger loss in output per capita, to 13.6% instead of 10.8% (relative to trend), and bigger drop in average pension per beneficiary, to 12% instead of 2.5%. One reason for these differences in outcome is that informality is larger, to 33.9% instead of 33.6%. Cuts in earnings-related pension benefits indeed discourage work in the formal sector.

6.5 Short-run analysis

This section's analysis considers the transition path from one equilibrium to the other given the aging shock (r0) for Slovakia. The change in mortality rates and the number of new entrants was gradually phased-in to replicate the change in the demographic structure over time as closely as possible. Table 11 illustrates the adjustment path. Given the projections from United Nations (2011) the population slightly increases after 2010 before steadily falling to about 80% of its 2010 value. The age-structure is also characterized by a non-monotonic trend, which can be seen when looking at the dependency ratio which rises up to more than 52% in the second half of this century before decreasing again and settling at a level of about 46%. A direct effect of the increase in life-expectancy is that households reduce consumption and start to save because they have to supplement their pensions for a longer period of time. Assets slowly build up, allowing households to enjoy consumption in the long run at the same level as in 2010. The non-monotonic behavior of the dependency ratio is also reflected in some of the labor supply outcomes, such as yearly hours per capita which are lowest in 2070 before slightly recovering again. The same is consequently true for the social security macro measures. Around 2070 pension expenditure and the social security deficit increase to a peak of 11.9 and 7.5%, respectively, before falling again. Another observation is that gross wages for the high-skilled workers are lower than in 2010 up to the mid of the 2020s before rising considerably afterward. The rise is explained by shifts in the endogenous skill-structure and relative scarcity of high-skilled workers. This also explains why the increase in the wage rate does not occur before the mid 2020s because workers altered education choices require time before affecting the labor market. The positive relation between the life expectancy and the informality rate was established in the previous section. Interestingly, the informality rate decreases in a U-shaped way over time while life expectancy increases monotonically. The slight increase in the informality rate in the second half of the century is explained by a relative drop in wage.

[25]The reform was only performed for Poland because capital income taxes are too low in Slovakia and can not be cut enough to have interesting simulation results.

Table 11: Results of the aging scenario over time for Slovakia

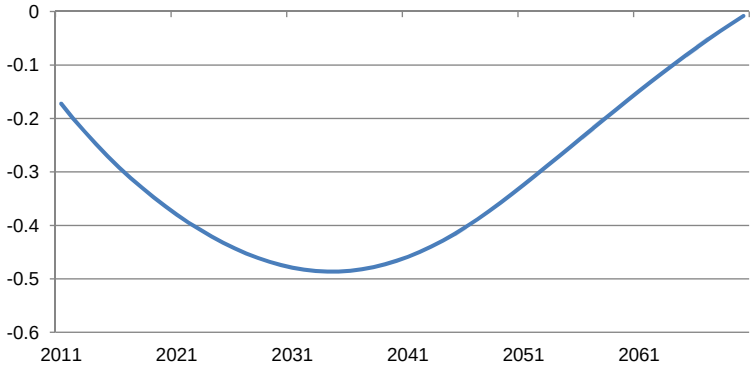
	2010	2020	2050	2070	Final SS
absolute numbers					
Population (15+, normalized)	100.00	101.19	95.55	91.27	81.00
Dependency ratio	19.17	26.23	46.67	52.38	45.69
Pensioners (in % of population)	24.87	29.88	41.68	43.84	40.31
Effective retirement age	58.02	58.18	58.28	58.25	58.22
Unemployment rate	14.74	14.24	13.81	14.05	14.41
Employment (yearly hours per formal worker)	1786	1784	1787	1786	1785
Effective formal employment (year hours/capita)	793	797	689	650	667
Low-skills population (in % of population)	9.06	9.13	9.34	9.47	9.68
Medium-skill population (in % of population)	75.18	75.73	76.78	77.13	77.23
High-skill population (in % of population)	15.76	15.14	13.88	13.40	13.08
Informality rate (in % of participants)	12.74	10.50	7.12	7.56	9.32
increase from basis in %					
Labor costs (low-skilled)	-	-3.58	-0.53	-1.57	-3.49
Labor costs (medium-skilled)	-	-3.20	-0.23	-1.06	-3.03
Labor costs (high-skilled)	-	-4.51	14.64	16.85	13.81
Pension payment per beneficiary	-	-2.23	1.39	6.50	-1.41
increase from basis in %					
GDP/capita	-	-1.03	-10.42	-15.08	-14.52
Informal GDP/capita	-	-17.73	-54.29	-55.07	-42.97
Consumption/capita (formal goods)	-	-8.82	5.43	8.26	5.36
Consumption/capita (formal & informal goods)	-	-9.81	-1.16	1.27	0.02
Government consumption/capita	-	-10.41	-46.13	-64.63	-56.12
Assets/capita	-	5.08	23.47	28.92	33.96
in % of basis GDP					
Pension expenditure	7.10	8.44	11.53	12.16	9.19
Pension expenditure (constant population)	7.10	8.34	12.06	13.32	11.34
Social security deficit	0.08	1.52	6.08	7.55	5.08
Social security deficit (constant population)	0.08	1.50	6.36	8.27	6.27
Pension social security deficit	0.04	1.40	5.54	6.78	4.40
Pension social security deficit (const pop)	0.04	1.39	5.80	7.43	5.43

Note: Final SS refers to the final steady state which approximately corresponds to the year 2100.

One conclusion from the long run analysis was that the level of informality is not a crucial driver of the social security deficit in the long run. In the short run, however, the effect is different. This conclusion is drawn from comparing the path of the social security deficit when informality declines spontaneously with age (r0) with the path of the social security deficit when informality is kept constant (r57). The difference in these paths is illustrated in figure 3. With endogenous informality the social security deficit is up to 0.5 %-points lower than if informality rates were constant. This has a simple explanation. The reduction in informality is beneficial for the social security system at first as formal employment and therefore social security contribution payments increase. In the long run however this effect is canceled as pension expenditure rises because of the strong earnings-to-pension link.

Table 21 in appendix C in addition presents the path for one example of reform, namely the permanent increase in social security contributions (r34) in 2011. The path of the social security deficit is shifted downward compared to table 11 where only aging is considered. This leads to a social security surplus in the first years after the reform but is not sufficient to contain the deficit in the long run.

Figure 3: Difference in social security deficit as % of 2010 GDP in percentage points between the aging scenario with endogenous informality (r0) and with constant informality (r57)



Note: A negative value means that the social security deficit is higher in the aging scenario where informality rates are constant.

6.6 Sensitivity analysis

This section presents the results of various sensitivity tests. We check the sensitivity of the previous results, denoted as basis calibration (s0), along six dimensions. We raise the behavioral responsiveness parameters for the informality, hours and participation margin. We consider a uniform increase in the informal income for all age-skill-groups. Next, we check the robustness of the results to making the informal income profile steeper along the skill-dimension, i.e. the difference between high- and medium-skilled informal income in comparison to low-skilled informal earnings is increased by 50%. The last sensitivity check concerns the profile of the informality rates. Given the limited data quality concerning age- and skill-group specific informality rates, we chose a sensitivity scenario where informality rates are completely identical for all households to check the qualitative and quantitative importance of the chosen profiles in the benchmark calibration. Table 12 summarizes the different sensitivity scenarios. For all of them[26] we simulated the pure aging case (Aging, r0) and an increase in the social security contributions (SSC+, r34) for both Poland and Slovakia. Tables 22 to 25 in appendix D report all the results. In the presentation of the sensitivity results we will focus on the pure aging scenario (r0).

The increase in the responsiveness at the informality margin (s1) amplifies the drop in informality due to aging from 12.7 to 7.5 instead of 9.5 for Slovakia and from 33.2 to 32.0 instead of 32.7 for Poland. As expected, the larger shift from informal to formal sector also impacts variations in GDP per capita. However, the long run effects on social security deficits are hardly changed. This supports the results from the previous section that changes in informality have only temporary effects on the net fiscal outcomes for the government as both revenues and expenditure change in size over the long run. For example in Slovakia long run pension expenditure increases from 9.15 % to 9.41 % of GDP compared to the benchmark calibration, while the social security deficit only changes from 5.07 to 5.11 % of GDP.

The increase in the elasticity of the hours and participation decision (s3 and s5) by 25% has only tiny effects. In addition the results also seem to be robust to changes in the level of informal income (s7). The model was recalibrated using a 5% uniform increase in the informal incomes which led to virtually unchanged pension and social security deficits.

As another sensitivity check we changed the informal income profiles along the skill class dimen-

[26]We also ran simulations with the opposite sensitivity changes to s1, s3, s5, s7 and s9. As the results were completely symmetric they are not reported in this report but available upon request.

sion (s9). The motivation is that country specific differences in income profiles, in general, explain the fact that variations in informality rates are higher in Slovakia than in Poland. We increased the difference of the high- and medium skilled informal incomes in comparison to the low-skilled by 50%. Simulations for both countries show that the model with this altered calibration delivers very similar results, in particular for the pension and social security deficits.

The last sensitivity check concern the profiles of the informality rates (s14) which were derived from Koettl and Weber (2012) (see appendix section A.1). This resulted in an informality rate profile that is decreasing in skill in Poland and increasing in skill in Slovakia. In the sensitivity analysis we eliminated these patterns by assigning the average informality rate to every skill and age group. As documented in tables 22 to 25 of appendix D, this does not affect the results qualitatively. The quantitative differences appear small, in comparison to the benchmark calibration.

The general conclusion of the sensitivity analysis is that the simulations with the benchmark calibration value are robust.

Table 12: Additional sensitivity simulations

Sensitivity parameter	*Change*	*Sensitivity code*		*Comment*
none	-	s0	basis	basis calibration
Elasticity of informality	+50%	s1	elast inf+	higher elasticity
Elasticity of hours decisions	+25%	s3	elast hour+	higher elasticity
Elasticity of participation	+25%	s5	elast part+	higher elasticity
Informal income level	+5%	s7	yinf+	uniform proportional increase
Informal income profile	+50%	s9	yinf steep	steeper profile
Equalized informality rate	100%	s14	equal inf rate	full equalization

6.7 Summary of findings

The eight main findings of the general equilibrium analysis of aging and reforms in Poland and Slovakia, taking informality, retirement and other households decisions into account, are the following: (i) the analysis confirms the challenge posed by population aging on the financing of social security, deficits growing by more than 5 percentage points of GDP in constant population terms until 2100; (ii) population aging alone, without any reforms, reduces the rate of informality by as much as 30%; (iii) reforms usually have the anticipated effects on deficits and informality in qualitative terms, with the exception of welfare benefit cuts, which do not reduce deficits; (iv) informality alone is not a cause for social security deficit in the long run; (v) however, in the short run a reduction in informality decreases social security deficits; (vi) reductions in pension benefits are the most efficient reforms to cut the social security deficit due to aging; (vii) variations in informality rates differ significantly between Poland and Slovakia; (viii) the results are qualitatively and quantitatively robust to calibration changes.

It is useful to remember that the macroeconomic set-up is not suitable for poverty and income inequality analysis, that we assumed constant per capita and per age-group health expenditures and that simulations relied on a technical choice for closing the government budget which isolates the effect of aging and reform but is not realistic and underestimates the public finance cost of aging.

The analysis delivers other interesting findings. We discuss and provide explanations together for the eight main and the other findings.

(i) The challenge of financing social security with population aging is standard. Most of the

increase in deficit is due to pension expenditures, which increase by 3% of initial GDP in Poland and by 5% in Slovakia until 2100. The reason is standard: as the likelihood of surviving past the retirement age increases, the number of contributors increases slower (even shrinks) than the number of beneficiaries.

(ii) A novel finding is that aging alone reduces the informality rate, sometimes by more than 30%. One reason is simply the increase in life expectancy, which makes the financing of post-retirement life more important. Earnings-related parts of pension benefits increase with more formal sector work, explaining the decline in informality. Another reason is related to human capital acquisition and the aging process. As the probability of dying young decreases, continuous training to increase productivity, wages and later earnings-related pension benefits becomes more interesting.

(iii) As expected, postponing retirement age or increasing contributions reduce the social security deficit. Higher exogenous productivity growth also reduces the deficit, but the associated increase in informality and decline in contributions wipe away most of the gains. The fact that welfare benefits cuts deliver no improvement in social security deficits may be unexpected. The reason is that the associated decline in informality has immediate positive consequences on the deficit, as more contributions are collected, but later negative consequences, as the earnings-related part of pension benefits increases, leading to higher pension expenditures.

Reforms usually have the expected effect on informality rates. Increasing contributions and tax rates, reducing the earnings-related part of pension benefits, increasing welfare benefits and the flat part of pensions all increase informality, because these reforms decrease the value of formal sector relative to informal sector work. The increase in informality caused by higher productivity growth may come as a surprise, if one is not aware of the fact that pension benefits are not fully indexed to wage and thus productivity growth.

(iv) Another potentially surprising finding is the fact that informality alone is not a cause for the growing social security deficit in the long run. An experiment where informality decisions are exogenous and constant shows that the social security deficit is identical, if not lower. The reduction of informality due to aging does not lead to a lower deficit. This finding is confirmed in the sensitivity analysis when higher elasticities at the informality margin are considered. This increases the reactions on the informality rate but has negligible consequences for long run social security deficits. The reason is the same as for welfare benefit cuts: immediate financing gains of lower informality are overturned by later higher expenditures, an immediate consequence of the strong earnings-related characteristics of the pension systems in both countries. In general and for the same reason, the reduction of informality due to any reform does not contribute to a reduction of the social security deficit. The reform may have other effects which overall reduce the deficit, but this is not due to informality. An early policy implication of the analysis is that a reduction of informality alone is not an appropriate measure if the sole target is the reduction of social security deficit. There may be however other reasons to target a reduction in informality. Simulations also show that if one adds other targets to reforms, such as a reduction in poverty by means of an increase in welfare benefits, then the deficit may increase in part because of an increase in informality. Informal decisions thus remain an important channel for welfare and public finance analysis.

(v) While changes in the informality rate have hardly any effect on long run social security deficits, they do affect them in the short run. The simple explanation is that a change in the informality rate has an immediate impact on revenues but a lagged effect on expenditures which only occurs when people retire.

(vi) From the limited simulations considered, a decrease in pension benefits is the only really successful reform to eliminate the deficit. An increase in retirement age by 4 years which is about 40% of the respective increase in life expectancy can almost eliminate the aging-related drop in GDP per capita but would reduce the rise in the social security deficit by only 50% for Poland and 30% for Slovakia.

(vii) There is a significant difference in the quantitative effect of aging on informality between both countries. Informality decreases by more than 30% in Slovakia and by less than 5% in Poland. The main reason for different outcomes in Poland and Slovakia are formal earnings profiles and skill choices. Aging generates more training for high skills than others, because they experience lower disutility costs from training. The formal labor supply shock initially reduces wages of high skills, changing education decisions in favor of medium skills, which later increases high skill wages again, in general equilibrium. This attracts workers away from the informal sector. High skilled workers in Poland earn more, relative to low skill workers. There is thus less of a reason to shift from high to medium skills, a lower variation in wages and thus a lower shift from the informal to the formal sector.

(viii) There are also large differences in the observed levels in informality rates between countries, illustrating the challenge of obtaining quality data and the difficulty in identifying informality. However, sensitivity analyses showed that differences in the choice of the informality parameters for the CGE model have little influence on the qualitative and quantitative results. The quantitative robustness in particular holds for simulation of the social security deficit over the long run, a direct consequence of finding (iv).

7 Policy implications

We present policy implications on the long run with a unique or multiple goals as well as implications for short run goals.

7.1 Long run single goal of financial sustainability

Over the long run, if one considers the reduction of the public finance deficit alone, making the difference between informal and formal sector or not leads to the same policy implications. In other words, informality does not play a role. Policy implications are standard. These are as follows.

Reforms are needed to secure the financial sustainability of the pension system as population ages. The challenge is not small. In Slovakia, the social security system starts from a balanced position in 2010 and ends up with a deficit of 5% of GDP by 2100. In Poland, the system starts with a deficit position of 8% of GDP in 2010 and reaches 11% by 2100.

Parametric pension reforms have the standard effects: increases in the retirement age, decreases in pension benefits or increases in social security contributions all improve the financing of the pension system. Each have their advantages and disadvantages.

Both in Poland and Slovakia, decreases in pension benefits are the most successful at improving the financing of the system. However, cuts in benefits may increase poverty risk to unacceptable levels.

Mild increases in the retirement age improve the financing of the pension system to a smaller degree but is more successful at maintaining the output level. When the increase in retirement

age is sufficiently large, financing of the pension system can be secured. How society balance its priorities between leisure and consumption also plays a role.

Increases in social security contributions help to the lower extent and have negative impacts on labor supply, output and consumption. By international standards, Poland and Slovakia have already large tax and contribution rates so this result is not surprising.

The intuition behind these policy implications are standard, with one exception. The exception concerns informality, which does not play a role over the long run when the sole objective is financial sustainability. A decline in informality helps over the short run as contributions increase, but over the long run, increases in pension expenditures neutralize this benefit.

7.2 Long run multiple goals

If financial sustainability is not the only goal then informality can play a role for long run policy design. For instance, if fairness is a consideration, governments may want to both decrease informality and ensure the financial sustainability of the pension system.

With this dual goal of informality decline and financing improvement, the standard policy implications which arise from analysis where there is no distinction between formal and informal sectors are modified. The main difference takes place for pension benefit reductions. Cutting the flat part is efficient while cutting the earnings-related part becomes counterproductive, as informality increases.

Increases in the retirement age reach the same pension financing improvements but have essentially no strong positive nor negative impacts on informality[27]. Increases in social security contributions become even less desirable, as it moves away from the informality reduction target: the rate increases.

Under this dual goal, cutting the flat part of pension benefits is the most efficient single dimension policy reform. It however increases the risk of poverty in old age.

If one consider the three goals of informality reduction, pension financing improvement and old age poverty reduction, which may be realistic for Poland and Slovakia, large increases in retirement age become the most desirable single dimension pension reform. This policy reform can also be the preferred one if the goals are informality reduction, pension financing improvements and high output per capita growth. Even though it has a limited impact on informality, it is successful in improving the financial sustainability of the pension system while not increasing the chance of old age poverty. It is at the same time the most effective of the policy considered in keeping output per capita growth close to productivity growth. Large increases in retirement age may however conflict with relative preferences on leisure and consumption.

Combination of single dimension reforms allow to balance targets.

For instance, combining light increases in retirement age, cuts in earnings-related pension benefits and decreases in capital income taxes to encourage private savings, achieves generally comparable outcomes as the sole increase in retirement but allows more improvements in financial sustainability at the expense of worse protection against old age poverty.

The combination of light increases in retirement age, cuts in earnings-related pension benefits and decreases in labor income taxes to encourage formal sector activity is appealing if financial sustainability is even more important and protection against old age poverty even less important. Fairness would also be improved.

[27] When the retirement age is increased 4 years, informality drops from 32.7% to 31.7% in Poland but increases from 9.3% to 9.5% in Slovakia.

Depending on the country institutions, combination of reforms may even be needed if one wants to eliminate the social security deficit. For instance, if the accrual of pension rights is large, even large increases in retirement age may leave some deficit. Small reduction in the accrual rate, added to large increases in retirement age, deliver significant improvements: elimination of the deficit, improvement in the fight against old age poverty and high output per capita growth[28].

Which of the policy reform combination precisely is optimal depends on current institutions, balance between the various goals of policy reforms and relative leisure and consumption preferences.

7.3 Adding short run single and multiple goals[29]

Informality has an impact on short run public finance positions and should thus be included in the analysis of all policy options which involve sustainability of the pension system.

Simulations for Slovakia show that the spontaneous decrease in informality caused by aging (making post-retirement income and thus formal sector earnings-related pension benefits more attractive) increases contributions on the short run and can lead to an improvement in the social security deficit reaching 0.5% of GDP after 20 years (and vanishing over the long run, when pension expenditures catch up).

Assuming that the financial sustainability of the pension systems remains a primary objective over the long run, the preferred policy reform scenario over shorter time horizons depends on the trade-off between various objectives.

Social security contributions increases and cuts in the earnings-related part of pension benefits both help to finance the pension systems in the long run but lead to an increase in the informality rate, so appear undesirable.

Increases in the retirement age help the long run pension financing but have a small impact on informality. Cuts in the flat part of pension benefits both improve pension financing and lead to a decline in informality but increase the risk of old age poverty. Whether increases in retirement age or cuts in the flat part of pension benefits are preferable thus depend on whether the primary objective is low poverty in the old age (retirement age increase is preferable) or fairness (cuts in the flat part of pensions is preferable).

We finish this section with caveat information. Due to its nature, data on informal activity is difficult to collect. As a result, the calibration of the informal component of the CGE model is less reliable than for other components. This uncertainty has however a low impact on policy implications, for two reasons. First, sensitivity analysis showed that the simulation results where robust. Second, we derived most policy implications from the qualitative outcomes of the simulation results. We thus believe that policy implications are robust in their qualitative dimension. We would urge more caution for interpretation of the quantitative part on informality in the simulation results.

[28] Caveat: additional simulations would be needed to discuss the effect on fairness (low informality rate), but we expect that fairness can not be degraded.

[29] Policy implications remain focused on the long run. This section adds short run considerations. Additional simulations would be necessary to derive policy implications focused on the short run only.

8 Conclusions

Like many other, countries in Europe and Central Asia face a mounting financial sustainability challenge as population ages. At constant retirement age, rising life expectancy and decreases in fertility lead to more retired households for a smaller working age population. Consistent with other studies, our general equilibrium simulations predict that the social security deficit would increase by more than 5% of GDP in Poland and Slovakia between 2010 and 2100 if no reforms are undertaken.

The novelty of these results is that they take into account activity in the informal sector. Although estimates vary, at 35% of GDP the average size of the shadow economy in Central Europe and Central Asia is two to three times larger than the average in OECD countries. As participants in the informal labor market do not pay social security contributions and fewer taxes but can rely on anti-poverty welfare benefits, high informality rates represent a significant challenge for financing social security.

We introduce informality decisions into an otherwise standard but rich overlapping generations model to investigate the effect of population aging and various reforms in two representative countries, Poland and Slovakia. Households decide how much to save, whether to work or not, how many hours to work or train, how hard to look for a job when unemployed and when to retire. On top of this, if they decide to work, they choose between a formal or an informal sector. By choosing the informal sector, they avoid social security contributions and labor income taxes but only have access to anti-poverty welfare and pension benefits. In the formal sector, they pay contribution and taxes but have access to higher benefits, related to their history of formal sector earnings.

We find that aging alone reduces the informality rate in the long run, as the increase in the post-retirement phase of life makes higher pensions, and thus work in the formal sector, more attractive. We confirm that informality is a challenge in the short run but find that it plays no role on the long run, if the sole objective of policy is financial sustainability. The spontaneous decline in informality could lead to a reduction of 0.5% of GDP in the social security deficit in Slovakia in the short run as contributions increase, compared to constant informality. In the long run however, the increase in contributions is matched by an increase in expenditures, as pension costs increase.

If the sole goal of pension reforms is the financing of the social security system, simulations show that cuts in pension benefits are the most efficient over the long run. They may however increase the risk of old-age poverty. If one consider the goals of informality reduction, pension financing improvement, old age poverty reduction or steady increases in output per capita, increases in retirement age may be the most balanced pension reform option.

Combination of reforms allow to balance multiple targets, to take into account current institutions and relative preferences over leisure and consumption. Simulations show that large increases in retirement with mild reductions in the accrual rates of pension rights would allow to wipe out the deficit in Slovakia and Poland, while improving output per capita growth and protection against old-age poverty. Light increases in retirement age, cuts in earnings-related pension benefits and decreases in labor income taxes would also eliminate the deficit but at the expense of lower protection against old-age poverty.

Additional investigations would be necessary for the analysis of policy reform options over the short run. The general equilibrium model would have to be further expanded for an analysis of pension reform options on mandatory private and other pillars.

A Details on calibration

We present in details the calibration procedure and data requirement for the new component of the full scale model, informality. We refer to documentation of the existing full scale model for the remainder of the calibration approach and data sources, which has been performed for Poland and Slovakia[30]. In this procedure, parameters are calibrated using micro-level data and empirical studies and scaled such that aggregate expenditures in the model match empirical targets. Although the model does not have a multi-pillar representation of the pension system, the existing pay-as-you-go pillar and labor market related institutions are calibrated to capture the main characteristics of multi-pillar systems. For example, no pension rights are earned during unemployment and non-participation periods, in contrast to other European countries.

A.1 Informality rates

We are using informality rates by age and skill classes. As planned, we used table 3 of Koettl and Weber (2012) for participation rates in the informal sector (given participation in any labor market). We use allocation rules to establish a correspondence between the table age and income classes in the paper and those of the model, which differ.

Taking the example of Poland, the correspondence for the age classes is given by:

Paper		Allocation	Model	
Age class	Rate (%)	rule	Age class	Rate (%)
15-24	44.6	=	15-19	44.6
		=	20-24	44.6
25-39	35.6	=	25-39	35.6
40-54	40.5	=	40-54	40.5
55-64	45.2	90%	55-69	48.0
65+	73.7	10%		

Skill levels and earnings are not perfectly correlated so we used the following correspondence:

Paper		Allocation	Model	
Income group	Rate (%)	rule	Skill level	Rate (%)
25-49% of AW	40.4	=	Low	40.4
100-200% of AW	29.3	=	Medium	29.3
>200% of AW	25.7	=	High	25.7

Assuming the same skill distribution of informality over each age class, taking into account the model assumption that medium skills educate until 20 and high skills until 25, the resulting informality rates by age and skill class used for calibration of the model are:

PL	low	medium	high
15-19	50.6	0.0	0.0
20-24	50.6	36.7	0.0
25-39	40.4	29.3	25.7
40-54	46.0	33.3	29.2
55-69	54.5	39.5	34.7

SK	low	medium	high
15-19	8.9	0.0	0.0
20-24	8.9	8.2	0.0
25-39	11.8	10.9	21.6
40-54	12.7	11.8	23.3
55-69	13.8	12.8	25.3

[30]Detailed documentation of Berger et al. (2009), as used for a European Commission project, is for instance available under http://ec.europa.eu/social/BlobServlet?docId=4276&langId=en. The calibration approach for Poland is presented in this document. Additional documentation is available upon request for Slovakia.

The resulting average informality rate is 33.2% for Poland and 12.7% for Slovakia[31].

A.2 Informal sector earning profiles

We rely on the EU-SILC database to calibrate the model with earnings profile in the informal sector. Recall that the individual levels of earnings carry no meaning in the model neither in the formal nor the informal sector, only the relationships matter. Our approach is therefore the following: we calibrate the earnings profile and level in the informal sector such that differences between informal workers are consistent with data, along age and skill dimensions, and such that the premium for working in the formal sector as opposed to the informal sector is consistent with data.

We identified informal workers in the data source based on Koettl and Weber (2012): employees for whom there is no employer social security contribution; all family workers[32]; self-employed with no employees who pays no social security contribution; self-employed with 1 to 5 employees who pays no social security contribution. Given the lack of earnings information for Slovakia, we relied on estimates for Poland[33]. For one skill and age class, the number of informal workers was low and we imputed the corresponding earning value from similar classes. Imputation was also performed for one outlier in the earnings profile for Slovakia.

The resulting earnings profiles in the informal sector are:

PL	low	medium	high
15-19	1.00	0.00	0.00
20-24	1.17	1.33	0.00
25-39	1.81	1.71	3.05
40-54	1.48	2.06	4.52
55-69	1.49	1.93	3.79

SK	low	medium	high
15-19	1.00	0.00	0.00
20-24	1.05	1.27	0.00
25-39	1.10	1.35	1.84
40-54	1.06	1.40	2.23
55-69	1.05	1.28	1.76

For comparison purposes, the wage profiles in the formal sector are:

PL	low	medium	high
15-19	1.00	0.00	0.00
20-24	1.17	1.37	0.00
25-39	1.46	1.81	3.28
40-54	1.63	2.22	4.38
55-69	1.55	2.22	4.63

SK	low	medium	high
15-19	1.00	0.00	0.00
20-24	1.05	1.32	0.00
25-39	1.12	1.44	1.98
40-54	1.14	1.51	2.15
55-69	1.10	1.48	2.15

Recall that these profile can only be compared in relative terms. Section A.3 provides information on levels.

A.3 Informal sector earnings levels

Participation information on informality is not enough to characterize households behavior, we also need to have productivity (or, equivalently, income) information. There are two options

[31] These numbers are different from the averages in Koettl and Weber (2012) and reduce the difference between the two countries, in order to have a more comparable picture. Uniform changes in the levels of informality are possible to match averages in Koettl and Weber (2012) but are unlikely to change the simulation results, as profiles are more important than levels in driving behavior responses.

[32] Due to missing data, we used all family workers, not just unpaid family workers, as in Koettl and Weber (2012). Given the small number of cases, we do not anticipate a big difference.

[33] We compared outcomes with the one transition country with sufficient data, Bulgaria, and confirmed that they are similar.

to have a measure of productivity in the informal sector. One is aggregate data, using shadow economy measures. Another is household-level data, using earnings reports. The first option may be more challenging, as one needs to remove the underreporting part from the shadow measure to isolate informality activity. Yet, the lack of empirical literature on the size of tax underreporting is notoriously problematic (for instance footnote 6, Schneider and Enste, 2000)[34]. We thus use the second option.

Taking into account earnings profile (see section A.2) and productivity variations over the life-cycle, we set the revenue in the informal sector such that the gross earning premium for working in the formal sector relative to working in the informal sector is consistent with micro-level data. The resulting earnings in the informal sector are then:

PL	low	medium	high
15-19	0.71	0.00	0.00
20-24	0.70	0.94	0.00
25-39	0.86	0.91	2.16
40-54	0.63	0.90	2.41
55-69	0.70	0.86	1.92

SK	low	medium	high
15-19	0.61	0.00	0.00
20-24	0.60	0.78	0.00
25-39	0.59	0.77	1.12
40-54	0.57	0.76	1.29
55-69	0.58	0.70	0.97

Since these values only have a meaning when compared to earnings in the formal sector, we compute the premium for working in the formal sector. The weighted average of the formal sector premium are 1.157 for the model and 1.169 in the data for Poland; 1.169 in the model and 1.166 in the data for Slovakia[35].

A.4 The response at the informality margin

The response at the informality margin is calibrated by setting the net disutility of formal work $\varphi_F(\zeta)$ accordingly. The functional form chosen in the full model is similar to the disutility of participation:

$$\varphi_F(\zeta) = \varphi_F^1 \cdot v_F \cdot \left[\exp\left(\frac{\zeta}{v_F}\right) - \exp\left(\frac{\zeta_{calib}}{v_F}\right)\right] - \varphi_F^2 \cdot [\zeta - \zeta_{calib}] \,.$$

Observe that in this specification disutility is normalized to zero in the initial steady state. Let MB_F denote the present value of the marginal benefit of working formally versus informally capturing differences in per-period net incomes but also all consequences for pension payments, etc. Then the implicit decision rule can be written as follows

$$\zeta = v_F \cdot \ln\left(\frac{MB_F + \varphi_F^2}{\varphi_F^1}\right).$$

The scale and shift parameters φ_F^1 and φ_F^2 are age- and skill-specific and are used to match the observed formality rates as described in section A.1. The size of the effect of a change in the marginal benefits of working formally on the formality rate is captured in the semi-elasticity parameter v_F. We chose the findings presented in Koettl and Weber (2012) as basis

[34] Another challenge may be the precision of shadow economy measures. For instance, two different empirical studies considering the same period (1989-90) and using the same method (physical input) estimate the shadow economy size in Poland at 17.7% of GDP and 27.2% respectively (table 5, Schneider and Enste, 2000).

[35] The information on Slovakia must be taken with care, as it is based on premium information for Poland. See section A.2.

for our elasticity choices. They find that a 1%-point increase in the formalization tax rate (FTR) decreases the probability of working formally by 1.1% on average. Low-wage earners, defined as persons earning about one third of the average wage, respond more (-2.5%-points). The formalization tax rate is computed as informal net income minus formal net income as percentage of informal net income,

$$FTR = \frac{[(1+\tau_c)y_{inf} + z] - y}{(1+\tau_c)y_{inf} + z}.$$

While y simply denotes formal net income, informal net income is defined as $(1+\tau_c)y_{inf} + z$ for workers, i.e. the return from working informally $(1+\tau_c)y_{inf}$ plus claimed welfare benefits z[36]. The static semi-elasticities v_F were set such that the equilibrium response to a 1%-point increase in the FTR leads to an average increase in informality by 1.1% for both countries as found in Koettl and Weber (2012). The model calibration results in a higher responsiveness of the low-wage earners than of average or high-wage earners. The reactions to a 1%-point rise in the FTR are 1.6%, 1.1% and 0.7% increases in the informality rate for low-, medium- and high-skilled. The response was also set to decrease in age (and therefore income) before slightly rising again for the last working age group. The sensitivity of the low-skilled was set lower than the reaction of the low-wage earners as defined in Koettl and Weber (2012) because they represent two different groups. In this model low-skilled workers earn about 70% of the average wage income which is about twice as much as for the group of low-wage earners analyzed in Koettl and Weber (2012).

A.5 Demographics and aging

Capturing the demographic structure and its change over time is a key task of the model. In the full model in period t an economy is inhabited by N_t persons who differ along two characteristics: age ($a \in \{1, ..., 8\}$) and skill ($i \in \{low, medium, high\}$) resulting in 24 representative households with mass $N_t^{a,i}$ each. The eight age groups are chosen as follows: 15-19, 20-24, 25-39, 40-54, 55-69, 70-79, 80-84, 85+. The first 4 age groups are comprised of potential workers. The age group 55-69 will partially participate in the labor market and partially retire given their retirement decision. The last three age groups are in retirement. The overlapping generations structure relies on the concept of 'Probabilistic Aging' (see Grafenhofer et al. (2007)). Individuals age stochastically which means that they switch from age group $a \in \{1, ..., 8\}$ to age group $a+1$ with a given probability $1-\omega^a$ per period. A period was chosen to be a year, hence the expected time a person stays in age group a is be $1/(1-\omega^a)$ years. In every period individuals face a death probability of $1-\gamma^a$, which is higher for members in old age groups. Over time the structure of the population evolves according to the following law of motion

$$\begin{aligned} N_{t+1}^{1,i} &= \gamma^1 \omega^1 N_t^{1,i} + New_{t+1}^i, \\ N_{t+1}^{a,i} &= \gamma^a \omega^a N_t^{a,i} + \gamma^{a-1}(1-\omega^{a-1}) N_t^{a-1,i}, \quad \forall a \in \{2, ..., 8\}, \end{aligned}$$

where New_{t+1}^i denotes the exogenous number of new entrants. Aggregation by age- and skill-class then simply follows from summing up.

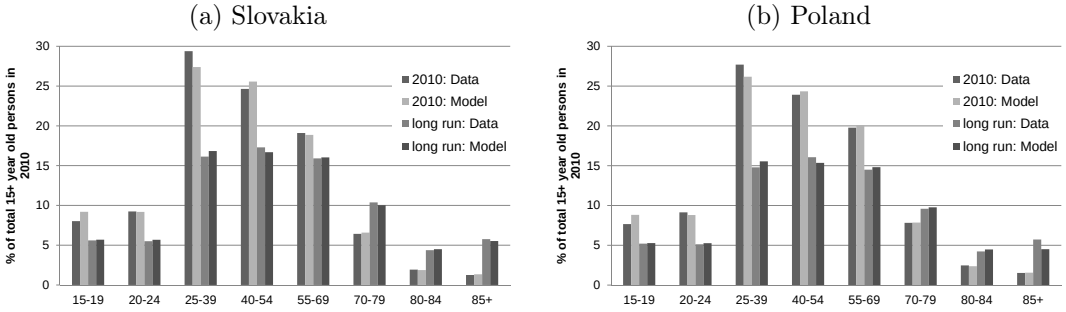
[36] Persons in the retirement stage age group 55-69 collect pensions instead of welfare benefits in case of informal work.

$$N_t^a = \sum_i N_t^{a,i}, \quad N_t^i = \sum_a N_t^{a,i}, \quad N_t = \sum_a N_t^a = \sum_i N_t^i.$$

The demographic structure is determined by two sets of parameters: a) the age-dependent survival rates γ^a and b) the number of new entrants New. Holding both constant implies convergence to a stationary demographic distribution. While the survival rates are solely responsible for the determination of the stationary age-structure, the new entrants simply pin down population size in the long run.

Hence, the task is to find appropriate values for γ^a and New in order to match the Slovak and the Polish demographic structure. A typical restriction when using equilibrium models is that a simulation has to start in an initial steady state although aging is an ongoing process. This implies two kinds of mistakes. On one hand, γ^a can be set to match the observed survival rates for the calibration year 2010. This implies realistic life-expectancies and therefore life-cycle decision making. The downside is that computing a stationary demographic distribution based on the currently observed γ^a will lead to a much older age-structure than actually observed in 2010. If on the other hand, γ^a are set to replicate the currently observed age-structure, this will lead to life-cycle decisions based on much short life-expectations. We carefully compromise between those two targets. The model fit of the demographic structure is illustrated in figure 4.

Figure 4: Model fit of the demographic structure for Slovakia and Poland



Source: Data from United Nations, World Population Prospects (2010).
Note: "long run" in the data refers to the year 2100.

For the final steady state the model was calibrated in order to match the demographic structure of the population forecasts of the United Nations for the year 2100. The age structure was matched by adjusting the survival rates γ^a accordingly, i.e. reducing the mortality rates for older individuals. In addition the number of new entrants[37] flowing into the pool of 15+ year old persons was reduced to replicate the predicted fall in population size (about -19% and -25% for the 15+ population for Slovakia and Poland, respectively). In the aging scenario therefore both γ^a and New are shocked while all other parameters were kept constant.

A.6 Changes in original calibration

The largest part of the procedure is inherited from the full scale model without informality. As planned, we relied on this procedure to calibrate all parameters not related to informality and were ready to adjust it, if needed. Although informality modifies some of the output of

[37]The new entrants are interpreted to capture both, newborns and net migration.

the original procedure, it turns out that the modification has no meaningful consequences so the original procedure remains untouched. Specifically, adding informality resulted in higher calibrated wages in the formal sector. As households now allocate a fraction of their labor supply to the informal sector, the effective labor supply in the formal sector decreases while output remains the same, inflating their productivity and wages. This has no impact, as the level of wages is never interpreted in the model but only the differences between households types and after reforms.

A.7 Summary data requirements

Table 13 summarizes the sources of information for the calibration related to informality and population aging.

Table 13: Informality parameters and calibration sources

Parameter	Data requirement	Data source
φ_0^a - Scaling net disutility of working formally	1 - Participation in black market, given participation	(1), Table 3
	2 - Total labor market participation, on formal and informal markets	(2)
v_F - Elasticity net disutility of working formally	Response informality rate with tax changes	(1), Table 4
y_{inf}^a - Income profiles informal sector	Separate income profiles for 5 age groups for informal workers	(2)
γ^a - Mortality rates by age-class	Projected demographic structure and size	(3)

Sources:
(1): Koettl and Weber (2012)
(2): EU-SILC
(3): United Nations (2011)

A.8 Summary of elasticities for labor supply margins

Table 14 reports the chosen elasticities for the labor supply margins as they have been used in Berger et al. (2009) and add those for informality.

Table 14: Elasticities of labor supply

Elasticity	Value (x)*	Interpretation
intensive labor supply (hours)	0.1/0.09/0.08	x% increase in hours for 1% increase in wage rate
participation	0.125/0.103/0.06	x%-points increase in participation rate for 1% decrease in effective tax factor
retirement	0.104/0.087/0.048	x%-points increase in retirement rate for 1% increase in effective tax factor
search intensity	0.111	x%-points change in unemployment rate for 1%-point change in replacement rate
informality	1.6/1.1/0.7	x% change in informality rate for 1%-point change in FTR

* Values are reported for low, medium and high skills. Motivation for labor supply elasticity choices other than informality can be found in Berger et al. (2009).

B Reforms table

This appendix reproduces the reforms table document dated 26 September 2012, which defined the reform scenarios to be analyzed in the project, updated after the discussion of the draft final report. The updates include the choice of combined reforms made by the World Bank on 22 April 2013. It also highlights the links between the model components and assumptions and what this implies for reform scenarios.

Reform	*Scenarios*	*Model component and illustration*
Retirement age	(+)	Workers choose when to retire depending, among others, on (Gruber-Wise) financial incentives for work after the statutory retirement age and penalties for retirement before E.g. an increase in retirement age reduce pension expenditures and increase social security budget revenue but could decrease labor supply attractiveness
Social security contribution rates	(+), (-), (1)	Households decide to participate in formal sector, in informal sector or not at all depending on net incomes E.g. a decrease in SSC rates could decrease contribution per formal work unit but encourage work in general and in the formal sector in particular, so social security budget could be impacted either way

Reform	*Scenarios*	*Model component and illustration*
Pension benefits	(+), (-), (2)	Households decide how much to save and self-finance for retirement, as well as retirement date and whether to join formal or informal sector, depending on social security pension benefits E.g. an increase in benefits (earnings-related or flat parts) draws more on social security budget but encourages work in general and work in the formal sector in particular
Welfare benefits	(+), (-)	Households decide to participate in formal sector, in informal sector or not at all depending on net replacement incomes + informal sector participants can claim welfare benefits as government can not observe informal sector participation E.g. higher welfare benefits increases attractiveness of non-participation and informal sector
Labor income taxes	(+), (-)	In general: see social security contribution rates Labor income taxes and SSC rates have different progressivity profiles, so are investigated separately
Consumption taxes	(+), (-)	Informal sector participants charge after-tax price and keep VAT E.g. an increase in VAT could increase informality: selling products on the black market can be more attractive since informal sector participants keep the VAT proceeds
Capital income taxes	(+), (-), (5)	No direct relationship to informality, as there are no informal sector banks. Population aging and capital income taxation could impact decisions, capital accumulation and growth.
Productivity growth	(+), (-), (3)	Productivity in both formal and informal sector grows at an exogenously given rate, impacting revenues in the same fashion (wages grow at the same rate as productivity in equilibrium) E.g. different productivity growth may impact decisions to self-finance for retirement, thus overall savings, capital stock and output
Pension indexation	(-)	Rationale: reducing the future financial burden of past promises on generous benefits
Labor income tax & Pension benefits	(-) & (-)	Rationale: stimulate work in the formal sector in a budget neutral way (ex-ante: neglecting anticipated positive household labor supply effect)
Labor income tax & Pension benefits & Retirement age	(-) & (-) & (+)	Rationale: stimulate work in the formal sector in a budget neutral way and contribute to deficit reduction

Reform	*Scenarios*	*Model component and illustration*
Labor income tax & Consumption tax	(-) & (+)	Rationale: belongs to policy reforms which could help job and output growth
Retirement age & pension benefits & capital income tax	(+) & (-) & (-)	Continued old age security policy reform mix made of increasing retirement age, earnings-related pension benefits cuts, encouraging private savings with capital income tax decrease

Table legend: (+): increase, (-) decrease, (1): changes on workers and firm social security rates, (2): changes on earning-related and flat parts of pensions, (3): exogenous variations, (4): selection will be based on experiments results, focused on interesting unexpected outcomes; (5) will be done for the final report.

Reminders:

- in all cases, population aging is taken into account (from demographic projections; consistent with the projected age-pyramid structure)
- government consumption and health-care costs will stay constant in per-capita terms (not age-dependent)
- simulations using non-distortionary taxes as budget closing instrument (keeping government debt constant) in a first step to quantify the fiscal gap. In a second step, the government budget will be closed using distortionary taxes which will introduce additional feedback effects on labor supply.

The effect of population aging and the policy reforms will be quantified and analyzed along several dimensions:

- Macroeconomic outcomes: changes in GDP/capita, consumption/capita
- Labor market outcomes: changes in participation rate, informality rate, unemployment rate, effective retirement age, hours supply on formal market, net wages on formal market
- Welfare and distributional outcomes: for each three skill and eight age classes, changes in labor earnings, welfare benefits, pension payments, total income
- Public finance outcomes: pension expenditures increase, government budget deficit, total social security budget deficit, total revenue variation, total expenditure variation

C Additional results

Table 16: Overview of further long run simulation results for Slovakia

		r0	r334	r24	r324	r327	r329	r106	r81	r86	r96	r71
	2010	Aging	SSC-	Pen-	Pen+	Pen flat+	Pen Ear+	Welfare+	IncTax+	IncTax-	VAT-	g-
absolute numbers												
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	40.17	40.42	40.21	40.70	40.18	40.31	40.50	40.14	40.20	40.37
Effective retirement age	58.02	58.22	58.33	58.13	58.30	57.92	58.32	58.22	58.08	58.35	58.30	58.17
Unemployment rate	14.74	14.41	13.79	15.00	13.88	14.46	13.85	14.09	15.22	13.70	14.01	14.14
Employment (yearly hours per formal worker)	1786	1785	1795	1776	1794	1786	1794	1785	1773	1796	1793	1786
Effective formal employment (year hours/capita)	793	667	726	621	714	654	718	629	602	734	710	708
Low-skills population (in % of population)	9.06	9.68	9.60	9.76	9.61	9.51	9.61	9.94	9.79	9.58	9.59	9.70
Medium-skill population (in % of population)	75.18	77.23	76.85	77.55	76.94	77.37	76.91	77.32	77.78	76.74	76.87	76.94
High-skill population (in % of population)	15.76	13.09	13.56	12.69	13.46	13.12	13.48	12.74	12.43	13.69	13.54	13.37
Informality rate (in % of participants)	12.74	9.32	3.56	13.82	4.81	10.43	4.48	14.03	15.83	2.83	5.01	3.73
increase from basis in %												
Labor costs (low-skilled)	-	-3.49	-4.27	-2.52	-4.35	-3.00	-4.42	7.60	-4.11	-2.94	-3.84	4.05
Labor costs (medium-skilled)	-	-3.03	-3.66	-2.40	-3.58	-2.93	-3.61	-3.08	-3.05	-3.03	-3.20	4.05
Labor costs (high-skilled)	-	13.81	12.46	15.03	12.79	13.01	12.79	13.39	19.03	9.63	12.44	21.86
Pension payment per beneficiary*	-	-1.41	10.88	-46.56	49.13	37.04	50.19	-6.22	-10.31	7.90	4.63	-0.38
increase from basis in %												
GDP/capita*	-	-14.52	-7.13	-20.29	-8.61	-15.89	-8.17	-18.60	-22.89	-5.91	-8.89	-7.47
Informal GDP/capita*	-	-42.97	-76.06	-17.74	-68.83	-37.07	-70.74	-18.64	-6.44	-80.44	-67.52	-64.03
Consumption/capita (formal goods)*	-	5.36	15.48	-4.32	15.81	10.21	16.19	3.92	-5.30	17.03	13.86	-3.25
Consumption/capita (formal & informal goods)*	-	0.02	5.38	-5.80	6.47	4.99	6.60	1.43	-5.43	6.28	4.88	-7.07
Government consumption/capita*	-	-56.12	-68.79	-26.24	-90.51	-95.80	-90.51	-66.53	-45.39	-70.64	-74.63	2.34
Assets/capita*	-	33.93	35.38	40.56	26.35	28.07	26.21	36.75	32.31	35.69	31.66	-8.97
in % of basis GDP												
Pension expenditure	7.10	9.19	10.30	4.99	13.86	12.90	13.95	8.74	8.40	10.01	9.72	11.37
Pension expenditure (constant population)	7.10	11.34	12.71	6.17	17.11	15.92	17.22	10.79	10.37	12.36	12.01	14.03
Social security deficit	0.08	5.08	7.36	1.43	9.19	8.95	9.24	5.05	5.07	5.09	4.99	6.07
Social security deficit (constant population)	0.08	6.27	9.09	1.76	11.35	11.05	11.41	6.24	6.26	6.29	6.17	7.49
Pension social security deficit	0.04	4.40	6.12	0.50	8.77	8.20	8.83	4.20	4.04	4.78	4.64	5.91
Pension social security deficit (const pop)	0.04	5.43	7.56	0.62	10.82	10.12	10.90	5.19	4.99	5.90	5.73	7.30

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g- (r71) scenarios compare absolute changes with pure aging scenario case (r0)

Table 17: Overview of further long run simulation results for Poland

		r0	r334	r24	r324	r327	r329	r106	r81	r86	r96	r71
	2010	Aging	SSC-	Pen-	Pen+	Pen flat+	Pen Ear+	Welfare+	IncTax+	IncTax-	VAT-	g-
absolute numbers												
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	38.99	39.04	39.03	39.08	39.00	39.04	39.08	38.99	38.99	39.26
Effective retirement age	59.37	59.33	59.37	59.33	59.34	59.30	59.36	59.33	59.30	59.37	59.37	59.16
Unemployment rate	13.36	13.20	12.63	13.47	12.94	13.17	12.84	13.16	13.85	12.62	12.76	12.91
Employment (yearly hours per formal worker)	1939	1936	1946	1930	1941	1937	1943	1935	1924	1946	1944	1936
Effective formal employment (year hours/capita)	604	506	551	489	522	506	530	496	462	551	542	551
Low-skills population (in % of population)	12.03	12.24	12.19	12.28	12.19	12.14	12.22	12.31	12.29	12.19	12.18	12.31
Medium-skill population (in % of population)	66.82	69.34	68.64	69.74	68.95	68.95	68.94	69.50	70.15	68.57	68.61	68.80
High-skill population (in % of population)	21.15	18.42	19.17	17.98	18.86	18.90	18.84	18.19	17.56	19.24	19.21	18.89
Informality rate (in % of participants)	33.18	32.68	27.81	34.36	31.02	32.68	30.26	33.88	37.55	27.85	28.75	26.13
increase from basis in %												
Labor costs (low-skilled)	-	-1.73	-3.12	-1.06	-2.35	-1.28	-2.83	-0.67	-1.14	-2.25	-2.53	6.41
Labor costs (medium-skilled)	-	-2.66	-3.28	-2.48	-2.84	-2.10	-3.17	-2.56	-2.52	-2.77	-2.72	6.26
Labor costs (high-skilled)	-	8.81	8.05	9.63	8.05	7.54	8.27	8.55	10.47	7.35	7.74	19.73
Pension payment per beneficiary*	-	-5.70	1.22	-28.65	18.09	16.48	19.19	-6.87	-10.66	-0.67	-1.58	-4.36
increase from basis in %												
GDP/capita*	-	-14.55	-7.23	-17.32	-11.79	-14.24	-10.65	-15.99	-21.96	-7.02	-7.69	-3.92
Informal GDP/capita*	-	-20.76	-31.67	-17.46	-24.06	-19.97	-25.92	-18.34	-9.96	-31.63	-29.26	-31.37
Consumption/capita (formal goods)*	-	-1.31	7.99	-7.36	4.89	3.12	5.77	-1.75	-10.71	8.76	7.14	-3.29
Consumption/capita (formal & informal goods)*	-	-7.26	-4.14	-10.45	-3.96	-3.94	-3.92	-6.82	-10.48	-3.59	-3.99	-10.62
Government consumption/capita*	-	-65.87	-75.35	-40.95	-91.92	-95.17	-90.89	-70.65	-54.63	-80.12	-79.94	19.58
Assets/capita*	-	9.04	8.15	17.42	0.29	0.99	-0.14	10.01	11.39	6.47	6.05	-11.83
in % of basis GDP												
Pension expenditure	13.16	13.96	14.97	10.57	17.48	17.27	17.63	13.79	13.24	14.69	14.55	16.65
Pension expenditure (constant population)	13.16	18.61	19.96	14.09	23.30	23.02	23.50	18.39	17.65	19.58	19.41	22.20
Social security deficit	8.04	11.25	13.66	8.04	14.59	14.55	14.66	11.19	11.04	11.47	11.37	12.77
Social security deficit (constant population)	8.04	15.00	18.21	10.71	19.45	19.40	19.54	14.92	14.71	15.29	15.15	17.02
Pension social security deficit	5.90	9.37	11.40	6.11	12.75	12.67	12.84	9.28	9.03	9.72	9.66	11.19
Pension social security deficit (const pop)	5.90	12.49	15.20	8.14	17.01	16.90	17.13	12.38	12.03	12.96	12.88	14.92

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g- (r71) scenarios compare absolute changes with pure aging scenario case (r0)

Table 18: Overview of long run simulation results for Slovakia, VAT budget closure (1/2)

	2010	r0 Aging	r56 Const HC	r57 Const Inf	r59 Const	r192 + 2years	r34 SSC+	r27 Pen flat-	r29 Pen Ear-	r101 Welfare-	r70 g+
absolute numbers											
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.74	40.48	40.61	40.58	38.01	40.85	40.10	40.69	40.68	41.06
Effective retirement age	58.02	57.89	58.09	57.99	58.02	59.96	57.81	58.38	57.93	57.94	57.66
Unemployment rate	14.74	16.17	15.15	15.89	15.03	15.53	16.80	14.85	16.04	16.40	18.18
Employment (yearly hours per formal worker)	1786	1755	1759	1763	1765	1757	1745	1776	1759	1759	1725
Effective formal employment (year hours/capita)	793	515	564	606	616	575	479	631	534	567	390
Low-skills population (in % of population)	9.06	10.02	9.06	9.98	9.06	9.95	10.07	9.97	9.94	9.83	10.24
Medium-skill population (in % of population)	75.18	78.78	75.18	76.61	75.18	78.31	79.14	77.52	78.46	78.40	80.36
High-skill population (in % of population)	15.76	11.20	15.76	13.41	15.76	11.74	10.79	12.50	11.60	11.77	9.40
Informality rate (in % of participants)	12.74	25.02	19.87	12.63	12.84	21.98	28.84	13.08	22.81	18.46	39.57
increase from basis in %											
Labor costs (low-skilled)	-	-2.00	2.92	-3.91	2.07	-4.04	-1.20	-3.59	-1.57	-12.60	-7.41
Labor costs (medium-skilled)	-	-2.33	2.76	-3.37	2.27	-2.25	-1.68	-2.96	-1.94	-2.37	-7.95
Labor costs (high-skilled)	-	20.91	-1.07	22.55	-0.95	20.54	22.83	16.53	19.16	20.32	20.65
Pension payment per beneficiary*	-	-21.89	-14.41	-10.27	-8.31	-14.00	-29.06	-45.32	-52.89	-15.29	-14.02
increase from basis in %											
GDP/capita*	-	-35.75	-27.68	-23.67	-20.77	-27.71	-40.40	-19.67	-32.22	-29.14	-20.49
Informal GDP/capita*	-	42.53	22.13	-22.68	-19.24	32.99	62.74	-21.70	30.98	9.40	76.93
Consumption/capita (formal goods)*	-	-21.75	-14.82	-11.76	-9.33	-14.83	-26.53	-8.10	-18.97	-16.84	-17.85
Consumption/capita (formal & informal goods)*	-	-14.66	-10.74	-12.96	-10.42	-9.55	-16.68	-9.60	-13.46	-13.94	-0.28
Government consumption/capita*	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.68
Assets/capita*	-	44.46	45.07	40.03	41.83	42.06	42.90	42.58	45.31	40.30	17.98
in % of basis GDP											
Pension expenditure	7.10	7.36	8.01	8.43	8.60	7.56	6.70	5.07	4.43	7.97	5.12
Pension expenditure (constant population)	7.10	9.08	9.89	10.40	10.62	9.33	8.27	6.26	5.47	9.84	6.33
Social security deficit	0.08	5.50	5.41	5.36	5.32	4.85	4.07	1.50	2.14	5.46	5.53
Social security deficit (constant population)	0.08	6.79	6.68	6.62	6.57	5.98	5.03	1.85	2.64	6.74	6.83
Pension social security deficit	0.04	3.59	3.87	4.02	4.10	3.36	2.54	0.51	0.52	3.85	2.41
Pension social security deficit (const pop)	0.04	4.43	4.78	4.97	5.06	4.15	3.14	0.63	0.65	4.76	2.97

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g+ (r70) scenarios compare absolute changes with pure aging scenario case (r0)

Table 19: Overview of long run simulation results for Slovakia, VAT budget closure (2/2)

	2010	r0 Aging	r334 SSC-	r24 Pen-	r324 Pen+	r327 Pen flat+	r329 Pen Ear+	r106 Welfare+	r81 IncTax+	r86 IncTax-	r71 g-
absolute numbers											
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.74	40.64	40.66	40.81	41.39	40.78	40.86	40.89	40.62	40.62
Effective retirement age	58.02	57.89	57.97	57.96	57.84	57.40	57.86	57.81	57.78	57.99	57.99
Unemployment rate	14.74	16.17	15.60	15.95	16.34	18.02	16.27	16.34	17.00	15.51	15.08
Employment (yearly hours per formal worker)	1786	1755	1763	1760	1751	1724	1752	1745	1742	1764	1769
Effective formal employment (year hours/capita)	793	515	551	541	496	403	501	452	470	556	613
Low-skills population (in % of population)	9.06	10.02	9.98	9.94	10.09	10.09	10.09	10.36	10.09	9.96	9.90
Medium-skill population (in % of population)	75.18	78.78	78.46	78.39	79.10	80.35	79.04	79.32	79.31	78.36	77.81
High-skill population (in % of population)	15.76	11.20	11.57	11.67	10.81	9.56	10.87	10.31	10.60	11.68	12.29
Informality rate (in % of participants)	12.74	25.02	21.27	22.17	27.27	37.24	26.76	32.76	29.85	20.79	13.44
increase from basis in %											
Labor costs (low-skilled)	-	-2.00	-2.74	-1.70	-2.30	-0.34	-2.40	10.22	-2.66	-1.37	4.90
Labor costs (medium-skilled)	-	-2.33	-2.94	-2.01	-2.64	-1.57	-2.69	-2.26	-2.36	-2.30	4.45
Labor costs (high-skilled)	-	20.91	19.32	18.92	22.64	28.57	22.42	23.21	26.98	16.30	25.88
Pension payment per beneficiary*	-	-21.89	-14.06	-52.82	7.13	5.24	7.55	-30.08	-27.86	-16.49	9.52
increase from basis in %											
GDP/capita*	-	-35.75	-31.14	-31.38	-39.51	-53.60	-38.81	-44.50	-41.84	-30.33	5.85
Informal GDP/capita*	-	42.53	22.43	27.58	54.27	104.47	51.61	81.05	68.06	19.77	-52.47
Consumption/capita (formal goods)*	-	-21.75	-16.86	-18.27	-24.42	-34.05	-23.90	-27.44	-27.89	-16.07	10.06
Consumption/capita (formal & informal goods)*	-	-14.66	-12.53	-13.21	-15.74	-18.76	-15.57	-15.47	-17.31	-12.11	-1.42
Government consumption/capita*	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-19.19
Assets/capita*	-	44.46	46.52	45.13	44.16	49.56	43.91	51.04	42.55	46.88	-11.81
in % of basis GDP											
Pension expenditure	7.10	7.36	8.07	4.43	10.11	10.07	10.14	6.60	6.82	7.84	9.98
Pension expenditure (constant population)	7.10	9.08	9.97	5.47	12.48	12.43	12.52	8.15	8.42	9.68	12.32
Social security deficit	0.08	5.50	7.27	2.05	8.69	10.01	8.65	5.61	5.49	5.52	6.13
Social security deficit (constant population)	0.08	6.79	8.98	2.54	10.73	12.36	10.68	6.93	6.78	6.82	7.57
Pension social security deficit	0.04	3.59	4.85	0.48	6.49	7.07	6.48	3.27	3.36	3.80	5.20
Pension social security deficit (const pop)	0.04	4.43	5.98	0.60	8.01	8.73	8.00	4.04	4.15	4.69	6.43

Notes: All reforms are simulated on top of the pure aging scenario (r0); (*): numbers for g- (r71) scenarios compare absolute changes with pure aging scenario case (r0)

Table 20: Results of the aging scenario over time for Slovakia with constant informality rates

	2010	2020	2050	2070	Final SS
absolute numbers					
Population (15+, normalized)	100.00	101.19	95.55	91.27	81.00
Dependency ratio	19.17	26.23	46.67	52.38	45.69
Pensioners (in % of population)	24.87	29.84	41.66	43.81	40.28
Effective retirement age	58.02	58.21	58.29	58.26	58.24
Unemployment rate	14.74	14.22	13.96	14.26	14.60
Employment (yearly hours per formal worker)	1786	1785	1787	1786	1785
Effective formal employment (year hours/capita)	793	777	645	611	640
Low-skills population (in % of population)	9.06	9.13	9.34	9.47	9.69
Medium-skill population (in % of population)	75.18	75.64	76.28	76.42	76.29
High-skill population (in % of population)	15.76	15.23	14.38	14.11	14.03
Informality rate (in % of participants)	12.74	12.82	12.81	12.74	12.68
increase from basis in %					
Labor costs (low-skilled)	-	-2.78	-1.59	-2.95	-4.82
Labor costs (medium-skilled)	-	-1.85	-0.75	-1.87	-3.75
Labor costs (high-skilled)	-	-2.36	18.61	19.97	16.68
Pension payment per beneficiary	-	-1.58	-0.74	1.97	-5.82
increase from basis in %					
GDP/capita	-	-3.38	-16.10	-20.19	-18.08
Informal GDP/capita	-	-1.54	-17.90	-22.77	-20.19
Consumption/capita (formal goods)	-	-11.05	1.15	4.47	2.76
Consumption/capita (formal & informal goods)	-	-10.00	-0.95	1.46	0.23
Government consumption/capita	-	-24.59	-64.71	-79.70	-69.48
Assets/capita	-	4.09	24.28	30.48	35.24
in % of basis GDP					
Pension expenditure	7.10	8.48	11.28	11.64	8.77
Pension expenditure (constant population)	7.10	8.38	11.80	12.75	10.83
Social security deficit	0.08	1.83	6.47	7.60	5.01
Social security deficit (constant population)	0.08	1.81	6.77	8.33	6.19
Pension social security deficit	0.04	1.61	5.66	6.59	4.18
Pension social security deficit (const pop)	0.04	1.59	5.92	7.22	5.16

Note: Final SS refers to the final steady state which approximately corresponds to the year 2100.

Table 21: Results of the SSC+ scenario over time for Slovakia

	2010	2020	2050	2070	Final SS
absolute numbers					
Population (15+, normalized)	100.00	101.19	95.55	91.27	81.00
Dependency ratio	19.17	26.23	46.67	52.38	45.69
Pensioners (in % of population)	24.87	29.97	41.82	43.98	40.45
Effective retirement age	58.02	58.12	58.18	58.15	58.12
Unemployment rate	14.74	14.63	14.37	14.65	15.04
Employment (yearly hours per formal worker)	1786	1777	1777	1777	1776
Effective formal employment (year hours/capita)	793	752	637	599	614
Low-skills population (in % of population)	9.06	9.13	9.37	9.52	9.76
Medium-skill population (in % of population)	75.18	75.80	77.04	77.47	77.61
High-skill population (in % of population)	15.76	15.07	13.59	13.01	12.63
Informality rate (in % of participants)	12.74	14.29	12.32	12.88	14.60
increase from basis in %					
Labor costs (low-skilled)	-	1.63	0.58	-0.65	-2.69
Labor costs (medium-skilled)	-	2.57	0.69	-0.34	-2.38
Labor costs (high-skilled)	-	2.22	15.83	18.52	15.29
Pension payment per beneficiary	-	-2.52	-3.54	-1.37	-11.77
increase from basis in %					
GDP/capita	-	-6.11	-17.00	-21.51	-21.11
Informal GDP/capita	-	8.38	-24.38	-26.23	-13.36
Consumption/capita (formal goods)	-	-16.31	-3.08	-0.20	-3.21
Consumption/capita (formal & informal goods)	-	-13.59	-5.43	-3.07	-4.33
Government consumption/capita	-	-4.33	-41.47	-57.25	-47.12
Assets/capita	-	1.59	21.49	27.46	32.71
in % of basis GDP					
Pension expenditure	7.10	8.44	11.00	11.30	8.25
Pension expenditure (constant population)	7.10	8.34	11.51	12.38	10.19
Social security deficit	0.08	-0.28	4.43	5.72	3.29
Social security deficit (constant population)	0.08	-0.28	4.64	6.27	4.06
Pension social security deficit	0.04	0.45	4.43	5.42	3.02
Pension social security deficit (const pop)	0.04	0.45	4.63	5.94	3.72

Note: SSC+ scenario includes aging and an increase of social security contributions by 3% of 2010 GDP.
Final SS refers to the final steady state which approximately corresponds to the year 2100.

D Details on sensitivity analyses

Table 22: Overview of selected aging simulation results for different calibrations for Slovakia

	s0		s1	s3	s5	s7	s9	s14
	basis		elast inf+	elast hour+	elast part+	yinf+	yinf steep	equal inf rate
	2010	Aging	Aging	Aging	Aging	Aging	Aging	Aging
absolute numbers								
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.31	40.33	40.32	40.23	40.32	40.32	40.30
Effective retirement age	58.02	58.22	58.21	58.21	58.28	58.21	58.22	58.22
Unemployment rate	14.74	14.42	14.34	14.42	14.40	14.41	14.42	14.17
Employment (yearly hours per formal worker)	1786	1789	1785	1787	1785	1785	1785	1785
Effective formal employment (year hours/capita)	793	667	681	667	669	667	666	667
Low-skills population (in % of population)	9.06	9.68	9.68	9.69	9.68	9.68	9.68	9.69
Medium-skill population (in % of population)	75.18	77.15	77.53	77.28	77.24	77.26	77.34	76.92
High-skill population (in % of population)	15.76	13.17	12.79	13.03	13.07	13.06	12.98	13.39
Informality rate (in % of participants)	12.74	9.54	7.49	9.31	9.30	9.33	9.40	9.50
increase from basis in %								
Labor costs (low-skilled)	-	-3.61	-3.11	-3.50	-3.48	-3.48	-3.54	-3.55
Labor costs (medium-skilled)	-	-3.27	-2.80	-3.03	-3.01	-3.06	-3.17	-2.91
Labor costs (high-skilled)	-	12.56	12.93	13.96	13.77	13.90	14.34	12.30
Pension payment per beneficiary	-	-1.77	0.90	-1.34	-0.82	-1.45	-1.53	-1.04
increase from basis in %								
GDP/capita	-	-14.86	-12.69	-14.45	-14.27	-14.55	-14.65	-14.56
Informal GDP/capita	-	-41.78	-54.76	-43.11	-42.94	-43.04	-43.58	-42.52
Consumption/capita (formal goods)	-	5.11	6.73	5.39	5.56	5.31	5.23	5.46
Consumption/capita (formal & informal goods)	-	-0.07	-0.06	0.04	0.21	-0.26	-0.16	0.16
Government consumption/capita	-	-56.47	-54.61	-56.06	-55.95	-56.17	-56.28	-56.53
Assets/capita	-	33.98	33.33	33.86	33.88	33.84	33.78	34.29
in % of basis GDP								
Pension expenditure	7.10	9.15	9.41	9.20	9.22	9.19	9.18	9.22
Pension expenditure (constant population)	7.10	11.30	11.61	11.35	11.39	11.34	11.33	11.38
Social security deficit	0.08	5.07	5.11	5.08	5.09	5.08	5.08	5.11
Social security deficit (constant population)	0.08	6.26	6.31	6.27	6.28	6.27	6.27	6.31
Pension social security deficit	0.04	4.38	4.51	4.40	4.42	4.40	4.39	4.43
Pension social security deficit (const pop)	0.04	5.41	5.57	5.43	5.45	5.43	5.42	5.47

Table 23: Overview of selected SSC+ simulation results for different calibrations for Slovakia

	s0		s1	s3	s5	s7	s9	s14
	basis		elast inf+	elast hour+	elast part+	yinf+	yinf steep	equal inf rate
	2010	SSC+	SSC+	SSC+	SSC+	SSC+	SSC+	SSC+
absolute numbers								
Population (15+, normalized)	100.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00
Dependency ratio	19.17	45.69	45.69	45.69	45.69	45.69	45.69	45.69
Pensioners (in % of population)	24.87	40.45	40.46	40.45	40.39	40.45	40.45	40.44
Effective retirement age	58.02	58.12	58.10	58.11	58.16	58.11	58.11	58.12
Unemployment rate	14.74	15.04	14.98	15.04	15.02	15.04	15.05	14.79
Employment (yearly hours per formal worker)	1786	1776	1776	1775	1776	1776	1776	1775
Effective formal employment (year hours/capita)	793	614	609	614	615	614	614	614
Low-skills population (in % of population)	9.06	9.76	9.76	9.77	9.76	9.76	9.76	9.77
Medium-skill population (in % of population)	75.18	77.61	78.06	77.67	77.64	77.64	77.72	77.41
High-skill population (in % of population)	15.76	12.62	12.18	12.56	12.60	12.60	12.52	12.82
Informality rate (in % of participants)	12.74	14.60	15.42	14.62	14.58	14.62	14.66	14.86
increase from basis in %								
Labor costs (low-skilled)	-	-2.69	-2.31	-2.71	-2.66	-2.69	-2.73	-2.80
Labor costs (medium-skilled)	-	-2.38	-2.12	-2.40	-2.36	-2.41	-2.52	-2.35
Labor costs (high-skilled)	-	15.29	14.31	15.44	15.23	15.38	15.83	14.02
Pension payment per beneficiary	-	-11.77	-12.17	-11.84	-11.55	-11.82	-11.88	-11.48
increase from basis in %								
GDP/capita	-	-21.11	-21.63	-21.17	-21.06	-21.15	-21.23	-21.24
Informal GDP/capita	-	-13.36	-9.75	-13.31	-13.45	-13.26	-14.87	-10.63
Consumption/capita (formal goods)	-	-3.21	-3.60	-3.28	-3.17	-3.25	-3.33	-3.15
Consumption/capita (formal & informal goods)	-	-4.33	-4.28	-4.39	-4.30	-4.41	-4.60	-3.98
Government consumption/capita	-	-47.12	-48.08	-47.23	-47.11	-47.18	-47.29	-47.64
Assets/capita	-	32.69	32.73	32.58	32.68	32.62	32.52	33.04
in % of basis GDP								
Pension expenditure	7.10	8.25	8.22	8.24	8.26	8.25	8.24	8.28
Pension expenditure (constant population)	7.10	10.19	10.14	10.18	10.20	10.18	10.17	10.22
Social security deficit	0.08	3.29	3.32	3.29	3.29	3.29	3.29	3.32
Social security deficit (constant population)	0.08	4.06	4.10	4.06	4.06	4.06	4.06	4.10
Pension social security deficit	0.04	3.02	3.02	3.01	3.02	3.01	3.01	3.05
Pension social security deficit (const pop)	0.04	3.72	3.73	3.72	3.73	3.72	3.72	3.76

Notes: All SSC+ (r34) reforms are simulated on top of the pure aging scenario (r0).

Table 24: Overview of selected aging simulation results for different calibrations for Poland

	s0 basis		s1 elast inf+	s3 elast hour+	s5 elast part+	s7 yinf+	s9 yinf steep	s14 equal inf rate
	2010	Aging	Aging	Aging	Aging	Aging	Aging	Aging
absolute numbers								
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.03	39.07	38.98	39.02	39.04	39.04	39.01
Effective retirement age	59.37	59.33	59.31	59.37	59.35	59.33	59.33	59.35
Unemployment rate	13.36	13.20	13.15	12.70	13.20	13.19	13.21	13.66
Employment (yearly hours per formal worker)	1939	1936	1936	1937	1936	1936	1936	1936
Effective formal employment (year hours/capita)	604	506	511	506	506	506	505	506
Low-skills population (in % of population)	12.03	12.24	12.23	12.03	12.24	12.23	12.26	12.27
Medium-skill population (in % of population)	66.82	69.34	69.58	66.82	69.34	69.32	69.41	69.40
High-skill population (in % of population)	21.15	18.42	18.19	21.15	18.42	18.45	18.33	18.33
Informality rate (in % of participants)	33.18	32.68	31.98	33.34	32.67	32.64	32.75	32.31
increase from basis in %								
Labor costs (low-skilled)	-	-1.73	-1.64	1.14	-1.71	-1.69	-1.82	-1.75
Labor costs (medium-skilled)	-	-2.66	-2.23	2.25	-2.64	-2.62	-2.78	-2.56
Labor costs (high-skilled)	-	8.81	8.37	0.97	8.78	8.71	8.94	9.07
Pension payment per beneficiary	-	-5.70	-5.24	-4.14	-5.61	-5.66	-5.83	-4.99
increase from basis in %								
GDP/capita	-	-14.55	-13.57	-13.22	-14.47	-14.49	-14.71	-14.07
Informal GDP/capita	-	-20.76	-23.57	-14.32	-20.72	-20.87	-21.94	-21.77
Consumption/capita (formal goods)	-	-1.31	-0.62	-0.07	-1.25	-1.27	-1.51	-0.93
Consumption/capita (formal & informal goods)	-	-7.26	-7.64	-4.43	-7.20	-7.47	-7.75	-7.30
Government consumption/capita	-	-65.87	-64.59	-65.08	-65.76	-65.81	-66.15	-65.85
Assets/capita	-	9.04	8.60	11.63	9.01	9.00	8.61	8.42
in % of basis GDP								
Pension expenditure	13.16	13.96	14.04	14.17	13.97	13.97	13.94	14.06
Pension expenditure (constant population)	13.16	18.61	18.72	18.90	18.62	18.62	18.59	18.74
Social security deficit	8.04	11.25	11.26	11.39	11.25	11.25	11.24	11.32
Social security deficit (constant population)	8.04	15.00	15.01	15.19	15.00	15.00	14.99	15.09
Pension social security deficit	5.90	9.37	9.40	9.54	9.37	9.37	9.36	9.44
Pension social security deficit (const pop)	5.90	12.49	12.53	12.72	12.50	12.50	12.48	12.59

Table 25: Overview of selected SSC+ simulation results for different calibrations for Poland

	s0 basis		s1 elast inf+	s3 elast hour+	s5 elast part+	s7 yinf+	s9 yinf steep	s14 equal inf rate
	2010	SSC+	SSC+	SSC+	SSC+	SSC+	SSC+	SSC+
absolute numbers								
Population (15+, normalized)	100.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dependency ratio	22.66	46.15	46.15	46.15	46.15	46.15	46.15	46.15
Pensioners (in % of population)	26.02	39.08	39.09	39.08	39.06	39.08	39.08	39.06
Effective retirement age	59.37	59.30	59.29	59.30	59.31	59.30	59.30	59.31
Unemployment rate	13.36	13.78	13.71	13.79	13.78	13.78	13.79	14.25
Employment (yearly hours per formal worker)	1939	1925	1924	1924	1925	1925	1925	1925
Effective formal employment (year hours/capita)	604	464	455	464	464	464	464	464
Low-skills population (in % of population)	12.03	12.28	12.26	12.28	12.28	12.27	12.29	12.29
Medium-skill population (in % of population)	66.82	70.03	70.46	70.07	70.03	70.01	70.06	70.06
High-skill population (in % of population)	21.15	17.69	17.29	17.65	17.69	17.72	17.64	17.64
Informality rate (in % of participants)	33.18	37.28	38.64	37.30	37.27	37.26	37.30	36.92
increase from basis in %								
Labor costs (low-skilled)	-	-0.25	0.09	-0.25	-0.25	-0.21	-0.33	-0.60
Labor costs (medium-skilled)	-	-1.98	-1.32	-1.98	-1.96	-1.93	-2.06	-1.80
Labor costs (high-skilled)	-	9.60	8.82	9.61	9.58	9.49	9.66	9.80
Pension payment per beneficiary	-	-11.86	-12.95	-11.93	-11.82	-11.83	-11.91	-11.23
increase from basis in %								
GDP/capita	-	-21.32	-22.61	-21.40	-21.29	-21.28	-21.40	-20.89
Informal GDP/capita	-	-10.57	-8.29	-10.55	-10.56	-10.60	-12.12	-11.88
Consumption/capita (formal goods)	-	-9.48	-10.51	-9.61	-9.46	-9.45	-9.61	-9.14
Consumption/capita (formal & informal goods)	-	-9.81	-9.83	-9.90	-9.80	-9.81	-10.38	-9.98
Government consumption/capita	-	-59.36	-61.08	-59.58	-59.32	-59.32	-59.58	-59.27
Assets/capita	-	9.82	10.21	9.42	9.81	9.81	9.34	9.31
in % of basis GDP								
Pension expenditure	13.16	13.06	12.91	13.05	13.06	13.07	13.05	13.15
Pension expenditure (constant population)	13.16	17.42	17.21	17.40	17.42	17.42	17.41	17.54
Social security deficit	8.04	9.29	9.25	9.29	9.29	9.29	9.28	9.34
Social security deficit (constant population)	8.04	12.38	12.34	12.38	12.38	12.38	12.38	12.46
Pension social security deficit	5.90	7.70	7.64	7.69	7.70	7.70	7.69	7.76
Pension social security deficit (const pop)	5.90	10.26	10.18	10.26	10.26	10.27	10.26	10.35

Notes: All SSC+ (r34) reforms are simulated on top of the pure aging scenario (r0).

References

Albrecht, J., L. Navarro, and S. Vroman (2009): "The Effects of Labour Market Policies in an Economy with an Informal Sector," *Economic Journal*, 119, 1105–1129.

Amaral, P. S. and E. Quintin (2006): "A competitive model of the informal sector," *Journal of Monetary Economics*, 53, 1541–1553.

Berger, J., C. Keuschnigg, M. Keuschnigg, M. Miess, L. Strohner, and R. Winter-Ebmer (2009): "Modelling of Labour Markets in the European Union," Final Report for DG EMPL of the European Commission.

Bird, R. M. and M. Smart (2012): "Financing Social Expenditures in Developing Countries: Payroll or Value Added Taxes?" International Center for Public Policy Working Paper Series paper 1206, Georgia State University.

Boeri, T. and K. Terrell (2002): "Institutional Determinants of Labor Reallocation in Transition," *Journal of Economic Perspectives*, 16, 51–76.

Chawla, M., G. Betcherman, and A. Banerji (2007): *From red to gray: the" third transition" of aging populations in Eastern Europe and the former Soviet Union*, The World Bank.

Economic Policy Committee and the European Commission (2012): *The 2012 Ageing Report: Economic and budgetary projections for the 27 EU Member States (2010-2060)*, vol. 2, European Economy.

Fortin, B., N. Marceau, and L. Savard (1997): "Taxation, wage controls and the informal sector," *Journal of Public Economics*, 66, 293–312.

Fugazza, M. and J.-F. Jacques (2004): "Labor market institutions, taxation and the underground economy," *Journal of Public Economics*, 88, 395–418.

Galiani, S. and F. Weinschelbaum (2012): "Modeling Informality Formally: Households and Firms," *Economic Inquiry*, 50, 821–838.

Grafenhofer, D., C. Jaag, C. Keuschnigg, and M. Keuschnigg (2007): "Economic ageing and demographic change," *Vienna Yearbook of Population Research*, 133–165.

Hayashi, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 50, 213–24.

Ihrig, J. and K. S. Moe (2004): "Lurking in the shadows: the informal sector and government policy," *Journal of Development Economics*, 73, 541–557.

Jimeno, J. F., J. A. Rojas, and S. Puente (2008): "Modelling the impact of aging on social security expenditures," *Economic Modelling*, 25, 201–224.

Koettl, J. and M. Weber (2012): "Does Formal Work Pay? The Role of Labor Taxation and Social Benefit Design in the New EU Member States," in *Informal Employment in Emerging and Transition Economies*, ed. by S. Polachek and K. Tatsiramos, Emerald Group, vol. 34 of *Research in Labor Economics*, 167–204.

OECD (2003): *Reforming Pulic Pensions, Sharing the experiences of Transtion and OECD countries*, OECD Publishing.

Schneider, F. (2012): "The Shadow Economy and Work in the Shadow: What Do We (Not) Know?" IZA Discussion Papers 6423, Institute for the Study of Labor (IZA).

Schneider, F., A. Buehn, and C. E. Montenegro (2010): "Shadow economies all over the world : new estimates for 162 countries from 1999 to 2007," Policy Research Working Paper Series 5356, The World Bank.

Schneider, F. and C. Burger (2005): "Formal and Informal Labour Markets: Challenges and Policy in the Central and Eastern European New EU Members and Candidate Countries," *CESifo Economic Studies*, 51, 77–115.

Schneider, F. and D. H. Enste (2000): "Shadow Economies: Size, Causes, and Consequences," *Journal of Economic Literature*, 38, 77–114.

Svejnar, J. (2002): "Transition Economies: Performance and Challenges," *Journal of Economic Perspectives*, 16, 3–28.

United Nations (2011): *World Population Prospects: The 2010 Revision*, United Nations, Department of Economic and Social Affairs, Population Division.

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