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A preliminary assessment of the impact of climate change on non-life insurance demand in the BRICS economies

Article (Accepted version) (Refereed)

Title: A Preliminary Assessment of the Impact of Climate Change on Non-Life Insurance Demand in the BRICS economies

Suggested Running Title: Climate Change and Insurance Demand

[Revised Draft Version 1.2, 25th October 2012]

Abstract

Over the past decade, growth in insurance demand in the BRICS has been a key driver of global non-life premium growth. Current forecasts suggest that these markets will continue to be areas of significant growth. For example, based on a simple model, we project that gross premium volumes in the BRICS economies could increase at a rate of between 5.4 and 12.3% per year over the coming decade, depending on the country. We consider how climate change may influence these trends in the period to 2030. We argue that the influence of climate change will be more multifaceted, complex and regionally variable than portrayed in the past. We suggest five pathways of influence: wealth; willingness to pay for insurance; policy and regulation; changes to the supply of insurance; and new opportunities associated with adaptation and mitigation. We conclude that, with the exception of policy and regulation, the influence of climate change on insurance demand to 2030 is likely to be small when compared with the expected growth due to rising incomes, but is not insignificant. For example, we expect the impact on premium volumes mediated through wealth to be small; less than a 0.4% adjustment in the annual growth rate to 2030. But, we also conclude that the scale of the risks and opportunities will depend partly on (re)insurer responses to the challenges of climate change. We outline five actions that could pave the way for future opportunities.

Keywords: Insurance demand, climate change, emerging markets, insurance penetration

1. Introduction

Over the past decade, growth in the emerging economies has been the dominant driver of global non-life premium growth; today, these markets account for 15.5% of world non-life premium volume, up from 11.5% in 2005 (Table 1). More than half (an 8.5% share) of this is

concentrated in Brazil, Russia, India, China and South Africa (the BRICS). Between 2005 and 2010, real non-life premium volumes in these countries increased significantly, with the largest increases observed in China (25% per year)[1]. Conversely, over the same period, annual growth in the industrialised countries was on average below 3%, and in some markets had stagnated. Consequently, the BRICS are seen as important areas of future market growth, as well as for allowing better risk diversification to benefit existing clients (Swiss Re, 2004).

Table 1: Non-life insurance premium volume ($ unadjusted).

	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%*	

*Source: Swiss Re 2006, 2011; *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 2008, 2011; Lloyd's, 2007a, b; Munich Re, 2009a), not only in terms of increasing premium volumes but also increasing insurance penetration, defined as *the total volume of premiums as a ratio of the gross domestic product (GDP)*. Firstly, the share of the non-life market of the BRICS economies is still small compared with their share of global GDP (26%) and population (42%), suggesting a significant catch-up potential. Secondly, over the past decade, real

[1] Compound annual growth rate (CAGRs) based on data from Munich Re and Swiss Re (2006a, 2011). Equivalent values for South Africa, Russia, India and Brazil were 2.9%, 6.9%, 9.1% and 12.5%, respectively.

premium growth has generally outstripped growth in real GDP, indicating a long-term trend toward increasing insurance penetration[2].

This paper concerns forecasts of insurance demand in the BRICS, at the national level. Such forecasts are of interest to the insurance industry for informing long-term business strategy and are a first step toward more detailed forecasts for specific lines of business (LOBs). Several studies have analysed the drivers of insurance market growth at the LOB or national level (e.g. Browne and Hoyt, 2000, Grace et al., 2004, and Michel-Kerjan and Kousky, 2010), including a number of studies that have focussed on the emerging markets specifically (e.g. Feyen *et al*. 2011; Enz 2000; Zheng *et al.* 2008, 2009). An open question not considered in the existing literature is how climate change might influence these trends. This is where we focus in this paper. Previous studies have explored the long-term implications of climate change for the global insurance industry (for example, Mills 2005, Herweijer *et al.* 2009). But none has focussed on the implications insurance demand, or the BRICS.

The existing scientific literature gives several clues as to how climate change may influence insurance demand. For example, over the coming few decades, climate change is expected to alter the global landscape of natural catastrophe risk (Solomon *et al.,* 2007). It could also alter the nature of energy markets and increase awareness of risk and climate risk management. This may impact many LOBs, including property, energy, agriculture, business interruption, life and health, political risk and liability (Mills, 2005). These changes are likely to influence insurance demand globally, but we focus on the BRICS for two reasons: firstly, because they are considered such important areas of future growth; and secondly, because

[2] 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.

these emerging markets are expected to be more vulnerable to the array of impacts of climate change than the more developed insurance markets (Mercer, 2010; Parry *et al*. 2007).

While the complex interactions and uncertainties mean that it is impossible to quantitatively forecast the future impacts of climate change on insurance demand, mapping the influences, their relative scale and directions is important for long-term planning as well as for informing (re)insurers and other stakeholders on what actions can be taken today to minimise future threats and capture opportunities. We consider the time horizons to 2015 and 2030. The 2015 time interval will likely be considered most relevant to the (re)insurance industry given their relatively short planning horizons. But, both time horizons are short compared with the timescales of climate change, where the impacts are predicted to be most significant beyond around 2030. One argument that we will make is that the (re)insurance industry can benefit from taking a longer term view in its strategic business planning.

Section 2 discusses the theoretical and empirical evidence on the drivers of insurance demand in the BRICS. Section 3 reviews the evidence on the impacts of climate change in the BRICS and then explores five potential pathways through which climate change could influence insurance demand. Section 4 draws conclusions on the implications for strategic planning today. Our analyses focus on the non-life insurance market[3], an area that is particularly relevant in a climate change context.

Climate change is only one of many exogenous factors that are expected to influence insurance demand over the coming two decades, with others including global population and

[3] We consider aggregate demand rather than an individual's decision to purchase insurance (where much previous research has focussed), individual lines of business or the split between private and public insurance. We largely consider primary insurance demand, but expect our findings to be relevant to the reinsurance and other risk transfer markets, as primary demand can be an important indicator of demand in these markets.

exposure growth, globalisation, and changes to financial market regulation (Cummins and Venard, 2008). A full discussion of each of these factors is beyond the scope of this paper.

2. Drivers of Insurance Demand in the BRICS economies

In this section, we review the evidence on the drivers of insurance demand in the BRICS. 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. To illustrate this, Figure 1 gives the relationship between income per-capita and non-life insurance penetration for around 200 countries, a relationship that we shall refer to as the 'Global Trend Line' (GTL). This relationship is equivalent to the 'S-Curve' identified by Enz (2000) and the 'World Insurance Growth Curve' identified by Zheng et al. (2008, 2009). Using these relationships, USAID (2006) categorises markets into four phases (indicated by dashed vertical lines in Figure 1): dormant, early growth, sustained growth and mature.

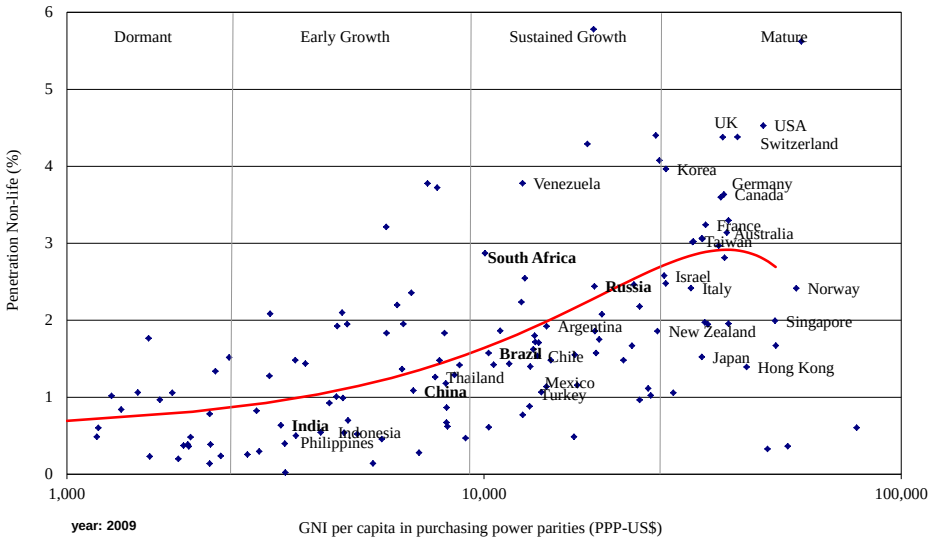

Figure 1: The relationship between gross national income (GNI) per capita (expressed in purchasing power parities, PPPs) and the penetration of non-life insurance (% of GDP) in 2009 for around 200 countries. The red line is known as the 'Global Trend Line' (GTL).GNI per capita is shown logarithmically, giving the characteristic's-curve'. Source: data provided by Munich Re. The dotted lines indicate approximate phases of market development based on USAID (2006).

Each of the BRICS economies is located in either the early growth or sustained growth phases. For these groups of countries, income and insurance penetration are positively correlated, suggesting significant potential for increasing insurance penetration as wealth increases. 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).

Feyen *et al.* (2011) and USAID (2006) explain that during the early growth and sustained growth 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.

However, income alone cannot wholly explain the long-term evolution of insurance penetration at a country level, or the differences in penetration between countries. Indeed, there are significant differences in insurance market conditions within the BRICS group, with for example, South Africa having a much more developed market compared with Brazil, though their income levels are similar (Lloyds, 2011b). This is illustrated by the heterogeneity of countries around the GTL 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 average effect of income alone (Enz 2000). Empirical studies have revealed a wide range of factors that influence national-level insurance demand beyond income (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 every year in response to, for example, recent catastrophe loss, changes in market conditions (which affect the price and availability of insurance) and local policy changes. For example, figure 2 shows the evolution of the *residual* insurance penetration from the GTL for each of the BRICS over the period 1990 to 2009; here, the residual is expressed as the difference between the implied insurance penetration (based on the level of income and the GTL) and the actual insurance penetration for a country in a given year. This shows that the insurance 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 and relatively stable. 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.

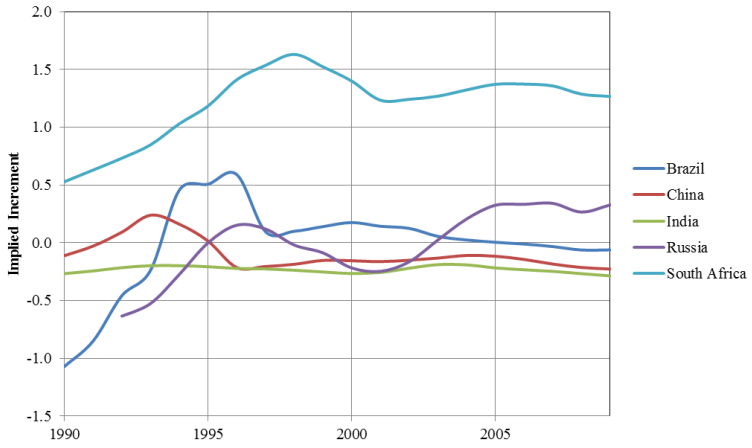

Figure 2: Residuals from the Global Trend Line (Figure 1) expressed as the implied 'Increment'. The increment is shown as moving averages over 3 years to remove annual volatility. Source: Data supplied by Munich Re.

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) and market liberalisation. In practice, it can be difficult to identify the influence of these factors on aggregate demand as their impact may be altered by the presence of other factors or they may only affect some LOBs. However, we can speculate that the increasing trend in insurance penetration relative to income in India and China between the late 1990s and the mid-2000s was 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); but, we cannot exclude the possibility that this apparent instability may have been caused by lower data quality.

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 quantitative and qualitative evidence to suggest that both income and non-income factors have been important determinants of insurance market growth in the BRICS economies over the past two decades. In the following section, we consider how climate change may influence these factors and the implications for future demand.

3. Climate change and its impacts on insurance demand

Based on current evidence (Barker *et al.* 2007; Parry *et al.* 2007; Solomon *et al*. 2007), we suggest that climate change will affect the BRICS economies in four main ways:

1. *Local impacts:* the direct and indirect impacts of gradual local climatic changes on assets, economic productivity (particularly climate-sensitive sectors, such as agriculture, insurance and water-intensive sectors), the local environment, human health and wellbeing, and the impacts of damages from extreme weather.
2. *Local adaptation:* Changing patterns of public and private financial flows, activity and resources in climate risk management, such as increases in investments in protective infrastructure, insurance systems and natural resource management.
3. *Local greenhouse gas (GHG) mitigation:* changing patterns of public and private financial flows, activity and resources in the energy markets, forestry and agriculture, and changing productivity of carbon-intensive sectors.
4. *Global impacts and responses:* the influence of global climate change and responses at the local level, including through changes in the global geopolitical environment, international trade, growth, investment, policy, migration and commodity prices.

Evidence suggests that the BRICS as a group are likely to be more vulnerable to climate change than the more developed insurance markets; though different countries are likely to be impacted in different ways. For example, Parry *et al.* (2007) conclude that countries in low-latitude regions, where climate-sensitive economic activities (such as agriculture) are an important part of the economy, such as India and China[4], are likely to be more negatively affected by local changes in climate. Conversely, Russia, due to its high-latitude location, could experience net benefits, at least in the short term. Higher impacts do not necessarily mean a greater investment in adaptation, as socioeconomic factors, such as wealth and cultural attitudes to risk are important (Parry *et al.* 2007). Countries like South Africa, Russia and China; where carbon-intensive production, including mining and manufacturing, form an important part of the economy would be most negatively impacted by GHG mitigation policies (Mercer, 2010). Indeed, as of 2005, each of the BRICS ranked in the top 25 of global GHG emitters (WRI, 2011)[5]. In terms of emissions intensity of production, China, South Africa and Russia ranked well above nations such as the USA and European Union countries. Finally, over the next 20 years, the macroeconomic effects of climate change, such as impacts on inflation rates, interest rates, commodity prices and growth are expected to be relatively small (Mercer 2010). However, there are significant uncertainties here. Hertel *et al.* (2010) suggest that prices of major food stables could rise by between 10 and 60% by 2030.

We find no studies that have shown empirically that climate change has already affected insurance demand. A common conclusion, based on theory and empirical evidence from existing insurance markets, is that a riskier and more uncertain world would be associated with an increase in insurance demand, at least until some local threshold were reached where

[4] In China and India, agriculture represented 12% and 19% of GDP, respectively, in 2005 (World Bank, 2011)
[5] China was the highest emitter of GHGs (16% of global emissions); Brazil ranked 4th (6%); Russia 6th (5%); India 7th (4%); and South Africa 22nd (1%).

the affordability of insurance or the insurability of risk were threatened (Herweijer *et al.* 2009; Botzen and van den Berge 2009a, b; Mills 2007). We argue that the influence of climate change will be more multifaceted, complex and regionally variable.

Based on the evidence presented in Section 2, we suggest five main pathways through which climate change could influence future insurance demand:

1. ***Wealth:*** the overall impact of climate change on growth in per-capita income levels.
2. ***Public policy and regulatory environment****:* the changing landscape of risk, and the responses of the insurance industry and the public, could trigger public policy interventions that would alter the operating environment for (re)insurers.
3. ***Risk and willingness to pay****:* changing hazard levels will affect the willingness to pay for insurance, through both the price of insurance and the perceived risk.
4. ***Supply factors****:* rising hazard levels could challenge the insurability of some types of risk, regions and LOBs, reducing the availability of insurance.
5. ***New products****:* adaptation and the transition to a low-carbon economy could create new demand for specialist LOBs, such as renewable energy insurance.

In the following Sections, we consider each of these pathways individually.

3.1. Wealth and insurance demand in a changing climate

In this section, we consider the influence of climate change on insurance demand through its impact on income. To do this, we first develop a simple regression model of insurance demand, based on the empirical relationship between income and insurance penetration, and using the method outlined by Zheng *et al.* (2009). The model is driven by forecasts of economic growth (from the IMF, Goldman Sachs and the Economist Intelligence

Unit) to generate baseline projections of future insurance penetration and premium volumes for the BRICS in 2015 and 2030. The method is described in full in Appendix A.

The next step is to incorporate the potential influence of climate change. There is a large uncertainty in projections of the impacts of climate change on income per capita. For illustration, we use projections from Mercer (2010). This study is used because it is unique in synthesising up-to-date estimates of the costs of physical impacts of climate change (based on Hope, 2006), adaptation (World Bank 2009) and GHG mitigation (Edenhofer *et al.* 2009) and assembling these estimates into scenarios that aim to capture the range of impacts from the underlying literature (see Appendix B for details). The *'Climate Breakdown'* scenario represents a world where no action is taken to curb GHG emissions and the climate responds sensitively to emissions. At the other end of the scale, the *'Stern Action'* scenario represents a world where strong action is taken to curb GHG emissions. It should be noted that these total costs from Mercer (2010), or any equivalent study, are not comprehensive. For example, the costs of changes in extreme events and non-monetary impacts are not fully represented. This could mean that the impact estimates given here are conservative.

The estimated costs of climate change from the two scenarios are integrated into the baseline economic growth forecasts to generate new projections of insurance demand. Table 4 gives the resulting projections for premium volumes in the BRICS in 2015 and 2030. Given the uncertainties in future economic forecasts, climate change projections and the model itself, these projections are considered illustrative only, however, we suggest that they do provide some useful insights into the potential scale of the effects of climate change relative to those of baseline economic growth.

Table 4: The mean and standard deviation of forecasts 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 change	Stern Action *relative to baseline*	Climate Breakdown *relative to baseline*	No climate change	Stern Action *relative to baseline*	Climate Breakdown *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).

The baseline projections suggest significant increases in non-life premium volumes in the BRICS due to the expected growth in these economies; with compound annual growth rates (CAGRs) over the period 2010 to 2020 ranging from 5.4% per year for South Africa to 12.3% per year for China. For all of the BRICS, the effect of climate change (mediated through income) is expected to be small relative to the total premium volume; equivalent to less than a 0.4% adjustment on the CAGR. The reason is that total economic costs of climate change are expected to be small relative to economic growth over the next 20 years. In general, the *Stern Action* scenario has a much greater impact on premium volumes than the *Climate Breakdown* scenario in 2015 and 2030, because it includes short-term investment in GHG mitigation. Consequently, the impacts on premium volumes are largest in the two most carbon-intensive BRICS, China and Russia. India is projected to experience a boost in premium volumes, due to the expected positive effects of mitigation policies on economic growth (Edenhofer *et al.* 2009). Impacts are also greater for India and China as the income elasticity of demand is greater (Figure 1). In the *Climate Breakdown* scenario, the high costs of physical impacts of climate change are not realised until after 2030 (Hope, 2006).

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 underestimates of the true scale of impacts (Parry et al. 2007).

3.2 Insurance demand, public policy and regulation

Public policy and regulation can be potent drivers of changes in demand, through creating the necessary preconditions for insurance and influencing the operating environment of the industry (Section 2). In this section we ask whether climate change could alter the progression of public policy and regulation in the BRICS leading to either an enhancement or suppression of insurance demand. To answer this, one must assess what factors drive these public interventions and if/how these could be influenced by climate change.

Table 5 summarises the theoretical impacts of a range of insurance policy and regulatory factors on penetration[6]. The table only those factors that are intended to have a direct influence on the insurance market; we note that policies not linked with insurance can also have an indirect impact on demand, for example, encouraging investment in insurable assets (such as property, through property rights), enhancing financial literacy (Cole *et al.* 2012)[7], building human capacity (including professional actuarial education), disseminating risk information, enhancing capital markets, creating stable and effective legislative regimes and consumer protection (Hussels *et al*. 2006; USAID, 2006; Brainard, 2008).

[6] While penetration may increase, the overall volume of business may drop due to reduced premiums (e.g. in the case of price regulation). Policy and regulatory factors can also impact profitability, through for example, increasing expenses and capital requirements, as well as the market share of private and foreign (re)insurers and reinsurance cession rates.

[7] Cole *et.al*. (2012) conduct a series of randomized field experiments in India to assess the impact of price and non-price factors for insurance demand. They conclude that lack of trust and financial illiteracy can create important barriers for insurance take-up.

Table 5: Theoretical relationships between public policy/regulatory factors and insurance penetration

Direct Public Policy/Regulatory Driver	**Effect on insurance penetration***	**Description**
Market Liberalisation	+	Insurance premiums typically fall due to increased competition and increased efficiency, increasing demand. In addition, there can be increased availability of insurance as new products and distribution channels open. There is some evidence that entry of foreign (re)insurers can enhance the market; bringing technical expertise, enhanced wealth management practices, innovation and capital.
Tax (tariffs) on Insurance	-	Premiums rise causing reduced penetration (except where tariffs are set below the actuarial premium). Can create market distortion[8].
Tax incentives for Insurance	+	Incentive for insurance uptake, but can create market distortions
Premium subsidies	+	Reduced premiums cause increased penetration
Price regulation	-	Typically price regulation aims to reduce premiums to increase affordability, so can lead to increased penetration. It can create market distortions that have negative effects through reducing market efficiency and in some cases, the availability of insurance.
Compulsory insurance cover	+	Increased penetration of compulsory insurance line (though rarely universal coverage) as well as positive spill over effects to other insurance lines through increased awareness
Introduction of public insurance	+/-	Public insurance can increase penetration where the premiums are kept artificially low; but can also have negative effects on penetration due to reduced competition (see liberalisation above).
Regulation of (re)insurance (including transparency, capital requirements etc)	+/-	Regulation of (re)insurance that brings the market into line with international best-practice and standards can lead to consolidation of the market, an increased number of foreign insurers, and increased capitalisation. This can lead to an increased capacity/availability of insurance and in cases, reduced premiums as a result of increased efficiency. Increased transparency and efficiency, as well as standards of conduct, can enhance public perception and confidence in insurance. Overly burdensome regulation can cause market distortions and reduce penetration by increasing premiums, reducing product innovation and consumer choice, reducing efficiency, and leading to exit of some insurers from the market.
Opening distribution channels (including bancassurance and brokers)	+	Increased accessibility of insurance and product innovation, as well as increased awareness, leading to higher demand.

**Note that in practice, other factors may complicate these relationships. Sources: Eling, Klein and Schmidt (2009), Hussels et al. (2006), USAID (2006), Swiss Re (2010, 2004)*

[8] Distortions may take several forms, for example, where premiums do not reflect risk or where particular insurers and lines of business are advantaged/disadvantaged. In general, distortions can lead to inefficiency, causing increased operating costs, reduced competitiveness, and ultimately increased premiums and lower availability.

There are several examples where changing risk levels or a rising awareness of risk (both associated with climate change) have led to changes in the policy and regulatory drivers outlined in Table 5. For example, concerns about Government exposure to reconstruction costs after a disaster or social protection against loss have often led to changes in the conditions for insurance, such as market liberalisation, tax incentives or subsidies for insurance, mandatory insurance lines, the introduction of public insurance or investing in pilot programmes and improvements in risk data. Such interventions are common in agricultural insurance markets, for example the state-subsidized agricultural insurance schemes in China and India and the Federal Crop Insurance Programme in the USA (Mahul and Stutley, 2010). But, they also occur in catastrophe insurance markets, such as the mandatory homeowner insurance of the Turkey Catastrophe Insurance Pool (Cummins and Mahul, 2009). Pressure from consumers associated with increased awareness of risk can also lead Governments to enter into public-private partnerships with insurers (for example, the Statement of Principles agreement between the government and private insurers of flood risk in the UK).

There is evidence that concern over the impacts of climate change has already increased awareness of climate risk and of the benefits of insurance. China's national adaptation plans explicitly recognise the benefits of insurance and as a result, pilot micro-insurance initiatives have been launched in collaboration with local mutual insurers (Zhang *et al.*, 2008). India's adaptation plans similarly highlight an ambition to expand the uptake of weather insurance for agriculture (Government of India, 2008). The *Cancún Adaptation Framework* of the UN Framework Convention on Climate Change (UNFCCC) explicitly recognised the benefits of risk transfer; policymakers are currently exploring options to implement schemes (including micro-insurance and an international climate risk insurance

facility) to support those most vulnerable to climate change (UNFCCC, 2011). While these will largely focus on facilities for least developed countries, their establishment would have positive spill-over effects in the emerging markets; for example, increasing the awareness of insurance, speeding the spread of international regulatory standards for insurance, enhancing technical capacities and financial literacy and increasing global insurance capacity.

It is difficult to assess the potential magnitude of the impact of climate change on insurance demand mediated through policy and regulatory changes[9]. We speculate that the direction and scale of these influences will depend (to an extent) on the level of insurance market development in a country today. Those with the largest potential for growth are countries where there is greatest opportunity for 'catch-up' to developed market conditions (that is, where current penetration is low relative to income-per-capita, or below the *Global Trend Line* in Figure 1); for example, in China and India. To gain an insight into the potential scale of the impact, if we assumed that market conditions in China and India strengthened due to climate change to developed market conditions (for example, as a result of rising awareness of the benefits of insurance and more conducive regulatory frameworks) this would suggest up to a 13% increase in premium volumes (around $6bn USD) in India by 2015 compared to the current forecasts outlined in Table 2; and up to a 6% increase in premium volumes in China (around $12bn USD) by 2015[10].

For all countries there is a risk of negative influences on insurance demand if climate change led to public and political responses that caused a less conducive environment for

[9] One could develop an empirical relationship between past events and changes in policy and regulation, but a preliminary survey suggests that the data available is likely to be of insufficient length and quality to accurately tease out the relationships between these variables from the broader influences. However, this area may warrant further study.

[10] This scenario assumes that insurance penetration gradually converges to that implied by the projected income levels in 2030 (i.e. the insurance penetration converges with the Global Trend Line in Figure 1). It uses the method outlined in Appendix B and assumes that the residual in the regression model increases linearly from the 2009 value to zero by 2030 (or to 1 in the case of the BRIP). Comparisons are made with the constant BRIP/Increment forecasts (not the time evolving).

insurance. For example, in Florida, abrupt increases in premiums, associated with high catastrophe losses in 1992, then in 2004 and 2005, prompted public and political discontent that led to price regulation of homeowner insurance and crowding out of the private market by the public insurer (Grace and Klein, 2009). Similar price regulation has been introduced into other US states. Further research is required to quantify the impacts on aggregate demand.

To an extent, the likelihood and impact of such negative interventions will depend on how insurers respond to changes in risk. Mills (2007) suggests that insurer responses that have led to public discontent include: abrupt increases in premiums, withdrawing from at-risk market segments, raising deductibles, limiting maximum coverage and non-renewal of policies. Also important is reputational damage, for example if the insurance industry were seen as not doing enough to respond to the impacts of climate change (Mills, 2005).

3.3 Risk and the willingness to pay for insurance

Theory and empirical analyses show that an individual's willingness to pay (WTP) for insurance is influenced by factors including (i) the price of coverage; (ii) the individual's level of risk aversion; (iii) an individual's income; and (iv) the level of risk perceived (Szpiro 1988). Increasing levels of risk with climate change could reduce the WTP by increasing the price of insurance, but at the same time increase the WTP by increasing the level of perceived risk (and vice versa); whether the overall effect is positive or negative would depend on the level of risk aversion (which may be influenced by climate change), income and other factors.

Botzen and van den Berg (2009a, b) conduct a survey-based analysis of the impact of rising risk on the WTP for flood insurance in the Netherlands. They conclude that the positive effects of rising flood risk on demand are approximately balanced by the negative effects of

increasing prices; but this balance is determined by the scale of the change in risk. They observe moderate increases in demand for moderate increases in flood risk, however there is a price threshold above which demand collapses[11]. Further research is required to assess how the balance between the level of risk and price of insurance would play out in the BRICS economies. The implication could be that for the highest-risk regions (such as the coastal megacities of China and India), increases in risk with climate change could reduce the demand for insurance (due to the dominance of the price effect); while for lower-risk regions, increases in risk could stimulate demand.

Climate change may also increase insurance demand through increasing the perceived risk and awareness of risk. Empirical studies have shown that the likelihood of purchasing insurance is increased if an individual, or neighbouring region, has recently experienced a loss (Kunreuther *et al.* 1976; Slovic *et al.* 1977). For example, Siegrist and Gutscher (2008) find that people who have not been strongly affected by a recent flood are likely to underestimate the impacts of a flood. Michel-Kerjan and Kousky (2010) find that the demand for cover is likely to rise in the wake of a devastating hurricane season. This could suggest that in a world of rising risks, where losses were more frequent, insurance demand could be increased. This effect may be largest in regions where risk awareness is currently low (Munich Re 2009a).

3.4 Supply factors: climate change and insurability

Herweijer *et al.* (2009) and Mills (2005) highlight that, all else being equal, climate change could challenge the insurability of risk, through increasing the technical uncertainty and volatility of losses, and increasing correlation[12] of losses. Higher, more volatile, more

[11] The availability of government aid after a disaster (which can crowd out insurance demand) and adaptation (which reduces risk and constrains price increases) are found to be determinants of the level of the threshold. They observe that, all else being equal, the increases in demand are non-linear and greater than one would expect from the expected value of the loss, suggesting that some other factor is amplifying the effect.

[12] For example, associated with geographically simultaneous events and multiple correlated impacts from single events.

uncertain and more correlated losses would create a quadruple upward-hit on pricing, and imply that (re)insurers will need to increase premiums. In extreme cases, it could also lead insurers to withdraw from certain regions and LOBs (particularly if pricing is constrained by regulation, Herweijer *et al.* 2009) or, if the changing risk environment is not properly anticipated, it could lead to insolvency (Herweijer *et al.* 2009). Both outcomes could reduce the supply of insurance. There is empirical evidence that rising hazard severity and frequency can limit the supply of insurance. For example, Born and Klimaszewski-Blettner (2012) investigate the impact of natural disasters and regulation on the supply decisions of US property insurers and find that, for homeowners insurance, companies are more likely to reduce their coverage in response to unexpected severe events.

It is not clear how this would impact aggregate insurance demand. If insurers are able to adequately anticipate and respond to the changing risk environment (for example, through gradually adjusting premiums and offering new products) then the impact may be minimal, restricted to only the highest risk regions and LOBs. If the transition is not well managed (for example, leading to abrupt changes in premiums and cancellations of policies), the response of the public and policymakers could create spill over effects into other regions and LOBs that could impact aggregate demand (as discussed at the end of Section 3.2). The potential negative impacts on insurance demand are likely to be greatest in regions and LOBs which have a high exposure to weather hazards, as in China and India (Dilley *et al.* 2005).

3.5 New opportunities for products and services

A potential area for significant growth in insurance demand in the BRICS is in LOBs linked to GHG mitigation and adaptation. For example, China, Brazil and India alone already account for 35% of global renewables production (2009 value, IEA, 2010). Under the central

scenario of the International Energy Agency (IEA) demand for renewable energy is expected to triple by 2035[13] (IEA, 2010). An open question is whether the growth in demand for new energy products will substitute that in existing LOBs (related to carbon-intensive industries and energy production) or be additional. Under most scenarios, the IEA forecasts an overall increase in energy demand in non-OECD countries to 2030, particularly in China (IEA, 2010); this suggests that at least in the BRICSs, there could be an overall increase in insurance demand rather than a substitution. Global capital investment in renewables soared to $155bn USD in 2008, up from only $33bn USD in 2004, and estimates suggest that it could reach $370bn USD by 2015 (Munich Re, 2009b). If insurance premia represented only 1% of the projected capital investment in 2015, it would imply a global premium volume of $3.7bn (or well over $1bn in the BRICSs alone). Finally, the nature of energy insurance could also change due to the decentralisation of production, potentially leading to an increase in smaller-scale (and possibly more vulnerable) and private (rather than public) contracts.

A 2006 survey reported that most insurers already offer at least one product for renewable energy projects[14], but it also identified several barriers to expansion of this market, such as a lack of risk data, low insured values and lack of specialist underwriting expertise (Marsh, 2006). Capturing these new opportunities will depend on an insurer's ability to innovate and overcome the barriers to entering these markets.

There are likely to be other new opportunities associated with the growth in 'green' technologies and processes; for example, a number of insurers already offer specialised

[13] Projection for the IEA's 'new polices scenario', which makes cautious assumptions about the implementation of the policy commitments and plans announced by countries around the world, including the national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-fuel subsidies.

[14] Mills (2009) reported that 22 insurance companies were already offering products specifically for green buildings, several companies are offering coverage for production loss in solar and wind energy facilities, and 2 companies had launched products designed to cover boards of directors in the event of climate change litigation.

coverage for hybrid cars and 'green' manufacturing (Mills, 2009). However, we suggest that these are likely to represent a substitution rather than a net growth market.

New markets created by climate change policy, such as carbon trading markets, also bring new opportunities. Indeed, several products are already available. For example, since the establishment of international carbon finance markets as part of the Kyoto Protocol, insurance has been available to assist investors and transfer some of the risks, mainly in the context of the Joint Implementation (JI) and the Clean Development Mechanisms (CDM), by combining traditional project insurance with cover for emission credits, such as credit delivery guarantees. The cover is against lack of or under-performance of climate investment in terms of the underlying emission reductions[15]. Examples are Swiss Re's cover for CDM projects, developed in 2006, or Munich Re's 'Kyoto Multi Risk Policy', developed for international carbon markets (Munich Re, 2007). It is difficult to assess the size of the transactions and the volume of supply and demand for these products – anecdotal evidence is that take up has so far been low. Looking purely at market potential, ABI (2007) concluded that if a premium rate of 1% is applied to the projected global asset value for the carbon trading markets then the total premium value could be £335 million in 2010.

Adaptation could also enhance demand for innovative risk transfer products, as well as value-add services (Herweijer *et al.* 2009). World Bank (2009) estimates that the costs of adaptation outside of OECD countries could total $100bn USD in 2030; the majority of this investment, and therefore demand for insurance, is expected to be in infrastructure and buildings, coastal zone protection, water supply and agriculture. Several studies have highlighted the opportunities related to alternative risk transfer products, including weather

[15] An example would be an industrial facility funded through a CDM investment, which then fails to deliver the expected emission reductions

derivatives (CII, 2009), catastrophe bonds (Mills 2009) and sovereign risk transfer (Cummins and Mahul, 2009). There may be opportunities to innovate more traditional insurance products to enhance demand, for example agricultural micro-insurance schemes aimed at poorer communities (Swiss Re, 2008) and property insurance that rewards investments in adaptation (Ward *et al.* 2008). The development of parametric insurance products, such as index-insurance for crops, provides empirical evidence of how the insurance industry is introducing new products to help respond to changing risk levels. Skees (2008) and Ghesquire and Mahul (2007) highlight the many technical innovations seen in this areas over the last few years and how this can also be replicated for other areas, such as shown in the Caribbean Catastrophic Risk Insurance Facility (CCRIF).

4. Discussion: implications for the insurance industry

Table 6 summarises our conclusions on the potential direction and scale of the influences of climate change and their regional variability. For comparison, we include an estimate of the potential growth in premium volumes due to baseline economic growth alone (from Ranger and Williamson, 2011). With the exception of the public policy and regulation pathway (which itself is an upper bound estimate and only for China and India), the potential impacts of climate change on insurance demand are estimated to be small relative to those of the baseline economic growth expected over the coming decade. The most significant impacts are expected in China and India, and to a lesser extent Brazil. These countries have the greatest potential impacts across all of the pathways. Beyond 2030, the impacts of climate change and therefore, the implications for insurance demand, are expected to increase significantly (Parry *et al.* 2007; Stern, 2007).

Table 6: Summary of conclusions on the influence on climate change on insurance demand

Pathway of Climate Change Influence	**Approximate Scale of Impact on Premium Volumes in BRICS economies in 2015 ($ bn)**	**Regional Focus and Direction of Impact** *(n.b. each has a dependence on (re)insurer responses)*
Impact on income levels	-4 to + 1bn	Small impact relative to baseline economic growth in most countries (i.e. less than around $1bn). Potential for more significant impacts in India (+/-) and China (-).
Public policy and regulation	Up to +6 (India) to +12bn (China)	Potential for sizeable positive impacts in India and China where insurance penetration is currently low relative to income levels. Potential for smaller positive impacts in other countries. Potential for some negative impacts in countries or regions with high exposure to natural hazards
Supply factors	*No data*	Potential for negative impact in regions and lines of business with high exposure to natural hazards (e.g. in particular, China, India and to a lesser extent Brazil).
Willingness to pay for insurance	*Not data*	Potential for positive impact in regions and lines of business with lower exposure to weather hazards (particularly where the 'catch-up' potential of insurance penetration is greatest, such as in India and China) and negative impact where there is high exposure (e.g. in particular, China, India and to a lesser extent Brazil).
New products and services	>+1bn (across all the BRICS)	Positive under most scenarios for the BRICS. Largely focussed in China, India and Brazil
Baseline economic growth (i.e. no climate change)	Up to around +20 to +30bn in most countries; or up to 125bn in China	Significant increase in premium volumes in all countries. The smallest increases are projected in South Africa (around $5bn by 2015) and largest in China (around $80-125bn by 2015). Source: Ranger and Williamson (2011).

In all cases, the scale of the influence of climate change on demand in the BRICS will depend on a number of uncertain factors, such as the scale of the physical changes in risk, the response of governments, the insurance industry and the insured, and the strength of global climate change policies. Given this, we suggest an optimistic and pessimistic scenario of the future for insurance demand:

- **Optimistic (high demand growth) world:** strong action to curb GHG emissions means that the costs of physical changes in climate are moderate; proactive government adaptation policy, gradually rising risk levels and increasing catastrophe

losses increase the awareness of risk and the benefits of insurance in the BRICS, leading to government action that improves the operating environment for (re)insurers and increases the willingness to pay for insurance; (re)insurers respond positively to rising risk levels by providing products that support adaptation such that trust in insurers grows and the industry is seen as part of the solution to climate change by the public and policymakers; strong GHG mitigation and adaptation policies create a rapidly growing market for new insurance products.

- **Pessimistic (low demand growth) world:** governments are ineffective in reducing the risks of climate change through domestic and international policy, leading to higher levels of damages from climate change and lower investments in adaptation and GHG mitigation; rapidly rising risk levels are not well anticipated by the (re)insurance industry causing sudden price increases, insolvencies and withdrawals from some markets; insurance becomes unaffordable or unavailable in some high risk areas, with negative impacts on the resilience of local people and economic activity; the resulting public and political discontent results in lower trust in insurance and a tougher regulatory environment for private (re)insurers, including price regulation and a shift toward public insurance in some markets; weaker global climate policies lead to stagnation of the new markets for renewables insurance and other products linked with GHG mitigation and adaptation (but more rapid growth of traditional energy business lines in the BRICS); towards 2030s, a lack of global action to curb the impacts of climate change leads to growing economic instabilities, including high inflation and lower rates of growth, which negatively impacts the insurance market.

The scenarios demonstrate that the insurance industry has a considerable stake in GHG mitigation and adaptation. While many of the factors that define the scenarios cannot be

controlled by the insurance industry, others are at least partly dependent on how the industry itself responds to the challenges of climate change. There are a number of ways that the industry can promote the optimistic growth path, rather than the pessimistic path:

- Raising awareness of risk and climate change through risk education and disseminating high-quality risk information (Ward *et al.* 2008)
- Taking a longer-term perspective in strategic business planning (for example, to 2030) and anticipating changing risk levels in underwriting and risk management practices to reduce the chance of insolvencies, rapid increases in premiums (or hardening in conditions) and withdrawals from markets in response to rising hazard levels.
- Supporting and encouraging adaptation, as well as enhancing reputation, through innovative product design and public-private partnerships (Herweijer *et al*. 2009).
- Innovating and building technical capacity to capture new market opportunities associated with the transition to a low-carbon economy.
- Informing the debate on climate change and actively lobbying government to take action to reduce risks and curb emissions of greenhouse gases.

This analysis leads us to suggest a number of characteristics of insurers that would lend them strength or weakness in responding to climate change to minimise threats and maximise opportunities. These are summarised as a SWOT diagram (Figure 3). This presentation is used because insurers are typically familiar with considering threats and opportunities in this way and using them in, for example, setting business objectives, evaluating strategies, analysing the competitive environment and monitoring progress.

We expect the arguments made in this paper to be applicable to insurance demand beyond the BRICS. However, based on our analyses, we conclude that the impacts of climate change

on insurance demand are expected to be larger in the BRICS than the industrialised countries as: firstly, as both the positive and negative impacts of climate change on economic growth are generally expected to be larger and the income elasticities of demand are greater; secondly, opportunities for new markets associated with GHG mitigation and adaptation are predicted to be deeper in the BRICS; and finally, the significant 'catch-up' potential in terms of the market conditions for insurance suggest a larger and more positive potential influence related to public policy and regulation and risk awareness.

Figure 3: SWOT analysis, displaying the potential areas of strength and weakness of an insurer in minimising the potential threats from climate change and maximising the potential opportunities

	Beneficial	Harmful
Internal	**STRENGTHS** • Firm is well established in the local non-life markets • Firm is strongly able to anticipate and respond effectively to changing risk levels in underwriting and risk management practices • Firm is well posed to rapidly capture opportunities related to climate change mitigation and adaptation, including technical expertise, appropriate distribution channels and a broad range of innovative products available • Firm has developed a positive reputation in the market and is proactive in working with regulators and policy makers and supporting efforts to reduce risk • Firm actively promotes risk awareness and good risk management practices through its products and risk education activities and openly providing risk information	**WEAKNESSES** • Firm has little/no presence in local non-life markets • Firm is weakly able to anticipate changing risk levels in underwriting and risk management practices • Firm has a narrow range of products related to climate change mitigation and adaptation and inadequate flexibility to capture new opportunities • Firm is unable to respond positively to rising risk levels by engaging activities that support adaptation • Firm does not actively promote risk awareness or risk management practices and protects in-house risk information
External	**OPPORTUNITIES** • Economic growth leads to significant increases in premium volumes in the BRICS • Climate change creates new opportunities for the insurance sector related to greenhouse gas mitigation (e.g. low-carbon energy technologies) and adaptation (e.g. agricultural insurance) • Climate change impacts lead to general increase in risk awareness and willingness to pay for insurance amongst consumers • Rising awareness of climate change and catastrophe risk lead to public policy and regulatory responses that improve the operating environment for insurers, including further liberalisation of market conditions, initiatives to broaden awareness and uptake of insurance and the introduction of mandatory insurance lines.	**THREATS** • Governments are ineffective in reducing the risks of climate change, leading to higher levels of catastrophe risk and lower levels of investment in low-carbon technologies and adaptation • Rapidly rising risk levels are not well anticipated by the (re)insurance industry, leading to high insured losses, rapid increases in premiums, insolvencies and withdrawals from some markets. • Insurance becomes unaffordable or unavailable in some high risk areas • Discontent amongst consumers and policy makers results in lower levels of trust in insurance and a tougher regulatory environment for private re(insurers) • Towards 2030s, a lack of global action to mitigate and adapt to climate change causes growing economic instabilities and a downturn in insurance markets.

5. Conclusions

We evaluate the potential influence of climate change on future growth with a view to informing long-term strategic planning in the insurance industry. While the complex interactions and uncertainties mean that it is impossible to quantitatively forecast the future impacts of climate change on insurance demand, we conduct a preliminary evaluation of their relative scale and directions based on evidence available today. We conclude that, with the exception of policy and regulation, the influence of climate change on insurance demand to 2030 is likely to be small when compared with the expected growth due to rising incomes, but not insignificant. The most significant influence on growth is likely to come through firstly, policy and regulatory responses to climate change and secondly, new opportunities related to GHG mitigation and adaptation policies. The largest impacts are expected in China and India, where there are the greatest opportunities for a catch-up in insurance penetration due to improved market conditions, increased risk awareness and new opportunities associated with climate policy. To some extent, the scale of the impacts and their direction depend on (re)insurer responses to the challenges of climate change. We outline five actions that could pave the way for future opportunities.

Acknowledgements

The authors thank Munich Re for sharing insurance market data. We are particularly grateful to Dr Hans-Jörg Beilharz for insightful discussions on insurance demand. We wish to thank Andrew Williamson for research assistance, including developing the empirical model of insurance demand used in Section 3.1. Finally, we gratefully acknowledge the support of our funders, the Grantham Foundation for the Protection of the Environment, the UK Economic and Social Research Council and Munich Re.

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Appendix A: Methodology for Quantitative Forecasts of Insurance Demand

This appendix outlines the method for generating quantitative forecasts of insurance demand. Section A.1 considers the influence of income only, while Section A.2 also includes a simple representation of trends in non-income factors.

A.1. 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. This simple method is proposed by, for example, 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 (e.g. the GTL) and income per capita and R_c is the country-specific residual.

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

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 2 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. The WIGC is taken directly from Zheng *et al.* (2009). 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)[16], and Goldman Sachs[17] (O'Neill

[16] 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.
[17] O'Neill and Stupnytska (2009) did not provide forecasts for South Africa and so these projections include only two sets of economic projections

and Stupnytska 2009). These three sources give a wide spread of projections for 2015 and 2030 (Table A.1).

Table A.1: Range of GDP per capita projections by type of GDP measure and by country across the three economic forecasts

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]

The residual, $R_{c,}$ is calculated and applied in two ways:

1. **Increment:** 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 (as shown in Figure 2). This assumes that the residual remains constant at the 2009 value.
2. **The Benchmark Ratio of Insurance Penetration:** 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 A.2. This shows that the largest rates of growth are expected in China, and between 2010 and 2020 for all countries. 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.

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]%

The premium volume (shown in Table 4) is calculated by combining the forecasts of insurance penetration with the economic growth forecasts from the three sources[18].

A.2. Representing trends in non-income factors

As discussed in Section 2, the *Increment* (Figure 2) or *BRIP* may change over time in response to non-income effects. 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, projected forward linearly. Otherwise, the structure of the forecasts is preserved, thus giving a new set of twelve insurance penetration forecasts.

[18] 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%).

Table A.3 gives 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 A.2 as the residual has declined over the past decade (Figure 2); conversely, the forecasts for Russia show more rapid growth. From a simple hindcasting experiment, we find that income-only forecasts tend to perform better (in terms of the root-mean-square error) than those with time-evolving residuals (in agreement with Feyen *et al.* 2011), except where there is a sizeable but stable trend in penetration relative to income over the preceding five to ten years[19].

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]%

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.

[19] 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.

Appendix B: Background Information on Climate Change Projections

The analyses in Section 3.1 draw on estimates of the economic impacts of climate change from Mercer (2010) projections. As explained in the main text, we use information from this study for three reasons. Firstly, it is unique in synthesising up-to-date estimates of the costs of adaptation, GHG mitigation and the residual impacts of climate change from multiple peer-reviewed sources. Secondly, these are assembled into scenarios that attempt to capture the uncertainties in costs portrayed by the underlying literature.

Mercer (2010) considers two scenarios: one representing a world where no action is taken to curb GHG emissions and the climate responds sensitively to emissions ('*Climate Breakdown'*) and the other, a world where strong action is taken to curb GHG emissions and the climate responds more moderately to those emissions ('*Stern Action'*). These scenarios attempt to capture some of the considerable uncertainty in climate change impacts, but should be interpreted as plausible scenarios rather than as giving an indication of the range of possible impacts.

The cost estimates for the two scenarios are given in Table B.1. These were derived as follows:

- ***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.

Table B.1: 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)**
Scenario: 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
Scenario: 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

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).

It is important to recognise that the estimates given in Mercer (2010), and equivalent studies, represent only a narrow range of the potential costs of climate change. For example, they do not include the potential non-market impacts of climate change on ecosystems, human health and wellbeing, or indirect impacts on the global macroeconomic environment. Damages from extreme events, both human and economic, are also not fully captured; Dilley *et al.* (2005) show that China and India and parts of Brazil are already global hotspots of risks from weather catastrophes. The costs of adaptation and GHG mitigation are also highly uncertain (Edenhofer *et al.* 2009, World Bank 2009).