Infrastructure in Developing Countries: Risk and Protection

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Abstract. We view the infrastructure of a developing country as a portfolio, which generates returns. Unlike in portfolio management for individuals, we assume that

- infrastructure generates a deterministic return,
- infrastructure is subject to loss due to natural catastrophes,
- governments cannot sell or diversify their portfolio.

From the viewpoint of risk management, there are only two strategies: buying ex-ante protection (insurance, cat-bonds or other risk transfer tools) or to borrow ex-post. Limitations to borrowing and the desire for stable, predictable growth make the ex-ante protection strategy attractive. We introduce a simple model for illustrating the benefits of this strategy.

1. Introduction

Most developing countries governments own a large portion of the infrastructure needed for their development (World Bank, 1994). Depending on the size of the country, its exposure to natural hazard loss, and its stock of infrastructure, losses from natural hazards impacting the country can cause significant loss to the infrastructure stock. Annually, approximately 20 billion USD of infrastructure is lost annually from natural catastrophe events (Freeman, 1999a). Since a catastrophe could impact a significant portion of the infrastructure within a country, the losses to the infrastructure are correlated. In this sense, a geographically constrained country is similar to a small, geographically limited insurance company. Is there a portfolio strategy available for them to reduce their exposure?

The portfolio of loss to infrastructure of a developing country has some distinctive characteristics. The portfolio consists of fixed assets. Once in place, infrastructure, like most real property assets, tends to be permanent. The investment in the infrastructure is presumed to have a fixed rate of return over the life of the asset. The rate of return is generally based on a cost/benefit analysis made at the time of the original investment decision. The World Bank estimates the infrastructure projects for which they have provided financing have annually earned on average 17% of the cost of the project (World Bank, 1994). The infrastructure is exposed to damage loss, either from natural disasters, civil disruption, or lack of proper maintenance. Portfolio theory generally applies where the total amount available for investment is known, but the rate of return on the assets is unknown. Portfolio theory explains how to maximize the rate of return within defined constraints. The primary planning tool is changing the individual assets owned in the portfolio. With a portfolio composed of assets whose returns are correlated (a portfolio of equities in Austrian banks, for example), maximizing return at reduced risk is aided by adding to the portfolio assets with return characteristics that are not correlated to the return characteristics of the existing portfolio. In this instance, adding the shares of Japanese car manufacturers to the portfolio would most likely diversify the portfolio since it is unlikely that the returns on the shares of Japanese car manufacturers are correlated to the performance of Austrian banks.

The portfolio strategy to deal with the risk of loss of the infrastructure of a developing country is different. This portfolio consists of a set of assets that are expected to create a predetermined rate of return. The risk is in the loss of the asset base through damage by natural catastrophe. The asset base is geographically fixed. The risk of loss from natural catastrophes is correlated both temporally and spatially, as subsequent sections of the paper will detail. The portfolio strategy is how to reduce the risk of loss from natural catastrophes to infrastructure to preserve the expected return from the infrastructure investment.

2. The Model

For purposes of this paper, we assume a country with an initial infrastructure base of 100. The infrastructure depreciates over a 30-year period. Annually, the country has the ability to borrow an amount equal to 10\% of its existing infrastructure base. This assumption intends to capture the ability of a country, based on existing economic performance, to increase external borrowing related to infrastructure. The additional borrowing can be used for one of three purposes; add new infrastructure, replace damaged infrastructure lost through natural catastrophe events, or purchase risk transfer protection for the existing infrastructure. This assumption is based on existing experience with developing countries and how they finance losses from natural catastrophes. Some studies suggest that a portion of new loans for developing countries are made to replace lost infrastructure, and that previously approved loans are diverted to pay for losses (Arriens, 1999). Generally, the new and diverted credits are structured to remain within a perceived borrowing limit for a country based on its existing economic performance. Here, the perceived borrowing limit for infrastructure purposes is 10% of the existing level of infrastructure. This is an arbitrary assumption.
The assumed interest rate for all borrowing is 8%, which is a blended rate of the average of 17% now paid by developing countries on commercially issued sovereign debt and the much lower concessional interest rate borrowing for developing countries from international development banks. Deutsche Bank estimates that the blended rate for developing countries for all borrowing is 8-9% (Deutsche Bank, 1999). Principal and interest on all borrowing is amortized over a ten-year period.
It is assumed that the rate of return on the infrastructure investment is 15%, whether existing or new infrastructure. This is slightly lower than the average return of 17% returned on existing World Bank infrastructure projects.
It is assumed that the infrastructure is subject to risk of loss of 25% of total infrastructure once every 25 years (a 4% event). It is assumed that risk transfer to cover a full 25% loss of infrastructure can be purchased at a rate equal to 5% of the infrastructure. This rate represents the risk rate of 4% (equivalent to the event likelihood) and an expected return to the professional risk taker equivalent 25% of the risk rate. Under current pricing for catastrophe risk transfer, this rate would be very high (Swiss Re, 1997).

With these assumptions in mind, a mathematical model was built and 1000 trajectories were simulated. We compared the net profit of the country for two situations:

- no insurance
- insurance which covers the damages up to 25% of the current infrastructure for a price which is 5% higher than the expected value.

In the following pictures, we show the net profit of the country.

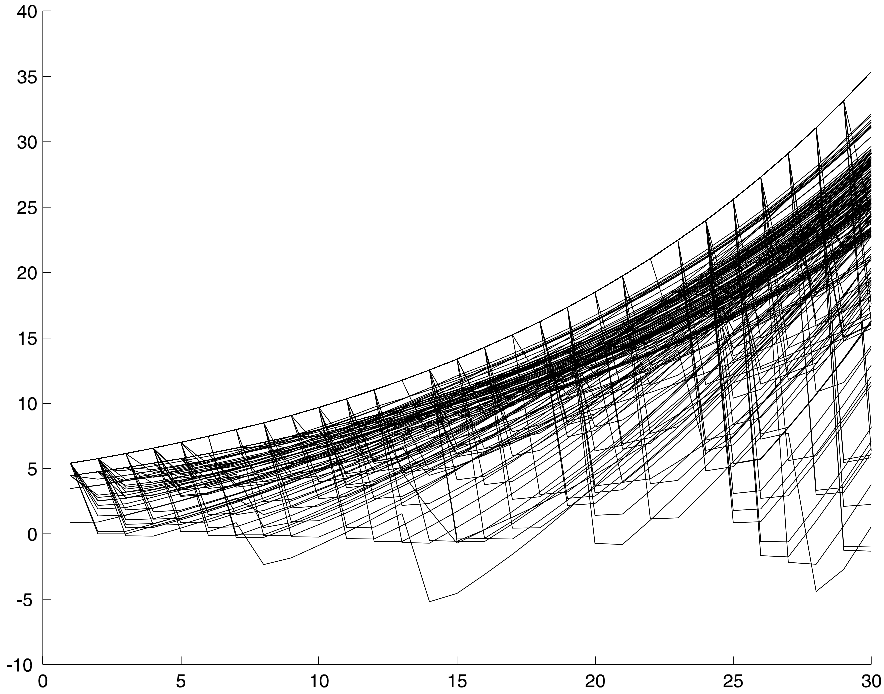

Fig. 1: Typical paths of the net profit for the coming 30 years, no insurance.

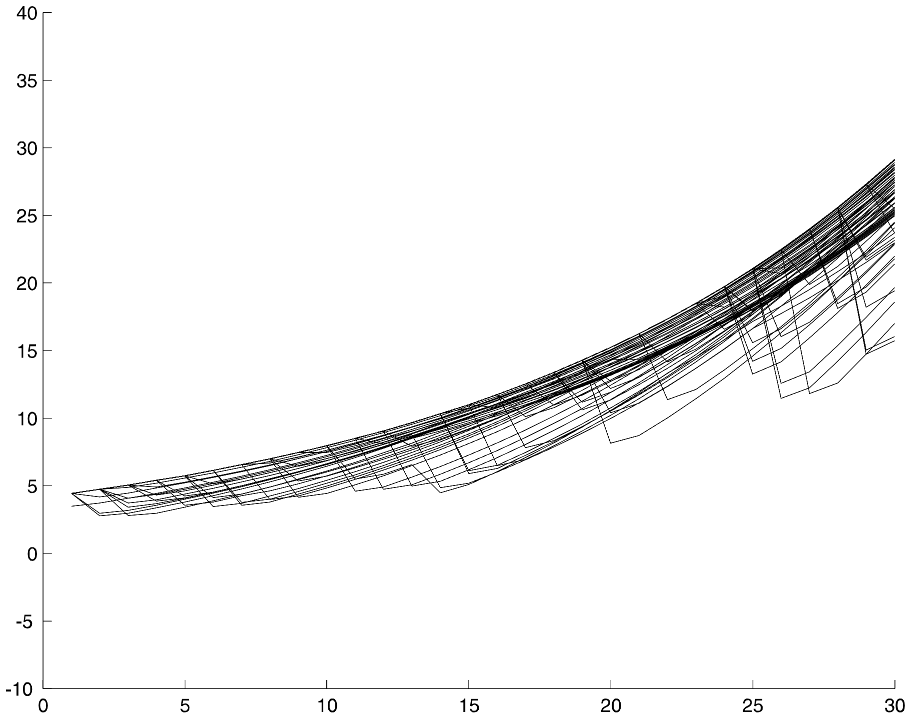

Fig. 2: Typical paths of the net profit for the coming 30 years, with insurance

As one can see, the insured paths are less dramatically dropping, there is no path which drops under the insolvancy line (net profit = 0), however for the price of a little smaller inrease in no catastrophic years.

3. Policy Conclusions

The analysis provides two broad policy conclusions. Risk transfer incurs cost in the current period, which reduces funds available for other uses. The classic question is whether the current cost and lost potential returns is justified. The answer is in the evaluation of the perceived benefit. As this exercise presents, the benefit lies in increased stability of performance within a narrower range. Risk transfer reduces volatility of performance at the cost of potentially higher overall performance. This is intuitively obvious. For a developing country, the issue is whether guaranteeing minimal economic performance (i.e., earning sufficient income to guarantee interest payment on externally incurred debt) outweighs the potential loss of some economic performance. The modeling provides a basis for evaluating the alternative options based on the desired mix of policy outcomes.

The second general conclusion is not one the authors have seen explored before. Interestingly, because of the correlated nature of the risk of damage to infrastructure, the addition of more infrastructures in the same region increases the variability of loss for the whole portfolio of infrastructure assets. If the risk was not correlated, the addition of new infrastructure would decrease variability through the law of large numbers. This conclusion could have significant policy implications. It would mean that the more infrastructures in place, the greater the benefit of risk transfer.