Government and Foreign Debt - Global Projections to 2050

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Long-term debt is the result of the accumulation of short-term budget decisions. Only when debt problems are acute do they become the focus of short-term policy. However it is not easy to turn around debt problems in the short term. An objective then, is to make debt a long-term issue rather than a short-term one.

As part of the planning process, it is useful to be aware of long-term issues that affect debt. Sometimes long-term factors can be predicted with a greater degree of confidence than short-term ones. With regard to government debt, long-term changes in population demographics that will affect government budgets can be seen well in advance. As populations age, government revenue per capita will decrease, and government expenditures will increase. This paper attempts to quantify this effect.

Another debt issue, not entirely unrelated, is that of foreign debt. Patterns of international trade in future are quite uncertain. However we can be reasonably certain that the trade surpluses of resource exporters will continue in future, and that these may intensify, as fossil fuel reserves decline and prices increase. This also may be forecast with a fair degree of confidence.

The financial imbalances that arise as a result of the geographical distribution of mineral resources around the planet is an issue that may prove even more intractable than that of government debt. Government debt issues are (Europe aside) generally within the purview of national governments to solve. Foreign debt issues may sometimes beyond the jurisdiction of the affected country to resolve. The purpose of this paper is to examine these issues.

In examining government debt issues, the purpose here is not to provide specific forecasts of government debt to 2050, but to assess the effects of demographic changes on government finances at that time. To do this, the methodology employed is to project government finances with, and without demographic changes, and to assess the effect of the changes as the differences between them. This analysis does not use a full model run with multiplier effects.

In examining foreign debt issues, a full simulation model is used. The purpose here *is* to provide a specific forecast of issues affecting debt. This is necessary in order to connect national depletion of fuel reserves with the effect on world trade and trade balances. Chronic trade imbalances will make fiscal imbalances harder to solve in deficit countries, because of the lack of domestic revenue.

Population and demographics

Global population is forecast to peak later this century. In many developed countries population is already declining. The major factors at work here are declining rates of fertility and increased life expectancy. As population matures in developing countries, a larger proportion moves from the dependent young age group (age less than 15) to the working age bracket (age 15 to less than 65). In developed countries, especially with respect to the baby boom generation, as the population matures, a larger proportion moves from the working age bracket to the more dependent age group (age 65 or more).

The United Nations produces extensive projections of population[1]. The assumptions underlying these are that fertility rates in developing countries will decline towards developed country levels and that life expectancy will generally increase. It is worth noting, perhaps, that the projections do not envisage that any catastrophic economic or environmental circumstances will intervene, causing for example severe shortages of food or water, to the extent that population levels will be affected. Thus it is assumed that technical progress and modernization will continue to forestall the 200-year old prognosis of Thomas Malthus. The extent to which the adverse effects of climate change may intervene is uncertain, but it is an additional risk.

Forecasts of population by region are summarized in Table 1. These are based on mid-range projections. One of the most striking features is the rise in population in Africa, which outpaces other regions. Africa moves from 9 percent of the world's population in 1980 to 19 percent in 2050. Asia (mainly India) also marginally increases as a proportion, while all other regions decline as a proportion of the total.

Table 1. Population by region, 2010-2050, millions

Region	1980	1990	2000	2010	2020	2030	2040	2050
World	4403.5	5223.6	6033.4	6818.1	7651.8	8422.4	8999.3	9403.9
North-America	252.1	277.6	312.9	344.1	376.1	409.1	442.5	476.1
Western Europe	383.0	391.7	402.1	421.2	435.2	443.8	446.6	443.5
Eastern Europe	287.7	296.3	289.9	278.8	276.1	269.7	257.3	241.9
Other Devel. Countries	145.2	155.3	162.0	167.1	169.1	166.5	160.1	149.8
China	987.0	1143.3	1267.4	1341.4	1413.9	1465.0	1462.8	1431.6
Latin America, Caribb'n	344.1	422.3	497.7	565.9	628.4	678.0	703.8	708.7
South and East Asia	1211.6	1500.2	1799.5	2088.0	2389.3	2657.8	2859.4	2985.8
West Asia & Mid. East	329.5	418.0	508.0	606.0	702.9	791.9	859.1	903.0
Africa	390.2	523.6	674.5	859.1	1078.4	1319.4	1552.3	1777.7
Least devel. countries	167.8	226.7	295.6	380.9	498.4	638.5	780.6	931.2

Source: Based on UNDESA and Population Reference Bureau data.

The corresponding growth rates of population by region are shown in Table 2. Only Africa and the least developed countries (which include some African countries) continue to grow strongly by 2050.

Table 2. Population growth by region, 2010-2050, percent

Region	1990	2000	2010	2020	2030	2040	2050
World	1.7	1.5	1.2	1.2	1.0	0.7	0.4
North-America	1.0	1.2	1.0	0.9	0.8	0.8	0.7
Western Europe	0.2	0.3	0.5	0.3	0.2	0.1	-0.1
Eastern Europe	0.3	-0.2	-0.4	-0.1	-0.2	-0.5	-0.6
Other Developed Countries	0.7	0.4	0.3	0.1	-0.2	-0.4	-0.7
China	1.5	1.0	0.6	0.5	0.4	0.0	-0.2
Latin America & Caribbean	2.1	1.7	1.3	1.1	0.8	0.4	0.1
South & East Asia	2.2	1.8	1.5	1.4	1.1	0.7	0.4
West Asia & Middle East	2.4	2.0	1.8	1.5	1.2	0.8	0.5

[1] See for example World Population to 2300, United Nations Department of Economic and Social Affairs, Population Division, 2004, and World Population Ageing 2009, *ibid*.

Africa	3.0	2.6	2.4	2.3	2.0	1.6	1.4
Least developed countries	3.1	2.7	2.6	2.7	2.5	2.0	1.8

Source: Based on UNDESA and Population Reference Bureau data.

Population for selected countries is shown in Table 3 and corresponding growth rates in Table 4. These countries have been selected because of their representative nature in terms of demographics and debt characteristics.

Table 3. Population, selected countries 2010-2050, millions

Country	1980	1990	2000	2010	2020	2030	2040	2050
Australia	14.7	17.2	19.3	22.2	26.2	29.6	32.6	34.3
Belgium	9.9	10.0	10.3	10.9	11.6	12.1	12.4	12.6
Brazil	118.6	146.6	171.3	193.3	210.0	219.2	220.9	213.8
Canada	24.5	27.6	30.6	34.1	38.1	42.0	45.2	47.7
China	987.0	1143.3	1267.4	1341.4	1413.9	1465.0	1462.8	1431.6
Costa Rica	2.3	3.0	3.8	4.6	5.1	5.6	5.9	6.1
France	53.7	56.7	59.1	63.0	65.8	67.9	69.0	69.1
Germany	76.8	78.9	82.1	81.6	79.5	77.3	74.4	71.4
Greece	9.6	10.2	10.9	11.2	11.6	11.9	11.9	11.7
India	692.6	862.2	1042.6	1215.9	1392.5	1544.3	1668.0	1745.6
Indonesia	148.0	179.8	205.1	234.4	263.7	288.2	303.2	309.4
Ireland	3.4	3.5	3.8	4.5	5.1	5.8	6.1	6.3
Italy	56.4	56.7	56.9	60.3	62.8	63.8	63.8	62.3
Japan	116.8	123.4	126.8	127.5	123.9	116.8	106.8	94.6
Mexico	67.6	83.2	98.0	108.6	119.1	127.3	129.0	127.0
Nigeria	68.4	90.6	119.0	156.1	197.0	242.4	287.6	332.2
Portugal	9.8	10.0	10.2	10.6	10.7	10.8	10.8	10.8
Russia	140.8	147.7	146.3	140.4	139.9	137.7	132.5	125.7
Saudi Arabia	9.3	15.2	20.5	26.1	31.5	37.7	43.9	50.6
Spain	37.4	38.8	40.3	46.0	49.2	50.5	51.1	49.8
United Kingdom	56.3	57.2	58.9	62.2	65.9	69.6	73.3	77.1
United States	227.6	250.0	282.3	310.0	338.0	367.1	397.3	428.4

Source: Based on UNDESA, Population Reference Bureau data and other sources.

Table 4. Population growth, selected countries, 2010-2050, percent

Country	1990	2000	2010	2020	2030	2040	2050
Australia	1.6	1.2	1.4	1.7	1.2	0.9	0.4
Belgium	0.1	0.3	0.6	0.6	0.4	0.3	0.1
Brazil	2.1	1.6	1.2	0.8	0.4	0.1	-0.3
Canada	1.2	1.0	1.1	1.1	1.0	0.7	0.6
China	1.5	1.0	0.6	0.5	0.4	0.0	-0.2
Costa Rica	2.7	2.4	1.8	1.2	0.9	0.5	0.2
France	0.5	0.4	0.6	0.4	0.4	0.3	0.2
Germany	0.3	0.4	-0.1	-0.3	-0.3	-0.4	-0.4
Greece	0.6	0.7	0.3	0.4	0.2	0.0	-0.2
India	2.2	1.9	1.5	1.4	1.0	0.8	0.5

Indonesia	2.0	1.3	1.3	1.2	0.9	0.5	0.2
Ireland	0.3	0.8	1.6	1.3	1.3	0.5	0.4
Italy	0.1	0.0	0.6	0.4	0.2	0.0	-0.2
Japan	0.6	0.3	0.1	-0.3	-0.6	-0.9	-1.2
Mexico	2.1	1.7	1.0	0.9	0.7	0.2	0.0
Nigeria	2.9	2.8	2.7	2.4	2.1	1.7	1.5
Portugal	0.2	0.2	0.4	0.1	0.1	0.0	0.0
Russia	0.5	-0.1	-0.4	0.0	-0.2	-0.4	-0.5
Saudi Arabia	5.0	3.0	2.4	1.9	1.8	1.4	1.3
Spain	0.4	0.4	1.3	0.7	0.2	0.0	-0.4
United Kingdom	0.2	0.3	0.6	0.6	0.5	0.5	0.5
United States	0.9	1.2	0.9	0.9	0.8	0.8	0.8

Source: Based on UNDESA, Population Reference Bureau data and other sources.

The proportion of population in three age groups is shown in the next three tables, for selected countries. These data are derived from a population model that computes male and female population by year of age for all countries. It is based on an initial population distribution which is then modified, year by year, with birth, death and net migration rates. These have been adjusted so that the total population, by country, matches the mid-range projections published by the Population Reference Bureau, for about 200 countries. Fine tuning birthrates by country was the primary mechanism used in calculations, to match the external population totals.

Table 5 gives the population age less than 15. This proportion declines for all countries, more so in countries where the birthrate is low, and less so for countries where the birthrate remains relatively high.

Table 5. Population age 0-14, selected countries 2010-2050, percent

Country	1980	1990	2000	2010	2020	2030	2040	2050
Australia	22.7	19.1	19.1	19.0	16.9	12.9	12.0	10.9
Belgium	22.1	16.9	17.0	17.0	16.3	15.6	13.8	12.6
Brazil	37.3	25.9	26.8	27.0	20.9	15.6	11.7	10.1
Canada	23.3	16.9	17.0	17.0	16.2	15.4	13.7	12.6
China	35.7	17.4	18.0	18.0	17.0	15.8	11.0	10.2
Costa Rica	30.1	22.9	23.0	23.0	21.3	17.7	13.7	10.7
France	22.1	18.3	18.1	18.0	18.6	17.5	15.3	13.6
Germany	22.1	13.7	13.9	14.0	12.6	12.4	10.8	10.7
Greece	22.1	14.6	14.2	14.0	16.0	15.4	12.6	11.2
India	38.6	31.1	31.8	32.0	26.9	23.1	20.3	16.6
Indonesia	43.0	27.7	27.9	28.0	25.0	21.9	17.2	13.2
Ireland	22.1	21.5	21.1	21.0	26.0	28.3	18.8	16.7
Italy	22.1	14.4	14.1	14.0	13.8	11.6	11.1	11.0
Japan	23.6	13.4	13.1	13.0	12.4	10.8	10.8	10.9
Mexico	27.9	28.0	28.7	29.0	25.5	22.6	15.0	11.0
Nigeria	45.0	43.0	43.0	43.0	43.4	42.0	39.0	36.7
Portugal	22.1	14.8	15.0	15.0	13.7	13.5	13.5	13.5
Russia	22.5	15.5	15.2	15.0	16.9	16.5	13.9	12.3
Saudi Arabia	43.0	37.1	37.8	38.0	35.1	33.8	29.6	27.4

Spain	22.1	15.4	15.1	15.0	13.6	11.0	11.0	10.9
United Kingdom	22.1	18.2	18.1	18.0	18.6	18.7	18.7	18.8
United States	22.8	19.8	20.0	20.0	19.7	19.7	19.7	19.8

Source: Based on Population Reference Bureau data and other sources.

Table 6 shows the proportion of working age people, ages 15 to less than 65. This proportion tends to rise for countries with a relatively young population which then matures. It declines for countries which are already relatively mature and have larger proportions moving into the elderly age bracket. Thus developed countries will have higher dependency ratios in future (ratio of <15 plus 65+ to 15-64), while for others it will be lower.

Table 6. Population age 15-60, selected countries, 2010-2050, percent

Country	1980	1990	2000	2010	2020	2030	2040	2050
Australia	66.2	68.4	67.9	68.0	68.0	68.8	65.8	63.5
Belgium	64.7	66.3	66.0	66.0	63.0	59.6	58.4	56.9
Brazil	58.5	66.8	66.1	66.0	67.8	66.9	64.3	60.0
Canada	65.5	69.2	69.0	69.0	66.1	62.5	60.6	58.6
China	59.6	74.2	73.8	74.0	66.1	57.7	52.2	49.4
Costa Rica	63.9	69.5	69.7	70.0	64.3	60.4	57.8	55.6
France	64.7	65.3	64.9	65.0	60.9	58.2	57.7	57.6
Germany	64.7	66.6	65.9	66.0	60.3	53.1	49.5	46.3
Greece	64.7	67.0	66.8	67.0	59.6	54.2	52.9	52.9
India	57.3	63.4	63.0	63.0	63.9	63.4	62.8	62.5
Indonesia	53.6	66.1	65.9	66.0	64.4	61.8	60.8	60.3
Ireland	64.7	66.3	67.6	68.0	55.3	48.6	55.5	56.7
Italy	64.7	66.8	66.0	66.0	63.5	61.0	57.7	55.7
Japan	67.2	66.2	63.8	64.0	57.7	54.2	46.6	42.7
Mexico	64.4	64.8	65.0	65.0	62.0	60.0	63.3	61.5
Nigeria	52.0	53.7	53.9	54.0	52.0	52.5	54.9	57.1
Portugal	64.7	67.4	66.9	67.0	62.7	57.0	53.3	51.2
Russia	68.0	71.5	71.6	72.0	60.4	53.3	52.4	53.7
Saudi Arabia	53.6	59.9	60.0	60.0	58.5	56.0	56.9	56.2
Spain	64.7	68.1	67.9	68.0	65.8	63.3	58.9	56.0
United Kingdom	64.7	65.9	65.9	66.0	60.9	56.7	54.9	54.7
United States	66.1	66.8	67.0	67.0	62.5	57.6	55.9	55.4

Source: Based on Population Reference Bureau data and other sources.

Table 7 shows the population aged 65 or more. There is substantial variation between countries and across time periods. In countries with fast-growing populations, the aged proportion decreases, due to the high growth in the younger age groups. In countries with low birth rates and falling populations, the aged proportion rises markedly.

Table 7. Population age 65-100+, selected countries, 2010-2050, percent

Country	1980	1990	2000	2010	2020	2030	2040	2050
Australia	11.1	12.5	13.0	13.0	15.0	18.3	22.2	25.6
Belgium	13.2	16.8	17.0	17.0	20.7	24.8	27.9	30.5
Brazil	4.3	7.3	7.2	7.0	11.3	17.4	24.0	30.0

Canada	11.3	14.0	14.1	14.0	17.7	22.0	25.7	28.9
China	4.6	8.4	8.3	8.0	16.8	26.5	36.8	40.3
Costa Rica	6.0	7.6	7.3	7.0	14.4	21.9	28.5	33.7
France	13.2	16.5	17.0	17.0	20.6	24.4	27.0	28.8
Germany	13.2	19.7	20.1	20.0	27.1	34.5	39.7	43.0
Greece	13.2	18.4	19.1	19.0	24.4	30.4	34.5	35.9
India	4.2	5.5	5.2	5.0	9.2	13.5	17.0	20.8
Indonesia	3.4	6.2	6.2	6.0	10.6	16.3	22.0	26.5
Ireland	13.2	12.2	11.3	11.0	18.7	23.1	25.7	26.6
Italy	13.2	18.8	19.9	20.0	22.7	27.4	31.1	33.2
Japan	9.3	20.4	23.0	23.0	30.0	35.0	42.5	46.4
Mexico	7.7	7.2	6.3	6.0	12.5	17.4	21.7	27.5
Nigeria	3.1	3.3	3.1	3.0	4.6	5.5	6.1	6.2
Portugal	13.2	17.8	18.1	18.0	23.6	29.4	33.2	35.3
Russia	9.5	13.0	13.2	13.0	22.7	30.2	33.7	34.0
Saudi Arabia	3.4	3.0	2.2	2.0	6.4	10.2	13.5	16.4
Spain	13.2	16.5	17.0	17.0	20.6	25.6	30.1	33.0
United Kingdom	13.2	16.0	16.1	16.0	20.5	24.5	26.4	26.5
United States	11.2	13.4	13.1	13.0	17.8	22.7	24.4	24.8

Source: Based on Population Reference Bureau data and other sources.

The rise in the aged population proportion is modified in developed countries that have higher net migration intakes, which are assumed to continue, but at reduced rates.

Government debt

In order to estimate the effects that demographic changes will have on government debt, we first need to establish the relationship between government deficits (expenditure less revenue) and debt. We then need a procedure to make long-term projections on this basis. Finally, we will need to analyse the effect of demographic changes on the projections.

The primary deficit (excluding interest payments and receipts) is given by:

$$\mathbf{P = X - R} \qquad (1)$$

where **P** is the primary deficit (a negative value indicates surplus), **X** is government expenditure, and **R** is government revenue.

The change in government debt is given by:

$$\mathbf{\Delta D = X - R + r D = P + r D} \qquad (2)$$

where **D** is government debt (a negative value indicates credit) and **r** is the interest rate on debt, so that **r D** is the debt servicing cost. Note that there will be no change in debt if **R = X + r D**, or **P = – r D**.

In terms of shares of GDP, the equation is:

$$\Delta D / Y = \frac{P}{Y} + r\frac{D}{Y} \qquad (3)$$

where **Y** is GDP. A relationship describing the change in the debt share of GDP is given by:

$$\Delta\frac{D}{Y} = \frac{P}{Y} + (r - g)\frac{D}{Y} \qquad (4)$$

where **g** is the nominal rate of GDP growth[1]. It is apparent from this that the debt level may be reduced by reducing the primary deficit, reducing the rate of interest, or increasing the rate of nominal GDP growth. Governments may thus seek to reduce the level of debt by offering the debt at a low rate or by using inflation to reduce its real value. This strategy may be thwarted if the government is forced to pay market rates for its debt, or if exchange rate changes increase its value. The debt will not be sustainable if $r > g$.

The equation implies that the debt will be stable $\left(\Delta\frac{D}{Y} = 0\right)$ if

$$\frac{P}{Y} = (g - r)\frac{D}{Y} \qquad (5)$$

and that the long-term debt level is given by

$$\frac{D}{Y} = \frac{P}{Y} / (g - r) \qquad (6)$$

Note that this implies that the long-term debt ratio will be 100 percent of GDP if the deficit is 1 percent of GDP and $g - r$ is 1 percent.

These relationships have been used to investigate debt levels by country. The IMF World Economic Outlook provides financial data for about 200 countries. These have been used to obtain the primary deficit and net debt levels. The data have been matched to equation (2), estimating missing data for debt, primary expenditure and revenue where necessary. This leaves **r**, the implicit interest average rate on debt as the remaining unknown. It can thus be estimated from the data. Using this relationship, the value of debt can be replicated over the historical period.

In order to project estimates for debt and deficits to 2050 using the above relationships we need to estimate suitable values for **r** and **g**. The average nominal GDP growth rate over the available historical data can be used as an estimate of **g**. To estimate **r** we can use:

$$r = (\Delta D - P) / D \qquad (7)$$

[1] To see how this is derived, note that by the quotient rule in differential calculus:

$$\begin{aligned}\Delta(D/Y) &= \Delta D/Y - (\Delta Y/Y)(D/Y)\\ &= P/Y + r\,D/Y - (\Delta Y/Y)(D/Y) \qquad \text{(using 3)}\\ &= P/Y + (r-g)\,(D/Y)\end{aligned}$$

For a comprehensive theoretical summary see Julio Escolano, *A Practical Guide to Public Debt Dynamics, Fiscal Sustainability, and Cyclical Adjustment of Budgetary Aggregates*, Fiscal Affairs Department, IMF, 2010.

where the average value of **r** can be computed from the historical data. However this estimate is imprecise for countries where D is near zero. Another method is to find the value of **r** that equates the calculated and actual value of D at the end of the historical period. In the results shown in Table 8 for 2010, a composite figure is shown. Government expenditures, revenues and debt figures are a four-year average.

Table 8. Government deficit, debt and interest, selected countries, 2010

Country	Interest rate on debt r	Nominal GDP growth g	Expenditure % of GDP X/Y	Revenue % of GDP R/Y	Primary Deficit % of GDP P/Y	Debt % of GDP D/Y
Greece	8.4	5.2	44.7	39.7	5.0	142.0
Japan	1.8	0.2	37.5	31.7	5.8	117.5
Italy	5.4	3.2	45.1	46.2	-1.1	99.6
Belgium	5.0	3.8	46.9	47.3	-0.4	81.5
Portugal	5.0	3.5	42.6	39.8	2.8	79.1
France	4.7	3.5	51.6	48.5	3.0	74.5
India	5.9	13.2	19.3	15.7	3.6	72.2
United Kingdom	5.0	4.8	41.5	36.5	5.1	69.4
Ireland	4.2	6.1	51.5	38.8	12.7	69.4
United States	3.6	4.5	37.3	31.2	6.1	64.8
Germany	5.3	2.3	42.2	43.0	-0.8	53.8
Spain	4.7	5.1	41.7	37.2	4.5	48.8
Brazil	12.5	11.1	28.5	31.0	-2.5	40.2
Costa Rica	8.8	12.7	20.1	19.7	0.5	39.4
Mexico	5.7	7.9	21.4	20.4	1.0	38.1
Canada	3.3	4.8	39.7	37.9	1.7	32.2
Indonesia	5.3	14.5	14.4	14.9	-0.6	26.9
Nigeria	2.6	19.9	23.7	21.0	2.7	18.3
China	7.1	12.8	17.0	16.6	0.5	17.7
Russia	6.8	17.3	32.7	33.0	-0.3	9.9
Australia	4.3	6.2	33.1	31.1	2.0	5.5
European Union	7.9	6.5	44.9	43.9	0.9	58.1

Source: Based on IMF World Economic Outlook 2011 data.

In Table 8, the same countries are shown as before, but in order of debt to GDP ratio. This highlights many of the countries currently in debt difficulties. For comparison, the European Union is included as the last row of the Table.

Note that for several countries the debt is unsustainable since **r > g**. In order to use (2) as a basis for long-term projection it has been assumed that **r** and **g** converge to values such that the debt is sustainable. To ensure that **g > r** it has been assumed that **g** converges geometrically towards **r+1** in 2050. If the value of **r** exceeds 4, it is also assumed that it converges geometrically towards 4 in 2050.

If government expenditure **X** and revenue **R** both grow at the same rate as GDP, then the deficit remains constant as a proportion of GDP. In order to stabilise the debt and balance the budget in

the long term, the primary deficit should be a surplus equal to the debt servicing cost. To achieve this, expenditure and revenue grow with GDP but are adjusted by a small increment, based on the initial imbalance, to bring debt to stability by 2050. This assumption can be written as

$$\dot{\mathbf{x}} = \alpha_x + \mathbf{g} \qquad (8)$$

$$\dot{\mathbf{r}} = \alpha_r + \mathbf{g} \qquad (9)$$

where $\dot{\mathbf{x}}$ and $\dot{\mathbf{r}}$ are the rates of change of **X** and **R** and α_x and α_r are the adjustment factors. The projected debt levels under these assumptions are shown in Table 9.

Table 9. Government deficit, debt and interest, selected countries, 2050

Country	Interest rate on debt r'	Nominal GDP growth g'	Primary Deficit % of GDP P'/Y	Debt % of GDP D'/Y
Greece	4.6	5.0	-2.9	232.9
Japan	1.8	2.5	-0.9	211.6
Italy	4.2	4.8	-3.4	25.4
Belgium	4.1	4.8	-2.8	19.0
Portugal	4.1	4.8	-1.5	102.7
France	4.1	4.8	-2.3	82.3
India	4.2	6.1	1.6	80.3
United Kingdom	4.1	5.0	-0.3	137.0
Ireland	4.0	5.1	0.6	234.2
United States	3.6	4.6	0.7	152.9
Germany	4.2	4.7	-1.8	15.0
Spain	4.1	5.0	0.0	107.6
Brazil	5.1	5.8	-1.9	-42.7
Costa Rica	4.6	6.0	-0.2	20.6
Mexico	4.2	5.4	0.1	38.6
Canada	3.3	4.3	-0.3	40.3
Indonesia	4.2	6.2	-0.7	-10.0
Nigeria	2.6	5.7	1.5	35.6
China	4.4	6.0	0.2	13.9
Russia	4.4	6.6	-0.3	-6.0
Australia	4.0	5.2	0.8	46.4
European Union	4.5	5.2	-1.6	44.4

Source: Based on IMF World Economic Outlook 2011 data.

In this table **r'** and **g'** are the final values of **r** and **g**, **P'** and **D'** are the final values of the deficit and debt level. Debt stabilises at the values indicated, which are sustainable given the values of **P/Y**, **r'** and **g'**. Whether these values are desirable or plausible is of lesser importance here. It is important that the results provide a base scenario from which the impact of demographic changes can be calculated. The base scenario represents the assumption that there are no demographic changes. Forecast errors will largely be eliminated when the difference between scenarios is taken.

In rates of change equations, the coefficients are elasticities. The effects of demographic changes have been implemented as follows. It is assumed that changes in government expenditures occur with a constant elasticity with respect to changes in the dependent age population proportion. It is also assumed that changes in government revenues occur with a constant elasticity with respect to changes in the working age population proportion. In both cases the elasticity is positive, in that increases in the dependent population would increase expenditure and increases in the working population increase revenue.

Modifying (8) and (9), the equations for the rates of change of **X** and **R** can then be rewritten as:

$$\dot{x} = g + \alpha_x + \beta_x \dot{d} \qquad (10)$$

$$\dot{r} = g + \alpha_r + \beta_r \dot{w} \qquad (11)$$

where $\dot{d}$ and $\dot{w}$ are the rates of change of the dependent and working populations and β_x and β_r are the elasticities. We can then recompute estimates for expenditure and revenue, and thus deficit and debt, using the demographic data from Tables 5 and 7 for the dependent population and Table 6 for the working age population. The results of this are shown in Table 10.

Table 10. Effect of demographics on government debt, selected countries, 2050

Country	Expenditure % of GDP X'/Y	Revenue % of GDP R'/Y	Primary Deficit % of GDP P'/Y	Debt % of GDP D'/Y	Difference in Deficit dP/Y (Revenue required)	Difference in Debt dD/Y
Greece	48.3	40.8	7.5	560.0	10.4	327.1
Japan	42.8	31.0	11.8	481.6	12.7	270.0
Italy	49.9	45.1	4.8	195.3	8.2	169.9
Belgium	51.3	46.5	4.8	194.9	7.5	175.9
Portugal	48.9	38.8	10.0	364.0	11.5	261.3
France	53.7	49.4	4.2	272.4	6.5	190.1
India	18.4	16.6	1.8	80.1	0.1	-0.3
United Kingdom	44.5	37.0	7.5	341.0	7.7	204.0
Ireland	52.0	42.2	9.8	595.7	9.2	361.5
United States	39.8	31.9	7.9	328.0	7.1	175.1
Germany	52.1	39.3	12.7	362.2	14.6	347.2
Spain	45.8	37.3	8.6	259.1	8.6	151.5
Brazil	31.2	29.9	1.3	-32.6	3.2	10.1
Costa Rica	23.7	18.8	5.0	125.3	5.1	104.7
Mexico	21.9	20.5	1.4	74.2	1.3	35.6
Canada	44.4	37.2	7.3	192.4	7.6	152.0
Indonesia	15.4	14.6	0.7	16.7	1.4	26.7
Nigeria	22.3	21.9	0.4	31.5	-1.1	-4.1
China	22.9	15.0	8.0	166.4	7.8	152.5
Russia	40.9	30.5	10.3	228.9	10.6	234.9
Australia	34.6	31.0	3.5	65.9	2.7	19.5
European Union	51.4	42.4	9.1	306.9	10.6	262.5
Euro zone	51.3	43.1	8.3	291.8	10.0	235.8

Source: Based on IMF World Economic Outlook 2011 data and demographic projections derived from Population Reference Bureau data.

The levels of government expenditure and revenue in this table show the effect of demographic changes. In the calculations, an elasticity value of 0.5 was used for the dependent population in the expenditure equation and a value of 0.3 was used for the elasticity of working population in the revenue equation. Health care costs for the aged is the principal reason that government expenditure is more sensitive to aging than is revenue. In the absence of any reliable across-the-board estimates, these values seem reasonable, at least for developed countries.

The results in Table 10 naturally show large blowouts in debt as a result of taking into account demographic changes. This does not suggest that these blowouts will occur. It is simply a consequence of the requirement of having an unconstrained experiment in relation to the base case. The most relevant results are those shown in the **dP/Y** column. These indicate the change in the deficit, and thus the funding requirement in order to accommodate the demographic changes.

For the United States, the results indicate that an additional tax revenue of 7.1 percent of GDP will be required. This compares with other U.S. estimates indicating that government spending on Social Security and Medicare will rise from 8.4 percent of GDP in 2010 to 14.5 percent in 2050, an increase of 6.1 percent[1]. This appears consistent with the results here, as it does not include the effect on revenue. In the case of Australia, government estimates also show similar results to those obtained here[2]. To this extent at least, the estimates appear satisfactory.

Conclusions – government debt

The results indicate that for countries that already have considerable debt problems, the situation will get substantially worse when demographic changes are taken into account. Ultimately, the only way the problems will be resolved will be by increasing taxes as a proportion of GDP by approximately the amount indicated by the population-adjusted deficit ratio. If social expenditures are to be funded from government revenue, there will be no alternative.

The amount of additional funding required is larger in countries where the government share of GDP is already large. Therefore one solution may be to apply more means tests to expenditures. However if revenue is to be raised, a carbon tax should be the vehicle of choice.

While tax increases are unpopular, economists should be prepared to advocate the benefits of a more equitable distribution of income and wealth. Surveys show a greater sense of perceived well-being in societies that are more equitable[3]. The theory of the declining marginal utility of income also implies that general welfare increases with equality. The fact that the marginal propensity to consume also declines with income also suggests the advantage of progressive taxation in minimising the fiscal effect of an increase.

By contrast with developed countries, in the case of high population growth developing countries, the results show that there will be a budgetary improvement as a result of the demographic shift.

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[1] A Summary of the 2009 Annual Social Security and Medicare Trust Fund Reports (2009), U.S. Social Security Administration quoted in *World Population Highlights: Focus on Aging,* Population Reference Bureau, 2010.

[2] *Australia to 2050: Future Challenges*, The 2010 Intergenerational Report, The Treasury.

[3] For example, a 2011 study by University of Virginia psychologist Shigehiro Oishi comparing 54 nations found that more progressive the tax policy is, the happier the citizens are.

In reality, their government finances are substantially different. They are included here for comparison. The fiscal benefit in these countries should be used to advantage while the opportunity exists, as they will likely face a range of other difficult issues.

Developed countries will need to pay for their low birth rate with a higher tax rate. Developing countries may need to pay for their high birth rate with a higher death rate. This gives new meaning to the old adage that nothing is certain except death and taxes.

Foreign debt

The relationship between the current account balance and foreign debt is somewhat analogous to that of the budget deficit and government debt. The current account balance can be described as

$$\mathbf{CAB = X - M + NY - NCT} \qquad (12)$$

where CAB is the current account balance, X is exports, M is imports, NY is net income from abroad and NCT is net current transfers. This is related to foreign debt according to

$$\mathbf{CAB = \Delta\, NFA + \Delta\, E - V} \qquad (13)$$

Where $\mathbf{\Delta\, NFA}$ is the change in net foreign assets, $\mathbf{\Delta\, E}$ is the change in equity investments and **V** are valuation effects. Unlike the situation with regard to government debt, it is quite difficult to find data that fully resemble this relationship for many countries[1]. In countries that have strong current account surpluses, the data reveal quite a strong relationship between the balance and asset increases, such that the cumulative current account balance equates quite closely with foreign assets.

$$\mathbf{NFA' = \Sigma\, CAB} \qquad (14)$$

Rather than seeking a standard relationship that applies across all countries, as for government debt, the approach here has been to obtain model results for the commodity components of trade that give rise to strong surpluses and deficits in particular countries[2]. The cumulative current account should provide a strong indication of pressures on foreign debt and asset positions over the forecast period.

It should be noted that considerable uncertainty surrounds these results for several reasons. Firstly, unlike with the government debt projections, where taking the difference between alternative projections of debt could be expected to eliminate some error, here, taking the difference between projections of exports and imports accentuates the errors in both. Calculating the cumulative balance compounds these errors.

Secondly, apart from data errors, the model results themselves are quite sensitive to the input assumptions, particularly with regard to projected fossil fuel use in relation to GDP. The major assumption used in producing the following results is that fossil fuel use will decline by about 3 percent per year in relation to GDP. The main justification for this is not that the world will begin

[1] Extensive investigations were conducted with the IMF's International Financial Statistics on CD ROM, which contains over 56,000 series.

[2] The used model was outlined at the Project LINK meeting in Bangkok in October 2009. See "Energy Resource Depletion and Carbon Emissions: Global Projections to 2050", which can be found at http://nieir.com.au/research_centre/project_link.html.

to enthusiastically adopt greenhouse gas abatement measures, but that circumstances will compel it due to declines in national fossil fuel reserves.

Aside from the factors leading to uncertainty, there is nevertheless a compelling logic to the fact that as countries run low on fossil fuel reserves, they will either import more or use less. Hence the following results should be viewed in this context. Results are provided separately for coal, oil and natural gas, for major world markets. The figures are cumulative deficits from 2003.

Table 11. Coal trade cumulative balance - $US trillion, current prices

Country	2010	2020	2030	2040	2050
United States	0.01	0.10	0.27	0.61	1.18
Russia	0.03	0.13	0.36	1.00	2.30
China	0.06	0.12	-0.34	-2.69	-8.03
Australia	0.15	0.39	0.87	1.87	3.59
India	-0.04	-0.11	-0.22	-0.43	-0.85
South Africa	0.03	0.11	0.24	0.51	1.07
Japan	-0.13	-0.37	-0.63	-0.74	-0.34

Source: MELTrade Model, NIEIR, Melbourne.

The projections for coal indicate that China, the world's largest coal consumer, will increasingly rely on imports for its supply of coal. China's accumulated trade deficit in coal is projected to rise to 8 trillion dollars (i.e million million dollars) This coal will be provided by the US, Russia and Australia, which have the largest reserves of coal. India, which also has large reserves of coal, but which is increasingly difficult to extract, will also rely on imports, but not the extent of China.

Table 12. Oil trade cumulative balance - $US trillion, current prices

Country	2010	2020	2030	2040	2050
United States	-2.10	-6.41	-12.86	-21.15	-30.83
Russia	1.01	2.43	3.26	2.96	1.92
China	-0.53	-2.42	-6.12	-10.74	-15.64
Canada	0.14	0.64	1.78	3.75	6.67
India	-0.38	-1.25	-2.77	-4.88	-7.42
Indonesia	-0.06	-0.31	-0.87	-1.69	-2.67
Japan	-0.85	-2.09	-3.68	-5.60	-7.75
Korea	-0.37	-1.01	-1.91	-3.03	-4.34
Saudi Arabia	1.40	4.45	10.01	18.28	29.18
Iraq	0.18	1.00	3.14	7.30	14.57
Iran	0.47	1.73	4.34	8.58	14.64
OtherWest Asia	0.68	1.94	3.95	6.59	9.42

Source: MELTrade Model, NIEIR, Melbourne.

The results for oil give an indication of the extent to which depletion of domestic oil reserves in the United States and China will impact upon their foreign balances. By 2030, the U.S. will have accumulated a 13 trillion dollar deficit in oil trade, and China a six trillion dollar deficit. By contrast Saudi Arabia, Iraq, Iran and other West Asia oil exporters will have amassed a

cumulative surplus of over $21 trillion by 2030[1]. By 2050 the combined US-China oil deficit has risen to over $45 trillion and the corresponding exporter surplus has risen to about $70 trillion.

Table 13. Natural gas trade cumulative balance - $US trillion

Country	2010	2020	2030	2040	2050
United States	-0.29	-0.18	1.06	4.70	12.34
Russia	0.16	0.47	1.37	3.30	6.16
China	-0.02	-0.06	-0.95	-6.53	-17.75
Canada	0.25	0.17	-0.55	-1.90	-3.87
India	-0.02	-0.12	-0.41	-1.04	-2.13
Indonesia	0.08	0.22	0.51	1.05	1.74
Japan	-0.26	-0.66	-1.23	-2.03	-3.13
Korea	-0.11	-0.32	-0.68	-1.17	-1.83
Iran	0.01	0.13	0.55	1.67	3.94
Other West Asia	0.13	0.51	1.50	3.73	7.67

Source: MELTrade Model, NIEIR, Melbourne.

The results for natural gas indicate the China will again be a major importer. It is assumed that recent revised estimates of US gas reserves will enable that country to be an exporter. The major exporter in the Other West Asia region is Qatar.

Conclusions – Foreign debt

The results indicate that significant financial imbalances will arise due to the geographical distribution on fossil fuel reserves. Within countries where resource wealth is spread inequitably across regions, national governments routinely intervene to spread the benefits more evenly. In cases where the scarcity value of minerals far exceeds the marginal cost of production, resulting in excess profits of mining companies, governments can also intervene to impose resource rent taxes[2].

In the international sphere there is no jurisdiction through which such taxes could be imposed. However the problems of inequity may be more acute internationally, and so some cooperative solution would be desirable.

Certainly from a global equity viewpoint it would be preferable if monopoly profits from the extraction of exhaustible resources could be used for the benefit of the international community. In the case of fossil fuel resources, increased prices due to resource depletion will eventually do what carbon taxes and trading schemes may not: substitution of energy production into renewables. However this may come too late to prevent damaging if not catastrophic climate change.

A global resource rent or carbon tax on production could be achieved with the agreement of a relatively small number of exporting countries. The funds received could be paid into a global

[1] By comparison, the International Energy Agency, in a report issued prior to the 2009 Copenhagen meeting on climate change, said that: “OPEC revenues from oil and gas exports in the 450 Scenario increase to $23 trillion between 2008 and 2030, a four-fold increase, compared to the period 1985-2007”. See *How the Energy Sector Can Deliver on Climate Change*, IEA, 2009, page 12.

[2] The Australian government will soon extend its resource rent tax to include iron ore, coal, oil and natural gas.

fund to assist production of alternative energy. Such a scheme should not properly be seen as merely a tax but as an investment in the future of the planet.

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