CLIMATE POLICY INITIATIVE

ISB | Bharti Institute of Public Policy

Reaching India's Renewable Energy Targets Cost-Effectively: A Foreign Exchange Hedging Facility

Arsalan Ali Farooquee
Gireesh Shrimali

June 2015

Technical Paper

Acknowledgements

The authors thank CPI staff David Nelson, Ruby Barcklay, Maggie Young, and Amira Hankin for internal review. We thank Darrell Duffie, Timothy Irwin, and Robert Sheppard for their feedback and guidance. We thank participants in our primary research for their contribution. We also thank ISB for its continued support toward our research efforts. The views expressed in this paper are the authors' own.

Descriptors

Sector	Renewable energy finance
Region	India
Keywords	Currency hedging, renewable energy finance, India
Contact	Gireesh Shrimali: gireesh.shrimali@cpidelhi.org

About CPI

Climate Policy Initiative is a team of analysts and advisors that works to improve the most important energy and land use policies around the world, with a particular focus on finance. An independent organization supported in part by a grant from the Open Society Foundations, CPI works in places that provide the most potential for policy impact including Brazil, China, Europe, India, Indonesia, and the United States.

Our work helps nations grow while addressing increasingly scarce resources and climate risk. This is a complex challenge in which policy plays a crucial role.

About ISB

The Indian School of Business (ISB) is a global business school offering world-class management education across its two campuses – Hyderabad and Mohali. The School has grown at a rapid pace over the twelve years since its inception and already has several notable accomplishments to its credit– it is the youngest school ever to consistently rank among the top Global MBA programmes, the first institution in South Asia to receive the prestigious AACSB accreditation, one of the largest providers of Executive Education in Asia, and the most research productive Indian management institution. A vibrant pool of research-oriented resident faculty and strong academic associations with leading global B-schools, have helped the ISB fast emerge as a premier global Business school in the emerging markets. For more details visit www.isb.edu.

Reaching India's Renewable Energy Targets Cost-Effectively: A Foreign Exchange Hedging Facility

Arsalan Ali Farooquee and Gireesh Shrimali

Abstract

A major barrier to deploying renewable energy in India is a shortage of debt at attractive terms. Domestic debt in India has high cost, short tenor, and variable interest rates, adding 30% to the cost of renewable energy. Currently foreign debt is as expensive as domestic debt because it requires market-based foreign exchange hedging solutions. This paper investigates a government-sponsored foreign exchange facility as an alternative way for facilitating provision of foreign debt at attractive terms. We use a representative stochastic model of the INR-USD foreign exchange rate. We find that the expected cost to provide a 10-year currency hedge via a government-sponsored foreign exchange facility is 3.5 percentage points, which is 50% lower than the cost of a market hedge. We also find that this facility has the potential to reduce the cost of renewable energy by up to 19% and the cost of government support by up to 54%. However, these benefits come with a caveat: the government should manage the risks related to unexpected and extreme currency movements appropriately. One option to manage these risks is via a capital buffer, which we explicitly model. We find that, for the facility to achieve India's current sovereign rating, the cumulative capital buffer would be almost 30% of the underlying loan. Finally, using option theory, we calculate the market cost of maintaining this capital buffer, which largely explains the difference between the market cost of hedging and the expected cost of hedging from this facility.

Keywords: currency hedging, renewable energy, foreign exchange risk, capital buffer

1. Introduction

India has ambitious renewable energy targets for 2022.[1] However because of the government's limited budget, a cost-effective policy path is crucial to achieving those targets. Achieving India's renewable energy targets cost-effectively faces two key barriers – a shortage of debt and inferior terms of debt (CPI, 2012).

The estimated availability of private capital for infrastructure investment during the 12th Five Year Plan is 27% lower than what's required (RBI, 2012). In addition, inferior terms of domestic debt, specifically high cost, short tenor, and variable interest rates, increase the cost of renewable energy in India by 30% compared to the US (CPI, 2012). This directly increases the cost of government support. More debt at attractive terms, specifically reduced cost, extended tenor debt, is needed to achieve India's renewable energy targets.

Domestic loans in India are expensive, typically costing more than 12% per year (CPI, 2012). In addition, these loans tend to be for shorter terms, and have variable interest rates. Foreign loans may be attractive for Indian policymakers, given that cheaper, longer-term, fixed-rate foreign loans have the potential to reduce the cost of renewable energy and, therefore, the cost of government support (CPI, 2012; CPI, 2014).

However, when a renewable energy project is financed by a foreign loan, the mismatch in the underlying currency of debt obligations (for example, USD) and currency of revenue (for example, INR) exposes the project to the risk of devaluation in the latter, necessitating the use of a currency hedge to protect against these devaluations.[2]

Hedging exposure in financial markets in India is expensive, and the high costs of hedging almost entirely negate the benefit of cheaper foreign borrowings. The typical cost of currency hedging in India is around 7% per year (Bloomberg terminal[3]), which makes a fully hedged foreign loan nearly as expensive as domestic loans (CPI, 2012).

Reducing the cost of foreign debt, by reducing the currency hedging cost, can mobilize foreign capital and spur investments in renewable energy by reducing the cost of capital. This would then reduce the delivered cost of renewable energy,[4] making renewable energy more competitive with electricity generated from fossil fuels (CPI, 2012); as well as reduce the government cost of support (CPI, 2014).

The Government of India has realized the role cheaper currency hedging mechanisms can play in expanding renewable energy capacity. The government has shown interest in providing cheaper currency hedging for renewable energy using funds from the National Clean Energy Fund.[5] Subsequent government announcements have discussed the initial design of a hedging facility.[6]

1 The government of India has recently revised the renewable energy targets to 160GW of solar and wind energy capacity by 2022. This is more than six times the current installed renewable energy capacity of 23GW.

2 In theory, INR has a market-determined exchange rate. However, RBI can intervene actively in cases of excessive volatility (HSBC, 2012).

3 Last accessed in January 2015

4 For this paper, delivered cost of renewable energy includes the per unit generation (only) cost to the consumer. In most cases, this is the same as the levelized cost, which is the per unit revenue required for a project to be viable; however, in some cases, it may include surcharges.

5 See http://www.livemint.com/Politics/ZfmQqAhTj0YR6epa7DS53J/India-may-leverage-clean-energy-fund-to-hedge-foreign-loans.html?utm_source=copy

6 See http://economictimes.indiatimes.com/industry/energy/power/power-minister-piyush-goyal-eyes-bidding-in-dollar-to-cut-solar-tariff/articleshow/46684838.cms

Given that government policies can influence currency rates, there is an argument for governments providing a currency hedging solution in strategic situations. Macroeconomic conditions are primary drivers of foreign exchange rates (IDBI, 2006), and most macroeconomic conditions can be influenced by government policies. Given that governments may be in the best position to bear (and respond to) currency risk, they can choose to bear this risk in certain strategic situations, such as deployment of renewable energy.

Another argument for the Indian government providing currency hedging is that bearing the currency risk for renewable energy offsets the risk the government (and the economy as a whole) takes on the currency risk related to future imported fossil-fuel purchases. This is particularly relevant for imported coal, which is the marginal fossil fuel that additional renewable energy is likely to replace (CPI, 2015).

However, the hedging proposals that the government has announced so far do not fully assess the risks associated with foreign exchange rate hedging adequately. These proposals discuss the average rate the INR has depreciated against the USD, and propose a facility that addresses this average depreciation. But currency movements can be unexpected and uncertain.[7]

This requires an in-depth assessment of not only the expected cost of providing such a hedging facility but also the risk implications. We do so by using a representative probabilistic model to model future foreign exchange rate movement; however, with the caveat that our results only provide an insight into various aspects of designing an FXHF, and a more detailed design would require in-depth modelling in collaboration with industry and academic experts.

2. A foreign exchange hedging facility (FXHF)

A government-sponsored FXHF ("the FXHF") could be a cheaper mechanism which could effectively support hedging of currency risk. The FXHF would provide hedging for expected currency depreciation and unexpected and extreme currency depreciation separately, hence providing greater control over risk exposure and risk assessment than hedging in the market.

Under the FXHF, the government can provide project developers or off-takers (for example, public distribution companies) protection from currency risk through a standalone fund. The cash flows under the FXHF depend on whether the project's power purchase agreement (PPA) is based on local currency (INR) or hard currency (USD). Both of these models are described below.

2.1 An FXHF for a local currency power purchase agreement

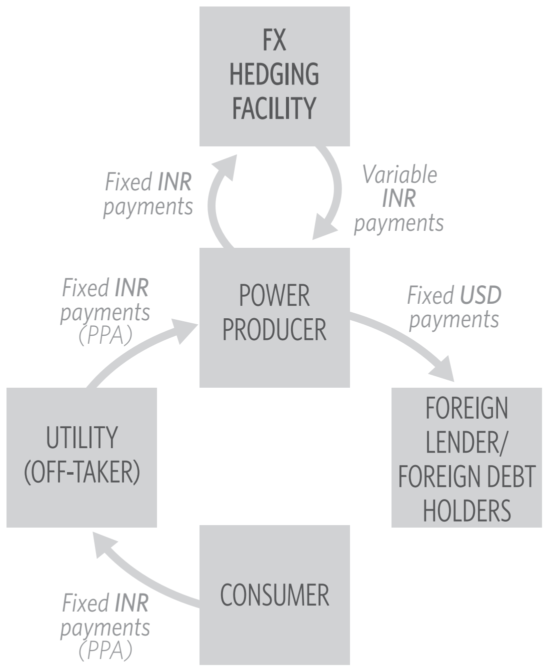
Under a local currency power purchase agreement, the power purchase agreement is denominated in local currency, and the project developer borrows in foreign currency; therefore, the foreign exchange risk exposure is borne by the project developer. In this case, the FXHF can enter into a swap – contract for differences (CFD)[8] with the project developer with exposure to currency risk.

7 Forecasting exchange rates in a deterministic manner is not easy because each of the existing exchange rate theories holds only in specific settings and explains only specific macroeconomic phenomena. No single theory contains all the factors that may have an impact on foreign exchange rates (ADBI, 2006).

8 The FX risk exposure of the project developer can be fixed at a pre-determined level beyond which FXHF will cover the risk by paying cash to the project developer. The frequency of this payment would be similar to debt payment obligations of the project developer.

Under a contract for differences, the two parties would sign a contract at a fixed foreign exchange rate and exchange payments for the differences between the actual and the contract foreign exchange rates. For example, if the fixed rate is 1 USD = 63 INR, then, at fixed periods when debt payments are due (yearly or quarterly), if the foreign exchange rate is higher than 1 USD = 63 INR, the FXHF would make a net payment to the project developer. Otherwise, the project developer would make a net payment to the FXHF.

The following flow-chart depicts the flow of payments for an FXHF for a local currency power purchase agreement:



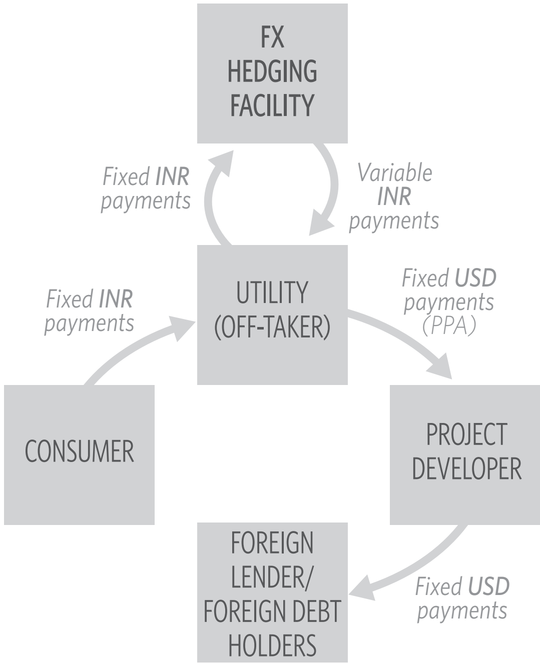
2.2 An FXHF for a hard currency power purchase agreement

Under a hard currency power purchase agreement, the power purchase agreement is denominated in a hard currency such as USD or Euro, and the off-taker is exposed to the foreign exchange risk. Since it may be politically difficult to pass the full foreign exchange risk to the customers,[9] a hard currency power purchase agreement could put severe strain on off-takers — in particular, distribution companies — if the foreign exchange risk is not adequately covered, especially because of the poor financial health of Indian distribution companies.[10] In this case, the foreign exchange risk is taken by the off-taker, or the distribution company, and hence the FXHF will enter into a contract for differences with the off-taker instead of the project developer.

9 Hard currency PPAs didn't work well in extreme stress situations as experienced in Indonesia and Argentina as these governments refused to increase tariffs to match currency depreciation against the USD. India experimented with such a tariff mechanism unsuccessfully with a combined cycle gas plant in 1997 (GVK Industries' 217 MW (Phase 1) in Jegurupadu, Andhra Pradesh (CPI, 2014(b)).

10 http://natgrp.org/2013/07/13/accumulated-losses-of-state-power-utilities-as-on-2013/

The following flow-chart depicts the flow of payments for a hard currency power purchase agreement:



2.3 Design considerations for an FXHF

The design of the FXHF would remain the same under both a local currency and hard currency power purchase agreement. Only the counterparty (the entity entering into the contract for differences) would be different. Under a local currency power purchase agreement, the counterparty would be the project developer; while under a hard currency power purchase agreement, the counterparty would be the off-taker.

However, designing the facility would be a large undertaking, given that currency movements can be uncertain and volatile. The design of the FXHF requires detailed analysis of the following:

- **Expected cost:** The expected net payments by the FXHF. This would be the net present value of the difference between the variable INR payments from the FXHF to the counterparty and the fixed INR payments from the counterparty to the FXHF.
- **Risk exposure:** The different risks – explicit and implicit – that the FXHF may face. In particular, the FXHF may face the risk of unexpected and extreme movements in the foreign exchange rate.
- **Capital buffer:** The amount required, beyond expected cost, to address unexpected and extreme movements in the foreign exchange rate. This buffer would ensure that, given a particular probability of default, the FXHF does not run out of money.
- **Size:** The total size of the FXHF, which is the sum of the expected cost and the capital buffer. This is the size of the FXHF required to ensure that the FXHF not only takes care of the expected cost but also provides the capital buffer for unexpected and extreme movements.

All of these require forecasting foreign exchange rates. In Section 3, we forecast long-term foreign exchange rates using annual foreign exchange time series data,[11] and a representative stochastic model, where the forecasted values have associated probabilities. In Section 4, based on the expected foreign exchange rates, we calculate the expected cost of currency hedging, the impact of FXHF on the delivered cost of renewable energy, and the cost of support for the government. In Section 5, we use different probability levels of foreign exchange rate forecasts to assess the risk exposure of the FXHF, and to estimate the capital buffer. Finally, we calculate the cost of maintaining the capital buffer or the market risk covered by the capital buffer using option pricing theory.

We note that this work is preliminary, and the final design of the FXHF would involve further detailed analysis. We also note our implicit assumptions: first, it is possible to forecast foreign exchange rates in a stochastic manner; and second, it is possible to not only provide a hedging solution with an expected cost but also to design a robust FXHF using an appropriate capital buffer. We understand that these assumptions can be challenged; however, the purpose of our analysis is meant just to provide insights into the design of an FXHF.

3. Forecasting foreign exchange rate

A deterministic model for a foreign exchange forecast is based on several economic and non-economic variables; such models forecast a single foreign exchange value for a particular point in time in the future. Different exchange rate theories are used as foundations for deterministic models (ADBI, 2006).[12] These include partial equilibrium models, general equilibrium models, and hybrid models. Each theory holds in a particular context and explains some macroeconomic conditions. However, no single theory comprehensively explains currency movements (ADBI, 2006). Therefore, a deterministic model for foreign exchange rate forecasting can easily go wrong.

To overcome these difficulties with deterministic models, we used a stochastic model to forecast the long-term foreign exchange rate based on historic data. A stochastic model considers cumulative (or combined) effects of multiple uncertainties (over the variables discussed above) on the foreign exchange rate. Thus, a stochastic model is a better representation of the movement of foreign exchange rates compared to deterministic models, and these models are regularly used in the market to price foreign exchange swaps and options. However, one caveat is that such a model is still not perfect as it is derived from historical data over a certain time period (in our case 1995-2014), while foreign exchange fluctuations can result from future (and unexpected) political and macroeconomic events which this particular historical data may not reflect, such as sovereign default.

Our long-term INR-USD exchange rate forecast involves the following steps: first, choosing an appropriate stochastic model; second, determining the key parameters of the stochastic model; and third, using the stochastic model to forecast the INR-USD exchange rate, using Monte-Carlo simulations.

11 This is for demonstration purposes only. Quarterly data can be used to match the actual flows from the FXHF, based on loan repayment profiles.

12 These models include the following (ADBI, 2006):
- Partial equilibrium models are single factor models. These include: (relative or absolute) power purchase parity (PPP), which considers only the goods market; (covered or uncovered) interest rate parity, which considers (only) the assets market; and the external equilibrium model, which considers only the balance of payments.
- General equilibrium models are more complex models. These include: the Mundell-Fleming model, which considers the equilibrium of the goods market, money market and balance of payments; the Balassa-Samuelson model, which considers maximization of firms' profits; the pricing to market model, which considers maximization of consumers' utilities; and the Redux model, which was developed by Obestfeld and Rogoff.
- Hybrid models, such as the Dornbusch model, are obtained by combining the monetary equilibrium with the adjustment of prices outputs toward their long run equilibrium, and can be called hybrids of monetary equilibrium with purchase power (or interest rate) parity.

3.1 Geometric Brownian motion

As the first step, we chose the geometric Brownian motion (GBM) as an appropriate stochastic model, based on its properties of log-normal distribution of returns[13] and a Markov process. Under a GBM, the foreign exchange rate is characterized by a trend (deterministic) component and a random (stochastic) component.

Representing a foreign exchange rate with a GBM is based on the assumption that the logarithmic returns are normally distributed. That is, the underlying assumption is that all the uncertainties affecting the foreign exchange rates are not only independent but also none of them are dominant. This assumption may be violated in reality, given that many of the uncertainties that affect foreign exchange rate, including government policies, may not satisfy these conditions. Other stochastic processes have been suggested as alternatives.

Despite this, GBM provides a reasonable, first-order, approximation to exchange rate movements, and has been extensively used for modelling purposes in not only academia but also in the finance industry. For example, in the exchange rate market, vanilla (the simplest) foreign exchange option prices are generally quoted using the Black-Scholes framework, which is based on a GBM. Also, the currency option pricing model proposed by Heston (1993) is based on a GBM. Hence, a GBM provides a suitable representative process for foreign exchange forecast modelling.

The following stochastic differential equation represents a GBM for a foreign exchange rate:

$$dS_t = \mu S_t dt + \sigma S_t dW_t \tag{I}$$

where μ is the drift rate and σ is the standard deviation, $\mu S_t dt$ is the trend (deterministic) component and $\sigma S_t dW_t$ is the stochastic (random) component. The solution of equation (I) gives the following process representing a foreign exchange rate:

$$FX_t = FX_o \exp\left[\left(\mu - \sigma^2/2\right) t + \sigma * W_t\right] \tag{II}$$

where FX_t is the foreign exchange rate at time t, FX_o is the foreign exchange rate at time $t= t_o$, and W_t is a Weiner process. In equation (II), $(\mu-\sigma^2/2)t$ represents the trend component and $\sigma * W_t$ represents the stochastic component of the foreign exchange rate movements. W_t can be further written as:

$$W_t = Z * \sqrt{t} \tag{III}$$

where Z is normally distributed random number between 0 and 1.

13 GBM implies that returns have a lognormal distribution; that is, the logarithmic returns have a normal distribution. Since a lognormal distribution prohibits negative values, a GBM can overestimate extreme depreciation in FX rates.

3.2 Extracting μ and σ for a GBM: The maximum likelihood estimation (MLE)

To use a GBM for forecasting purposes, we need to estimate two key parameters of the GBM – the μ and σ. μ can be derived from historical values of foreign exchange rates or from inflation (or interest rate) differential. However, deriving μ from inflation differential would lean towards theories of a partial equilibrium model, which don't appear to hold for the INR-USD exchange rate. σ can be taken either as a constant or be modelled as a dynamic function of time (Heston, 1993). However, it is not uncommon to take implied volatility as a constant for example, while pricing vanilla foreign exchange options.

We assumed that a historical foreign exchange rate time series can provide reliable estimates of trend and random components in the foreign exchange rate movements. Therefore, the key parameters for the GBM were estimated from the history of the INR-USD foreign exchange rate.

To find μ and σ that yield the best fit to any historical dataset, we used maximum likelihood estimation (MLE) – that is, we derived the most likely parameters of a GBM that would represent this dataset. The following closed form expressions for the mean and variance of the log returns samples $x_i = \log FX_{t_i} - \log FX_{t_{i-1}}$, were used as the MLE estimates:[14]

$$m = \Sigma x_i / n; v = \Sigma (x_i - m)^2 / n \quad \text{(IV)}$$

where $m = (\mu - \sigma^2/2)$, $v = \sigma^2$, and "n" is the number of samples. Given "m" and "v", μ and σ can be calculated in a straightforward manner.

For forecasting purposes, to model for the case that the foreign exchange rate on the day of INR-USD conversion may be higher than the yearly average, we focused on the yearly maximum foreign exchange time series. Based on the 20-year data (1995-2014),[15] MLE provided m = 0.0292 and v = 0.00543, resulting in μ = 0.0319 and σ = 0.0737.

3.3 Forecasting foreign exchange rates: Monte-Carlo simulations

For the foreign exchange rate forecast for 2015-2024 (t = 1 to 10 years), we used: FX_o (foreign exchange rate at the end of the year 2014) = 63, μ = 3.19%, σ = 7.37%. Using the GBM equation (I), we generated 10,000 different foreign exchange rate paths for every time period – that is, for t = 1 to 10 years. We then created histograms – probability distributions – based on each of these 10 sets of 10000 predictions. Figure 1 shows the histogram for the year 2024 (for t = 10).

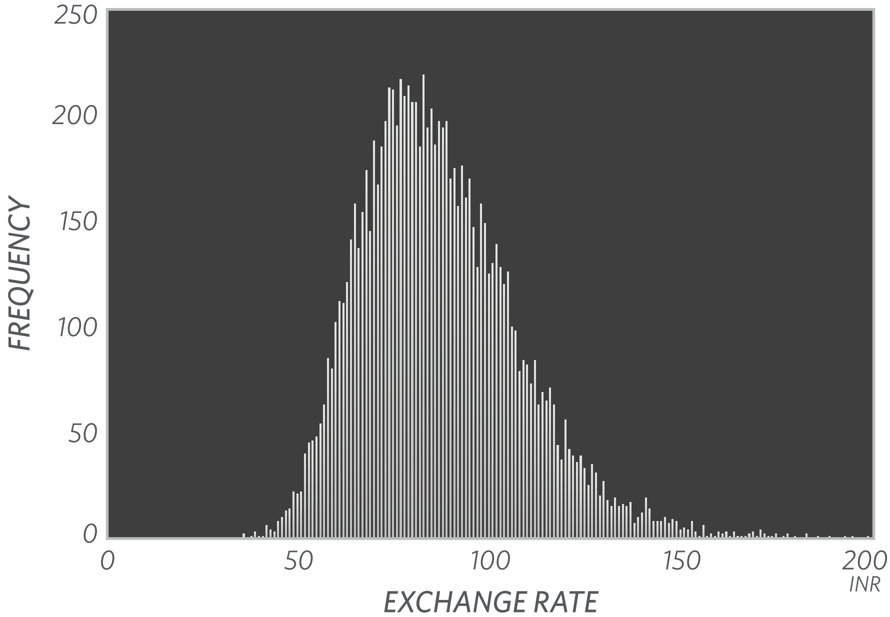
3.4 Results: Foreign exchange forecast for 2015-2024

On the basis of these histograms, we forecast the long term INR-USD foreign exchange rates for every year over 10 years in Table 1. In this paper, we focus on yearly values only. We forecast yearly maximum values of foreign exchange rates to ensure that we capture the worst case values of foreign exchange rates and, therefore, FXHF net payments, in any year.

14 These are derived as the solution for the maximum of the log-likelihood function of the underlying probability distribution. FX_{t_i} denotes the FX rate at time t_i and $FX_{t_{i-1}}$ denotes the FX rate at time t_{i-1}.

15 The time series data has been taken from the year 1995, given that INR has full current account convertibility since then.

Figure 1: Histogram of INR-USD forecast in 2024



These forecast values have associated probability levels (for example, P50, P95, etc.). For example, in year 2015, there is 50% probability that the INR-USD exchange rate would be 1 USD = 65.04 INR or lower (the P50 value), and a 95% probability that the INR-USD exchange rate would be 1 USD = 72.95 INR or lower (the P95 value). The foreign exchange forecast with an associated probability of 50% is taken as the expected foreign exchange rate, which facilitates the calculation of the expected cost of FXHF. The foreign exchange forecasts with other levels of probabilities (for example, 95%) facilitate calculations of capital buffer requirements.

Table 1: Yearly maximum foreign exchange forecast for the period 2015-2024 (in INR)

Year	Probability Levels			
	P50	P75	P85	P95
2015	65.04	68.29	70.03	72.95
2016	67.16	71.9	74.45	78.73
2017	69.33	75.35	78.58	84
2018	71.58	78.77	82.63	89.11
2019	73.91	82.22	86.68	94.17
2020	76.31	85.72	90.78	99.27
2021	78.78	89.3	94.45	104.44
2022	81.34	92.97	99.22	109.71
2023	83.98	96.74	103.59	115.1
2024	86.7	100.62	108.09	120.64

4. The impact of the FXHF: Hedging costs and government cost of support

The FXHF, with an expected cost of 3.5 percentage points, may reduce hedging costs by nearly 50%, the delivered cost of renewable energy by up to 19%, and the cost of support by up to 54%.

In Section 3, we forecasted long-term foreign exchange rate values using a representative stochastic model. These forecasted values have associated probability levels. We took the foreign exchange forecast with an associated probability of 50% (the P50 level) as the expected foreign exchange rate. Using this expected foreign exchange rate, we can now calculate the expected cost of the FXHF, using an example involving a local currency power purchase agreement.

In our example, the counterparty takes a 10 year USD 10 million loan in 2015, at a fixed interest rate of 5.5% per year. At the initial INR-USD exchange rate (1 USD = 63 INR in 2015), this is equal to INR 630 million. At the fixed USD interest rate of 5.5%, the fixed debt payment obligations are $1.33 million per year for 10 years. To mitigate foreign exchange risk, the counterparty enters into a contract for differences with the FXHF at a fixed rate of 1 USD = 63 INR.

Table 2 shows the payments between the counterparty and the FXHF, including the FXHF net payments. The first row represents the yearly fixed payments that the counterparty would make to the FXHF. These correspond to the yearly $1.33 million obligations converted to INR using the contract for differences contract rate of 1 USD = 63 INR. The third row represents the expected yearly variable payments that the FXHF is expected to make to the counterparty, by converting the yearly $1.33 million obligation to INR, and using the expected foreign exchange rates (based on P50 levels). The fourth row – the expected yearly net payments – is the difference between the first two rows.

The FXHF, with an expected cost of 3.5 percentage points, may reduce hedging costs by nearly 50%.

Table 2: INR payments by the counterparty and the FXHF

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Fixed payments from counterparty to FXHF (A)	83.79	83.79	83.79	83.79	83.79	83.79	83.79	83.79	83.79	83.79
Expected foreign exchange rate	65.04	67.16	69.33	71.58	73.91	76.31	78.78	81.34	83.98	86.70
Expected variable payments by FXHF to counterparty (B)	86.50	89.32	92.21	95.20	98.30	101.49	104.78	108.18	111.69	115.31
Expected net payments by FXHF to counterparty (B-A)	2.71	5.53	8.42	11.41	14.51	17.70	20.99	24.39	27.90	31.52

Assuming an INR risk-free rate of 7.5%, the expected cost to the FXHF (**the FXHF expected cost**) is the Net Present Value (NPV) of the expected yearly net payments (see Row 4 in Table 2). This can be calculated as INR 100.39 million, or approximately 16% of the INR 630 million loan and (assuming the typical debt to equity ratio of 70:30) approximately 11% of the capital expenditure. At the current capital cost of solar energy (INR 7.13 crore/MW), this amounts to approximately INR 7.95 million/MW.

In other words, for our INR 630 million loan, an amount equal to INR 100.39 million, when put in a risk-free account, would take care of the expected devaluation of the INR against the USD under our representative probabilistic model. Given that an annuity of 3.5% on the original INR 630 million loan has the same net present value of INR 100.39 mllion, this indicates that the expected cost of the FXHF is approximately 3.5 percentage points.

Depending on policy choice, this FXHF expected cost of 3.5 percentage points can be passed on to the counterparty, still resulting in a reduction of approximately 3.5 percentage points in the cost of hedging and, therefore, the cost of debt. That is, compared to the cost of currency hedging in the market at 7 percentage points, hedging via the FXHF would likely be approximately 50% cheaper.

The FXHF may reduce the delivered cost of renewable energy by up to 19% and the cost of support by up to 54%.

The impact of the FXHF on the delivered cost of renewable energy would depend on policy. The FXHF can take one of the following design features:

- The expected cost of the FXHF is borne by the Government. The rationale for this could be that this is similar to an interest subsidy (CPI, 2014).
- The expected cost of the FXHF is passed onto the counterparty either as a one-time fee (of INR 100.39 million) or as annual interest payments (of 3.5 percentage points).

The FXHF would reduce the delivered cost of renewable energy by reducing the cost of debt and, therefore, the cost of capital through a reduction in the cost of debt and an increase in the debt to equity ratio. This would then reduce the total cost of support –the total subsidies required – for renewable energy (CPI, 2014).[16] We calculate the impact on the delivered cost of renewable energy as well as the cost of support using our cash-flow models (CPI, 2014). When the expected cost of the FXHF is passed onto the counterparty, under a local currency power purchase agreement, it is passed on as an increase in the levelized cost of electricity; whereas, under a hard currency power purchase agreement, it is passed on as a surcharge on the consumers.

We find that, if the FXHF expected cost is borne by the government, the cost of debt for the counterparty can be reduced by 7 percentage points and, therefore, the delivered cost of renewable energy by 19% and the cost of support by 54%. However, if the expected cost of the FXHF is passed onto the counterparty, the FXHF can reduce the cost of debt by approximately 3.5 (or 7) percentage points if the power purchase agreement is local currency (or hard currency) and, therefore, the delivered cost of renewable energy by approximately 9% and the cost of support by 33%.[17] The gains typically arise due to substituting expensive equity with cheaper debt, especially as projects optimize leverage (CPI, 2014).

16 This includes: The feed-in premium embedded in a renewable energy power purchase agreement; other subsidies such as an interest subsidy; and, changes in taxes.

17 The reduction in the delivered cost of renewable energy is similar for local and hard currency power purchase agreements. In the former, the impact on the cost of debt is reflected in the levelized cost for the project; and in the latter, the impact is a direct surcharge of INR 0.64/kWh or 9.8% of unsubsidized tariff.

Table 3: Impact of the FXHF on the delivered cost of renewable energy

Power Purchase Agreement	Scenario	Net cost of debt to project developer	Approximate reduction in delivered cost of renewable energy
Local currency	Expected cost of the FXHF is borne by the government	5.50%	19%
	Expected cost of the FXHF is passed onto the project developer	9.00%	9%
Hard currency	Expected cost of the FXHF is borne by the government	5.50%	19%
	Expected cost of the FXHF is passed onto to the off-taker	5.50%	9.8%

5. Risk considerations in an FXHF

To safeguard the FXHF against unexpected and extreme foreign exchange rate movements, a capital buffer is one option to consider; achieving India's sovereign rating of BBB- would require this buffer to be approximately 30% of the size of the loan; and, the market cost of maintaining this buffer could be as high as 79% of the expected cost.

We note that the FXHF, as discussed so far, is similar to ones discussed in government announcements.[18] However, this mechanism examines only the expected movements in foreign exchange rates, and ignores two key issues.

First, what would happen in the presence of unexpected and extreme movements in foreign exchange rates? In this case, even if the FXHF is sized to take care of expected movements, the whole FXHF may be wiped out due to unexpected and extreme movement in any particular year. Second, the large difference between the FXHF expected cost and the cost of a market hedge – 3.5 percentage points in our example – raises questions about what causes the difference, and the role of market risk (due to volatility of foreign exchange movements).

A capital buffer is one option to cover unexpected and extreme movements in foreign exchange rates.

The expected cost to the FXHF takes into account the likely foreign exchange rate movements. But, unexpected and extreme movements in foreign exchange rates can put a severe strain on the FXHF, potentially causing it to default, thereby putting the counterparty at risk.

One way to deal with this is for the guarantor (the government) to take the risk of unexpected and extreme foreign exchange movements in the form of a sovereign guarantee – either explicit or implicit. One potential option for this is a capital buffer in a standalone facility, which may be funded by the National Clean Energy Fund (NCEF), for example.

The capital buffer would be the amount needed beyond the FXHF expected net payment to ensure that the 10 year default probability of the FXHF is below a pre-specified threshold. This capital buffer requirement would depend on the risk exposure that the FXHF is designed to cover – for example, the capital buffer requirement to provide a lower probability of default (for example, 5%) would be higher than the capital buffer requirement to provide a higher probability of default (for example, 10%).

18 http://economictimes.indiatimes.com/industry/energy/power/power-minister-piyush-goyal-eyes-bidding-in-dollar-to-cut-solar-tariff/articleshow/46684838.cms

Table 4 provides the cumulative capital buffer requirements for different 10 year probabilities of default. It is evident that the capital buffer requirement is zero if the 10 year probability of default is 50% or higher, and that the capital buffer requirement grows as the 10 year probability of default goes down.

The capital buffer is assumed to be invested in a risk-free INR security and, therefore when needed, may help address unexpected and extreme movements in foreign exchange rates. Given expected movements in currency, if funded by a corpus such as the NCEF, the capital buffer may not have direct cost implications. It is possible, however, to fund the capital buffer by levying a surcharge (under a hard currency power purchase agreement) with direct cost implications, which we explicitly calculate.

Table 4: Capital buffer requirements for a standalone facility with different probabilities of default

Probability of default of the FXHF	Cumulative capital buffer requirement for 10 years *(as % of loan)*	Cumulative capital buffer requirement for 10 years *(as % of capex)*	Cumulative capital buffer requirement for 10 years *(INR million/MW)*	Surcharge in a hard currency power purchase agreement	
				(INR/kWh)	*(% of unsubsidized tariff)*
50%	0	0	0	0	0%
25%	11.72%	8.20%	5.84	0.47	6.56%
15%	17.95%	12.56%	8.95	0.73	10.20%
5%	28.58%	20.00%	14.26	1.16	16.20%

A capital buffer of approximately one-third the size of the underlying loan may help ensure that the FXHF achieves India's sovereign rating.

Assuming this default probability to be less than 5% over the entire tenor of the FXHF (10 years), the required cumulative capital buffer is INR 180.04 million – about 1.8 times the expected cost, about 29% of the size of the loan, about 20% of capital expenditure at current capital cost for solar, and about a INR 1.16/kWh surcharge. That is, the size of the FXHF would be INR 280.43 million – about 2.8 times the expected cost, about 45% of the size of the loan, and about 30% of the capital expenditure.

Based on cumulative default rates of globally rated bonds, for a 10 year probability of default less than 5% (at P95 level of risk coverage), this FXHF would achieve a credit rating equivalent to India's current sovereign rating of BBB- (see Table 6 in the Appendix). This is commonly known as breaching the sovereign ceiling, given that risk coverage beyond this level would not be necessary or required.

The difference between the cost of currency hedging in the market and the FXHF expected cost is largely due to the cost of maintaining a capital buffer.

The difference between the market cost of hedging and the FXHF expected cost can be attributed to a combination of factors including: risk-premium, liquidity-premium,[19] and regulation costs.

19 The market charges a liquidity premium for a cross currency swap, which can be derived from the cross currency basis spread.

Risk-premium essentially means that the market views FX hedging as a risky activity due to the volatility of FX rate movements and, therefore, the market price of the hedge includes a premium to compensate investors for the "market" risk they are taking; in a way very similar to other risky investments, such as equities. The risk-premium can also be thought of as the premium demanded, over and above the FXHF expected cost, to keep the capital buffer that covers for unexpected and extreme movements in foreign exchange rates.

Liquidity-premium would exist in illiquid FX markets, where investors may demand a premium for holding an illiquid asset. Regulation costs are related to costs due to regulations, such as Basel III capital requirements. For example, Basel III's credit value adjustment charge (CVA) can add up to 55 basis points to the cost of a 10 year cross currency swap.[20] However, the INR-USD hedge market is fairly liquid up to 10 years and, therefore, a significant liquidity premium is unlikely.

We calculate the risk-premium using standard FX option-pricing theory. We first find the expected cost of providing a hedge. This includes the risk-premium and, therefore, we call this the **expected market risk adjusted cost** of providing a currency hedge. We then subtract the FXHF expected cost of 3.5 percentage points from the expected market risk adjusted cost to find the risk-premium.

We calculate the expected market risk adjusted cost as 6.26 percentage points and, therefore, the risk-premium as 2.76 percentage points. This largely explains the difference between the FXHF expected cost of 3.5 percentage points and the cost of currency hedging in the market of 7 percentage points. The remaining difference of 0.74 percentage points can be attributed to liquidity premium and transaction costs related to regulation cost.

To find the risk-adjusted market cost, we model the contract for differences between the FXHF and the counterparty as a series of pairs of call and put options at the strike price equal to the fixed foreign exchange rate – at 1 USD = 63 INR. In each of the ten call-put pairs, at the strike price of 1 USD = 63 INR, the FXHF would sell the counterparty a call option – the option to buy 1 USD at 63 INR – and the counterparty would sell the FXHF a put option – the option to sell 1 USD at 63 INR.

The difference between the costs of the call and put options in any particular year, which would be calculated using option-pricing theory, would be the expected risk-adjusted market cost for the contract for that year. The net present value of all the yearly expected risk-adjusted market costs would then provide the expected risk-adjusted market cost for series of pair of options. We use the currency option pricing formulae provided by Biger and Hull (1983) to calculate the cost of call and put foreign exchange options, as follows:

$$C = e^{-r^*T} S \cdot N\left\{\frac{\ln(S/X) + [r - r^* + (\sigma^2/2)]T}{\sigma\sqrt{T}}\right\} - e^{-rT} X \cdot N\left\{\frac{\ln(S/X) + [r - r^* - (\sigma^2/2)]T}{\sigma\sqrt{T}}\right\} \quad \text{(V)}$$

$$P = C + Xe^{-rt} - Se^{-r^*t} \quad \text{(VI)}$$

20 http://www.risk.net/risk-magazine/feature/2191990/risk-25-how-basel-iii-is-turning-borders-into-barriers

where,

1. S: spot price of one unit of foreign currency (USD) on the day of contract – in this case S = INR 63
2. σ^2: instantaneous variance of the return on foreign currency (USD) holding – in this case σ = 7.37%
3. X: exercise price to purchase one unit of foreign currency (USD) – in this case X = INR 63
4. T: exercise date – in this case, T = 1, 2, … , 10
5. r: risk-free rate of interest in the home country (India) – in this case r = 7.5%
6. r* : risk-free rate of interest in the foreign country (US) – in this case r* = 2%

Using equation (V and VI), Table 5 provides the costs of the call (Row 2) and put (Row 3) options for yearly 1 USD = 63 INR options. The net present value (at the risk-free rate of 7.5%) of the annual differences between the costs of these 1 USD = 63 INR call and put options is INR 138.46. We then calculate the corresponding net costs for the USD 10 million loan discussed earlier, given that the USD 10 million loan would require ten annual payments of USD 1.33 million. Thus, we calculate the net cost of providing the ten pairs of options for the contract for differences as the net present value of the ten yearly cash flows at the INR risk-free rate as INR 184.16 (= 138.46 * 1.33) million.

Table 5: Cost of yearly 1 USD = 63 INR call and put options

Time to maturity (in years)	1	2	3	4	5	6	7	8	9	10
Cost of a 1 USD Call option	3.89	6.75	9.34	11.71	13.86	15.81	17.58	19.16	20.58	21.84
Cost of a 1 USD Put option	0.58	0.45	0.32	0.23	0.16	0.11	0.08	0.06	0.04	0.03

This INR 184.16 million is equivalent to a 10 year annuity at 6.26 percentage points per year on the original loan amount of INR 630 million. This is essentially the expected market risk adjusted cost, and is 2.76 percentage points higher than the FXHF expected cost of 3.5 percentage points. That is, the risk-premium discovered by option pricing theory is 2.76 percentage points.

6. Conclusion

Increasing availability of low-cost, long-term debt will be crucial to achieving India's ambitious renewable energy targets in a cost-effective manner. Cheap foreign debt is a promising source of more capital. However, it requires currency hedging, which can be expensive enough to negate almost all the benefits of foreign debt. A government-sponsored currency hedging mechanism is potentially cheaper than a market-based mechanism, and, therefore, of interest to Indian policymakers.

In this paper, we begin to examine a possible design of a government-sponsored currency hedging facility (FXHF), along with associated cost and risk implications. We analyse the FXHF using a representative stochastic model of foreign exchange rates. Our analysis reveals that the expected cost to provide a 10 year currency hedge via the FXHF is 3.5 percentage points, approximately 50% of the market cost of providing this hedge, or 16% of the underlying loan amount.

If the expected cost of the FXHF is borne by the government, the cost of debt can be reduced by 7 percentage points, the delivered cost of renewable energy by 19%, and the cost of government support by 54%. If the expected cost of the FXHF is passed onto the developer, the cost of debt can be reduced by 3.5 percentage points, the delivered cost of renewable energy by 9%, and the cost of government support by 33%.

However, the government should be aware of the risk exposure of the FXHF. One way to protect against the risk of unexpected and extreme movements in foreign exchange rates, and to ensure that the FXHF does not default, is a capital buffer. For example, for the FXHF to achieve India's current sovereign rating of BBB-, the cumulative capital buffer requirement for 10 years is almost 30% of the underlying loan amount.

The FXHF discussed in this paper can serve as a reference for currency hedging facilities proposed by the government and other institutions, such as multilateral development banks. However, in addition to adequate risk and cost considerations, the FXHF would also need to incorporate clear guidelines and rules, including clear eligibility criteria for project selection and a suitable governance model.

A more detailed design of an FXHF would also require additional analysis, including: assessing additional stochastic processes for the USD-INR foreign exchange rate forecast modelling; assessing the benefits of using stochastic volatility (Heston, 1993) i.e. volatility of volatility; assessing the effect of the FXHF on mobilization of additional foreign debt; and assessing distortive incentive effects of the FXHF in the currency hedging market.

References

ADBI (2006), Existing Theories of Exchange Rate Determination, http://www.adbi.org/book/2006/05/16/1819.renminbi.exchange.rate/existing.theories.of.exchange.rate.determination/

Biger N and J Hull (1983), The Valuation of Currency Options, Financial Management, 12 (1): 24-28.

CPI (2012), Meeting India's Renewable Energy Targets: The Financing Challenge, http://climatepolicyinitiative.org/publication/meeting-indias-renewable-energy-targets-the-financing-challenge/

CPI (2014), Solving India's Renewable Energy Financing Challenge: Which Federal Policies can be Most Effective? http://climatepolicyinitiative.org/publication/solving-indias-renewable-energy-financing-challenge-which-federal-policies-can-be-most-effective/

CPI (2014 b), Solving India's Renewable Energy Financing Challenge: Instruments to Provide Low-cost, Long-term Debt. http://climatepolicyinitiative.org/wp-content/uploads/2014/04/Instruments-to-Provide-Low-cost-Long-term-Debt.pdf

CPI (2015), Reaching India's Renewable Targets Cost-effectively, http://climatepolicyinitiative.org/wp-content/uploads/2015/04/Reaching-Indias-Renewable-Energy-Targets-Cost-Effectively.pdf

HSBC (2012), Emerging Markets Currency Guide, http://www.hsbcnet.com/gbm/attachments/rise-of-the-rmb/currency-guide-2012.pdf?WT.ac=CIBM_gbm_pro_rmbrise_pbx01_On

Heston S L (1993), "A Closed-Form Solution for Options with Stochastic Volatility with Applications to Bond and Currency Options", Review of Financial Studies, 6 (2): 327-343

Appendix

Table 6: Average cumulative (10 years') default rates of bonds

Global rating	Average cumulative (10 years) default rates
AAA	0.78%
AA	0.86%
A	1.77%
BBB	4.88%
BB	15.59%
B	28.70%
CCC/C	51.65%

Source: Standard & Poor's Annual U.S. Corporate Default Study And Rating Transitions