Forecasting non-life insurance demand in the BRICS economies: a preliminary evaluation of the impacts of income and climate change

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Abstract

Insurance demand is driven by many factors, but for the emerging economies, one of the most significant historical drivers of growth has been income per capita. Based on a simple forecasting approach, we project that insurance penetration in the BRICS economies could increase at a rate of between 1.6 and 4.2% per year over the coming decade, depending on the country, due to rising per capita income. When other factors are included, this broadens to between 0.1 and 4.3% per year. This equates to a rate of increase in gross premium volumes of between 5.4 and 12.3% per year. The largest growth in insurance penetration and premium volumes is expected in China, closely followed by India and Russia. A concern for (re)insurers is how climate change may impact these growth paths. Based on current projections, we expect the impact on growth mediated through income to be small; less than a 0.4% adjustment in the annual growth rate in premium volumes to 2030.

I. Introduction

Over the past ten years, the emerging economies, in particular the BRICS economies (Brazil, Russia, India, China and South Africa), have seen rapid rates of growth in insurance premium volumes. Today, emerging markets account for 15.5% of the total world non-life premium volume, up from 11.5% in 2005 (Table 1). The five BRICS economies alone have an 8.5% share of the world non-life market. In each of these countries, premium volumes have increased significantly since 2005; compound annual growth rates (CAGR) in real non-life premium volumes between 2005 and 2010 were: South Africa 2.9%; Russia 6.9%; India 9.1%; Brazil 12.5%; and China 25.1%[1]. Conversely, over the same period, annual growth in the industrialised countries (accounting for 84.5% of the world market in 2010), was on average below 3%, and in some markets had stagnated. Yet, the share of the non-life market

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[1] based on Swiss Re (2006, 2011) and data supplied by the global reinsurer Munich Re

of the BRICS economies is small compared with their share of global GDP (26%) and population (42%), suggesting a significant catch-up potential.

Table 1: Non-life insurance premium volume ($ unadjusted). Swiss Re 2006, 2011

	Total Premium Volume in 2010 ($US millions)	Share of World Market in 2010*	Total Premium Volume in 2005 ($US millions)	Share of World Market in 2005*	Premiums per Capita in 2010 ($US)
World	1,818,893	100%	1,452,011	100%	263.0
Emerging Economies	286,383	15.5%	170,694	11.5%	48.5
Africa	19,475	1.0%	12,230	1.0%	18.9
Of which: South Africa	*10,111*	*0.5%*	*7,256*	*0.5%*	
South and East Asia	98,007	5.5%	74,086	5.0%	27.4
Of which: China	*71,628*	*4.0%*	*20,539*	*1.5%*	
India	*10,562*	*0.5%*	*4,848*	*0.5%*	
Latin America and Caribbean	73,320	4.0%	35,336	2.5%	125.6
Of which: Brazil	*30,847*	*1.5%*	*13,399*	*1.0%*	
Central and Eastern Europe	68,187	4.0%	36,322	2.5%	211.6
Of which, Russia	*40,742*	*2.0%*	*16,618*	*1.0%*	

values rounded to the nearest 0.5%

The rapid growth of insurance demand in the emerging economies is expected to continue over the next several years (Hussels *et al.* 2005; Swiss Re 2011), not only in terms of increasing premium volumes but also increasing *insurance penetration*. Insurance penetration measures the total volume of premiums as a ratio of the gross domestic product (GDP). In the emerging economies over the past decade, real premium growth has generally outstripped growth in real GDP, indicating a long-term trend toward increasing insurance penetration. Conversely, in some industrialised countries, premium volumes have grown more slowly than GDP over the past few years, indicating a slight fall in penetration level[2].

In this paper, we are concerned with projecting changes in premium volumes and insurance penetration in the BRICS economies over the next two decades; a period particularly relevant for long-term strategic planning in the insurance industry. Previous authors have analysed the drivers of growth in the emerging economies at an aggregate level and have shown a strong relationship between per-capita income and non-life insurance demand (e.g. Feyen *et al.* 2011; Enz, 2000; Zheng *et al.* 2008, 2009). For this reason, income forecasts are commonly used by the insurance industry to forecast market potential. Here, we investigate the use of forecasts of per-capita income to project demand in the BRIC economies to 2030. In Section II, we review the evidence on the drivers of aggregate insurance demand in the BRICS

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[2] In North America (40% of global non-life market share) real premiums increased by only 0.5% in 2010 (below the ten-year average of around 2.5% per year), while real GDP increased by 2.8% (Swiss Re, 2011).

economies. Section III then uses economic forecasts from three sources to generate forecasts of non-life insurance penetration. In Section IV, we present a new method for forecasting insurance demand that attempts to include trends in non-income factors.

Finally, in Section V, we consider the impact of climate change on insurance demand. A concern expressed by (re)insurers is whether climate change could limit the effectiveness of existing forecasting tools. Over the coming few decades, climate change is expected to alter the global landscape of natural catastrophe risk (Solomon *et al.,* 2007) and could begin to affect aggregate economic growth (Parry *et al.* 2007). We estimate the impact of climate change on insurance demand mediated through income, using current projections of the economic impacts of climate change. An accompanying paper, Ranger and Surminski (2011), evaluates the impacts of climate change on insurance demand beyond income.

This paper focuses on the non-life (property & casualty) insurance market, an area that appears much less well researched than the life insurance market (Feyen *et al.* 2011), but which is particularly relevant in a climate change context.

II. Drivers of Insurance Demand in the BRICS economies

Enz (2000) and Zheng *et al.* (2008, 2009) show empirically that increasing wealth has been an important long-term driver of growth in aggregate insurance demand in the emerging economies. Figure 1 demonstrates the relationship between income per-capita and non-life insurance penetration for around 200 countries, which we shall refer to as the *'Global Trend Line'* (GTL). This relationship is equivalent to the *'S-Curve'* identified by Enz (2000)[3] and the *'World Insurance Growth Curve'* identified by Zheng *et al.* (2008, 2009)[4]. In low and middle-income countries, such as the BRICS, income and insurance penetration are positively correlated; Enz (2000) concludes that for these country groups the income elasticity of demand may reach two or more. Conversely, for the lowest and highest income countries, Enz (2000) finds an income elasticity of demand close to one. Similar conclusions have been drawn in many empirical studies (Hussels *et al.* 2006 *and references therein*). Using these relationships, USAID (2006) categorises insurance markets into four phases (indicated by dashed vertical lines in Figure 1): dormant, early growth, sustained growth and mature.

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[3] The relationship given by Enz (2000) took the form of an 'S-curve' rather than a smooth curve as in Figure 1 because income was expressed logarithmically.

[4] Quantitative differences are due to the alternative sources of insurance penetration and income estimates.
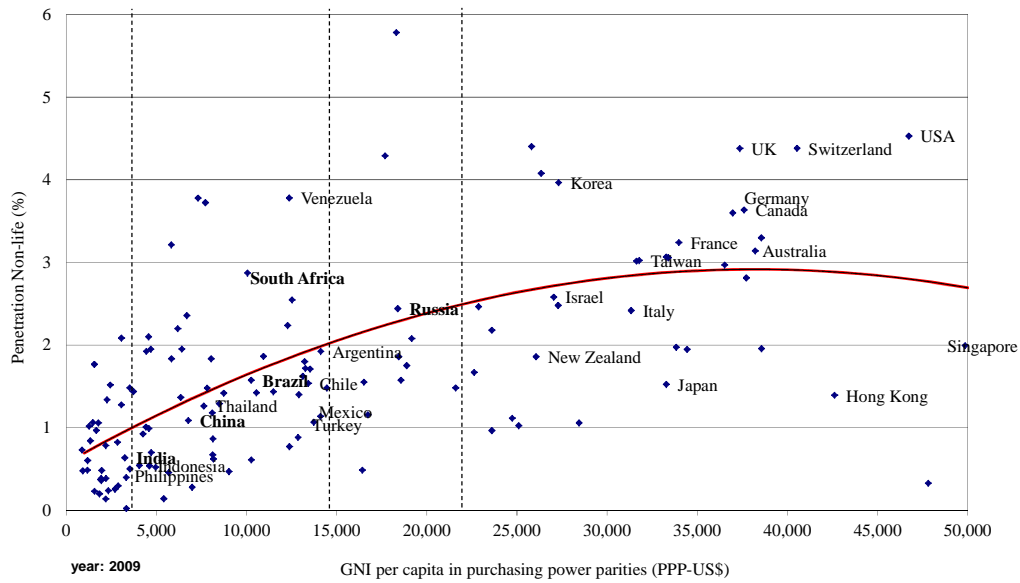
Figure 1: The relationship between gross national income (GNI) per capita (expressed in purchasing power parities, PPPs) and the penetration of non-life insurance (% of GDP) in 2009 for around 200 countries. The red line is known as the 'Global Trend Line' (GTL). Source: data provided by Munich Re. The dotted lines indicate approximate phases of market development based on USAID 2006: dormant, early growth, sustained growth and mature.

Each of the BRICS economies is located in either the early growth or sustained growth phases suggesting significant potential for increasing insurance penetration as wealth increases. Feyen *et al.* (2011) and USAID (2006) explain that during these phases, rising levels of per-capita income are associated with an increased affordability of insurance products as the growing middle-class population acquire greater disposable incomes (the direct effect), but also with a more conducive environment for insurance (an indirect effect), including rising levels of education, financial literacy and risk awareness, a higher priority on risk management, deepening client markets (e.g. growing financial sector, increasing markets for consumer durables, property and business ownership and greater investment in fixed capital), and more stable governance regimes.

Income alone cannot wholly explain the long-term evolution of insurance penetration at a country level, or the differences in penetration between countries. This is illustrated by the heterogeneity of countries around the *'Global Trend Line'* (GTL)[5] in Figure 1. The deviations from the trend line indicate the presence of local factors that tend to increase or suppress the penetration of insurance relative to the effect of income alone (Enz, 2000). Empirical studies

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[5] The equation of the GTL is given by a 2nd order polynomial least squares fit to penetration and income data for all 200 countries over the past 10 years (supplied by Munich Re).

have revealed a wide range of factors that impact insurance demand beyond income; these are summarised in Table 2.

Table 2: Drivers of non-life insurance demand beyond income

Group of Drivers	Examples
Macroeconomic factors	Economic stability Inflation rates Developed and stable financial markets Openness to trade
Political, regulatory and legal factors (including pre-conditions for insurance)	Stable legal and institutional frameworks Adequate insurance law Opening distribution channels (e.g. bancassurance) Conducive regulatory environment Property rights Judicial efficiency and transparency Mandatory insurance lines
Socio-cultural factors	Education Financial literacy Religious and cultural attitudes to risk and insurance Perception of other available financing in the event of a loss, such as disaster aid
Risk factors	The nature of exposure, such as the number of cars Natural catastrophe exposure Risk awareness linked with recent catastrophe experience

Sources: Brainard, 2008; Feyen et al. 2011, Hussels et al. 2006; Swiss Re, 2004; USAID, 2006

The main drivers of demand can vary over time and between countries. Indeed, insurance penetration can vary significantly on an annual basis in response to, for example, recent catastrophe loss, changes in market conditions (which affect the price and availability of insurance) and local policy changes. Figure 2 shows the evolution of the residuals (i.e. the deviation, proposed by Enz 2000) from the GTL for each of the BRICS over the period 1990 to 2009. The residual is defined as the difference between the *implied insurance penetration*[6] and the actual insurance penetration for a country in a given year (the *Increment*). The penetration in South Africa has been consistently high relative to per-capita income levels since 1990, while China (since the mid-1990s) and India have remained low but increasing. Since the late 1990s, penetration in Brazil has remained close to that implied by its per-capita income; whereas estimates for Russia suggest an increasing trend since the early 2000s.

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[6] The implied insurance penetration is given by the GTL equation and the GNI per capita for the country in that year (EIU, 2011).
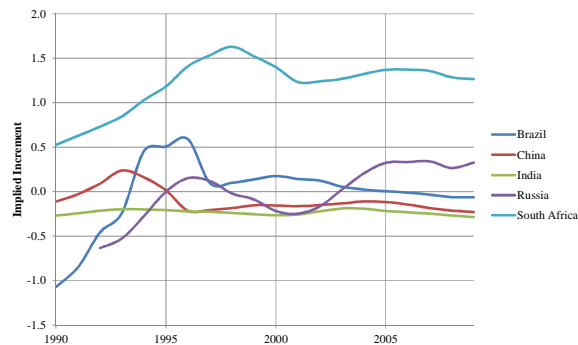
Figure 2: Residuals from the Global Trend Line (Figure 1) – the Increment. The residual values are shown as moving averages over 3 years to remove annual volatility. Data supplied by Munich Re.

To better understand what has driven the evolution of insurance penetration relative to income in the BRICS economies, Table 3 summarises the qualitative evidence on non-income factors reported to have influenced demand since 1990. The majority of these factors are related to public policy and financial services regulation; in particular, the introduction of mandatory classes of insurance (mainly motor[7]) and market liberalisation. In practice, it can be difficult to identify the influence of these factors on aggregate demand as their influence may be altered by the presence of other factors or they may only affect some lines of business. However, we can speculate that the increasing trend in insurance penetration relative to income in India and China over the past 10 years is at least partly associated with market liberalisation. In addition, the step change in penetration in Russia after the early 2000s may be associated with regulatory changes and the introduction of mandatory motor insurance. The fluctuations in penetration relative to income prior to the 2000s may reflect the significant political and economic changes in the BRICS economies between 1990 and 2000 (Kong and Singh, 2005; Swiss Re, 2003b)[8]; however, we cannot exclude the possibility that the apparent instability over this period may also reflect lower data quality[9].

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[7] Motor insurance is the dominant non-life business line in most emerging economies, followed by property, accident and health insurance (Swiss Re, 2004).

[8] Such as the Russian recession in the late 1990s; the Brazilian recession and high inflation rates during the 1990s; and in China the rapid growth and structural changes during the transition to a capitalist economy in the 1990s. Macroeconomic conditions have a broader influence on demand besides income; an unstable economic environment can result not only in lower disposable incomes, but are also associated with higher inflation, increased uncertainty for the insurer and the insured. Weaker macroeconomic conditions can also challenge the balance sheet of insurance companies through increasing the value of claims and increasing reserving needs due to inflation, declining value of insurer assets and reduced availability (higher cost) of capital (reducing capital position and increasing risk of insolvency), and reducing income from premiums due to contract terminations and declining demand (leading to lower premiums); this can lead to a reduced availability of insurance.

[9] Lower data quality prior to the year 2000 may result from less stable reporting practices or the effect of unstable market exchange rates on the calculations of insurance penetration.

Table 3: Qualitative evidence on non-income-led drivers of insurance demand in the BRICS

China	• Growth in China, as in many other developing countries, has been hampered by a relatively low awareness of risk and insurance, both in the general and commercial insurance markets. In addition, levels of income per capita hide income inequalities; insurance is still unaffordable for a large portion of the population, particularly those in rural areas. • Since 1988/9, China has undergone a privatisation of insurance and increased competition (some state-owned insurers remained, but have been gradually privatised since around 2003). The first insurance law was promulgated in 1995 and updated in 2002. The regulatory authority, the China Insurance Regulatory Commission, was established in 1998. • China allowed foreign investment in the insurance sector in 1992 and trade restrictions have gradually lifted since China became a member of the World Trade Organisation in 2001. However, local insurers make up the vast majority of total business volume (intensely competitive). Since December 2003, foreign non-life insurers can write all lines of business except statuary classes. Since 2004, foreign non-life insurers have been able to open subsidiary branches without regional restrictions. • The recent increase in broker market share of commercial insurance since 2002 is positive in terms of increasing customer awareness of insurance, but there is significant further growth potential. Bancassurance was introduced in 2001, allowing new distribution channels for insurance. • Insurance lines were de-tariffed in the early 2000s (except statutory lines). Mandatory motor insurance (2006) and subsidies on agricultural insurance have increased demand. • In 2009, premium growth was boosted by growth in public infrastructure investment and policy-driven growth in agricultural and liability lines. • The insurance law was revised in 2009, introducing a new supervisory regime; further tightening of solvency requirements is expected.
Brazil	• Liberalisation of the insurance market in 1996 and the reinsurance market in 2007 gave a boost to the sector; though at the time there remained some barriers to entry for foreign (re)insurers these were subsequently lifted making the market open to competition. Market share by foreign companies has increased substantially over the past 15 years. • The sector has benefited from increased distribution channels for products through banks and utilities companies, generating new interest in insurance. • Brazil has mandatory motor insurance (personal injury), collected as a fraction of road tax, and mandatory fire insurance for properties. • In the late 2000s, the market continued to grow strongly due to tax incentives for insurance.
Russia	• Liberalisation began in 1991, leading to a dramatic increase in the number of insurance companies and brokers, but there was slower growth in the late 1990s due to the recession. • Regulatory structures were put in place in the early 2000s, leading to improved conditions for competitiveness, a more attractive market for international insurers, and as a result, broadened product ranges. The concept of insurance has become embedded in the economy. Regulatory refinements were made in 2008/09 and more are expected, leading to potential market consolidation. Since 2007, foreign reinsurers have become dominant but insurers are subject to stricter capital requirements and the share remains low. • Introduction of mandatory motor insurance in 2003. Rising investment in property, often secured by finance, has led to increase uptake of property insurance. But, penetration in voluntary markets is low due to lack of awareness and unwillingness to buy insurance products. Recovery of the liability business in the mid-2000s contributed to growth.
India	• The Indian market has undergone significant structural change and growth since 1999/00, as a result of policy reforms allowing private companies into the insurance market. State-owned insurers have remained, and maintain a dominant share of the non-life market, but operate as private commercial entities. The share of the market carried by foreign companies was capped to 26% and foreign entries must be in the form of joint ventures with local partners. Progress toward further de-regulation and liberalisation has been slow; proposals have been made to increase the cap in foreign direct investment to 49% and allow foreign reinsurers to open local branches. • Policy reforms have opened up new distribution channels; including bancassurance in 2001. Distribution still remains an issue for accessing large portions of the population. • The general insurance market has been largely de-tariffed since 2007 (motor third party liability insurance remains tariffed); this led to short-term fluctuations in prices. • Motor insurance (third party liability) is mandatory in India.
South Africa	• Considered to be a developed insurance market, though premiums per capita are relatively low. State-involvement in the market is minimal and regulation on par with developed markets. Concentrated market with a relatively small market share held by foreign insurers (14% of non-life in 2002) due to the strength of local insurers. Strong broker market. • Several compulsory classes of insurance including motor third party bodily injury liability (state scheme), workers compensation (state scheme) and professional indemnity for pension fund trustees. Low penetration (around 25%) for third party liability motor insurance. • Declining growth rates in the early 2000s were associated with political and economic conditions. The recovery since around 2003 linked to the rising middle-class population.

Sources: Arkell (2008), Clyde & Co (2010), Lloyd's (2007a, 2007b, 2011a, 2011b), Munich Re (2009), Swiss Re (2003a, 2004, 2006, 2008, 2010), UNCTAD (2007)

This Section has given qualitative evidence to suggest that both income and non-income factors have been important determinants of growth in the BRICS economies over the past two decades. However, empirical studies have tended to suggest income is the only driver that can be sufficiently well quantified to act as a predictor for aggregate changes (e.g. Feyen *et al.* 2011). The following section uses forecasts of income to predict future insurance demand growth in the BRICS economies. Section IV then considers a broader range of factors.

III. Quantitative forecasts of insurance demand based on income

The empirical relationship between insurance penetration and income per-capita at a global level (e.g. the GTL in Figure 1), alongside the known country-specific residual (Figure 2), provides the basis for a simple forecasting model of insurance penetration based on forecasts of economic growth (as suggested, for example, by Feyen *et al.* 2011 and Zheng *et al.* 2008). Our forecast model is given by Eqn. 1, where $P_c(t)$ is the insurance penetration for country c at time t, $I_c(t)$ is the forecast income per capita for country c at time t, $f(I)$ is the global empirical relationship between insurance penetration and income per capita and R_c is the country-specific residual.

$$P_c(t) = f(I_c(t)) + R_c \qquad\qquad (1)$$

There are three sources of uncertainty in such a forecast: the empirical relationship between insurance penetration and income-per capita $f(I)$ itself; the economic growth forecasts $I(t)$; and the residual R_c. To explore this uncertainty, we use multiple scenarios for each source.

Two versions of the empirical relationship are used: firstly, the GTL introduced in Section II and secondly, the *World Insurance Growth Curve* (WIGC) or *'ordinary growth model'* for non-life insurance penetration developed by Zheng *et al.* (2009). For the GTL, $f(I)$ is determined by a polynomial least squares fit to data on insurance penetration and income per capita for the past 10 years for 200 countries provided by Munich Re. We refer to $f(I_c(t))$ as the *implied insurance penetration*.

We use three sets of economic forecasts from the Economist Intelligence Unit (EIU, 2011), the World Economic Outlook of the International Monetary Fund (IMF, 2011)[10], and

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[10] IMF (2011) provides forecasts to 2016. After 2016, we assume a constant growth rate at the 2016 value. Appendix B discusses the implication of this assumption.

Goldman Sachs[11] (O'Neill and Stupnytska, 2009). Further details are given in Appendix A. These three sources give a wide spread of projections for 2015 and 2030 (see Appendix A).

Finally, we apply the residual in two ways[12]. Firstly, using the relationship given in Eqn. 1, where the residual R_c is given by the absolute difference between the actual and implied insurance penetration in 2009 (the *Increment*). This assumes that the residual remains constant at the 2009 value. Secondly, we use an alternate forecast model, given by Eqn. 2, where the residual becomes a ratio, known as the *Benchmark Ratio of Insurance Penetration* (*BRIP*, proposed by Zheng *et al.* 2008, 2009). The BRIP is equal to the ratio of the actual insurance penetration to the implied insurance penetration for 2009. In this formulation, the absolute residual (i.e. in Eqn. 1) is assumed to vary linearly with the income per capita. In real terms, this could be interpreted as representing the indirect effects of income; for example, the more conducive operating environment for insurance typically associated with economic growth.

$$P_c(t) = f(I_c(t)) \times BRIP_c \qquad (2)$$

Combining these inputs and formulations leads to a total of twelve forecasts per country. The resulting forecast insurance penetration rates for 2015 and 2030 and compound annual growth rates (CAGRs) over the period are given in Table 4. This shows that the largest rates of growth are expected in China, and between 2010 and 2020 for all countries.

Table 4: Summary of forecasts of non-life insurance penetration based on income only

Country	Forecast Non-Life Insurance Penetration (%) *Mean and Range*		Compound Annual Growth Rate in Non-Life Penetration (CAGR, %) *Mean and Range*	
	2015	2030	2010-2020	2020-2030
Brazil	1.79 [1.75-1.83]	2.40 [2.27-2.57]	2.1 [1.8 – 2.4]%	1.7 [1.4 – 1.9]%
China	1.40 [1.31-1.51]	2.34 [1.92-2.83]	4.2 [3.3 – 5.3]%	2.6 [1.8 – 3.5]%
India	0.74 [0.68-0.84]	1.18 [0.92-1.80]	2.4 [1.3 – 4.4]%	2.9 [1.8 – 4.8]%
Russia	2.59 [2.53-2.70]	3.22 [3.05-3.45]	1.9 [1.6 – 2.4]%	1.1 [0.8 – 1.4]%
South Africa	3.16 [3.05–3.35]	4.09 [3.66–4.56]	1.6 [1.0 – 2.2]%	1.5 [1.0 – 2.1]%

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[11] O'Neill and Stupnytska (2009) did not provide forecasts for South Africa. See Appendix A.
[12] As shown in Figure 2, the actual insurance penetration for a country can deviate from the insurance penetration implied by its income per-capita (the *implied insurance penetration*). This deviation is called the residual. The residual must be applied to a forecast based on income per capita to obtain a country-specific forecast.

For all countries, the range of forecasts suggests considerable uncertainty in future insurance penetration. The standard error for the forecasts is largest for India, followed by China and South Africa. The main source of uncertainty is different for each country. For Brazil and China, and to a lesser extent South Africa, the economic forecast is the most important source of forecast uncertainty in future non-life insurance penetration (i.e. it generates the greatest spread in insurance penetration, all else being equal). For Russia and South Africa, the definition of the residual is important. Uncertainties are larger for the period from 2015 to 2030 than 2010 – 2015, as one would expect from the greater assumptions that are implied about long-term economic growth and insurance conditions.

IV. Representing trends in non-income factors

As discussed in Section II, the *Increment* (Figure 2) or *BRIP* (Appendix C) may change over time in response to non-income effects. The lack of representation of changes in non-income factors can lead to under-performance of income-based forecasts (Munich Re, *pers. comm.*). A challenge is that there is a limited understanding of how these factors will evolve over time. In this section, we attempt to go some way toward capturing trends in the residual by representing their historical trends in the forecast. Forecasting abrupt shifts in the residuals, as observed in Russia in the early 2000s (Figure 2), is beyond the scope of this study.

We represent decadal-scale trends using a time-evolving residual; that is, replacing R_c with $R_c(t)$ in Eqn. 1 and $BRIP_c$ with $BRIP_c(t)$ in Eqn. 2. $R_c(t)$ and $BRIP_c(t)$ are given by the historical linear trend over 2000 to 2009 for each country. Otherwise, the structure of the forecasts is preserved, thus giving a new set of twelve insurance penetration forecasts.

Table 5 gives a summary of the projections for the twelve new forecasts with a time-evolving residual. For South Africa and Brazil these forecasts predict slower growth compared with those in Table 3 as the residual has declined over the past decade (Figure 2); conversely, the forecasts for Russia show more rapid growth. Additional analyses given in Appendix D suggest that a shorter calibration period (i.e. five years of historical data than ten) can lead to improved performance of the forecasts.

Table 5: Summary of the twelve forecasts using the time-evolving residual

Country	Forecast Non-Life Insurance Penetration (%) *Mean and Range*		Compound Annual Growth Rate in Non-Life Penetration (CAGR, %) *Range only*	
	2015	2030	2010-2020	2020-2030
Brazil	1.55[1.49-1.62]	1.46 [1.15-1.88]	0.1 [-0.7 – 0.8]%	-0.6 [-2.0 – 0.9]%

China	1.46 [1.40-1.55]	2.50 [2.00-3.37]	4.3 [3.3 – 5.9]%	2.7 [1.8 – 4.1]%
India	0.79 [0.74-0.86]	1.30 [1.07-1.76]	2.7 [1.9 – 3.9]%	3.1 [2.1 – 4.6]%
Russia	3.24 [3.12-3.38]	5.38 [3.76-6.17]	4.2 [3.6 – 4.8]%	2.7 [2.2 – 3.5]%
South Africa	3.11 [3.06–3.15]	3.65 [3.29–3.84]	1.1 [0.8 – 1.3]%	0.9 [0.3 – 1.3]%

IV.1 Comparison of forecast performance

To ascertain whether the inclusion of a time-evolving residual improves the forecasts we conduct simple hind-casting experiments. The methods and detailed findings are given in Appendix D. From this analysis we draw the conclusion that income-only forecasts tend to perform better (in terms of the root-mean-square error) than those with time-evolving residuals, except where there is a sizeable but stable trend in penetration relative to income over the preceding five to ten years[13]. We also conclude that the performance of forecasts is better over 5-years than for longer forecasts and that the performance varies significantly between countries. The lowest forecast performance is found for Russia and this may be explained by the low stability of the penetration relative to income over the past ten years.

There are few forecasts of non-life insurance demand in the academic literature to compare with our findings. Zheng *et al.* 2008 uses a similar forecasting approach to the income-only approach given in Section III (though only considers the uncertainty from economic forecasts) and predicts a non-life insurance penetration in 2020 of between 1.30% and 1.48%. This is less optimistic than the forecasts presented in this study; which using an income-only approach suggest a non-life insurance penetration of between 1.31% and 1.51% by 2015. The differences can be explained by the more recent insurance penetration and income data used in this study (up to 2009, rather than 2005) and the differences in the economic forecasts.

V. Incorporating the impact of climate change on income

Mills (2005) speculates that climate change may impact many lines of insurance, including property, agriculture, business interruption, life and health, political risk and liability. One potential pathway through which climate change could impact insurance demand is through its impact on economic growth. Studies have suggested that climate change could reduce global GDP by several percent relative to the baseline (no climate change) case over this century (Stern, 2007; Parry *et al.* 2007). In this Section, we provide a preliminary evaluation of the potential scale of this influence on insurance demand over the coming two decades.

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[13] We find that with time-evolving residuals, the forecast should be conditioned on the period over which the trend is stable to obtain the greatest performance.

There is huge uncertainty in forecasts of the impacts of climate change on income per capita. For illustration, we use projections from two scenarios developed for Mercer (2010) (see Appendix E for details). The 'Climate Breakdown' scenario is a high-end scenario of future physical impacts of climate change in the BRICS; it represents a world where no action is taken to curb greenhouse gas (GHG) emissions and the climate responds sensitively to emissions. Conversely, the 'Stern Action' scenario represents a world where strong action is taken to curb GHG emissions (i.e. roughly consistent with the vision laid out in Stern, 2007). Mercer (2010) give projections of the costs of climate change associated with GHG mitigation, adaptation and residual damages from physical impacts. These costs are integrated into the three sets of baseline income forecasts to generate new income forecasts, which are used to drive the insurance penetration models. The method is outlined in Appendix E. It should be noted that the integrated assessment models on which estimates of the aggregate economic impacts of climate change are based (as in Mercer 2010) are not comprehensive; for example, the impacts of changes in extreme events are not fully represented. This could mean that the impact estimates given here are conservative.

The findings are given in Table 6, which shows the non-life premium volume for the baseline (no climate change) scenario and the differences under the two climate change scenarios. The premium volume is calculated by combining the forecasts of insurance penetration with the economic growth forecasts from the three sources[14]. For all of the BRICS, the effect of climate change (mediated through income) is small relative to the total premium volume; less than a 0.4% adjustment on the CAGR. This is because the overall economic costs of climate change are expected to be small relative to economic growth over the next 20 years. Indeed, the vast majority of the projected impact on premium volumes in the 'Stern Action' scenario comes from the effect of mitigation costs on economic growth and is consequently largest in the two most carbon intensive of the BRICS, China and Russia (Mercer, 2010); India is projected to experience a boost in premium volumes, due to the expected positive effects of mitigation policies on economic growth. Impacts are also greater for India and China as the income elasticity of demand is greater (Figure 1).

Table 6: The mean and standard deviation of all forecasts using the GTL, expressed in terms of the total non-life premium volume. Shown are the absolute values for the scenario without climate change and relative values (on the mean) for the two scenarios with climate change.

Country	Non-Life Premium Volume (no climate change) 2010-2020 CAGR	2015 Non-Life Premium Volume *US$PPPbn 2005*			2030 Non-Life Premium Volume *US$PPPbn 2005*		
		No climate	Stern Action	Climate Breakdown	*No climate change*	Stern Action	Climate Breakdown

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[14] Accordingly, the uncertainties in premium volumes are much larger than those in the insurance penetration. We show the impacts of climate change on premium volume rather than insurance penetration because the effects of climate change are too small to be observable on the penetration (they are generally less than 0.01%).

	(%)	change	*relative to baseline*	*relative to baseline*		*relative to baseline*	*relative to baseline*
Brazil	5.8 ± 1.3%	44 ± 4	-0.0	-0.2	*103 ± 32*	-0.6	-0.8
China	12.3 ± 1.9%	207 ± 15	-4.3	-0.4	*992 ± 432*	-5.3	-0.1
India	11.1 ± 1.4%	48 ± 3	+1.2	-0.2	*261 ± 103*	+5.9	-1.4
Russia	7.1 ± 1.4%	74 ± 9	-0.9	-0.2	*180 ± 53*	-1.5	+0.0
South Africa	5.4 ± 0.9%	19 ± 1	-0.0*	-0.1*	*48 ± 7*	-0.3*	-0.4*

* The estimated climate change impact for South Africa may be biased, as these values reflect totals for sub-Saharan Africa. Relative to sub-Saharan Africa, South Africa may experience higher costs of mitigation (due to its sensitivity to carbon-intensive sectors) and lower climate impacts (due to its lower vulnerability to climate).

We conclude that based on current projections, the impact of climate change on insurance demand mediated through income is likely to be small over the coming two decades. However, we recognise that there are considerable uncertainties in current climate change projections and that forecasts of the impacts on economic growth are not comprehensive and so could be underestimates of the true scale of impacts (Parry *et al.* 2007). Further work is required to evaluate the implications of climate change beyond income, for example, through its effects of public policy (Herweijer et al. 2009), the willingness to pay for insurance (Botzen and van den Bergh, 2009) and opportunities for new products (Mills, 2009).

VI. Conclusions

We have investigated the potential effects of income on the growth in non-life insurance demand in the BRICS economies to 2030 and presented a new approach that aims to capture trends in non-income factors, such as regulation. We conclude that income alone could lead to an increase in insurance penetration of 2.1%, 1.9%, 2.4%, 4.2% and 1.6% per year between 2010 and 2020 for Brazil, Russia, India, China and South Africa, respectively, based on mean forecasts. When other factors are included, these rates can be adjusted up or downwards by more than 2%; the largest effects are seen in Brazil and Russia, which have experienced significant adjustments in insurance penetration relative to income over the past decade. However, in general we conclude that forecasts based on income alone tend to perform better, unless there has been a stable trend in insurance penetration relative to income over the preceding period. We also investigate the impacts of climate change on insurance demand mediated through income and conclude that, based on current projections, this impact is likely to be small (less than a 0.4% adjustment on rates of increase in premium volumes). Further work is required to investigate the influence of climate change on demand beyond income.

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APPENDICES

A. Background on the economic forecasts

Economic Intelligence Unit (EIU, 2011): The EIU historic annual data (to 2010 and 2009) on real gross domestic product (GDP) are sourced from national statistical offices. The long-run forecasts by country are based on a supply-side forecasting framework of long-run trends. Both the PPP and market exchange rate per capita data provided by EIU use 2005 as their base year.

International Monetary Fund (IMF, 2011): The IMF historical data are sourced from the World Economic Outlook database. The nominal value of real GDP at US$ and real GDP at US$PPP for 2005 have been used to rebase the series. The historic real GDP series in local currency units has then been used to chain the series back from 2005, and forward to 2016, the last year of published forecasts from the IMF. Post-2016, we assume an annual growth rate equal to that for 2016. This creates some possibly optimistic forecasts for countries like China, where the IMF's average annual forecasts to 2016 run at around 9%, noticeably higher than the forecasts supplied by the EIU and Goldman Sachs. This forecast is optimistic, but not infeasible[15]. Data on per capita GDP use total population data and forecasts supplied by the United Nations POPIN database (UN, 2011).

Goldman Sachs (O'Neill and Stupnytska, 2009): O'Neill and Stupnytska (2009) do not provide sufficient historical data for our purposes, but source historic data to the IMF. As a result we use the data calculated from the IMF (2011) as described above. The Goldman Sachs forecasts are average annual real GDP growth rates for 2011-2020 and 2021-2030. These values have been used to calculate the real GDP at US$ 2005 market price series and real GDP at US$PPP 2005 series for each of the BRIC countries. The series are then divided through by total population data and forecasts supplied by the United Nations POPIN database (UN, 2011) to provide the per capita data. Goldman Sachs does not provide forecasts for South Africa, so the series derived from the IMF forecasts is used as a substitute.

Table 1: Range of GDP per capita projections by type of GDP measure and by country

Country	GDP per capita (US$ 2005 PPP) *Mean and Range*		GDP per capita (US$ market prices) *Mean and Range*	
	2015	2030	2015	2030
Brazil	12,764 [12,112-13,214]	22,978 [19,591-25,451]	6,654 [6,549-6,737]	11,198 [10,897-11,707]
China	10,482 [10,194-10,980]	29,467 [19,462-42,986]	4,230 [4,029-4,339]	11,557 [8,188-16,513]
India	4,560 [4,410-4,751]	11,824 [8,887-15,350]	1,377 [1,268-1,497]	3,161 [2,763-3,755]
Russia	17,478 [17,306-17,807]	29,936 [29,150-30,966]	7,771 [7,646-8,016]	13,631 [13,348-14,180]
South Africa	12,044 [11,924–12,105]	22,678 [21,183–23,426]	6,953 [6,800–7,260]	12,500 [12,301–12,897]

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[15] E.g. see comment from the Chief Economist of the World Bank on 23rd March 2011:
http://www.businessweek.com/news/2011-03-23/china-can-grow-8-for-20-years-to-top-u-s-world-bank-says.html

B. Alternative forecasts for China

This section provides two sets of alternative insurance penetration forecasts for China, which use more pessimistic assumptions about long-term economic growth rates. A recent report by the Asian Development Bank (ADB) (Eichengreen *et al.* 2011) provided new evidence that rapidly growing economies tend to experience a significant reduction in economic growth (by at least two percentage points) when their per capita income reaches around $17,000 in year 2005 constant (PPP) international prices. If this were the case, it could suggest that our forecasts of future insurance demand growth for China are too optimistic. To test the sensitivity of our insurance demand forecasts to assumptions about long-term economic growth; we generate two new sets of forecasts for China:

- **3.5%:** An average annual growth rate in per capita income of 3.5% for all forecasts from 2015.
- **ADB:** A 2% reduction in the annual growth rate once the US$17,000 GDP per capita is breached, based on Eichengreen *et al.* 2011.

Figure 1 and Table 2 compare the insurance penetration forecasts under these assumptions to our original assumptions. We conclude from Table 2 that the assumption based on Eichengreen *et al.* 2011 does not impact our insurance penetration forecasts in 2015, but does moderate the forecast for 2030 (i.e. a 0.3 – 0.4% reduction in CAGR over the period 2020 to 2030). The more pessimistic assumption of a 3.5% economic growth rate from 2015 does have a more significant impact on insurance penetration in 2015 and 2030. From Figure 1, we conclude that the original three forecasts (EIU, IMF and GS) do cover the range of possible futures well (including that suggested by Eichengreen *et al.* 2011); the EIU forecast is below that implied by the GS and IMF forecast including the ADB assumption. Therefore, we suggest that the three original forecasts provide an adequate coverage of the uncertainties in long-term economic growth for the purposes of this paper.

Table 2: China insurance penetration forecasts under alternative long-term economic growth assumptions

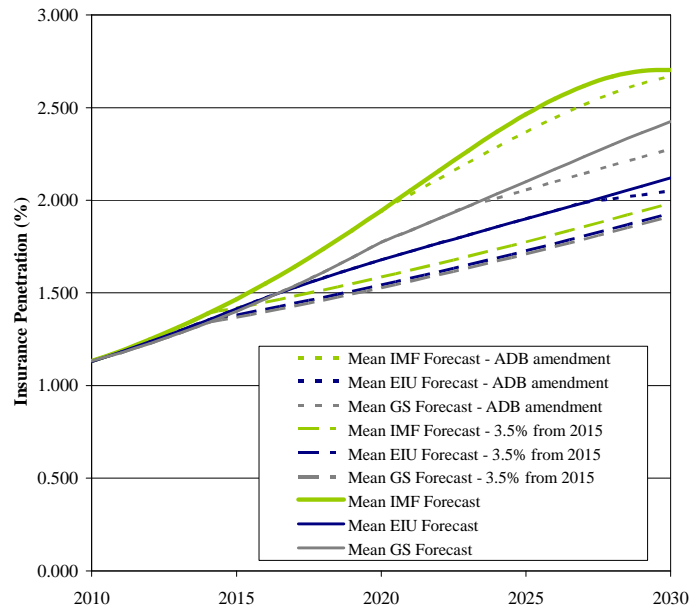| Long-term growth assumption	Insurance Penetration (Range of absolute values, %)		Insurance Penetration (Range of CAGR, %/yr)	
	2015	2030	2010 - 2020	2020 - 2030
Baseline	1.31 – 1.55	1.92 – 3.37	3.6 – 6.5%	1.9 – 4.5%
ADB Assumption	1.31 – 1.55	1.86 – 3.25	3.6 – 6.5%	1.6 – 4.1%
3.5% Assumption	1.28 – 1.49	1.77 – 2.35	2.7 – 4.1%	1.8 – 3.1%

Figure 1: The average insurance penetration forecasts for a given economic forecast (IMF, EIU or GS) under three assumptions about long-term economic growth: (1) the original (baseline) forecast, (2) an assumption based on Eichengreen *et al.* 2011*, and (3) a 3.5% pear year growth rate from 2016.*

C. Trends in the Benchmark Ratio of Insurance Penetration
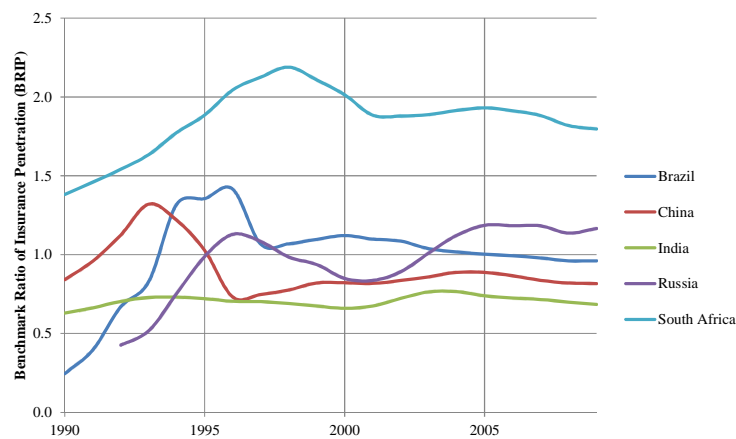
Figure 2: Residuals from the Global Trend Line expressed in terms of the Benchmark Ratio of Insurance Penetration. The BRIP is shown as a moving average over 3 years to remove annual volatility.

D. Insurance penetration forecast validation

To ascertain whether the inclusion of a time-evolving residual improves the forecasts we conduct a simple out-of-sample forecast validation. We generate hindcasts for the period 2000 to 2009, based on historical data for 1990 to 1999 using each of the forecast methods. Instead of economic forecasts for 2000 to 2009, the hindcasts used actual economic data and so the quality of the hindcasts should be higher than we might expect for actual forecasts. Table 3 summarises the calculated root-mean-square

error (RMSE) for the forecasts. In general, we find that the income-only forecasts perform better (i.e. they have a lower RMSE score) than the forecasts with time-evolving residuals over five years and ten years. The only exception is the India 5-year forecast and the Russia ten-year forecast (Table 4).

Table 3: Root-mean-square forecast errors (for known economic growth rate)

Country	Income-only forecasts RMSE Range		Forecasts with time-evolving residual RMSE Range	
	5-year forecast*	10-year forecast	5-year forecast	10-year forecast
Brazil	0.09-0.12	0.15-0.19	0.48-0.54	0.78-0.92
China	0.05-0.55	0.04-0.54	0.14-0.88	0.24-0.97
India	0.06-0.63	0.05-0.67	0.05-0.73	0.10-0.84
Russia	0.28-0.41	0.40-0.64	0.33-0.94	0.29-1.34
South Africa	0.21-0.30	0.19-0.39	0.78-0.93	1.14-1.48

Table 4: Top 3 performing forecast types by RMSE (based on 2000-09 hindcasts)

	5-yr forecast	**10-year forecast**
Brazil	GTL-EIU-Fixed Increment GTL-EIU-Fixed BRIP WIGC-EIU-Fixed Increment	
China	GTL-EIU-Fixed BRIP GTL-IMF-Fixed BRIP GTL-GS-Fixed BRIP	
India	GTL-GS-Time-evolving BRIP GTL-IMF- Time-evolving BRIP GTL-EIU- Time-evolving BRIP	GTL-EIU-Fixed BRIP GTL-IMF-Fixed BRIP GTL-GS-Fixed BRIP
Russia	GTL-EIU-Fixed BRIP GTL-IMF-Fixed BRIP GTL-GS-Fixed BRIP	GTL-EIU-Time-evolving Increment GTL-EIU-Fixed BRIP GTL-IMF-Fixed BRIP GTL-GS-Fixed BRIP
South Africa	WIGC-IMF-Fixed Increment WIGC-GS-Fixed Increment WIGC-EIU-Fixed Increment	

Red text indicates top ranked, though all top 3 tend to have similar RMSE scores

To ascertain whether the forecasts with time-evolving residuals perform better during the period of more stable growth in the 2000s, we repeat the exercise generating hindcasts for 2005 to 2009 based on 2000 to 2004 data. The RMSE values are given in Table 5. We find that the errors for these forecasts (based on a shorter and more stable calibration period) are much lower, but in most cases the income-only forecasts still perform better. Brazil and South Africa are exceptions. From this we conclude that the time-evolving forecasts can perform well where there is a sizeable but stable trend in the BRIP or Increment over the forecast calibration period.

Table 5: Root-mean-square forecast errors and top 3 performing forecasts based on 2005-2009 hindcasts using only the 5 preceding years data for time-evolving residuals

Country	Income-only forecasts RMSE Range	Forecasts with time-evolving residual RMSE Range	Good/Poor performing forecasts*
Brazil	0.06-0.11	**0.05-0.10**	Majority perform well (<0.1 RMSE) but time-evolving BRIP/Increment forecasts tend to perform better
China	**0.02-0.13**	0.07-0.14	Fixed BRIP/Increment forecasts tend to

			perform better
India	**0.03-0.14**	0.06-0.17	Fixed BRIP/Increment forecasts tend to perform better
Russia	**0.14-0.40**	**0.17-0.34**	Fixed BRIP/Increment forecasts tend to perform better
South Africa	0.08-0.22	**0.07-0.19**	Time-evolving BRIP/Increment forecasts tend to perform better

* No top 3 is given as many forecasts tend to perform highly. Here we focus on the poorest performers.

E. The Mercer (2010) climate change projections

The climate change projections quoted in the Mercer (2010) study were based on scenario development and analyses by the Grantham Research Institute on Climate Change and the Environment and Vivid Economics. The analyses were based on the following studies and processed as follows for this paper:

- **Residual damage costs of physical climate change:** projections are extracted from the integrated assessment model PAGE2002 (Hope, 2006). An advantage of the PAGE2002 model is that it is probabilistic; hence, it captures a range of projections from the existing literature. This model was also used in the Stern Review on the Economics of Climate Change (Stern, 2007); though the impact estimates in Mercer (2010) are lower as they include only market impacts. The impacts estimates included in the 'Climate Breakdown' scenario represent the 95th percentile forecast from PAGE, whereas the 'Stern Action' scenario includes a more optimistic impact estimate (the 50th percentile forecast by PAGE).

- **Adaptation costs:** projections are based on estimates from World Bank (2009) and transposed to different climate scenarios and timescales using simple adaptation cost functions.

- **Costs of GHG mitigation**: estimates are derived from the WITCH model (Edenhofer *et al.* 2009) for the 'Stern Action' scenario, adjusted and applied for different regional definitions. Costs are assumed to be negligible for the 'Climate Breakdown' scenario.

A summary of the costs given by Mercer (2010) used in this paper is given in Table 6. Mercer (2010) does not provide scenarios for each country, only for regions (e.g. sub-Saharan Africa), and therefore we assume that the impacts on economic growth at a regional level are evenly distributed between countries in the region. This could create some biases in the projections, particularly for South Africa which is less vulnerable to physical changes in climate than the remainder of sub-Saharan Africa and more carbon-intensive. Projections from Mercer (2010) are linearly interpolated to provide annual forecasts to 2030 and converted into income per capita using populations projections from UN (2011).

Table 6: Estimates of the costs of climate change in 2030 from Mercer (2010)

Region	Total Costs (%GDP)	Mitigation Cost (%GDP)	Adaptation Costs (%GDP)	Residual Damage Costs (%GDP)
Stern Action				
China and East Asia	4.4	4.3	0.1	0.0
Russia and the former Soviet Union	3.7	3.4	0.3	0.0
Latin America and Caribbean	1.2	0.6	0.4	0.2
India and South Asia	-3.8	-4.0	0.1	0.1
Sub-Saharan Africa	1.4	0.6	0.6	0.2
Climate Breakdown				
China and East Asia	0.1	0.0	0.1	0.0

Russia and the former Soviet Union	0.3	0.0	0.3	0.0
Latin America and Caribbean	1.6	0.0	0.4	1.2
India and South Asia	0.9	0.0	0.2	0.7
Sub-Saharan Africa	2.1	0.0	0.8	1.3