

# A Theory of Optimal Reserves Allocation and Sudden Stops in Emerging Economies

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# This paper

- Question
  - Why have emerging economies sharply increased their foreign reserves since 1997-2001

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- Question
  - Why have emerging economies sharply increased their foreign reserves since 1997-2001
- Answer
  - Optimal response to sudden stops (of capital inflow)

# What we do

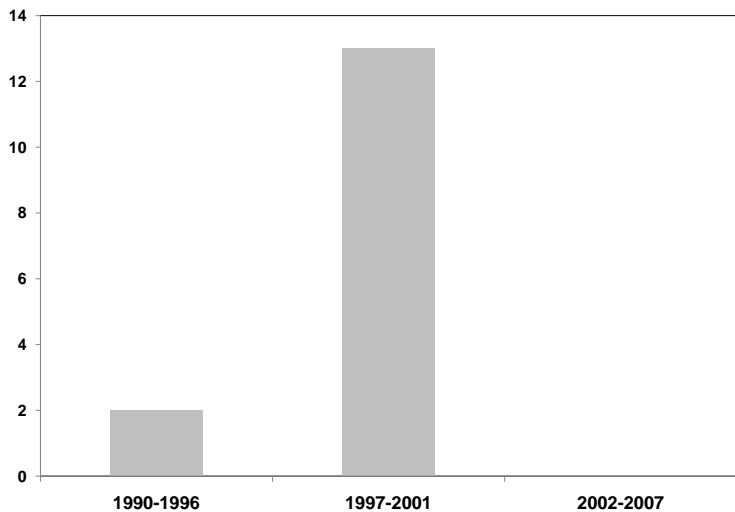
- Facts on emerging economies
  - sudden stop experiences
  - foreign reserves
  - external debt
- A theory of foreign reserves allocation and sudden stops
- Quantitatively account for the stylized facts

## Facts on reserves and liabilities

- Fact 1: The frequency of sudden stops in emerging economies
  1. low in 1990-1996, 2002-2007
  2. high in 1997-2001

# Fact 1: Sudden stop occurrences

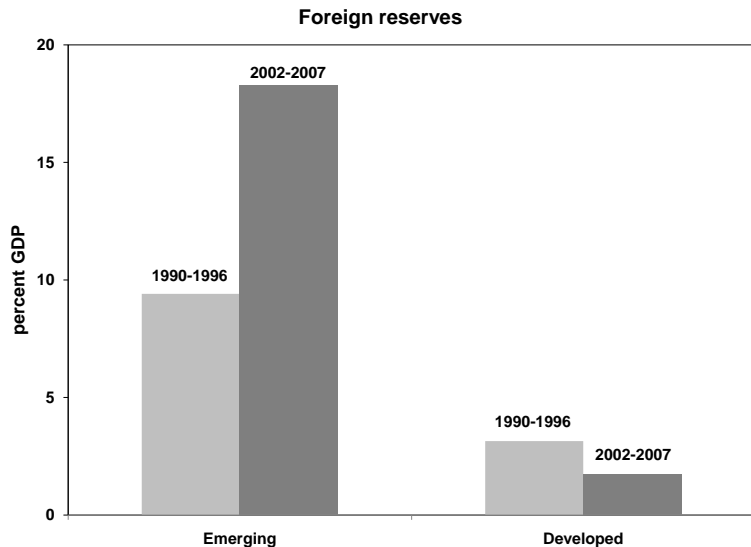
## Sudden stops in emerging economies



## Stylized facts on reserves and liabilities

- Fact 1: The frequency of sudden stops are
  1. low in 1990-1996, 2002-2007
  2. high in 1997-2001
- Fact 2: **Foreign reserves**
  1. increasing and large in emerging economies
  2. decreasing in developed economies

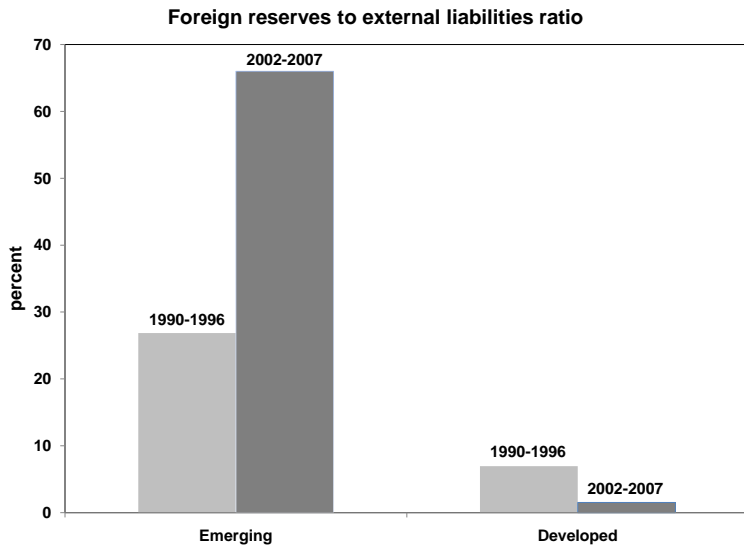
## Fact 2: Foreign Reserves on the Rise



## Stylized facts on reserves and liabilities

- Fact 1: The frequency of sudden stops are
  1. low in 1990-1996, 2002-2007
  2. high in 1997-2001
- Fact 2: Foreign reserves in emerging economies are
  1. increasing and large in emerging economies
  2. decreasing in developed economies
- Fact 3: The **ratio of reserves and external liabilities** is
  1. increasing and large in emerging economies
  2. decreasing in developed economies

## Fact 3: Reserves-to-liabilities on the rise



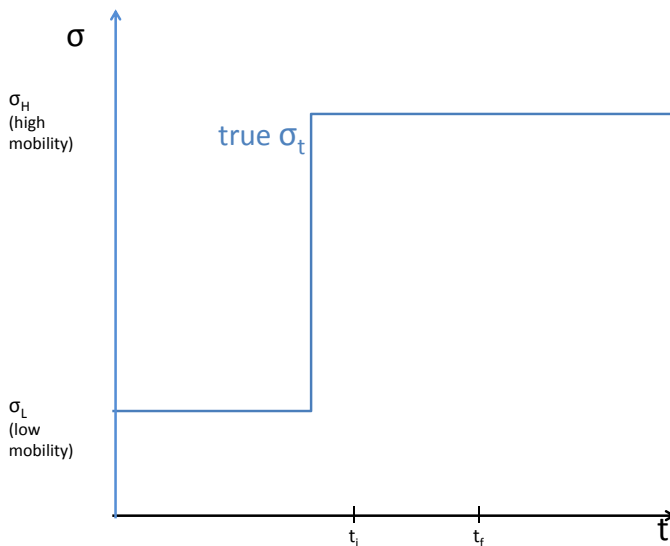
# Our story

## Modelling approach

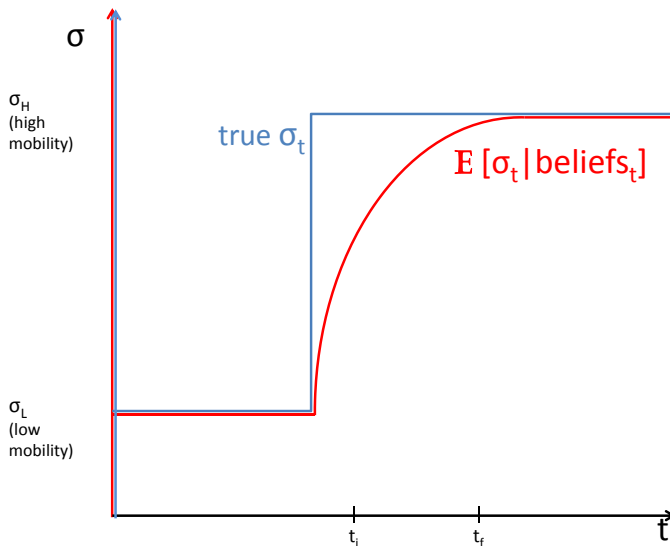
We model a world with

- N emerging economies, which finance long-term domestic projects with short-term foreign debt
- Foreign investors face liquidity shocks as in Diamond-Dybvig
- Change in the liquidity shock process  
(reduced form for an increase in capital mobility)
- Bayesian learning of the new process using **endogenous** sudden stop probabilities

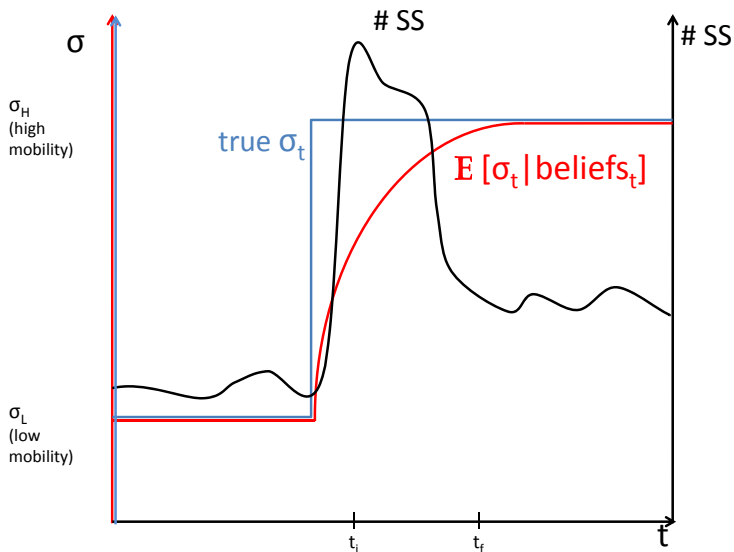
# Regime switch



## Regime switch and gradual learning



## Misaligned beliefs and sudden stops



# The model

## Environment

- $t = 0, 1, 2, \dots, \infty$
- Every period  $t$  has three stages  
 $s_t = 0$  (initial), 1 (interim), 2 (final)
- $j = 1, 2, \dots, N$  identical countries
- Countries have common beliefs  $\rho_t$   
about liquidity shock process parameter  $\sigma_t$

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about liquidity shock process parameter  $\sigma_t$
- Today, we present a simplified version of the **3 stage model**  
to highlight the key mechanisms

# Agents

1. a unit measure of risk-neutral foreign lenders
  - each lends callable debt  $D$  in the initial stage
  - if the lender receives a liquidity shock in the interim
    - they must call the loan
  - otherwise they can choose to call or roll over

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  - otherwise they can choose to call or roll over
2. a welfare-maximizing government in each country  $j$ 
  - takes world interest rate  $r$  as given
  - sets the terms of its debt contract
  - commitment but limited liability

## Interim Liquidity Shocks

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- A fraction  $\varphi_j \in [0, 1]$  of foreigners lending to country  $j$  receive liquidity shocks in the interim
- These fractions  $\varphi_j$  follow a cumulative distribution function  $F_\sigma$
- What we call sudden stops
  - sudden stop  $\equiv$  all lenders refuse to roll over the loans made to country  $j$
  - a sudden stop is not simply a large aggregate shock, but an **endogenous** result of the optimal decision of lenders

# Technology

- Long term technology

initial stage (investment)	interim stage (divestment)	final stage (output)
$-K$	$\lambda S$	$A(K - S)^\theta$

# Technology

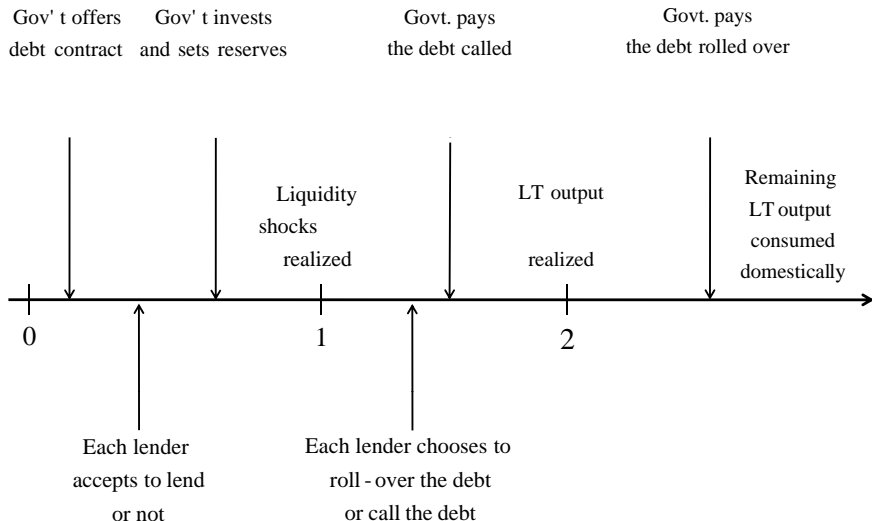
- Long term technology

initial stage (investment)	interim stage (divestment)	final stage (output)
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- 'Reserves' technology

initial stage	interim stage	final stage
$-1$	$1$	
	$-1$	$1$

# Timeline



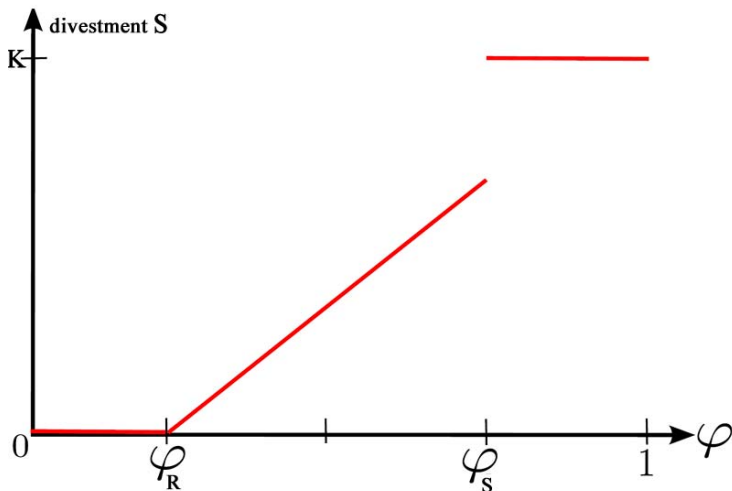
# Divestment, Payment, Call/Rollover policies

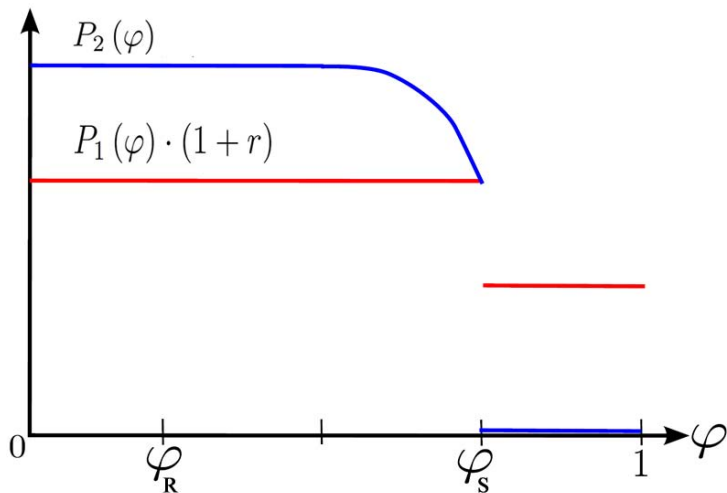
- In the paper, we solve for equilibrium
  - divestment and payment policies of the government
  - call/rollover policies of the foreign lender

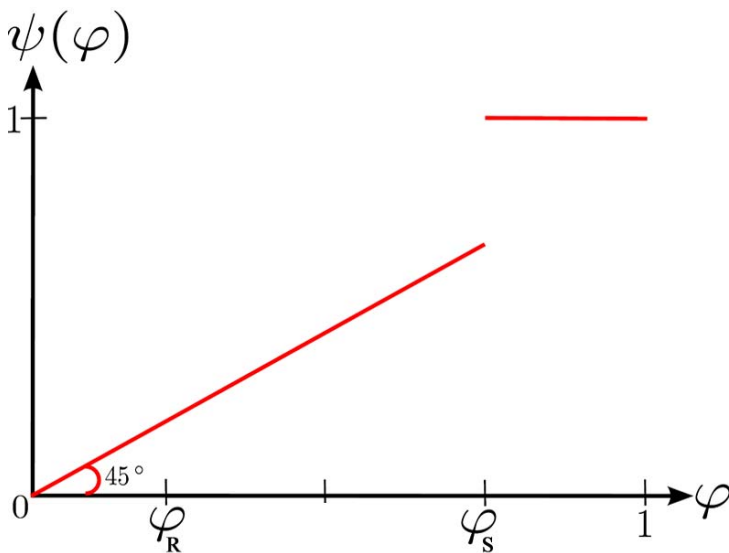
## Divestment, Payment, Call/Rollover policies

- In the paper, we solve for equilibrium
  - divestment and payment policies of the government
  - call/rollover policies of the foreign lender
- These policies are characterized by cutoff levels  $\varphi_R, \varphi_S$  that depend on the debt contract
- We outline these policies in the following slides

## Interim divestment policy $S(\varphi)$



Payment policies  $P_1(\varphi)$ ,  $P_2(\varphi)$ 

Fraction of loans called  $\psi(\varphi)$ 

So what is the optimal contract

## Static Optimal contract definition

Given reserve endowments  $R_0$ , interim divestment policy  $S(\varphi)$ , payment policies  $P_1(\varphi), P_2(\varphi)$ , and call fraction  $\psi(\varphi)$  an optimal contract  $C^* = \{\hat{r}^*, D^*, R^*, K^*\}$  solves

$$\begin{aligned} \max_C \quad & \mathbb{E}_0 \left[ A(K - S(\varphi))^\theta + \underbrace{R_2(\varphi)}_{\text{remaining reserves}} - \underbrace{(1 - \psi(\varphi)) P_2(\varphi)}_{\text{total stage 2 payments}} \right] \\ \text{s.t.} \quad & \text{[RC]} \quad R + K \leq R_0 + D \\ & \text{[LMR]} \quad R_2(\varphi) = \max\{R - \psi(\varphi)P_1(\varphi), 0\} \\ & \text{[PC]} \quad \underbrace{\mathbb{E}_0 V}_{\text{Expected returns}} \geq (1 + r)^2 D \end{aligned}$$

## Features of optimal contract

- Reserves-to-debt ratio is increasing in  $\sigma$  (liquidity shock process)
- $\hat{r}$  increasing in  $\sigma$ , i.e. interest premia increasing
- $\varphi_D, \varphi_S$  not monotone
- probability of sudden stop increasing in  $\sigma$

## Thought Experiment

- Suppose the CDF of the liquidity shocks shifts rightward without agents knowing
- Once the shift occurs,
  - gov'ts initially underinvest in reserves
  - sudden stops occur in many countries

## Thought Experiment

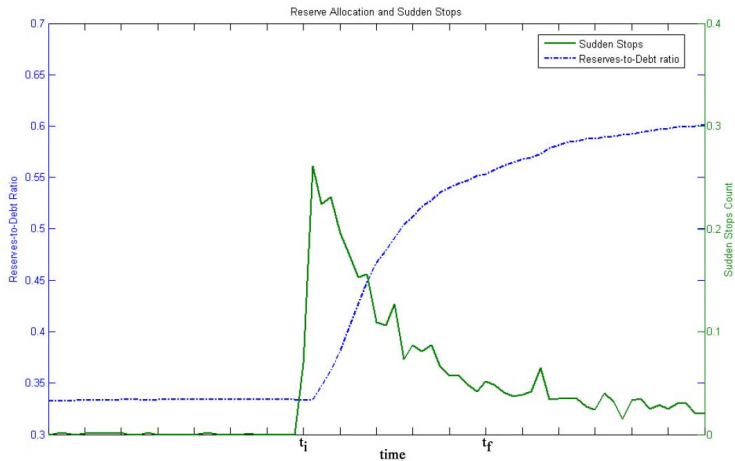
- Suppose the CDF of the liquidity shocks shifts rightward without agents knowing
- Once the shift occurs,
  - gov'ts initially underinvest in reserves
  - sudden stops occur in many countries
- Gov'ts observe sudden stop occurrences across countries and update beliefs according to Bayes' Rule
- Once gov'ts learn the true process, reserve-to-debt ratio is higher and sudden stops decrease

## Bayesian updating

At the end of each period  $t$ , agents use the vector of sudden stops  $\chi_t$  and initial belief  $\rho_t \equiv \Pr(\sigma = \sigma_L)$  to update their beliefs:

$$\begin{aligned}\rho_{t+1} &= \Pr(\sigma_t = \sigma_L | \rho_t, \chi_t) \\ &= \frac{\rho_t \Pr(\chi_t | \sigma_t = \sigma_L)}{\rho_t \Pr(\chi_t | \sigma_t = \sigma_L) + (1 - \rho_t) (\Pr(\chi_t | \sigma_t = \sigma_H))}\end{aligned}$$

# Simulated results

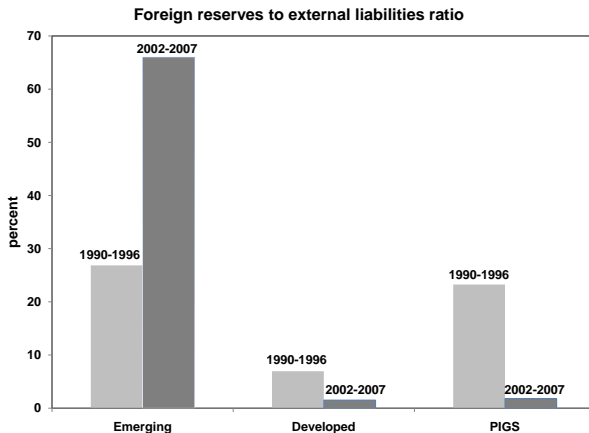


# Conclusion

- Existing theories model reserves as
  - a consumption smoothing device against **exogenous sudden stops**
- In this theory, reserve holdings **endogenously** decrease the probability of sudden stops
- It can successfully account for
  - the sudden stop experiences in emerging economies
  - the changes in reserves-to-debt ratios since the late 90s

## Concluding thoughts

PIGS behaved like emerging economies in 1990-1997, but like developed economies in 2002-2007



# Appendix

## Sudden stops

- Sudden stop: sudden slowdown or reversal of capital flows into emerging economies ( year-on-year fall in capital flows of at least 2 standard deviations below the mean )
- sudden stops classified in Durdu, Mendoza, Terrones (2009): Argentina, Mexico (1994), Indonesia, Malaysia, Philippines, South Korea, Thailand (1997), Brazil, Chile, Colombia, Pakistan, Peru, Russia (1998), Argentina, Turkey (2001).

## Emerging economies

- The list of emerging economies includes :  
Argentina, Brazil, Chile, China, Colombia, the Czech Republic, Egypt, Hungary, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, South Africa, South Korea, Thailand, and Turkey

▶ Fact 2

▶ Fact 3

# Foreign reserves

- Foreign reserves are constructed as Total Reserves minus Gold.
- This includes convertible foreign exchange, SDR holdings, and IMF reserve position

▶ Fact 2

▶ Fact 3

	Foreign Reserves/GDP			Foreign Reserves/External Liabilities		
	1990-1996	2002-2007	% Change	1990-1996	2002-2007	% Change
<i>Emerging</i>						
Argentina	4.9%	12.5%	154%	14.3%	21.4%	50%
Brazil	4.8%	8.3%	73%	19.5%	35.3%	81%
Chile	20.1%	15.7%	-22%	50.9%	39.0%	-23%
China	8.1%	32.9%	306%	54.3%	271.3%	400%
Colombia	9.7%	10.5%	8%	35.6%	35.1%	-1%
Czech Republic	18.3%	25.2%	38%	57.2%	77.5%	36%
Egypt	18.8%	19.3%	3%	35.2%	65.5%	86%
Hungary	15.8%	16.7%	5%	26.6%	26.2%	-2%
India	3.4%	18.2%	429%	11.8%	101.0%	754%
Indonesia	6.7%	12.4%	86%	11.7%	25.2%	116%
Korea	5.5%	24.6%	345%	28.0%	97.4%	248%
Malaysia	28.7%	47.0%	64%	77.0%	125.6%	63%
Mexico	4.6%	8.1%	78%	12.2%	40.9%	235%
Morocco	10.4%	28.7%	175%	15.9%	99.0%	522%
Pakistan	1.8%	10.2%	472%	4.3%	28.2%	552%
Peru	11.1%	18.2%	64%	16.7%	49.1%	195%
Philippines	8.1%	17.2%	113%	13.3%	28.4%	113%
Poland	7.0%	14.0%	101%	15.9%	35.8%	125%
Romania	4.0%	18.1%	352%	22.7%	53.9%	138%
Russia	3.2%	22.9%	615%	7.3%	68.5%	836%
Saudi Arabia	7.3%	9.4%	28%	56.2%	87.3%	55%
South Africa	1.0%	7.0%	591%	4.7%	34.9%	646%
Thailand	19.8%	30.6%	54%	41.8%	112.1%	168%
Turkey	3.9%	10.6%	171%	13.0%	25.5%	96%
<i>Developed</i>						
France	2.1%	1.7%	-19%	3.8%	1.3%	-66%
Germany	3.9%	1.8%	-54%	8.7%	1.5%	-83%
United Kingdom	3.6%	1.8%	-49%	2.4%	0.6%	-73%
United States	1.0%	0.5%	-46%	3.2%	0.8%	-74%