July 2007
IMF Country Report No. 07/256

Republic of Estonia: Selected Issues

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International Monetary Fund
Washington, D.C.

INTERNATIONAL MONETARY FUND

REPUBLIC OF ESTONIA

Selected Issues

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Approved by European Department

July 11, 2007

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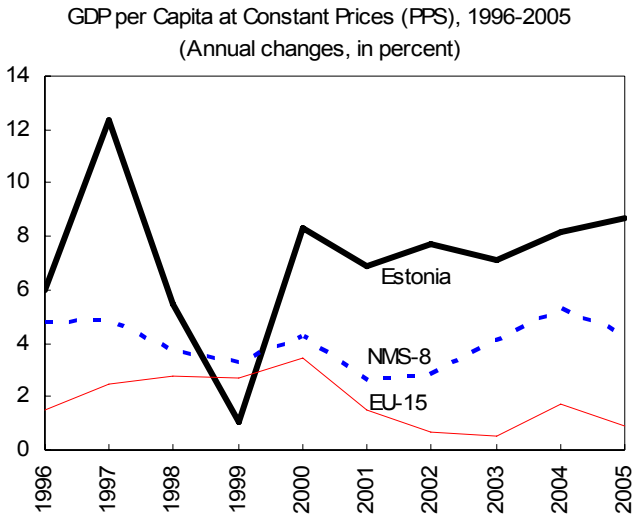
I. Medium-Term Growth and Productivity in Estonia: A Micro Perspective[1]

A. Introduction

1. **Estonia has experienced a period of unprecedented growth since the mid-1990s.** Between 1995 and 2005, Estonia's real GDP per capita rose by an average of 6½ percent a year, exceeding the annual growth rates of all other countries in the EU. This impressive growth performance is partly explained by the recovery from the immediate post–central planning drop in output. But changes in policies and institutions enhancing catch-up and a favorable global environment have also played an important role.



Sources: EC (AMECO database); Eurostat; OECD; GGDC Total Economy Database; and IMF staff calculations.

2. **However, there is still a big income gap with the EU-15 (Figure 1).** Although that gap has narrowed since 1995, the Estonian GDP per capita (at current prices and purchasing parity standard, PPS) was only 50.9 percent of the EU-15 average in 2005. Most of the gap stems from a low level of labor productivity. While this is largely due to the paucity of capital, the total factor productivity (TFP) gap relative to the EU-15, at 40 percent in 2005, is also substantial, and catch-up will depend crucially on closing that gap.[2]

3. **These developments raise the question of whether Estonia's strong growth performance can be maintained over the medium term.** To address that question, this paper tries to identify the proximate cause of the recent growth in Estonia and draws some implications for the future. We proceed in two steps. First, we use a growth-accounting methodology based on growth theory to establish some stylized facts at the macro level.[3] Since TFP turns out to have been the main engine of Estonia's growth during the last decade, we then examine the determinants of TFP using micro data. The micro-oriented approach has

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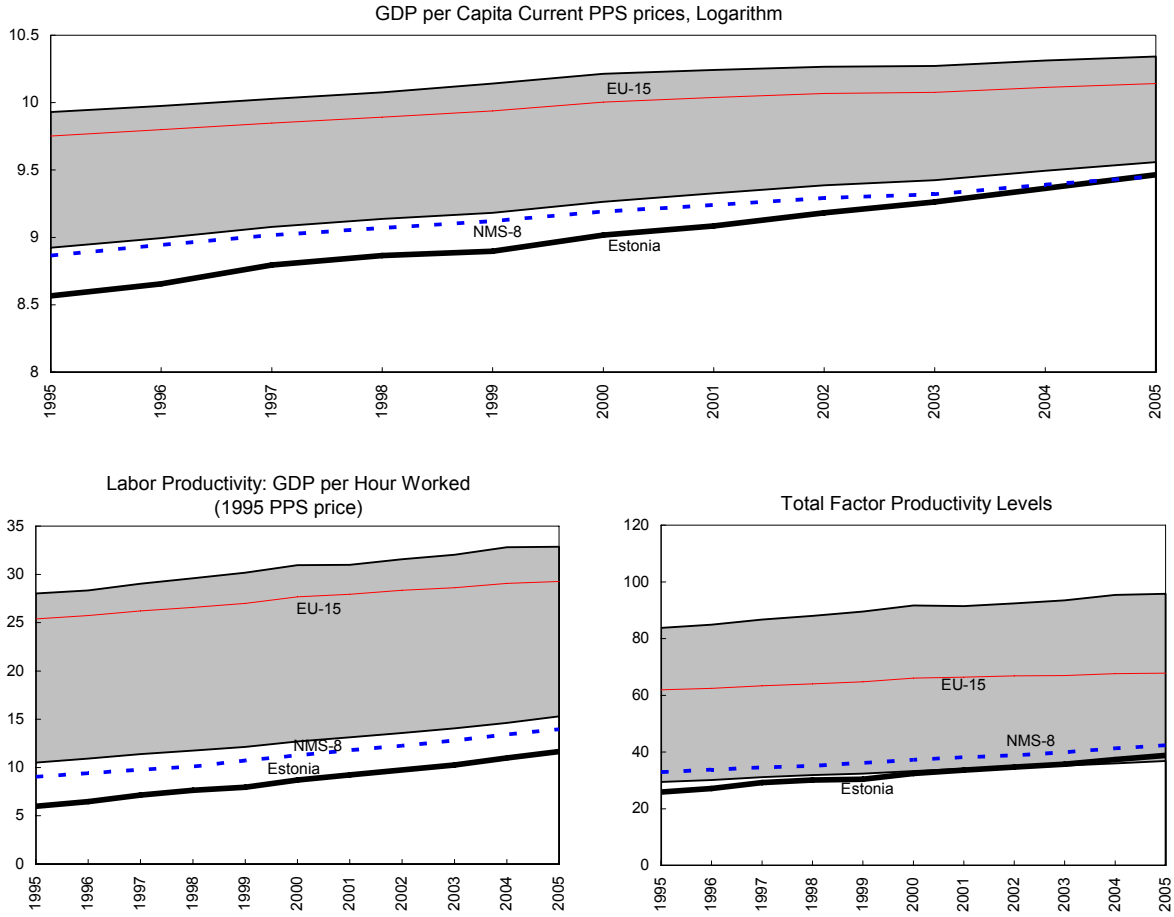
[1] Prepared by Marialuz Moreno-Badia. I thank Larissa Merlukova and Kadri Rohulaid of the Centre of Registers and Infosystems for the data and valuable clarifications on the Registrar's Office database.

[2] Estonia's capital-labor ratio is only about one-third of that of the EU-15.

[3] The recent literature is increasingly using the growth-accounting framework to assess potential growth. For an application, see, for example, Musso and Westermann (2005).

three advantages. First, since data coverage is better at the micro level, for example on capital stock, micro estimates can be used to cross-check macro findings. Second, micro data give a better picture of the sectoral composition of productivity growth. Finally, micro data provide insights into the firms' dynamics at play, in particular, restructuring and reallocation, which are critical to understand differences in productivity and growth across sectors and time.[4]

Figure 1. GDP per Capita and Productivity Measures, 1995-2005 1/



Sources: EC (AMECO database); Eurostat; OECD; GGDC Total Economy Database; and IMF staff calculations.
1/ The shaded area shows the average for EU-25 (excluding Malta) plus/minus one standard deviation. NMS-8 comprises the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic, and Slovenia.

4. **This paper makes several contributions to the literature on growth and productivity dynamics in Estonia**. First, we analyze productivity growth from a macro and

[4] Empirical papers highlighting the relevance of the connection between aggregate and micro productivity growth include Baily and Solow (2001), Foster, Haltiwanger, and Krizan (1998), Haltiwanger (1997), Olley and Pakes (1996), and Griliches and Regev (1995).

micro perspective. Second, we use a more recent data set, with a better coverage of the business sector. Third, we match the sectoral distribution of firms with the macro data. Fourth, we improve the estimation of TFP by using the semiparametric approach developed in Levinsohn and Petrin (2003). Finally, we analyze the contribution of different sectors to productivity growth.

5. **The rest of the paper is organized as follows**. Section B introduces a simple growth-accounting framework and examines Estonia's growth performance relative to other countries in the EU. Section C analyzes the determinants of TFP growth from a micro perspective. Section D presents a scenario analysis of the impact that changes in specific factors of growth can have on medium-term growth, and Section E concludes.

B. What Do The Macro Data Tell Us?

Growth-accounting framework

6. **In order to quantify the contribution of different factors to growth and to the evolution of Estonia's differential with respect to other economies in the EU, GDP per capita is decomposed into several components.** Using a simple identity, we can express output per capita as the product of three components: (1) demographics, (2) labor utilization, and (3) labor productivity:

$$\text{Real per capita GDP} = \frac{Y}{Pop} = \underbrace{\left(\frac{N}{Pop}\right)}_{Dem} * \underbrace{\left(\frac{E}{N}\right) * \left(\frac{L}{E}\right)}_{Lab} * \underbrace{\left(\frac{Y}{L}\right)}_{Prod}, \qquad (1)$$

where Y is GDP at constant 1995 prices; Pop is population; $\frac{N}{Pop}$ is the ratio of working-age population to total population (inverse dependency ratio); $\frac{E}{N}$ is the employment rate; $\frac{L}{E}$ is the average hours worked per employee; and $\frac{Y}{L}$ is labor productivity (i.e., output per hour worked).[5] Assuming a Cobb-Douglas production function, labor productivity can, in turn, be decomposed into

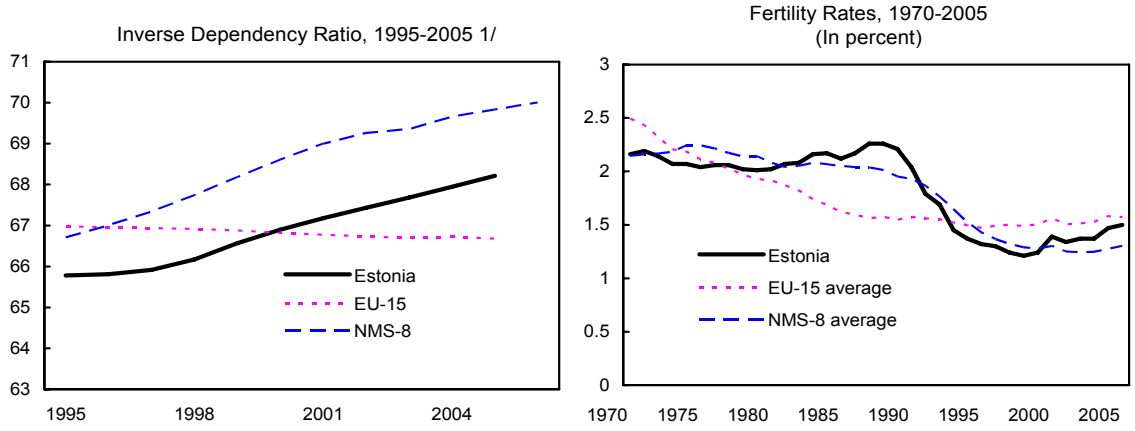
[5] For a detailed description of the data and definitions, see Appendix I.

$$\frac{Y_t}{L_t} = A_t * \left(\frac{K_t}{L_t}\right)^{\alpha}, \qquad (2)$$

where A_t represents TFP, a measure of the efficiency in combining a given amount of capital and labor to produce output; $\frac{K_t}{L_t}$ is the stock of capital per unit of labor, or capital-labor intensity; and the parameter α represents the output elasticity with respect to capital and is set to 0.35.[6] Given data for output, capital, and labor for all countries and periods in the sample, we compute TFP (A_t) for each country as a residual. Hence, TFP encompasses implicitly a variety of factors, such as technological progress, human capital, quality of institutions, etc., that are not captured by the explicitly modeled factors of production—capital and labor.[7]

How does Estonia compare with other EU countries?

7. **The growth-accounting exercise indicates that demographics have made small but positive contributions to growth in Estonia since the mid-1990s (Table 1).** In contrast to the EU-15, Estonia's inverse dependency ratio has increased steadily during the last decade, partly reflecting favorable demographic factors. This has resulted in an annual increase in GDP per capita averaging some 0.3 percent, similar to that of other new member states (NMS).



Sources: EC (AMECO), and Eurostat.
1/ Working-age population over total population.

[6] This is the value used in Schadler and others (2006) and is adopted here to facilitate international comparisons.

[7] As Abramovitz (1956) put it, TFP is a measure of our ignorance. Because it is a residual, it includes unwanted components like measurement errors, omitted variables (such as the quality and utilization of capital and labor), and model misspecification. For a review of the literature on TFP, see Hulten (2001).

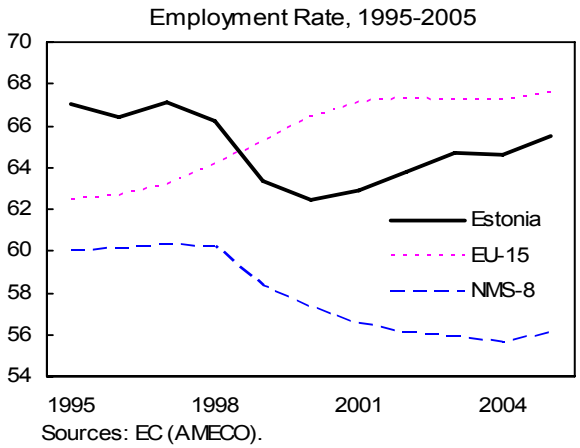
Table 1. Sources of Growth 1/
(Average annual percentage change)

	Estonia	EU-15	NMS-8	Baltics
		2001-05		
GDP per capita (1995 prices) *(Y/Pop)*	7.7	1.1	3.8	8.1
Demographics *(N/Pop)*	0.4	0.0	0.4	0.3
Labor utilization	1.2	0.0	-0.9	1.2
Employment rate *(E/N)*	1.0	0.3	-0.5	1.2
Hours worked per employed person *(L/E)*	0.2	-0.4	-0.5	0.0
Labor productivity	6.0	1.1	4.4	6.5
Of which:				
Total factor productivity (TFP) component *(A)*	3.7	0.5	2.6	4.3
Capital-labor ratio component *(K/L)* $^{\alpha}$	2.2	0.6	1.8	2.1
		1996-2000		
GDP per capita (1995 prices) *(Y/Pop)*	6.6	2.6	4.2	5.8
Demographics *(N/Pop)*	0.3	0.0	0.6	0.2
Labor utilization	-1.5	0.9	-0.8	-0.3
Employment rate *(E/N)*	-1.4	1.3	-0.9	-0.4
Hours worked per employed person *(L/E)*	-0.1	-0.4	0.1	0.2
Labor productivity	7.8	1.7	4.5	5.8
Of which:				
Total factor productivity (TFP) component *(A)*	4.6	1.3	2.5	3.5
Capital-labor ratio component *(K/L)* $^{\alpha}$	3.1	0.4	1.9	2.3

Souces: EC (AMECO database); Eurostat; OECD; GGDC Total Economy Database; and IMF staff calculations.

1/ Indicators for the EU-15, NMS-8 and Baltics are for the consolidated group (rather than simple averages for the member countries). "Demographics is the working-age population to total population ratio; "labor utilization" is hours worked per working-age person; "employment rate" is the ratio of persons employed to working-age population; "labor productivity" is output per hour worked. GDP and capital stock are valued at 1995 prices and converted to a common purchasing parity standard (PPS) unit of account.

8. **After declining during the 1990s, labor utilization has also provided an additional boost to growth.** As in other NMS, the employment rate fell sharply during the 1990s, reflecting transition-related factors—such as the downsizing or privatization of state-owned enterprises and labor market rigidities—as well as the effect of the Russian crisis in the late 1990s. The fall in employment was compounded by a decline in hours worked and, as a result, labor utilization made substantial



Sources: EC (AMECO).

negative contributions to Estonia's growth during the mid-1990s. In this respect, Estonia stands in stark contrast to the EU-15 countries, where the labor input made large contributions to growth during the same period. However, the downward trend of employment and hours worked has been reversed since 2000, thanks to a buoyant economy that has led to stronger job creation than in NMS and EU-15 countries.

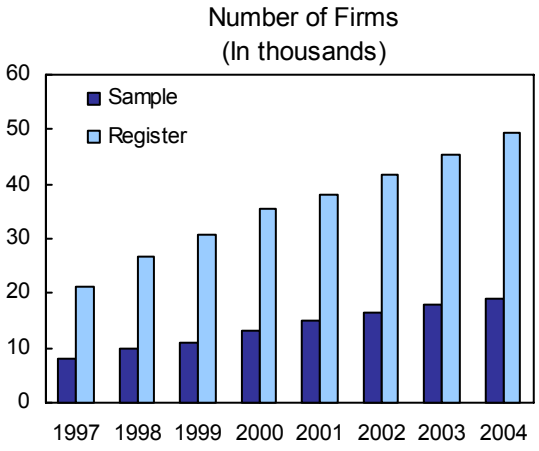
9. **But the main force behind Estonia's catch-up in GDP per capita has been labor productivity.** Estonia's labor productivity growth was more than four times that in EU-15 countries and about 75 percent higher than in the NMS during the mid-1990s. The most important factor behind this striking performance was TFP growth, although capital deepening also played an important role (Table 1).[8] While the contributions to growth from the capital stock and TFP have eased since 2000, they are still high, particularly compared with EU-15 countries. The lower rise in capital intensity in recent years may be related to a slower substitution of capital for labor, as the flexibility of the labor market has improved, and to the shift toward less capital-intensive sectors, like services. Since the services sector may have absorbed relatively low-skilled workers, this may also explain, at least partly, the slowdown in TFP growth as TFP includes the impact of unmeasured labor quality.

10. **What can explain the strong productivity growth during the last decade?** One potential explanation is that within-industry efficiency gains—from privatization, greater market incentives, and the adoption of new managerial methods and technologies—increased productivity levels. But shifts in the composition of output toward high-productivity sectors could have also played an important role. To test these hypotheses, we turn to the micro data in the next section.

C. What Is The Micro Story?

Data

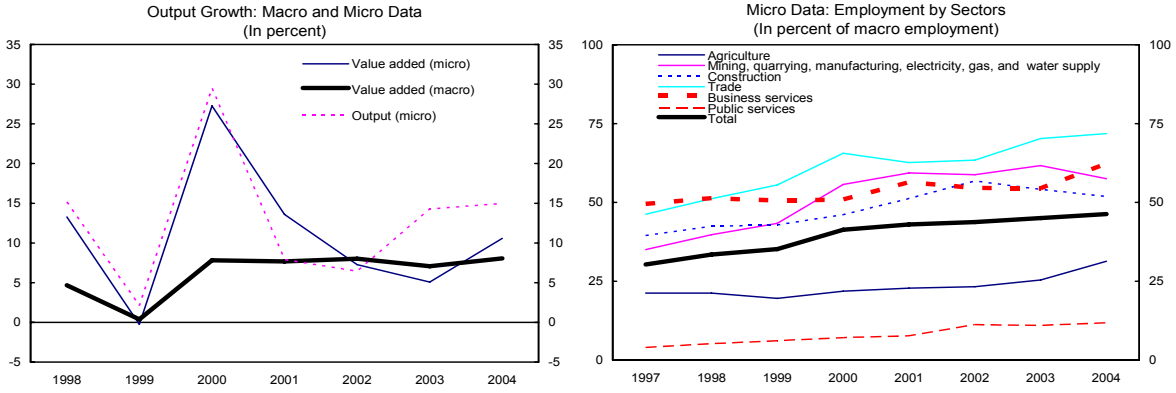
11. **Our micro data come from the Estonian Business Registry and cover the period 1997-2004**. The Business Registry database includes firm-level data from all economic sectors, allowing us to analyze how firm dynamics affect aggregate productivity. Other unique features of the data set include the absence of size thresholds, the availability of transactions data (e.g., mergers), and the provision of detailed



[8] To the extent that the capital stock is underestimated or the gray labor market is large, TFP is overestimated. However, it is widely accepted in the literature that TFP growth has accounted for a large share of labor productivity and growth in Estonia (see, for example, Schadler and others (2006) and Vanags and Bems (2005)).

information on balance sheets, income, and costs.[9] The number of business entities in the registry between 1997 and 2004 more than doubled, and coverage also improved over time. However, because of missing information, we only use the data of about 40 percent of the firms in the registry. Table A.1 presents summary statistics of the variables used in the econometric analysis. Value added and intermediate inputs are deflated by the respective deflators of the system of national accounts provided by the Statistical Office of Estonia. Capital is deflated by the gross capital formation price index. As with most empirical work at the level of aggregation of this paper, the results reported below should be interpreted with caution in light of issues related to data coverage, and measurement and conceptual problems.[10]

12. **The coverage of the micro data improves after 2000.** The value added of enterprises in our sample accounted for only 45 percent of the aggregate value added in 1997 but increased to 60 percent by 2004.[11] Similarly, employment coverage improved over time and was above 50 percent of the macro level in 2004 for all sectors except agriculture and public services, where enterprises are not the main employers. The improvement in data quality may be related to the introduction in 2000 of fines penalizing those firms that do not submit income or balance sheet statements. One drawback, however, is that growth rates in 2000 may be biased because of the improved coverage in that year.[12]



Sources: Estonian Business Registry database; Statistics Estonia; and IMF staff calculations.

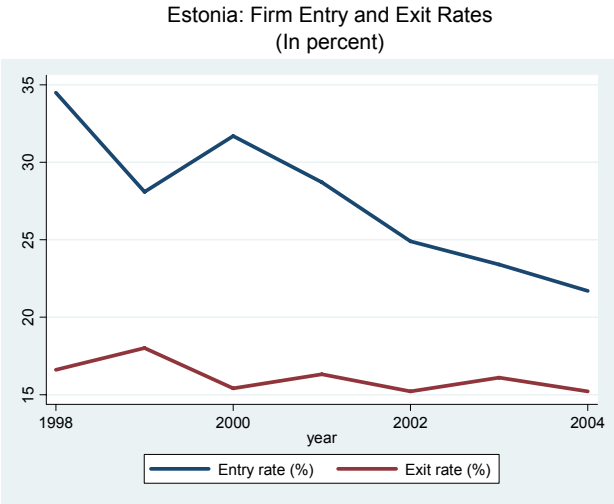
[9] For a detailed description of the data and definitions used in this paper, see Appendix I. For more details on the data set, see Masso, Eamets, and Philips (2004).

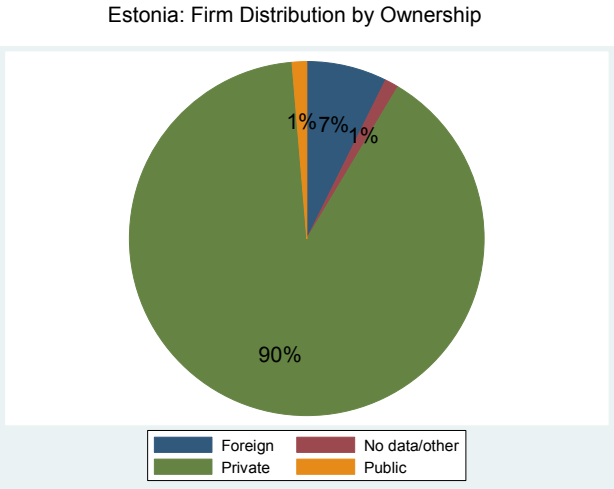
[10] For example, our sample does not include data for the two major banks in Estonia. Therefore, results concerning the financial sector could be biased.

[11] Comparability between the micro and the macro data is limited, however, owing to methodological inconsistencies. Value added at the macro level is a broader concept since it covers not only the activities of enterprises but also of other economic units. According to the Statistical Office of Estonia, all enterprises registered in Estonia accounted for about 70 percent of aggregate value added in 2005.

[12] In fact, discrepancies between the value-added growth rates at the micro and macro level widen in 2000.

13. **A preliminary analysis suggests that the business environment has been very dynamic in the recent past**. Estonian entry and exit rates are fairly high by international standards, although entry rates have declined over time.[13] The high firm turnover may be partly related to the restructuring during the transition period, when there was a shift from large-scale production to smaller units. Also, the relative importance of sectors changed during the sample period (Table A.2). In particular, agriculture has contracted while construction has expanded in recent years. Most firms, however, belong to the services sector, which was underdeveloped during central planning and where smaller firms dominate. Firm size is very small (Table A.3)—about 70 percent of firms are micro enterprises (less than 10 employees)— and is getting smaller across all sectors (Table A.4). In fact, according to Statistical Office of Estonia (2005), the recent increase in the number of enterprises is explained mainly by the birth of micro enterprises.





Methodology

14. **We use two alternative methodologies to estimate TFP**. Although there is an extensive literature on the empirical identification of production functions, there is some disagreement about the appropriate estimation method. To test the sensitivity of our results to the choice of estimates, we use two methods:

[13] Entrants are defined as those firms for which we have data in period *t* but not in period *t-1*. Exiting firms are those for which we have data in period *t-1* but not in period *t*. As a result, the entry and exit rates reported in this paper may be overestimated because of missing data. In any case, Masso, Eamets, and Philips (2004) also find similarly high entry and exit rates using a definition that controls for some of the problems related to missing data.

- **Method 1: Industry shares (IS)**. Assuming a Cobb-Douglas production function, TFP can be calculated as value added minus weighted labor and capital input:

$$TFP_{it} = \log Y_{it} - \alpha_k \log K_{it} - \alpha_l \log L_{it},$$

(3)

where Y_{it} is the real value added of firm *i* at time *t*; K_{it} is the real capital input; L_{it} is the labor input (total employment); and α_k and α_l are the industry cost shares of capital and labor (measured at the two-digit industry level), respectively. Assuming a constant-returns-to scale technology, the capital share is just the residual of the labor cost share, $\alpha_k = 1 - \alpha_l$.

- **Method 2: Levinsohn-Petrin (LP)**. Assuming a Cobb-Douglas production function, TFP can be obtain by estimating the equation

$$\log Y_{it} = \alpha_k \log K_{it} + \alpha_l \log L_{it} + \omega_{it} + \varepsilon_{it},$$

(4)

where the error has two components: the unobserved TFP, ω, and the error term, ε, which is uncorrelated with the input choices. Estimators ignoring the correlation between inputs and unobservable ω will yield inconsistent results.[14] To solve for this problem, we follow the semiparametric methodology developed in Levinsohn and Petrin (2003) and use intermediate inputs as a proxy for productivity.[15] The main advantage of this method relative to method 1 is that one can test the hypothesis of constant returns to scale since it allows for varying returns to scale across sectors (i.e., α_k and α_l do not have to add up to one).[16]

15. **To assess the contribution of reallocation and restructuring to productivity growth, we follow Foster, Haltiwanger, and Krizan (1998)**. Productivity at an aggregated level TFP_t at time *t* is the weighted average of the productivity of individual firms and can be calculated as

[14] Profit-maximizing firms should respond to positive productivity shocks by expanding output, which requires additional inputs, and vice versa. Therefore, estimating equation (4) by ordinary least squares (OLS) will yield inconsistent estimates. See Griliches and Mareisses (1998) for an overview of the discussion on this subject.

[15] Equation (4) is estimated for 40 different sectors (measured at the two-digit industry level). For a detailed description of the semiparametric approach of Levinsohn and Petrin and estimation results, see Appendix II.

[16] Girma and Gong (2007) have found that the LP and the translog production function methods are superior to the industry shares approach.

$$TFP_t = \sum_i s_{it} * tfp_{it}, \tag{5}$$

where s_{it} is the output share of firm *i* in period *t* and tfp_{it} is the TFP measure. After adjusting the shares s_{it} to match the sectoral distribution of output in the national accounts data, productivity growth can be decomposed as follows:

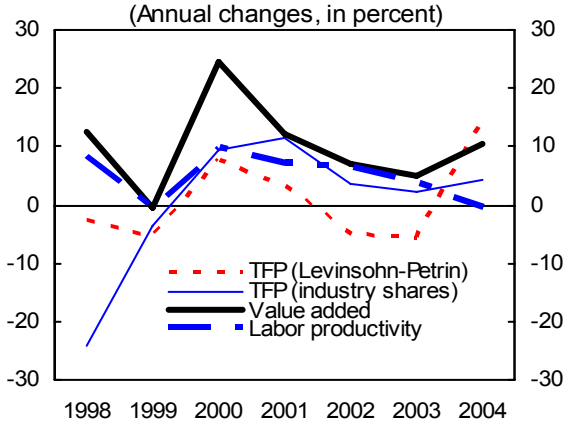
$$\begin{aligned}\Delta TFP_{t,t-1} = TFP_t - TFP_{t-1} = \sum_{i\in C} s_{it-1} * \Delta tfp_{it} + \sum_{i\in C} \Delta s_{it} * \left(tfp_{it-1} - TFP_{t-1}\right) + \\ + \sum_{i\in C} \Delta s_{it} * \Delta tfp_{it} + \sum_{i\in N} s_{it} * \left(tfp_{it} - TFP_{t-1}\right) - \sum_{i\in X} s_{it-1} * \left(tfp_{it-k} - TFP_{t-1}\right),\end{aligned} \tag{6}$$

where *C*, *N*, and *X* denote continuing, entering, and exiting firms, respectively. The first term in this decomposition represents the within effect, that is, the productivity growth within existing firms keeping the market shares fixed. These productivity gains could be the result of introducing new technological or organizational methods, or of changing the optimal mix of inputs. The second term is the between-firm effect, which reflects productivity growth due to changing output shares. This term will be positive when output shares increase for continuing firms with higher-than-average productivity levels in the previous year. The third term represents a cross (i.e. covariance-type) term. This term will be positive when output shares increase for continuing firms with rising productivity. The last two terms represent the contribution of entering and exiting firms. An entering firm will contribute positively to productivity growth if the firm has higher productivity than the aggregate productivity the year before, while an exiting firm will contribute positively only if the firm exhibits productivity lower than the average in the previous year.

Results

16. **The aggregated results from the micro approach are consistent with those based on macro data.** In particular, labor productivity has been the main driver of growth at the enterprise level, with TFP accounting for a large share of its variation. Although there is a divergence between productivity growth and value-added growth in 2000, this may be due to the bias introduced by the improved firm coverage in that year. Of the two TFP estimates, LP follows developments in labor productivity closer than IS. Since the assumption of constant return to scale is rejected for most of the sectors, IS probably overestimates the contribution of

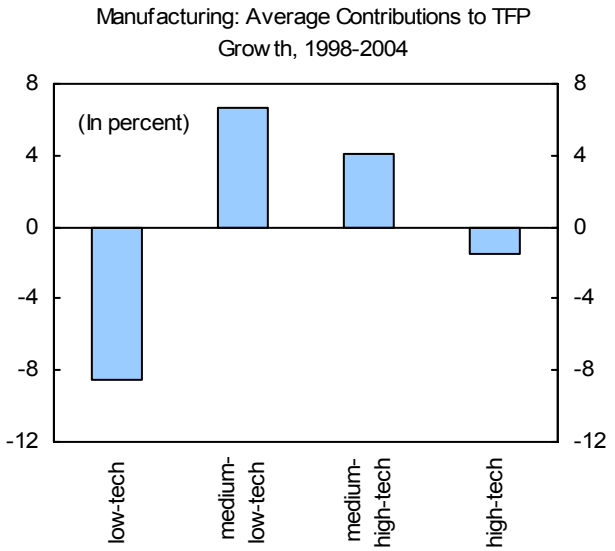
Comparing Productivity Measures
(Annual changes, in percent)



Sources: Estonian Business Registry database; and IMF staff calculations.

capital to growth, and, therefore, LP estimates give a better picture.[17]

17. **The sectoral decomposition indicates that most of the TFP gains are explained by the trade and business services sectors (Figure 2)**. Average TFP growth between 1997 and 2004 ranged from 0.4 percent (IS measure) to 2.6 percent (LP measure)—compared with a macro estimate of 3.1 percent. Despite this wide margin, the general message from the two estimates is remarkably consistent: both methods indicate that, although agriculture and public services made negative contributions to TFP growth during the period, these were more than offset by large contributions from trade and business services. The industrial sector also made positive contributions to growth but of a smaller scale. The ranking of sectors, however, differs between the two estimates: business services is at the top, according to IS, and trade, according to LP estimates. The performance of the business services is driven by the remarkable TFP growth in the financial intermediation sector, which experienced important changes during the period with the entry of foreign institutions in the Estonian market.[18] Within manufacturing, the low-tech and, surprisingly, the high-tech firms exerted a drag on productivity growth.



Sources: Estonian Business Registry database; and IMF staff calculations.

18. **At the same time, firm turnover and reallocation have been the key factors driving TFP dynamics (Figure 3).** According to IS estimates the contributions to TFP growth from net entrants have exceeded those from continuing firms for the periods 1998-2004 and 2001-2004. LP estimates shows the same result but only after 2000.[19] The positive contribution of firm turnover is due to both entering and exiting firms. In particular, entering

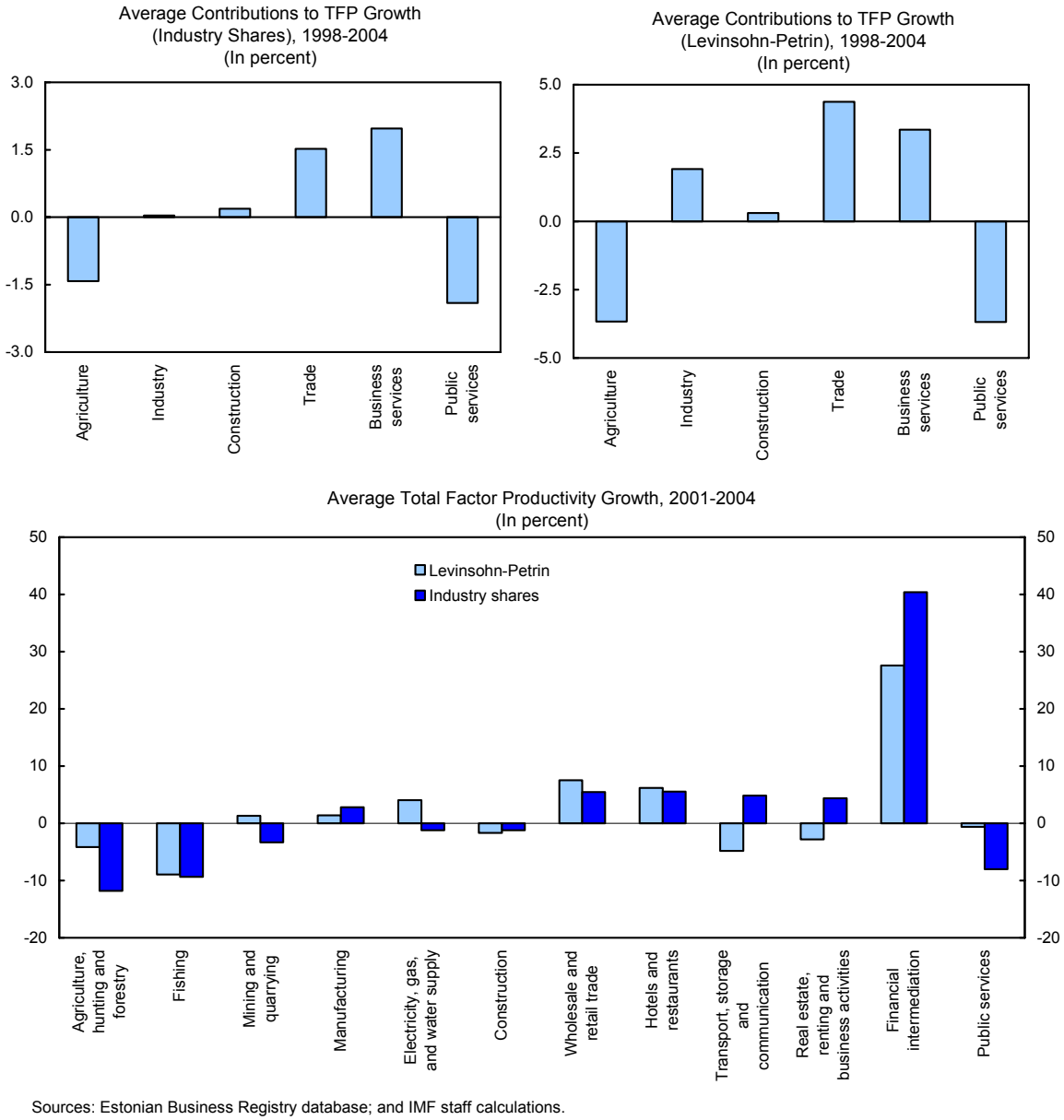
[17] Table A.5 reports LP estimates and results of the Wald test of constant returns to scale.

[18] It could be argued that foreign institutions may have boosted productivity in the financial sector by bringing in more advanced technologies and organization.

[19] LP estimates suggest that, on average, continuing firms made larger contributions to growth during 1998-2004. However, we should interpret this result with caution. First, data quality improves after 2000 and, therefore, estimates for the period prior to that may be biased. Second, the net entry effect depends on the horizon over which productivity growth is measured. Other studies on productivity dynamics in Estonia have focused on longer horizons that the one year considered in this paper (e.g., Masso, Eamets and Philips look at 2,

(continued…)

Figure 2. Estonia: Sectoral Decomposition of TFP Growth



Sources: Estonian Business Registry database; and IMF staff calculations.

firms have on average higher productivity levels than the incumbents had, while exiting firms have lower productivity that continuing firms. But this is far from the whole story. The decomposition of TFP growth also reveals that, although the within and between components

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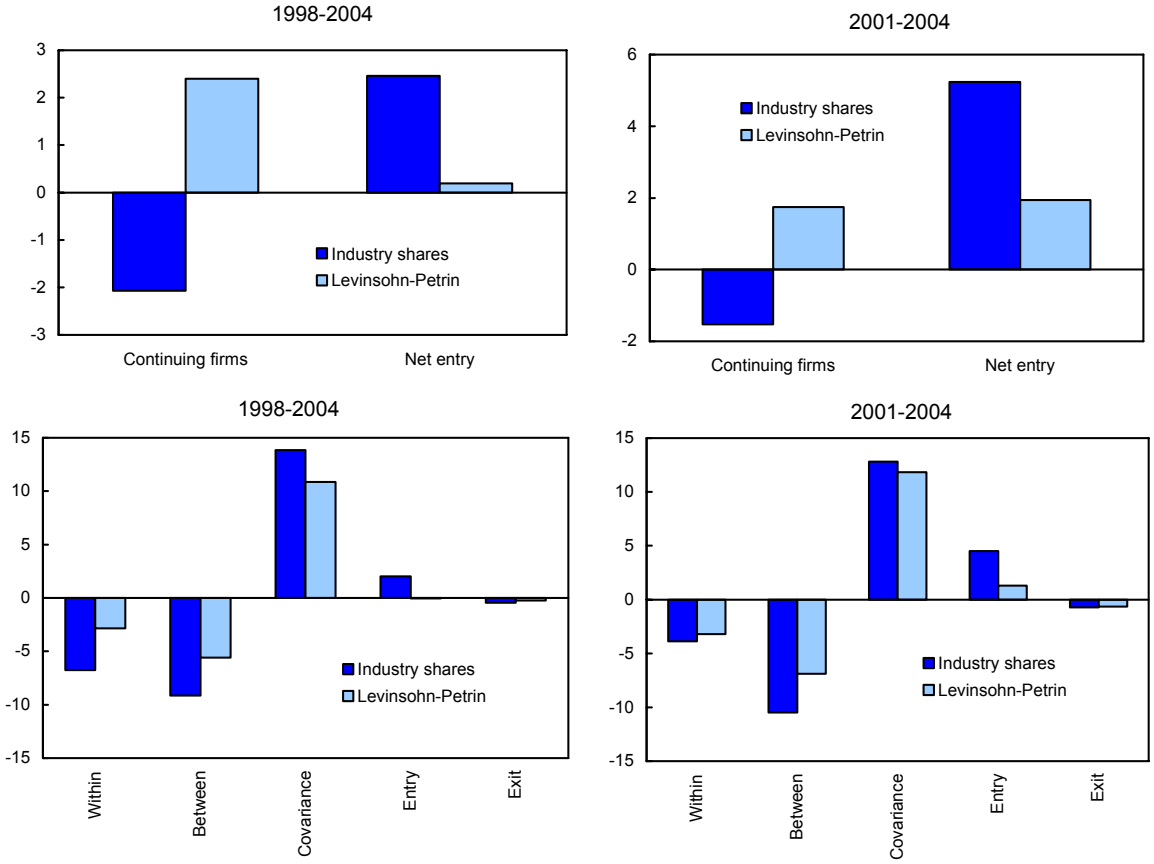
3 and 5 years horizons). As pointed out by Foster, Haltiwanger, and Krizan (1998), studies that focus on high frequency variations (like this paper) tend to find a smaller contribution of net entry to aggregate productivity growth.

of continuing firms have been consistently negative, they have been offset by a large and positive covariance component. That is, aggregate productivity growth has been boosted by the reallocation of output across continuing firms—specifically, firms with rising productivity.

Figure 3. Estonia: Decomposition of TFP Growth 1/
(In percent)



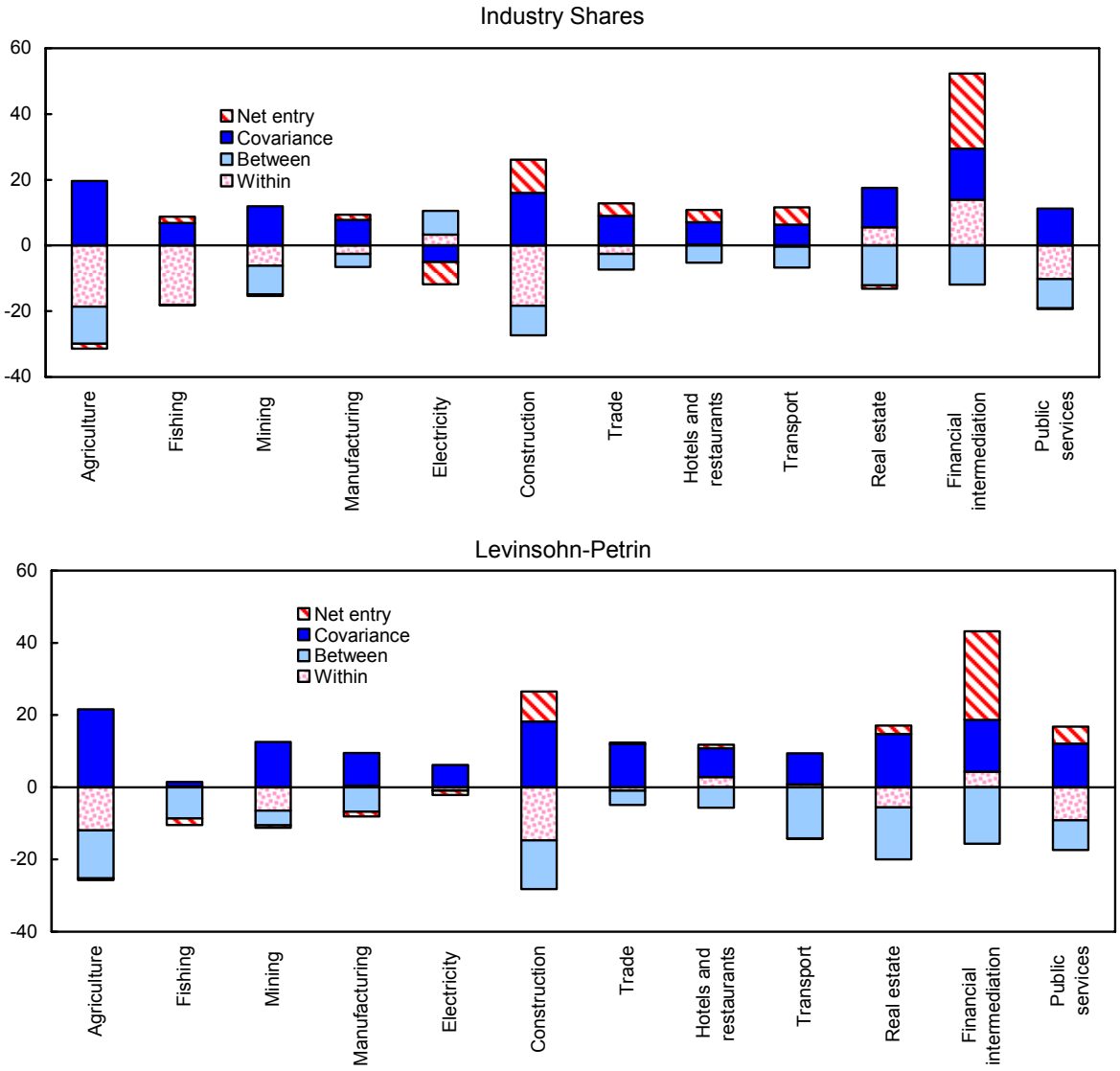
Sources: Estonian Business Registry database; and IMF staff calculations.
1/ Contributions to TFP growth are calculated on an annual basis. The figures reported in this graph are average over the corresponding periods.

19. **And within each industry, output reallocation has been the main engine of TFP growth (Figure 4)**. A consistent feature across most of the industries is the importance of the covariance and the negative contribution of the between component. This means that there has been a reallocation of output toward the firms with rising productivity and away from those firms with higher productivity levels. Also, the within component indicates that firms with larger output shares have experienced negative productivity growth. Finally, firm turnover has been important only for the construction and the financial services sectors.[20]

[20] The net entry in this decomposition is not comparable to the one defined at the aggregate level since entry and exit refer to the specific industry under consideration. For example, a firm that merges with another one and

(continued…)

Figure 4. Estonia: Sectoral Decomposition of TFP Growth, 2001–04
(In percent)



Sources: Estonian Business Registry database; and IMF staff calculations.

20. **These findings are subject to several caveats**. First, by deflating output and inputs by an industry-level price index we implicitly assume perfect competition. However, under imperfect competition, output prices will differ among firms and, therefore, the firm-level price deviations from the industry-level price will end up in the error term, causing an

changes the main sector of operation is considered to have exited the industry where it was operating before the merger, even when it has not actually closed down.

omitted price variable bias in our estimations. This bias could be potentially important in the financial sector where some firms might have price-setting power. Second, our estimates may suffer from selection bias generated by the relationship between the unobserved productivity variable and the shutdown decision. Third, the covariance effect may be overestimated because measurement errors in output will yield a positive covariance between productivity changes and changes in shares and a spuriously low within-firm effect.

D. Growth Scenarios

21. **What do these findings suggest about medium-term growth prospects?** We consider three alternative scenarios**.** The first one assumes three different TFP growth patterns based on historical data. The second one considers the implication of a 50 percent decline in firm entry and exit. Finally, the third scenario analyzes the impact of no further reallocation of output across sectors. All of these scenarios are purely illustrative in nature and should not be confused with projections of medium-term growth.

22. **The three scenarios share some common assumptions (Table 2)**. Population and the inverse dependency ratio are projected to decline over the next 10 years as a result of low fertility rates (see United Nations (2005)). The employment rate is assumed to increase 0.9 percent on average, reflecting the average employment growth rate since 1998. This assumption implies a sharp fall in unemployment (to 2 percent) unless participation rates rise above 73 percent. Hours worked are expected to decline based on income effects and convergence towards lower hours in Europe. However, a further compositional shift of employment toward services or part-time employment could cause a larger decline in hours worked than assumed here. Finally, the capital stock is assumed to increased by 7½ percent per annum over the next 10 years. This is the estimated annual increase in the net capital stock over the period 1998-2005. However, there is scope for faster capital accumulation, given the large capital-labor ratio gap with the EU-15.

Table 2. Estonia: Growth Scenarios—Assumptions

Variable		Annual Growth	Comments
Population	*P*	-0.27	U.N. (medium variant).
Inverse dependency ratio	*N/P*	-0.19	U.N. (medium variant).
Employment rate	*E/N*	0.9	Based on the average employment growth since 1998 (0.4 percent).
Average hours worked per employee	*L/E*	-0.25	Based on income effects and convergence toward Europe.
Capital-labor ratio	$\left(\frac{K}{L}\right)^{\alpha}$	2.52	Based on average increase in capital stock since 1995.

Sources: United Nations; and IMF staff calculations.

23. **The scenario analysis shows that maintaining the strong growth performance of recent years is not a sure thing (Table 3)**. The first scenario considers three alternative historical patterns of TFP growth: average, best, and worst performance during the period 2001-04. The resulting GDP growth varies within a wide interval—from ½ percent to 13.7 percent. But even if Estonia were to maintain the average TFP growth over the recent past, real GDP growth would slow to about 6 percent. Under the second scenario, TFP growth is dampened by the reduction of firm entry and exit rates, resulting in GDP growth rates below 6 percent. Finally, the third scenario assumes that the output shares of all industries remains fixed at the level of 2004 and TFP growth for each industry equals the average over 2001-04. By keeping output shares fixed, this scenario rules out the reallocation of resources toward the sectors with faster productivity growth, reducing GDP growth to 4-6 percent. These last two scenarios suggest that, a reduction of firm turnover or reallocation could have a significant impact on GDP growth.

Table 3. Estonia: Total Factor Productivity and GDP Growth: Scenarios
(In percent)

		TFP 1/		GDP	
Scenario		Min	Max	Min	Max
Scenario 1: Historical	Average	3.7	3.7	6.1	6.1
	Best	10.4	11.2	12.8	13.7
	Worst	-2.0	0.5	0.4	3.0
Scenario 2: Decline in entry and exit 2/		1.1	2.7	3.5	5.2
Scenario 3: No further output reallocation 3/		1.6	3.5	4.1	6.0

Source: IMF staff calculations.

1/ Based on Industry shares and Levinsohn-Petrin estimates for the period 2001-04.

2/ This scenario assumes a 50 percent decline in entry and exit rates.

3/ This scenario assumes sectoral productivity equal to the average productivity over the period 2001-04 and industries' output shares fixed at the 2004 level.

E. Conclusions

24. **Increases in labor productivity have underpinned the positive performance of the Estonian economy during the last decade.** Most of the convergence with the EU-15 achieved during this period stems from closing the gap in labor productivity and, specifically, TFP, which has been boosted by remarkable productivity gains in the business services and trade sectors. Also, productivity dynamics have been dominated by entry and exit. This suggests new firms have introduced technologies and innovation boosting productivity and displaced inefficient firms. At the same time, the reallocation of output toward firms with faster productivity growth has been an important determinant of aggregate and within-sector productivity.

25. **But further productivity increases are needed to close the still large gap with respect to advanced economies in the EU**. The large TFP gap with respect to the EU-15

underscores Estonia's substantial growth potential.[21] However, strong performance is not guaranteed. Productivity gains in recent years have been driven by firm turnover and reallocation of resources across sectors. But since entry and exit rates have fallen over time and there is a limit to the continuous reallocation of resources, productivity growth might decline in the near future, dampening GDP growth. Therefore, going forward, the main challenge will be to ensure continuous creative destruction and reinvention to move toward (and eventually shift) the technology frontier. Although the assessment of measures to improve productivity lies beyond the scope of this paper, it is worth emphasizing that policies promoting human capital development, R&D investment, the provision of public goods with positive production externalities, and efficient and flexible markets will be critical to foster innovation and rapid productivity growth.

[21] In addition, higher employment rates and faster capital accumulation could also help maintain rapid income convergence.

APPENDIX I. DATA SOURCES AND DEFINITIONS

Macro data

All macro data come from the Annual Macroeconomic Database (AMECO) of the European Commission unless otherwise noted.

Real GDP: Real GDP at 1995 prices. For comparison purposes, real GDP is converted into a notional currency (PPS) using PPS exchange rates.

Working population: Population aged between 15 and 64 years.

Capital stock: Sum of produced fixed assets that provide ongoing services by being used in the production process for more than one year. For all new member states, capital stock was calculated using the perpetual inventory model with the following inputs: the initial capital-output ratios came from Schadler and others (2006); gross fixed investment was taken from AMECO; and depreciation was assumed to be 5 percent.

Hours worked: Number of hours worked per year and per person employed. Sources: OECD and the Total Economy Database of the *Groningen Growth and Development Centre and the Conference Board*.

Micro data

The micro data comes from the Estonian Business Registry database. The database covers the period 1995-2004 but, due to missing information, we use data only from 1997. In order to create our sample we follow three steps:

1. Construct a longitudinal panel using registration codes. Several corrections are made to take into account the change in registration codes: (i) firms that change registration codes because of the transfer from the Enterprise Registry to the Business Registry are considered the same firm; (ii) in case of acquisitions, the acquiring and acquired firms are considered a unique firm for the whole sample period; the employment of the acquired firm is added to the employment of the acquiring firm; and (iii) for all other transactions (mergers, breakup, and divesture), we treat firms involved before and after the transaction as different.

2. Exclude unrealistic observations for the variables used to estimate TFP. In particular, exclude individual observations where value added, employment, capital, and intermediate inputs are zero or negative.

3. Exclude those firms for which there is no clear information about the industry they belong to (e.g., because of mergers).

Variable definitions

All variables are in real terms. Value added and intermediate inputs are deflated by the respective deflators of the system of national accounts provided by the Statistical Office of Estonia. The deflators are available for 16 sectors (corresponding to the one-digit ISIC Rev. 3.1). Capital is deflated with the gross capital formation price index.

Value added: Output minus intermediate inputs.

Output: Net sales plus the change in the inventories of final goods.

Employment: Number of employees.

Capital stock: Tangible and intangible fixed assets minus goodwill.

Intermediate inputs: Cost of goods, raw materials, and services purchased for core activities.

Staff costs: Wages and salaries, social security costs, and pension expenses.

Industry classification: Estonian EMTAK code (Classification of Economic Activities of Estonia). Available at: http://www.eer.ee/emtak_sisu_eng.phtml.

The tables below present some basic statistics about the data.

Table A.1. Summary Statistics 1/

Variable	Mean	Std. Dev.
Value added	3.7	27.6
Output	11.6	69.2
Employment	17.0	92.3
Capital	3.8	87.5
Intermediate inputs	8.0	51.7
Staff costs	1.4	8.7

Sources: Estonian Business Registry; and IMF staff calculations.
1/ Employment is expressed in number of workers. The remaining variables are expressed in millions of kroons.

Table A.2. Estonia: Number of Firms by Industries
(In percent of total number of firms)

	1997	1998	1999	2000	2001	2002	2003	2004
Agriculture	5.0	4.6	4.6	4.9	4.7	4.7	4.6	4.9
Mining and quarrying	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Manufacturing	17.4	17.0	16.9	16.8	16.6	16.9	16.5	16.8
Electricity, gas, and water	1.3	1.1	1.0	1.0	0.9	0.9	0.8	1.0
Construction	8.6	8.6	8.8	9.3	9.0	9.6	10.5	9.3
Private services	61.9	62.9	62.5	61.7	62.1	61.0	60.6	61.7
Public services	5.5	5.6	5.9	6.0	6.3	6.7	6.7	6.0
Total	100	100	100	100	100	100	100	100

Sources: Estonian Business Registry database; and IMF staff calculations.

Table A.3. Distribution of Observations Across Size Classes, 1997-2004

Size class	Number of employees	Frequency	Percent
1	1–9	74,326	67.16
2	10–19	18,292	16.53
3	20–49	11,919	10.77
4	50–99	3,771	3.41
5	100–249	1,687	1.52
6	250–499	418	0.38
7	More than 500	262	0.24
	Total	110,675	100

Sources: Estonian Business Registry database; and IMF staff calculations.

Table A.4. Firm Size Across Sectors and Time

Sector	Year	Mean Employment	Std. Dev. Employment	Coefficient of Variation
Primary	1997	23.1	33.2	1.4
	1998	20.8	29.1	1.4
	1999	16.8	23.8	1.4
	2000	14.8	23.5	1.6
	2001	13.2	19.5	1.5
	2002	12.0	18.9	1.6
	2003	11.1	17.3	1.5
	2004	12.4	22.6	1.8
Secondary	1997	32.7	89.2	2.7
	1998	30.0	155.6	5.2
	1999	26.6	83.5	3.1
	2000	29.0	147.9	5.1
	2001	27.2	150.5	5.5
	2002	24.0	111.4	4.6
	2003	23.4	104.1	4.5
	2004	21.8	109.6	5.0
Tertiary	1997	19.0	127.5	6.7
	1998	16.7	107.1	6.4
	1999	15.4	95.9	6.2
	2000	13.9	81.8	5.9
	2001	12.6	72.3	5.7
	2002	12.3	69.9	5.7
	2003	11.8	66.0	5.6
	2004	11.5	52.9	4.6
Total economy	1997	23.1	114.1	4.9
	1998	20.5	120.0	5.8
	1999	18.6	90.5	4.9
	2000	18.0	102.7	5.7
	2001	16.6	98.7	6.0
	2002	15.4	82.0	5.3
	2003	15.0	77.4	5.2
	2004	14.4	72.7	5.1

Sources: Estonian Business Registry database; and IMF staff calculations.

APPENDIX II. LEVINSOHN AND PETRIN: METHODOLOGY AND RESULTS

Assuming a Cobb-Douglas production function, total factor productivity can be obtained by estimating the following equation:

$$\log Y_t = \alpha_k \log K_t + \alpha_l \log L_t + \omega_t + \varepsilon_t =$$
$$= \alpha_l \log L_t + \phi_t(K_t, M_t) + \eta_t,$$

where M_t is the intermediate input and

$$\phi_t(K_t, M_t) = \alpha_k \log K_t + \omega_t(K_t, M_t).$$

Levinsohn and Petrin (2003) find that by substituting a third-order polynomial approximation in K_t and M_t as $\sum_{i=0}^{3}\sum_{j=0}^{3-i} \delta_{ij} K_t^i M_t^j$ in place of $\phi_t(K_t, M_t)$, one can consistently estimate the parameters α_l and ϕ_t using OLS. This is the first stage of the estimation procedure. In the second stage , the elasticity of capital α_k is defined as the solution to

$$\min_{\alpha_k^*} \sum_t \left(\log Y_t - \hat{\alpha}_l \log L_t - \alpha_k^* \log K_t - \varpi_t\right),$$

where ϖ_t is a nonparametric approximation $E[\omega_t \mid \omega_{t-1}]$. A bootstrap approach is used to construct standard errors for $\hat{\alpha}_l$ and $\hat{\alpha}_k$. In this study, 50 replications are performed. Once consistent estimates of the input elasticities have been calculated, the log of productivity can be obtained as

$$\hat{\omega}_t = \log Y_t - \hat{\alpha}_l \log L_t - \hat{\alpha}_k \log K_t.$$

Table A.5 reports the estimated coefficients of the log of labor and capital in the production function of different sectors, as well as the results of the Wald test of constant returns to scale.

Table A.5. Estimated Coefficients of the Production Function (Levinsohn-Petrin)

Industry code	Sector name	Log Labor		Log Capital		Constant Returns to Scale 1/
		Coeff	Std. Err	Coeff	Std. Err	
1	Agriculture, hunting, and related activities	0.41	0.03	0.30	0.04	No
2	Forestry, logging and related activities	0.36	0.03	0.31	0.05	No
5	Fishing, firm farming and related activities	0.66	0.07	0.21	0.14	Yes
10-14	Mining and quarrying	0.43	0.09	0.33	0.12	Yes
15	Manufacture of good products and beverages	0.47	0.03	0.25	0.05	No
17	Manufacture of textiles	0.56	0.06	0.17	0.05	No
18	Manufacturing of wearing apparel	0.73	0.04	0.06	0.05	No
19	Tanning and dressing of leather	0.58	0.07	0.17	0.08	No
20	Manufacture of good except furniture	0.44	0.03	0.24	0.03	No
21-22	Manufacture of pulp and paper; publishing and printing	0.49	0.04	0.11	0.04	No
23-24	Manufacture of coke, refined petroleum products, nuclear fuel, and chemicals	0.40	0.06	0.12	0.15	No
25	Manufacture of rubber and plastic	0.66	0.06	0.24	0.06	Yes
26	Manufacture of other non-metallic mineral	0.56	0.06	0.12	0.07	No
27-28	Manufacture of basic metals and fabricated metal products	0.53	0.02	0.19	0.03	No
29	Manufacture of machinery and equipment, nie	0.46	0.04	0.09	0.06	No
30-31	Manufacture of office machinery, computers, electrical machinery and apparatus, nie	0.69	0.07	0.13	0.08	Yes
32	Manufacture of television and radio	0.62	0.08	0.15	0.11	No
33	Manufacture of medical, precision and optical instruments	0.55	0.08	0.15	0.10	No
34-35	Manufacture of transport equipment	0.63	0.07	0.14	0.09	No
36-37	Manufacturing nec	0.43	0.03	0.22	0.04	No
40-41	Electricity, gas, and water supply	0.59	0.05	0.15	0.06	No
45	Construction	0.60	0.02	0.21	0.01	No
50	Sale, maintenance and repair of motor vehicles and motorcycles	0.48	0.02	0.14	0.02	No
51	Wholesale trade and commission trade	0.39	0.01	0.16	0.01	No
52	Retail trade, except motor vehicles and motorcycles	0.44	0.02	0.15	0.01	No
55	Hotels and restaurants	0.65	0.03	0.16	0.02	No
60-62	Land, water, and air transport	0.46	0.02	0.27	0.02	No
63	Supporting and auxiliary transport activities	0.70	0.04	0.15	0.03	No
64	Post and telecommunications	0.48	0.08	0.13	0.08	No
65-66	Financial intermediation	0.65	0.10	0.21	0.14	Yes
67	Activities auxiliary to financial intermediation	0.36	0.21	0.10	0.18	No
70	Real estate activities	0.44	0.02	0.07	0.02	No
71	Renting of machinery and equipment	0.47	0.05	0.35	0.10	Yes
72	Computer and related activities	0.86	0.05	0.21	0.05	Yes
73-74	R&D and other business activities	0.71	0.01	0.15	0.01	No
75 and 80	Public administration and defense; social security; education	0.45	0.05	0.18	0.04	No
85	Health and social work	0.59	0.04	0.10	0.02	No
90	Sewage and refuse disposal	0.60	0.05	0.33	0.07	Yes
92	Recreational, cultural and sporting activities	0.63	0.06	0.21	0.06	No
91 and 93	Activities of membership organization, nie; other service activities	0.67	0.04	0.10	0.03	No

Sources: Estonian Business Registry; and IMF staff calculations.

1/ Wald test of constant returns to scale based on a 5 percent significance.

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II. Population Aging and Fiscal Sustainability in Estonia[22]

A. Introduction

26. **The aging of Estonia's population creates a fiscal sustainability gap that is mitigated, but not closed, by its current strong fiscal position.** As in most other European countries the population is expected to age over the next 40-50 years as a result of rising longevity and low fertility rates. These demographic changes will lead to an expansion in age-related expenditures on pension and health care. Moreover, planned reductions in personal and corporate income tax rates will add further pressure to public finances. This paper quantifies the fiscal costs of the long-term expenditure trends and planned tax cuts, and uses the IMF's Global Fiscal Model (GFM) to assess alternative medium-term fiscal policies that would ensure long-term fiscal sustainability.

27. **The rule for indexation of pension benefits plays a pivotal role in the evolution of age-related expenditures.** The current formal rule for pension benefit indexation, with equal weights to inflation and wage bill growth, is fiscally sustainable, but would reduce a benefit ratio that is already among the lowest in Europe. This is understood by the government, which regularly increases pensions by more than what is required under the rule. In fact, pension benefits over the past five years have grown even faster than wages. A continuation of these ad-hoc pension increases is not sustainable. As a first step to putting public finances on a sustainable footing it is important to come up with an indexation rule that avoids excessive ad hoc pension hikes, but does not erode the benefit ratio. This would plot an intermediate course between the formal rule and current practice.

28. **This paper tries to quantify the impact of the age-related expenditure trends and tax cuts from a long-term perspective.** In a scenario with a continuation of current policies and practices (including continued ad-hoc pension benefit increases) age-related expenditures on pensions and health care will gradually increase by about 6½ percentage points of GDP by 2050. Moreover, existing legislation will reduce the personal and corporate income tax rates from 24 in 2005 to 20 percent in 2009, which could weaken the fiscal balance by 1-1½ percentage points of GDP. The bulk of the expenditure increase is projected to emerge after 2015, leaving a window of opportunity to prepare the public finances for the cost of aging and decided tax cuts.

29. **The adjustment needed to ensure fiscal sustainability is not trivial, but it is within reach thanks to the current solid fiscal position**. Simulations with GFM show that even if no fiscal adjustment is undertaken the government accumulate assets at first, but

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[22] Prepared by Michael Skaarup. Many helpful comments and suggestions from Franek Rozwadowski and Mark DeBroeck are greatly appreciated.

later enters an explosive path of debt accumulation. Stabilizing the government's net financial position in the long-term requires a fiscal adjustment of about 2½ percentage points of GDP over the next 8-10 years if it is combined with an indexation rule that links pension benefits to wage growth and puts an end to ad-hoc benefit increases. Such an early fiscal adjustment implies long-term accumulation of government assets, but requires less of an adjustment and yields a larger impact on output compared with a more delayed response.[23] Delaying the fiscal adjustment by 20-25 years will double the needed adjustment. Given upside risks to spending pressures,[24] early adjustment would leave more room for future possible additional adjustment needs and would address inter-generational equity considerations by ensuring that all generations bear some of the adjustment burden.

30. **The rest of the paper is organized as follows:** Section II analyses the demographic outlook, derives an estimate of age-related expenditure pressures, and assesses the fiscal adjustment required to ensure long-term fiscal sustainability. Based on the required fiscal adjustment section III uses the GFM to evaluate the effects of two sustainable fiscal strategies to address the aging costs and stabilize the government's net financial position in the long-term. Section IV analyses the sensitivity of the projected age-related expenditures to other demographic scenarios and parameters. Section V offers some concluding remarks.

B. Demographic Outlook, Age-Related Expenditures, and Fiscal Sustainability

Demographic outlook

31. **According to United Nations projections the demographic structure of Estonia will undergo large changes in the coming decades.** In 2050, the population is expected to be considerably older and slightly smaller than today as a consequence of rising longevity (life expectancy) and low fertility rates. The United Nations population projections show that life-expectancy will increase by 7-8 years (see United Nations, 2007) and that the most populated five-year age cohort will change from 15-19 to 60-64. The projected increase in life-expectancy is in contrast to the previous 30 years where it remained roughly constant. The United Nations also project that the current low fertility rate will rise in the long-term—but still be below reproductive levels—and that the recent negative net migration pattern will end in 2010.

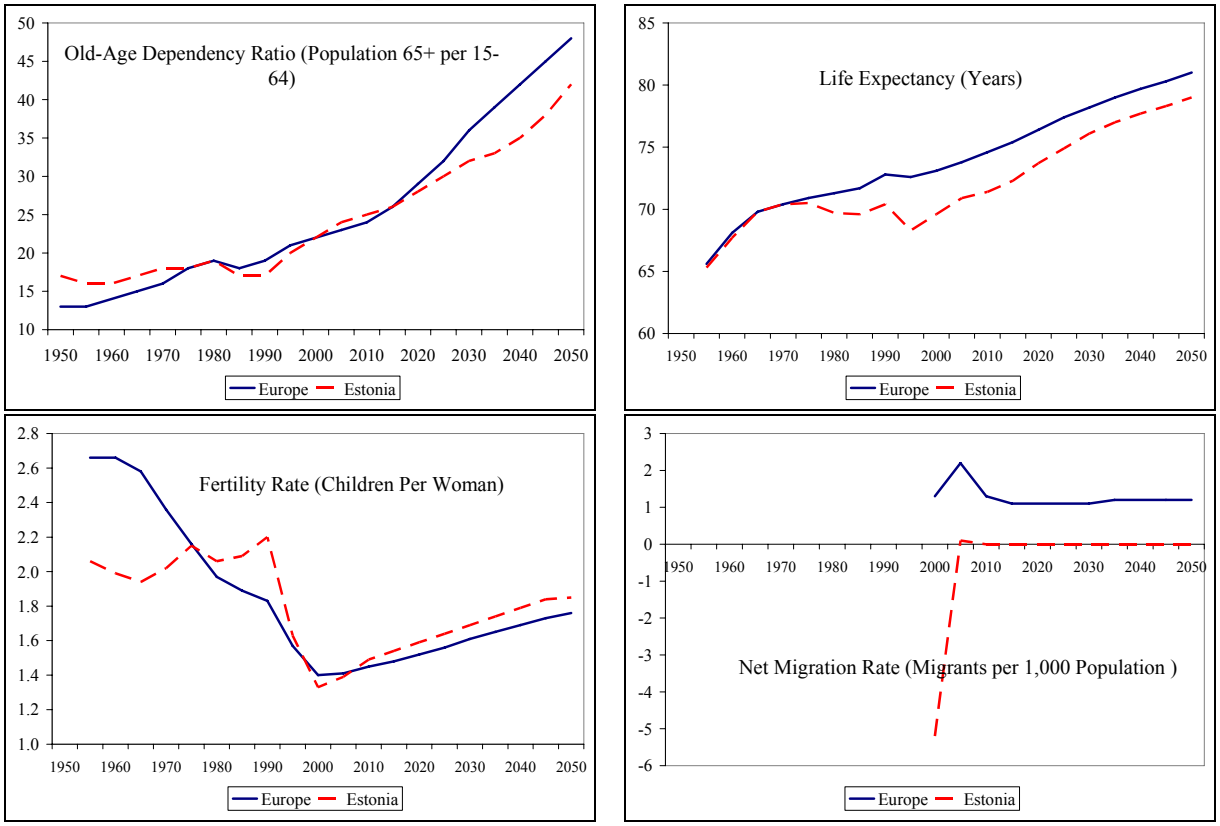
32. **These changes imply a significant increase in the old-age dependency ratio.** This increase reflects a projected decline in the number of working-age people (15 to 64) by about 27 percent and a 30 percent increase in the number of elderly people. This is in

[23] This result is supported by Barro (1979) and Jensen and Nielsen (1995) who show that tax smoothing can be motivated in terms of efficiency gains.

[24] For discussions of (upside) risks to long-term expenditure projections, see Broda and Weinstein (2004), Heller (2003), Heller and Hauner (2006), and Hauner, Leigh and Skaarup (2007).

contrast to the period from the 1950s until the mid-1990s where the old-age dependency ratio remained broadly constant (Figure 1). Although substantial, this increase is somewhat smaller than in Europe in general which to a large extent reflects the fact that Estonia did not have large fertility rates in the 1950s and 1960s and, thus, is not influenced by the retirement of a "baby-boomer" generation.

Figure 1. Demographic Developments in Estonia and Europe, 1950–2050



Source: United Nations (2007)

Macro economic assumptions

33. **Labor supply is projected to decrease by 25 percent from 2005 to 2050.** This is mainly a result of the declining working age population; the labor force participation ratio is projected to increase by only 3 percentage points over the period. The labor force participation ratio is projected using a "cohort" methodology, which takes into account that each five-year cohort for men and women has specific exit and entry rates into the labor market (See Appendix 1).[25]

[25] This approach is also used by both international organizations such as OECD and EU and national institutions, see Scherer (2002), Burniaux et al. (2003), European Commission (2006), and Australian Productivity Commission (2005).

34. **Real GDP growth is projected to decline to just above 1½ percent from almost 8 percent during 2005-10 (Table 1).** The slow down in GDP growth reflects both falling employment and declining productivity growth as per capita GDP converges to the EU level. The structural unemployment rate is assumed constant and potential productivity growth is expected to gradually getting closer to—but still above—the EU level, while inflation is expected to converge to 2 percent per year. Finally, the growth-adjusted interest rate (nominal interest rate minus nominal growth) on government debt has been set equal to 1 percent on average over the projection period.[26]

Table 1. Average Annual Growth Rates

(Percent)

	2005-10	2010-20	2020-30	2030-50	2005-50
Structural unemployment rate (level)	5.5	5.5	5.5	5.5	5.5
Labor force	0.5	0.0	-0.9	-0.9	-0.5
Structural employment	0.5	0.0	-0.9	-0.9	-0.5
Productivity (potential)	6.9	5.1	3.4	2.5	3.8
Potential GDP	7.5	5.1	2.5	1.6	3.2
Inflation	4.6	2.7	2.2	2.0	2.5
Wage rate	11.8	7.9	5.8	4.5	6.3

Source: Staff's own projections.

Tax and expenditure projections

35. **The fiscal baseline is built on neutral assumptions regarding taxes, pensions and health costs.** For taxes, the baseline projection is based on the decision to gradually reduce the personal and corporate income tax rate to 20 percent, while leaving other taxes unchanged.[27] The projected evolution of health care spending is based on the demographic projection and cross country evidence on how health spending rises with income. Finally, for pensions, the baseline is based on the assumption that the recent practice of ad hoc increases in benefits will continue, with the size of the increases gradually tapering off.[28] The assumptions on age-related spending (pensions and health) are discussed in more detail below. All other expenditure and revenue components are assumed to remain unchanged as

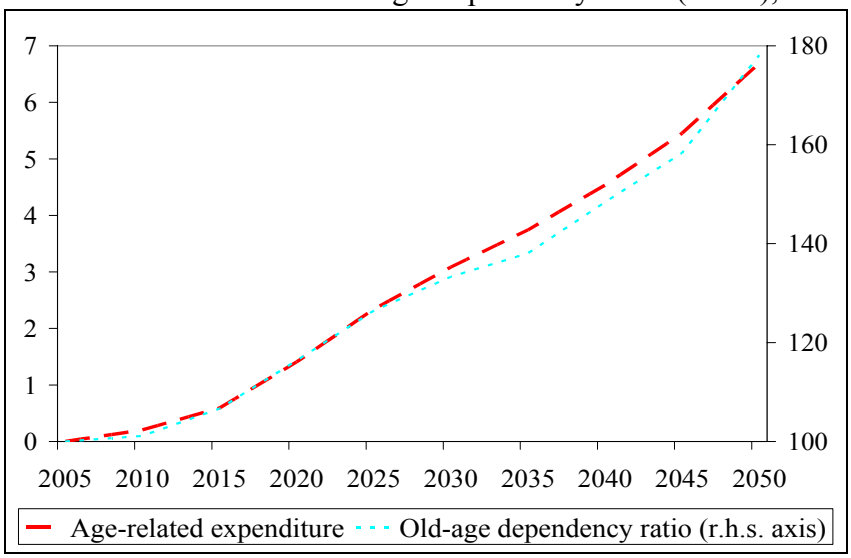
[26] This should be seen as an average assumption for the entire projection period. In some years it will be higher, while in others lower—or even negative as in the past few years.

[27] The projection incorporates the effect of planned income tax cuts prior to the new government's State Budget Strategy for 2008-11. Incorporating the additional income tax cuts and partly offsetting indirect tax hikes, which are part of the new strategy, would add to the projected decline in the fiscal balance since the Estonian ministry of finance estimates those to have a negative budget impact of about 1 percentage point of GDP.

[28] Since this paper aims to assess the fiscal impact of pensions, it models only the first pillar pension system.

a share of GDP throughout the projection period. These assumptions generate an expenditure trajectory that mirrors the evolution of the old-age dependency ratio (Figure 2).

Figure 2. Age-Related Expenditures Relative to the 2005-level (Percent of GDP) and the Cumulative Increase in the Old-Age Dependency Ratio (Index), 2005-50



Source: Statistics Estonia (2006), United Nations (2007), and own calculations.
Note: The old-age dependency ratio measures the number of persons older than 65 to the number of persons of working age.

36. **The combined effect of these assumptions is a decline in the fiscal balance by more than 8 percentage points of GDP over the next 45 years.** In net present value terms (NPV) this is equivalent to a permanent fiscal deterioration of about 6½ percentage points of GDP. Pension increases account for a little more than half of the decline; the rest is divided roughly equally between higher health care expenditures and the tax cuts (Table 2).

Table 2. Change in Age-Related Expenditures and Lower Taxes, Compared to 2005
(Percentage points of GDP)

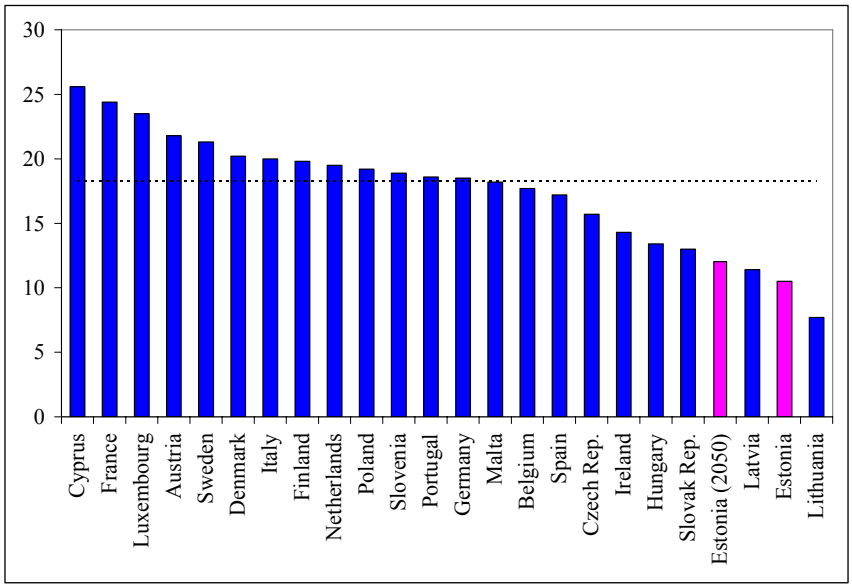
	2005	2010	2020	2030	2050	NPV terms
Health care expenditures	**0.0**	**0.1**	**0.5**	**1.0**	**2.2**	**1.7**
demographic effect	0.0	-0.1	0.0	0.2	0.9	0.8
per capita GDP effect	0.0	0.2	0.5	0.8	1.3	0.9
Pension expenditures	**0.0**	**0.1**	**0.9**	**2.1**	**4.5**	**3.4**
demographic effect	0.0	-0.1	0.6	1.7	4.4	3.6
retirement age (women) effect	0.0	-0.3	-0.9	-1.1	-1.3	-1.1
benefit ratio effect	0.0	0.4	0.8	1.2	1.0	0.9
Taxes	**0.0**	**-1.3**	**-1.3**	**-1.4**	**-1.5**	**-1.4**
personal and corporate income tax cuts	0.0	-1.2	-1.2	-1.2	-1.2	-1.1
payroll tax	0.0	-0.1	-0.2	-0.2	-0.4	-0.3
Fiscal balance effect	**0.0**	**1.5**	**2.7**	**4.4**	**8.2**	**6.6**

Source: Staff's own calculations

37. **The baseline pension scenario is based on projected demographics, existing legislation, and continued ad-hoc adjustment of benefits.** Key features of pension legislation are: a gradual increase in the statutory retirement age for women and a fully funded second pension pillar (Box 1). The ad hoc benefit adjustments reflect a judgment call on what is a likely outcome. Over the past five years pension benefits have grown, on average, almost twice as fast as prescribed by the formal rule for indexation of pension benefits, leading to a gradual increase in benefits relative to wages. The ad-hoc hikes indicate that the current low level of benefits is considered inadequate. The baseline scenario assumes that the tendency for benefits to grow faster than wages will continue, although at a gradually declining pace. The assumed additional benefit growth corresponds to an increase in the pension benefit ratio by 30 percent over 25 years. Even with this assumed benefit growth, the ratio of public pensions relative to output per worker will in 2050 still be lower than the current EU25 average (Figure 3).

Figure 3. Pension Benefit Ratio in the EU25 Countries, 2004[29]

(average relative to worker)



public pension output per

Source: European Commission (2006) and own calculations.

[29] The figure compares benefit ratios based on public social security systems only. Estonia, as well as many other European countries, also has second and third pillar pension systems. Including those may change the ranking somewhat, although Estonia likely still would be in the lower end.

Box 1. Estonian Pension System

The Estonian pension system has three pillars: a first pillar with the traditional pay-as-you-go (PAYG) based public pension system; a fully funded second pillar that is compulsory for new entrants to the labor market and all persons born after 1983 and voluntary for other workers; and a voluntary private third pillar.

The first pillar system is financed by social contributions and a budgetary transfer from the state budget to cover any deficit. The social contribution rate to the first pillar is 20 percent for persons that have not joined the second pillar system and 16 percent for persons that have. The first pillar benefits have two components. First, employment-related benefits for the old, the disabled and survivors, composed of a flat rate base benefit and a variable benefit, originally based on length of service, now insurance based with the benefit size determined by the amount of social contributions. Second, a flat rate national pension benefit granted to all residents from the age 63 who are not entitled to employment-related old age pension (only about 2 percent of all pensioners receive this benefit)

The compulsory second pillar system was introduced in 2002 and starts paying out pensions in 2009. Workers, who are not obliged to join, have the option to do so until 2010. The contribution rate is 4 percent, with an additional 2 percent paid by employees from gross wages. Workers who participate in the second pillar remain eligible to first pillar benefits, although at a correspondingly lower level. However, incentives such as full tax deductability of contributions have meant that about 500,000 workers have voluntarily joined the second pillar system.

The retirement age for both pillars is 63 for men and 60 for women, with the latter rising to 63 in 2016. Indexation of benefits in the first pillar is based on a rule that attaches equal weights to inflation and the growth in social tax revenue (wage growth). However, the rule has been overwhelmed by additional ad-hoc increase, which have raised pension benefits twice as fast as the rule suggests (and faster than wage growth). The second pillar benefits are based on actuarial rules.

38. **Pension expenditures in the baseline increase by 4½ percentage points of GDP between 2005 and 2050.** This increase is mainly driven by demographic changes since the effects of pension legislation and the ad-hoc benefit increases broadly offset each other. In an alternative scenario with a constant pension benefit ratio, pension expenditures would only increase by about 2 percentage points of GDP. If the current indexation rule for pension benefits were followed strictly, pension expenditures would decline relative to GDP and the pension benefit ratio would drop by more than 50 percent (Figure 4 and 5).[30] This

[30] The decline in the benefit ratio (of the first pension pillar) would, however, be partly mitigated by growing pension benefits from the gradually maturing second pension pillar. Thus, the relative income decline for future pensioners would be smaller than implied by the projected benefit ratio decline under the indexation rule.

result is similar to that in the latest EU commission report on aging (European Commission, 2006).

Figure 4. Pension Benefit Ratio (First Pillar)
(Pension benefit in percent of wages)

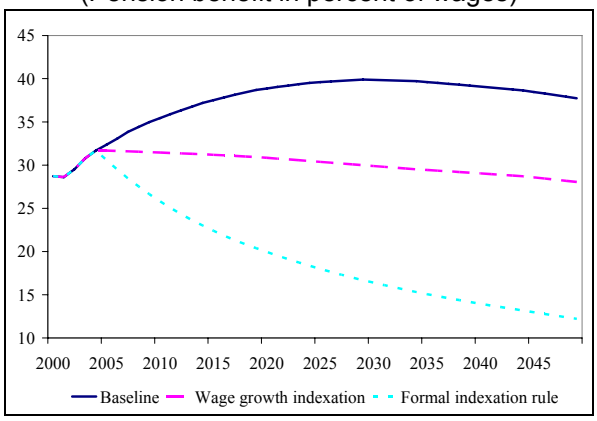
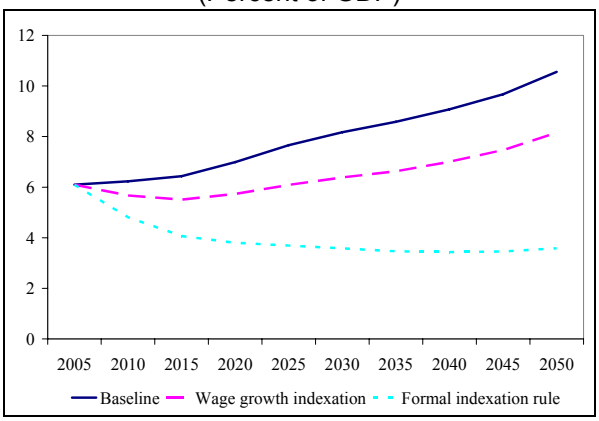


Figure 5. Pension Expenditures (First Pillar)
(Percent of GDP)



Source: Statistics Estonia (2007) and own calculations.

39. **The rising share of the elderly and the increase in per capita GDP are estimated to raise health care spending by more than 2 percentage points of GDP (Figure 7).** This projection takes into account that the demand for health care depends on people's health as well as their age. The projection incorporates the assumption that the projected higher life-expectancy is not just spent in "bad health", but that changes in life-expectancy will also shift the age distribution of expenditure in a "constant health" scenario (Figure 6). This means that the average health care cost associated with, for instance, the age of 60 will be lower in 2050 than now.

Figure 6. Age-Profile of Health Expenditures
(Euros per capita)

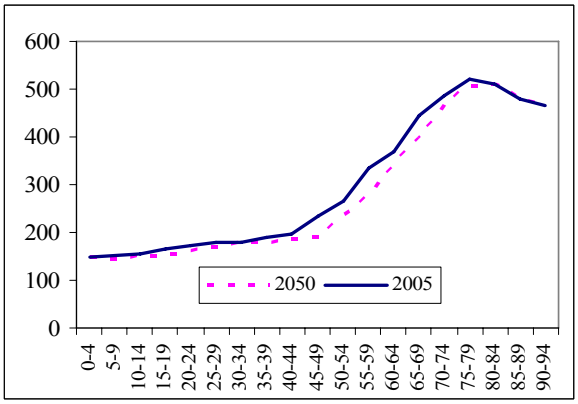
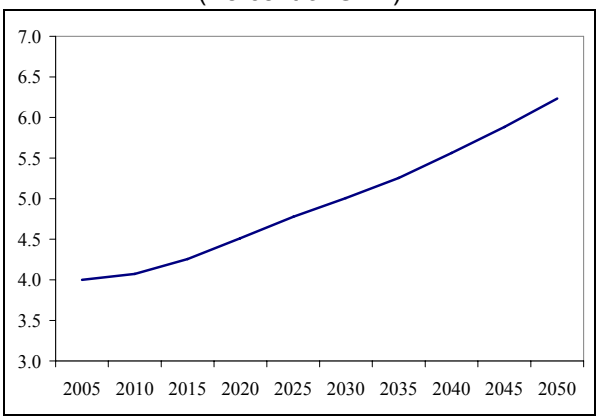


Figure 7. Health Care Expenditures, 2005-50
(Percent of GDP)



Source: Statistics Estonia (2006), United Nations (2007), and own calculations.

40. **The projection incorporates the empirical regularity that the share of health care spending in GDP depends on per capita GDP.** As per capita GDP increases it can be

expected that health care spending will increase as well (Box 2)—independent of demographic changes. This is in line with a recent OECD study (OECD, 2006) showing that over the past 20-30 years real per capita health care expenditures in OECD countries have grown 1½ percentage point faster per year than can be explained by demographic changes and real per capita GDP growth combined. Explanations for this additional growth may come from both the demand and supply side: 1) demand for health care may grow faster than income (making health care a luxury good); 2) health care costs may be growing faster than per capita GDP because of new, more expensive, technologies.

41. In addition to higher age-related expenditures, planned income tax cuts are estimated to worsen the fiscal balance by 1¼ percentage points of GDP. This is the estimated direct budgetary impact of the government's intention to reduce the personal and corporate income tax rates from 24 percent in 2005 to 20 percent by 2009. Moreover, the revenue from social contributions is projected to decline somewhat (about ¼ percentage point of GDP) as fewer will pay the high payroll tax when gradually more workers are covered by the mandatory fully funded pension system. Intended tax changes in the State Budget Strategy for the period 2008-11 are not included in the projection. However, the net effect of those tax changes would according to the Estonian ministry of finance entail a further weakening of the fiscal balance.

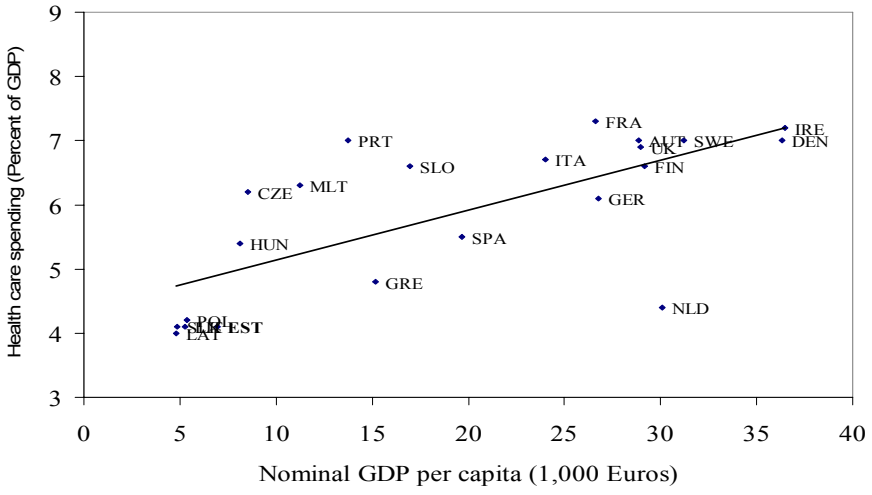
Box 2. Relationship Between Health Spending and Per Capita GDP

Based on cross country 2004 data for 25 European Union countries the following relationship between health care spending (as a share of GDP) and per capita GDP can be estimated

*Health care spending to GDP = 4.357 + 0.078*per capita GDP in million euros*
(11.4) (4.5) R-square = 0.498

with t-values in parenthesis below the parameters. The estimated relationship is used in this paper to project non-demographic growth in health care spending until 2050. On that basis health care spending is projected to increase by about 1½ percentage points of GDP over the next 45 years over and above the demographics-induced spending increase.

Figure. Health Care Spending and Per Capita GDP in EU countries, 2004.



Fiscal sustainability

42. **This section uses a standard indicator to assess fiscal sustainability in Estonia.** This sustainability indicator, S, is based on the European Commission's approach to assessing fiscal sustainability.[31] The indicator is concise and is also familiar in the policy debate in EU member countries. It measures the inter-temporal budget gap, that is, the immediate change in the primary balance needed to equate the present discounted value of future primary balances to the current level of debt. It thus indicates the adjustment required to stabilize debt at a level that is *permanently* sustainable. However, the sustainability indicator should be seen as a measurement of a fiscal gap that at some point needs to be closed rather than literally as an adjustment to be implemented at once. Nonetheless, it is illustrative to flesh out the impact of adhering strictly to a policy rule.

43. **The sustainability indicator is derived from the government's overall budget constraint and can be expressed as (European Commission, 2006)**:

$$S = p_0 - r \cdot d_{-1} + r \cdot NPV$$

Where p_0 is the initial primary balance, d_{-1} is the initial debt stock, and r is the growth-adjusted interest rate (nominal interest rates minus nominal growth), assumed to be constant for all periods. The primary balance and debt stock are measured as a share of GDP. NPV is the net present value of the projected future change in the primary balance as a share of GDP for all periods

44. **The indicator consists of three components:** (i) the initial (cyclically-adjusted) primary balance (the *balance* component); (ii) the interest costs of the initial debt stock (the *debt* component); and (iii) the net present value of the projected change in the primary balance in the baseline multiplied by the growth-adjusted interest rate (the *NPV* component). A change in the primary balance has a one-to-one effect on the indicator, whereas a 1 percentage point increase in the initial debt stock reduces the indicator (i.e. increases the fiscal adjustment needed to restore sustainability) by a factor related to the growth-adjusted interest rate. The NPV impact of the projected change in the primary balance is non-linear and depends on the time profile of the expenditure increase and tax cuts and the assumed growth-adjusted interest rate (see Appendix 3 for an example of the indicator).

45. **The sustainability indicator yields a fiscal gap of about 4 percent of GDP in Estonia.** In other words, to put public finances on a sustainable path and close the inter-temporal budget gap related to population aging, an immediate permanent fiscal adjustment

[31] European Commission (2004). A similar approach is used in HM Treasury (2006).

equal to about 4 percent of GDP is required according to a strict interpretation of the sustainability indicator. If such adjustment is not implemented government debt will at some point end on an explosive upward path. The required adjustment reflects the net present value of the projected increase in age-related expenditures and the planned income tax cuts, both as described above. The sound fiscal position with low debt and a structural primary surplus works in the other direction, and reduces the need for adjustment (Table 3).

Table 3. Sustainability Indicators for Estonia, 2005
(Percent of GDP)

	Contributions to the Indicator
Primary structural balance in 2005 (p_0)	2.5
Debt (rd_{-1})	-0.0
NPV of change in primary balance (rNPV)	-6.6
Sustainability Indicator	-4.1

Source: Eurostat and own calculations.

C. Medium-Term Fiscal Strategy

46. **A prudent medium-term fiscal strategy would be to aim for surpluses that ensure long-term sustainability.** While many strategies could close the fiscal gap we will focus on two: 1) adjust during 2008-15 and implement a new pension indexation rule that fully ties benefits to wages; 2) delay the adjustment until the period 2030-40. The new indexation rule in the former strategy charts an intermediate course between the current rule and current practice, and ensures that living standards of pensioners do not decline relative to those of workers.

47. **To assess the adjustment strategies we simulate, with GFM, three different scenarios.** These are:

- *No adjustment.* A scenario with no adjustment for the projected increase in age-related expenditures and planned tax cuts (Figure 8).

- *Early adjustment.* A scenario where the pension indexation rule immediately is changed so that benefits track wages and non age-related expenditures are reduced by 2½ percentage points of GDP over 2008-15. This expenditure reduction can be obtained by limiting real non-age related current expenditure growth to 2 percentage points less than real GDP growth per year during 2008-15 (Figure 9).[32]

[32] Non-age related current expenditures on goods and services, and transfers and subsidies amounted to roughly 16 percent of GDP in 2005. Real expenditures are here defined as nominal expenditures deflated by the GDP-deflator. Since at least half of non-age related expenditures (compensation of employees) can be expected to grow in line with private sector wages the suggested growth path may entail real reductions in other expenditure components.

- *Late adjustment.* A scenario where the expenditure reduction is delayed to the period 2030-40, which is when government assets otherwise would be depleted. In this scenario, pension benefits evolve as in the baseline scenario.[33] To restore sustainability a 5 percentage point of GDP expenditure reduction is needed. To facilitate this reduction real non-age related expenditures should grow by 3½ percentage points less than real GDP in this ten-year period. Since real GDP growth in the 2030-40 period has slowed down, this target implies negative real expenditure growth (Figure 10).

[33] The baseline pension expenditure projection assumes that pension benefits follow wages from 2030. Thus, a change in the pension indexation rule to track wages has no effect in the late adjustment scenario.

Figure 8. Baseline Scenario With Aging and Tax Cuts (Deviation from Steady State)

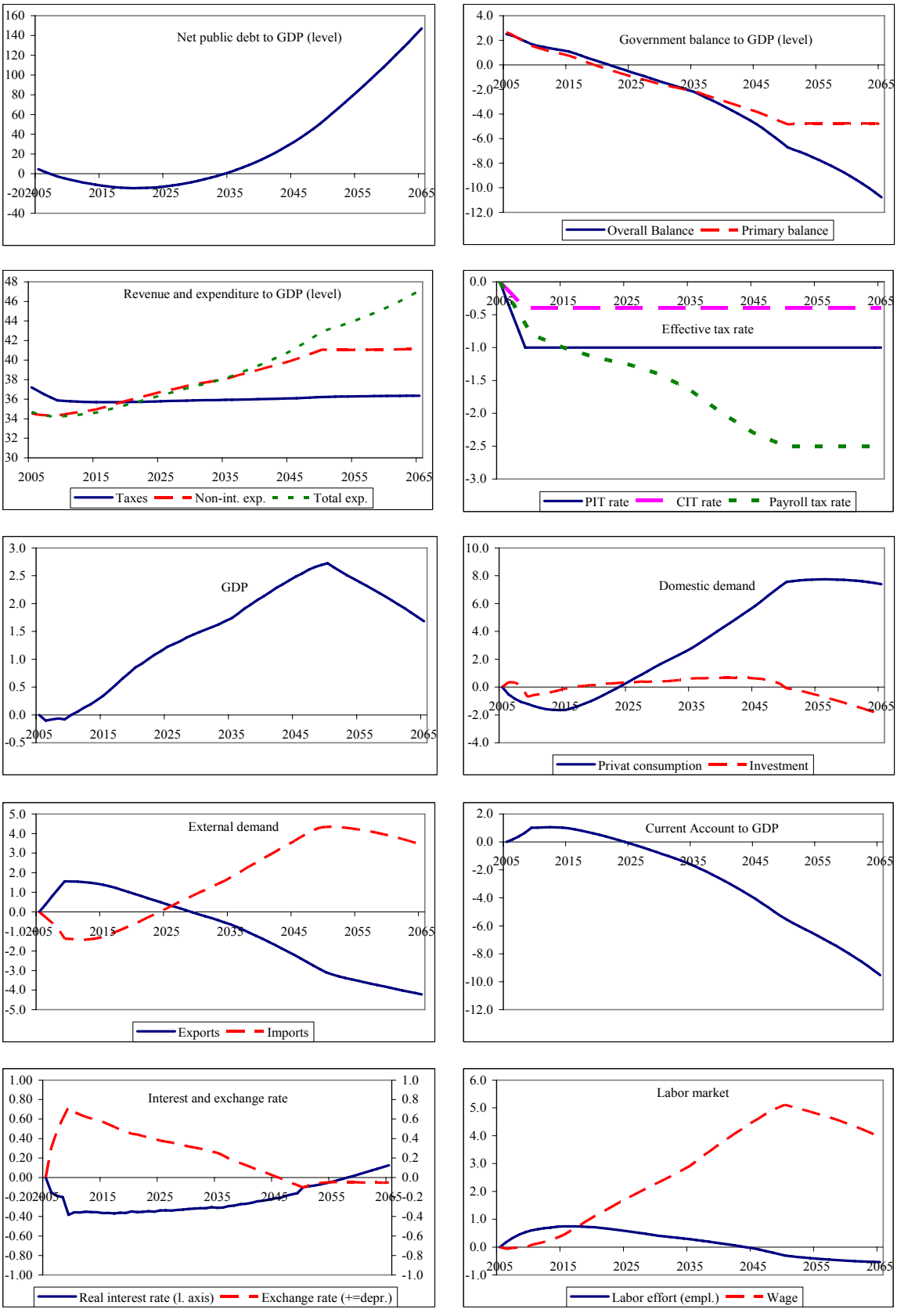


Figure 9. Scenario With Early Expenditure Adjustment (Deviation from Steady State)

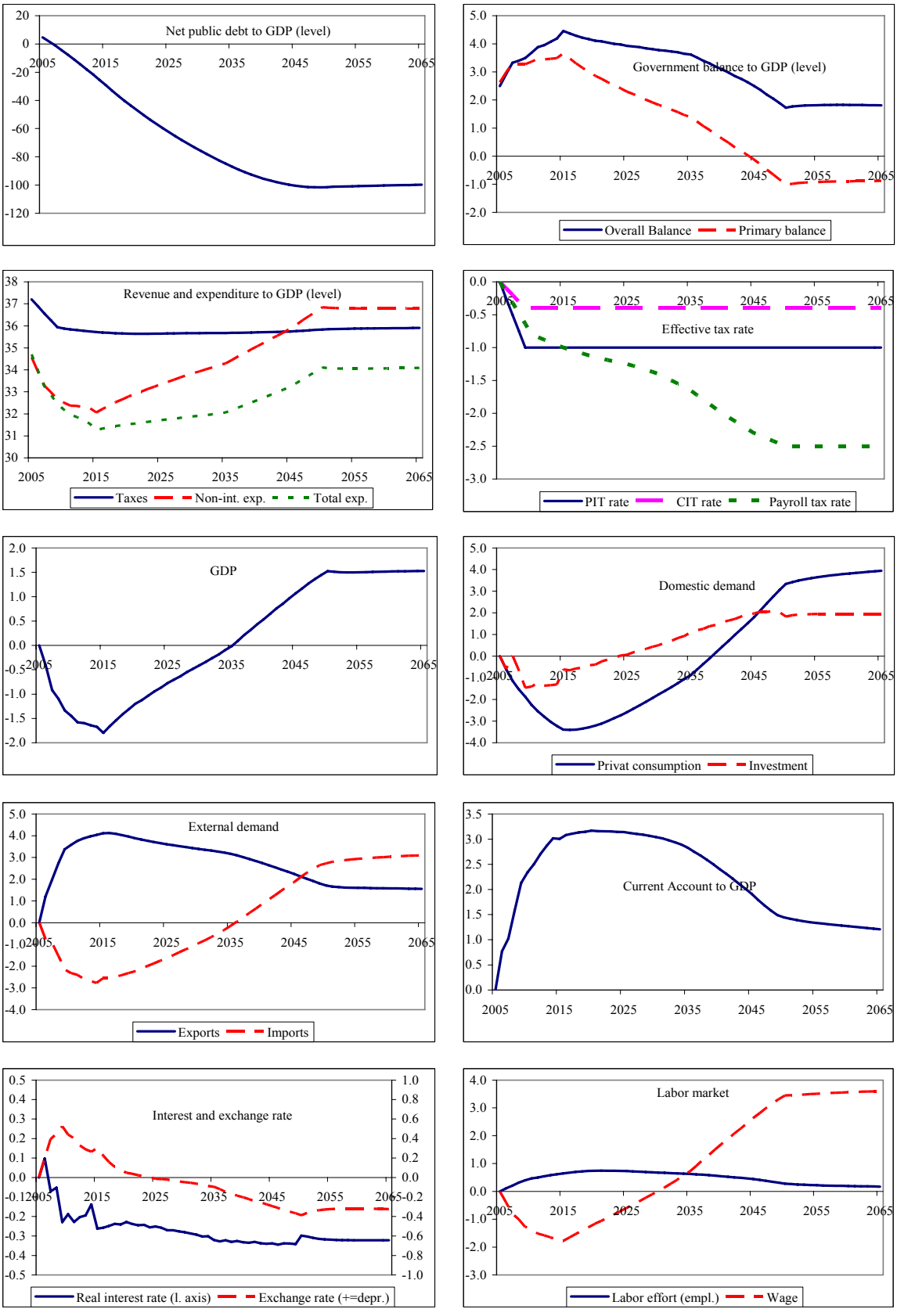
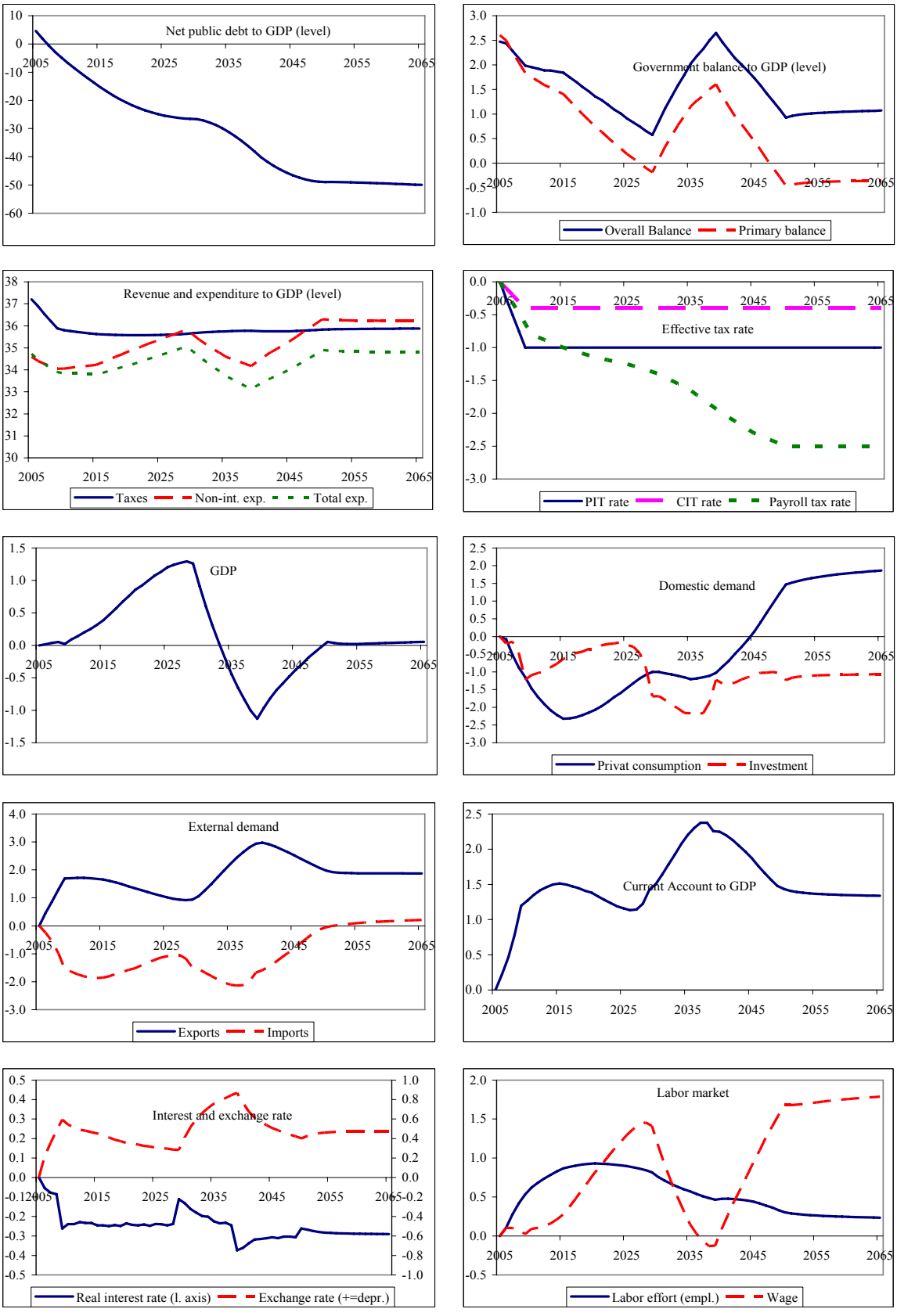


Figure 10. Scenario With Late Expenditure Adjustment (Deviation from Steady State)



48. **The adjustment scenarios support the standard result that the earlier the adjustment is implemented the smaller it needs to be.** The difference in the size of the needed fiscal adjustment (between the early and late response) can be attributed to the positive growth-adjusted interest rate (the discount factor), which attaches more weight to early adjustments, while later adjustment implies a debt profile with more interest costs.[34] This also explains why both adjustments are larger than that suggested by the sustainability indicator of the previous section, which shows the required adjustment if implemented immediately.

49. **The GFM simulation results confirm that the current set of policies is not sustainable.** When no policy action is taken the fiscal balance deteriorates steadily, reflecting both the debt-financed expenditure increase and growing interest payments. Debt accumulation accelerates, and the debt-to-GDP ratio enters an unsustainable upward trend. The first 20 years or so are misleadingly stable. The fiscal balance remains in surplus, debt is eliminated and net assets accumulate. But, these benign developments hide the underlying pressures stemming from demographic changes. Since insufficient assets are accumulated to pay for future expenditures, and structural reforms are not implemented to reduce expenditure pressures, rising expenditures push the fiscal balance into deficit at around 2025, and the deficit grows thereafter.

50. **Early fiscal adjustment leads to a sizeable net government asset position by the end of the projection period.** Net government assets increase then stabilize at around 2050. The primary fiscal balance shows surpluses of about 3 percent of GDP on average until 2015, then declines after 2015 as the cost of aging sets in. This pre-funding strategy implies that part of the future age-related expenditures will be financed through the interest earned on government assets.[35] In this scenario, there is a long term dividend on GDP and domestic demand because of lower interest rates and higher labor supply and wages. But, both GDP and domestic demand will (for a period) be lower as a result of the expenditure reduction. This easing of domestic demand strengthens the external current account, which continues to show surpluses, even when net exports eventually decline, due to higher interest income on net foreign assets.

51. **The government will also accumulate assets if the fiscal adjustment is delayed by 25 years or so.** However, the asset position will be smaller than in the early adjustment

[34] Without a change in the pension indexation rule, the needed adjustment would be 4½ percentage points of GDP in the early adjustment scenario. This can be compared to the 5 percentage point adjustment in the late scenario.

[35] While the simulation provides an indication of the potential asset position it should not be seen as a forecast of the exact outcome. Even small changes in interest rates or the fiscal balance can change the asset path significantly. Nevertheless, it provides an useful indication of the direction of government assets.

scenario. Moreover, this asset accumulation comes at the expense of a much larger fiscal adjustment. In fact, this adjustment is so large that there is no positive long-term effect on GDP. During the period of adjustment output declines about 2-3 percentage points relative to a baseline with stable growth. This reverses a negative external current account trend, so a permanent improvement is maintained.

Box 3. Why Adjust Sooner Rather Than Later?

When preparing for the fiscal impact of population aging the question arises whether to start consolidating public finances before aging costs begin to rise strongly or whether to delay the decision. In the case of Estonia it is fair to ask why the adjustment should be done now since this would lead to a sizeable asset position. Some of the benefits from acting earlier rather than later are:

- the fiscal adjustment needed to ensure long-term sustainability is smaller,
- the long-term impact on economic activity is more positive,
- it creates more room for future unanticipated additional adjustment needs,
- it addresses inter-generational equity considerations by ensuring that current and later generations share the adjustment burden,
- the current fiscal position allows such strategy without an overly strict fiscal policy.

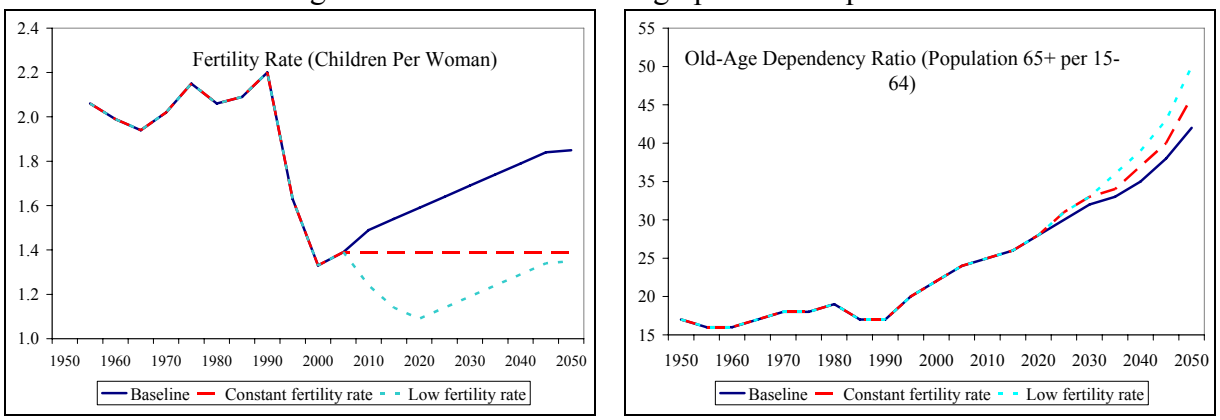
Pre-funding strategies have already been implemented in Australia (see Au-Yeung, McDonald and Sayegh, 2006) and New Zealand (see Whitehead, 2006) as well as countries such as in Canada, Ireland and Norway. Medium-term fiscal policies in Denmark and Sweden (see IMF Staff Reports, 2005, 2006), also aim at solid fiscal surpluses to pay down debt and prepare for aging.

D. Sensitivity of Aging Projections and the Sustainability Indicator

52. **This section briefly touches upon the robustness of the aging projections and the sustainability indicator to alternative underlying assumptions.** In particular, the analysis re-evaluates aging costs and the sustainability indicator under alternative assumptions on fertility rates, an alternative age-profile for health care costs, and a lower growth-adjusted interest rate.

53. **The cost of population aging is rather sensitive to alternative scenarios for fertility rates.** As a consequence of the long time horizon the aging projections will logically be surrounded by uncertainty. To illustrate this we consider two different scenarios for the fertility rate: i) a scenario where the fertility rate stays constant at its 2005 level; and ii) a scenario where it declines for a period and then rebounds to its 2005 level at the end of the projection period. In both scenarios, the old-age dependency ratio increases more than in the baseline, mainly as a result of their being fewer people in working ages (Figure 11). Consequently, age-related expenditures will increase more and the needed fiscal adjustment to ensure sustainability is between 0.5 to 1.3 percentage points of GDP higher.

Figure 11. Alternative Demographic Assumptions



Source: United Nations (2007)

54. An alternative age-profile for the use of health care services in line with EU15 experience increases projected health care expenditures. The age-profile for health care costs in Estonia slopes downward after age 75. This is similar to other new EU member states, but not to the EU15, where health costs continue to increase with age (European Commission, 2006). When assuming an age-profile for Estonia comparable with that of the EU15 countries the projected health care costs increase by 0.3 percentage points of GDP in 2050. As the additional increase is gradual the impact on the sustainability indicator is only half this amount.

55. **The growth-adjusted interest rate assumption affects the sustainability indicator through two channels with opposite effects.** On the one hand, for a given stock of government debt, a lower interest rate reduces the debt component of the sustainability indicator. On the other hand, future age-related expenditures are discounted using a lower interest rate, which increases the NPV component. Overall, reducing the growth-adjusted interest rate from 1 to ½ percent reduces the sustainability indicator by 0.7 percentage point of GDP.[36] This result reflects the increase in the net present value of aging costs; the reduction in the estimated interest payments on the current low debt is marginal. While an assumption of a constant growth-adjusted interest rate has merit in terms of simplicity it is not realistic for a rapid changing economy like Estonia. To assess the sensitivity of our results to this assumption we have therefore recalculated the sustainability indicator for the case where the *nominal interest rate* is constant. Fixing the nominal interest rate at 6 percent at all times implies that the growth-adjusted interest rate still equals 1 percent *on average*, but that it will vary over time as a result of varying nominal GDP growth. The real interest rate increases in this scenario from about 3 percent in 2010 to 4 percent in 2030 and then stays constant. This change in the interest rate assumption increases the needed fiscal

[36] The effect of an increase in the growth-adjusted interest rate from 1 percent to 1½ percent has the same magnitude, but with opposite sign.

adjustment by 1.1 percentage points of GDP since a lower—and even negative—growth-adjusted interest rate until 2025 implies that the aging costs is discounted by less. As a result the net present value of the aging costs is higher. In fact, because of the negative growth-adjusted interest rate the cost of aging is in net present value terms for a period of time even larger than the direct effect on the fiscal balance.

Table 4. Effect on Aging Costs and Sustainability Indicator of Alternative Assumptions
(Percent of GDP)

	Additional increase in age-related expenditures	Change in sustainability indicator
Fertility rate constant at 2005 level	0.8	0.5
Lower fertility rate	2.0	1.3
Age-profile for health care comparable to EU15	0.3	0.1
Lowering of growth-adjusted interest rate from 1 to 0.5 percent	-	0.7
Nominal interest rate constant at 6 percent	-	1.1

E. Concluding Remarks

56. **Population aging will lead to a sizeable expansion in pension and health care costs in Estonia.** This paper shows that, with a continuation of current policies and practices, age-related expenditures on pensions and health care will rise by 6½ percentage points of GDP between 2005 and 2050. This future fiscal weakening is compounded by planned reductions in personal and corporate income tax rates until 2009.

57. **The adjustment needed to ensure fiscal sustainability is manageable.** This is so mainly because of the current good fiscal position with almost no debt and a significant fiscal surplus. Given that the bulk of the expenditure increase is projected to emerge after 2015 there is merit in starting already now to prepare public finances for the cost of aging. Simulations with the IMF's Global Fiscal Model demonstrated that ensuring long-term fiscal sustainability requires a reduction in non-age related expenditures of about 2½ percentage points of GDP until 2015 if it is combined with a pension indexation rule linking benefits to wage growth. This would be commensurate to targeting primary fiscal surpluses of about 3 percent of GDP on average to 2015. Delaying the expenditure reduction by 20-25 years will double the needed adjustment.

58. **There are benefits to pre-funding the fiscal costs of aging.** Firstly, the fiscal adjustment needed to ensure long-term sustainability is smaller the earlier it is implemented. Secondly, the long-term impact on economic activity is positive, while it may be negative if the response is significantly delayed. Thirdly, early adjustment leaves more room for future unanticipated additional adjustment needs. Fourthly, early adjustment addresses inter-generational equity considerations by ensuring that both current and later generations bear the adjustment burden. And finally, the current fiscal position allows such strategy without imposing an unmanageable fiscal adjustment burden.

Appendix I. Methodology for Making Age-Related Expenditure Projections

Age-related (or person-related) expenditures can in simple terms be expressed as expenditures, *E*, equaling a benefit level, *b*, times the numbers of recipients/users, *R*:

(1) $E = b \cdot R$

When making long-term projections it is important to identify the underlying (demographic) trends that change the number of recipients and the benefit level. To better understand these trends the expenditure equation can usefully be extended in the following way:

(2) $E = b \cdot \frac{R}{P} \cdot \frac{P}{P^{1564}} \cdot \frac{p^{1564}}{L} \cdot L$

Where P reflects the potentially eligible population for a particular expenditure item (health care, pensions etc.), P^{1564} is the working age population and L is employment. The eligible population could be total population, the population older than 65 or some other relevant grouping and, thus, the ratio $\frac{R}{P}$ can be understood as the "coverage ratio" of the given expenditure item. The ratio $\frac{P}{P^{1564}}$ is the dependency ratio and $\frac{p^{1564}}{L}$ is the inverse employment ratio. For projection purposes it is assumed that the benefit level is linked to nominal GDP, *Y*, per worker (as a proxy for the wage rate):

(3) $b = br \cdot \left(\frac{Y}{L}\right)$

This assumption does not preclude the projection taking into account indexation rules that differs from the above relation as this would be captured in the benefit ratio, *br*. However, the assumption implies that expenditures will stay constant as a share of GDP if there is no change in relative prices, the population composition is unchanged and economic policies do not change the benefit ratio, the coverage ratio and the employment ratio. In the current projections we assume that the benefit ratio will increase for pension expenditures due to ad-hoc decided benefit hikes, while it is also rising for health care expenditures following the effect of non-demographic drivers. Incorporating the relation for the benefit ratio into (2) and taking log-change yields the following equation for the growth in age-related expenditures as a share of GDP:

(4) $\Delta \log\left(\frac{E}{Y}\right) = \Delta \log(br) + \Delta \log\left(\frac{R}{P}\right) + \Delta \log\left(\frac{P}{P^{1564}}\right) - \Delta \log\left(\frac{L}{p^{1564}}\right)$

This general equation allows us to undertake long-term expenditure projections taking into account changes in demographics and economic policies. In case of Estonia, the eligible population is assumed to be persons older than 65 when projecting both pension and health care expenditures. The projected number of recipients for pension takes into account the change in the statutory retirement age, while the projected index of health care users is based on the age distribution (five year cohorts) of health care spending (includes the entire population).

Appendix II. Labor Force Projection Using the Cohort Methodology

Rather than assuming unchanged age-specific participation ratios for the full projection period, the cohort methodology allows for changing participation ratios in line with observed exit and entry rates in each five-year cohorts. Due to socio-cultural factors and individual characteristics younger women's participation rates tend to be higher than older women's, leading to an autonomous increase in female labor force participation in the years ahead, when the cohort projection methodology is used. In Estonia this positive cohort effect is projected to raise female labor force participation by about 6½ percentage points, while a negative cohort effect for men is projected to lead to a decline in their labor force participation by 1½ percentage points, implying that by 2025 women will have higher labor force participation than men (see Figures A1 and A2).

Figure A.1. Age-Specific Labor Force Participation Rates
(Labor force as percent of working age population)

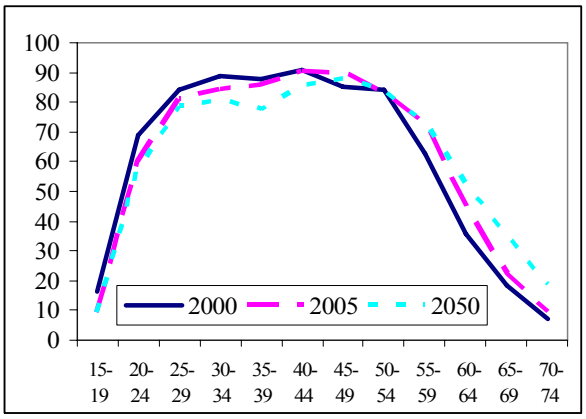
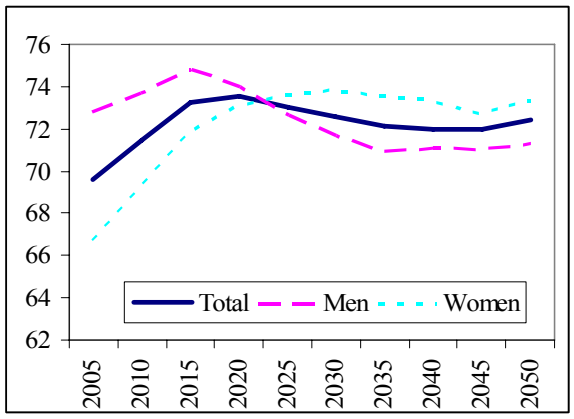


Figure A.2. Aggregate Labor Force Participation Rates
(Labor force as percent of working age population)



Source: The International Labor Organization (2007), United Nations (2007), and own calculations.

Appendix III. The Global Fiscal Model

Model overview

The IMF's Global Fiscal Model (GFM) is a four-country dynamic general equilibrium model based on the New Open Economy Macroeconomics (NOEM) tradition, but designed to examine fiscal policy issues.[37] It is particularly suitable for studying temporary or permanent changes in taxes or expenditures, whether implemented rapidly or occurring gradually (as is the case of age-related expenditure pressures). The GFM analyzes the impact of fiscal policy on real activity through both aggregate demand and supply channels. Aggregate demand responses result from the absence of debt-neutrality and consumers' impatience. Aggregate supply responses arise from the distortionary effects of taxation. The model features marginal payroll taxes on workers that exceed the average rate, which allows for the consideration of the effects of tax base broadening. The GFM extends the NOEM framework by introducing non-Ricardian features via three distinct channels to allow for thorough fiscal policy analysis:

- Households have finite horizons and as a result, even temporary changes in fiscal policy affect consumption patterns since any offsetting action required by the government's intertemporal budget constraint is (perceived to be) borne by future generations and there is no bequest motive.
- Liquidity-constrained households (a fraction of all households) that consume all their disposable income every period and thereby immediately respond to fiscal policy initiatives that change their disposable income.
- Distortionary labor- and capital taxes affecting incentives to consume and invest.

Other main aspects of the model are:

- Consumption and production are characterized by constant elasticity of substitution functions. Firms and workers have some market power, so that prices and wages are above their perfectly competitive levels.
- There are traded and non-traded goods that allow for a bias toward domestic goods in private or government consumption.
- There are two factors of production – capital and labor – which are used to produce traded and non-traded goods. Capital and labor can move freely between sectors, but are not mobile internationally.

[37] See Botman, Laxton, Muir and Romanov (2006) for a detailed description of the GFM.

- Investment is driven by Tobin's Q with adjustment costs. Firms respond sluggishly to differences between the discounted value of future profits and the market value of the capital stock.

- Wages and prices are fully flexible. As a result, monetary policy is ineffective.

- There are two kinds of financial assets, government debt (traded internationally) and equity (held domestically). International trade in government debt implies the equalization of nominal interest rates across countries over time. However, real interest rates across countries could differ because of the presence of non-traded goods and home bias in consumption.

GFM provides a good platform for discussing the relative merits of alternative fiscal consolidation measures and has been applied to several countries.[38] The non-ricardian structure of the model implies empirically plausible responses of key macroeconomic variables to changes in fiscal policy. The wide ranging menu of taxes allows a detailed analysis of the composition of adjustment while the strong microfoundations allow to consider the fundamental determinants of the effects of fiscal policy, such as the response of consumers and producers to changes in fiscal policy as well as the sensitivity to the structure of the economy. Finally, as GFM is an open economy model, it allows for the study of fiscal interdependence.

Calibration

The parameters of the model are calibrated to reflect the macroeconomic features of Estonia (Table A1). In particular, the ratios of consumption, investment, government spending, wage income, and income from capital relative to GDP are set to their current values. Similarly, key fiscal variables—revenue to GDP ratios from taxation of corporate, labor, and personal income and consumption tax, as well as government debt and current government spending—have been calibrated to Estonia's fiscal structure. Also, the calibration reflects the trading patterns between Estonia, the other Baltic countries and the Nordic countries, Europe, and the rest of the world.

The calibration of behavioral parameters is based on general microeconomic evidence found in the literature (see Table A2). [39] These include parameters characterizing real rigidities in investment, markups for firms and workers, the elasticity of labor supply to after

[38] The model has been applied by IMF staff for background work on recent Article IV consultations with Canada, Germany, Japan, the United Kingdom, and the United States.

[39] Other structural parameters have been calibrated using evidence from Laxton and Pesenti (2003) and Batini and others (2005).

tax wages, the elasticity of substitution between labor and capital, the elasticity of intertemporal substitution, and the rate of time preference.

- The sensitivity of labor supply to the real after-tax wage (Frisch elasticity) is equal to -0.10 in the baseline value.

- The elasticity of substitution between labor and capital in the production function equals -0.75.

- The baseline value for the elasticity of intertemporal substitution is 0.40. This parameter describes the sensitivity of consumption to changes in the real interest rate.

- The wedge between the rate of time preference and the yield on government bonds determines consumers' degree of impatience and has not been subject to extensive microeconomic analysis. We have set the baseline value of the wedge to 15 percent (corresponding to a planning horizon of 7 years).

- The baseline assumes that 70 percent of consumers are liquidity constraint (i.e. excluded from participating in financial markets). As these consumers have no wealth, these households consume 40 percent of aggregate consumption.

- The baseline assumes that the markup over marginal cost in the tradables sector equals 17 percent and in the nontradables sector equals 25 percent.

Table A.1. Key Macroeconomic Variables in the Initial Steady State

Estonia			
National expenditure accounts at market prices			
Expenditure ratios		Factor Incomes	
Consumption	48.6	Capital	57.1
Government consumption	20.4	Labor	42.9
Investment	31.0	Government	
Imports	51.0	Net debt	
		Gross debt	4.6
Tax rates and revenue			
Payroll Taxes (Worker and Employer)		On Personal Income	
as % of GDP	10.5	as % of GDP	5.4
On Corporate Income		On Consumption (VAT and excises)	
as % of GDP	1.3	as % of GDP	11.7

Trade flow matrix

	Estonia	Euro area	Nordic and Baltics	Rest of the World
Total exports	51.0	40.0	45.0	30.0
to Estonia		1.2	1.2	0.9
to Euro area	17.9		21.9	16.2
to Nordic and Baltics	15.3	17.2		12.9
to Rest of the World	17.8	21.5	21.8	

Source: IMF staff estimates

Table A.2. Behavioral Assumptions and Key Parameters in the Initial Steady State

Planning horizon of consumers	7 years
Labor disutility parameters	0.90
Fraction of rule-of-thumb consumers	0.70
Intertemporal elasticity of substitution	0.40
Elasticity of substitution between capital and labor	0.75
Depreciation rate on capital	
Capital adjustment cost parameters	1.0
Elasticity of substitution between varieties	
Tradables sector	16.7
Price markup over marginal cost	1.06
Nontradables sector	25.0
Price markup over marginal cost	1.04
Capital share in production tradables sector	0.70
Capital share in production nontradables sector	0.70
Utility from real money balances	0.02
Price stickiness parameters	0
Home bias in government consumption	yes
Home bias in private consumption	no
Elasticity of substitution between traded and nontraded goods	0.40
Bias towards domestically produced tradable over nontradables	2.50

Source: GFM simulations.

Appendix IV. Stylized Example Explaining the Sustainability Indicator

Consider a stylized economy with an initial primary deficit of 1 percent of GDP, an initial debt stock of 90 percent of GDP, a growth adjusted interest rate of 2 percent, and aging costs increasing linearly by 5 percent of GDP during 2005–50 and stay constant as a share of GDP beyond 2050. With the assumed parameters and time horizon an increase in the initial debt stock or the NPV of aging costs by 1 percentage point of GDP reduces the indicator by 0.02 percentage point of GDP.

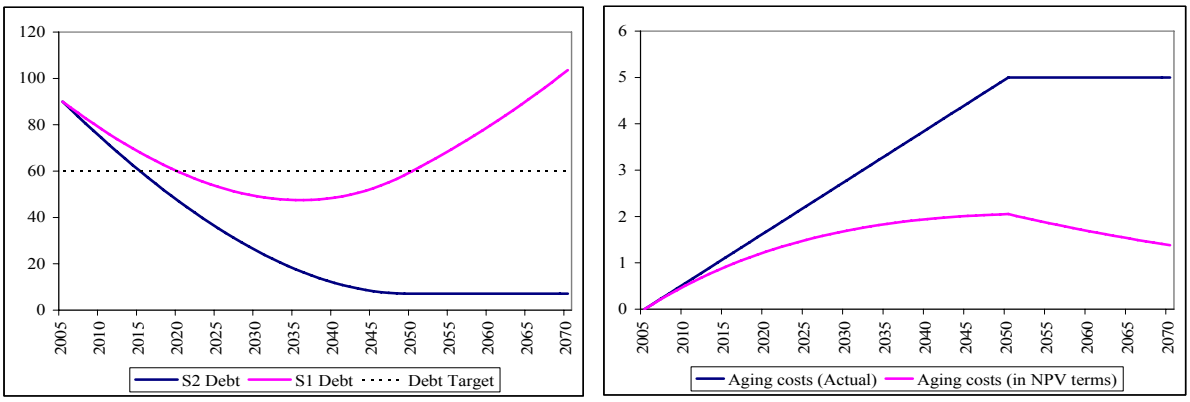
In this example the indicator produces an adjustment of 6 percentage points of GDP to restore sustainability. The *balance* component contributes with 1 percentage point of GDP, while the *debt* component adds 1.8 percentage points of GDP to the indicator. The contribution from the *aging* component is 3.3 percentage points of GDP, which is smaller than the total expenditure increase because of the gradual phasing of the higher expenditures and the discount factor (See Table A.3).

Table A.3. Stylized Example of How to Calculate the Sustainability Indicator
(Percent of GDP)

	Technical terms	Stylized example
Balance	P_0	-1.0
Debt	$-r \cdot d_{-1}$	-1.8
Aging	$r \cdot NPV$	-3.3
Indicator		-6.1

It is worth emphasizing that compliance with the sustainability indicator always stabilizes the debt ratio at a permanently sustainable level. The debt dynamics as a result of applying the indicator can in some instances even be negative, depending on the initial debt stock and primary balance as well as the profile of age-related expenditure increases.

Figure A.3. Debt Dynamics and Aging Costs in the Stylized Example
(Percent of GDP)



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