RISK MITIGATION OPPORTUNITIES FOR FOREIGN EXCHANGE (FX) RISK EXPOSURE IN PUBLIC PRIVATE PARTNERSHIP PROJECTS

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Abstract

Foreign exchange risk mitigation is a key task in Public Private Partnership (PPP) projects in emerging markets. The economic foreign exchange (FX) exposure exists because PPP projects typically sell their outputs domestically and generate revenues in local currency, while their financing costs and O&M costs are denominated in hard currencies. Governments frequently implement risk mitigation instruments (RMIs) to compensate FX loss. However the value of a RMI depends on the affordability and the willingness of the government to compensate unforeseen FX fluctuation. Therefore the overall objective in this paper is to analyze possible RMIs and to design a methodology to value RMIs by simulating country risk. The paper aims to establish a foreign exchange exposure model to analyse the value of a RMI. Acting as an assessment system, the model includes a country reliability risk (CRR) index. The CRR index is developed and simulated in a Conditional Credit Rating Transition Matrix (CCRTM). The methodology is illustrated in a case study of a PPP power plant in South East Asia.

As a result, the model can be used to calculate economic FX exposure on selected risk mitigating instruments, to allocate capital, and to evaluate selected RMIs. Similarly, it can also help sponsors to apply financial strategies and to estimate the necessary FX protection in PPP infrastructure projects.

Keywords: Public Private Partnership; Risk Mitigation; Foreign Exchange Exposure.

Introduction

Foreign exchange (FX) fluctuations can significantly affect the project's internal rate of return (IRR), return on equity (ROE), and the net present value (NPV) of a special purpose company (SPC). The FX risk can be defined as the variability in the value of a project or as an interest in the project that results from unpredictable variation in the exchange rate (Gray, 2003). Macroeconomic factors like import and export as well as natural disasters and political decisions can have significant influence on the volatility of FX rates.

FX exposure in Public Private Partnership (PPP) projects can be seen from the perspective of the project as a whole or from the perspective of parties with an interest in the project, such as private investors, customers, or the host country government. Boey (1998) states that the priority of the FX risk and political risks are rated equivalent by foreign lenders and equity investors.

FX risk allocation to the host country government and offtakers

The host country government can be differentiated by three categories: (i) national government, (ii) local government, and (iii) contracting authority. Based on the type of infrastructure, the relevant sub-category of the national government will influence currency volatility by its macroeconomic policies and undertakings regarding exchange rate policies. Governments can influence exchange rates through monetary and fiscal policies as well as through foreign currency market interventions. They can influence the underlying source of risk by reducing the rate of depreciation or maintain currency volatility by keeping budget deficits small and inflation low. Local governments are often responsible for contractual fulfilments of RMI. The contracting authority is generally structured as a state owned company and operates as the offtaker of the output of the PPP infrastructure.

The governments' ability to influence exchange rates by policies is a strong occasion to allocate the FX risk in full extent to the host government. In addition, governments have an information advantage compared to all the other shareholders. However, contingent claims due to foreign currency devaluation may be payable at a time when the government is least able to manage the risk. Therefore investors still have the uncertainty about: (i) the policy that a government will adopt in response to an external shock, (ii) the policies that may be adopted by future governments, (iii) the willingness of the public authority to compensate regarding contractual arrangements, (iv) the insolvency of the offtaker, (v) the delay in compensational payments, and (vi) the delay in tariff adjustment or other agreed risk mitigation instruments.

Therefore, foreign currency lenders will always require the FX risk protection. Several mechanisms can be provided at the national level if long-term local debt is not available and derivative markets do not exist to mitigate the FX risk exposure. The most common RMI are: (i) fixed exchange rate, (ii) exchange rate guarantee, (iii) public sector lending in local currency, (iv) local lending by Multi Lateral Agencies, (v) local currency fund schemes, (vi) partial credit guarantee, (vii) partial risk guarantee and political risk insurance, (viii) local currency guarantee facilities, (ix) tariff adjustment mechanisms, and (x) compensation payments. All mechanisms should be developed to avoid moral hazard of the various parties.

Offtakers are often governmental owned companies. They are the buyers of the output produced by the infrastructure. Therefore, they have an essential role in the FX risk allocation. The mismatch between local currency revenue and hard currency obligations is often solved by hard currency payments to the SPC. In this case, the SPC is paid by the offtaker in hard currency which is adjusted by the actual exchange rate on a regular basis. Investors now depend on the solvency of the offtaker. To secure the solvency of the offtaker, they often have a counter guarantee by the ministry of finance (MOF). The remaining risk to the investors is therefore: (i) the willingness of the offtaker to pay for the contractual payments during currency devaluation periods, (ii) the willingness of the offtaker to adjust tariffs or to pay compensational payments, (iii) the feasibility of the offtaker to pay for the contractual payments during currency devaluation periods, and (iv) the risk that similar guarantees will be provided to other infrastructure projects which will increase the government overall risk exposure and make all guarantees less creditworthy by the possibility of multiple calls.

Research methods

The purpose of this research is to investigate a methodology to quantify the FX exposure in PPP infrastructure projects. The economic FX exposure depends on unforeseen changes in FX rates, on the cash flow, the applied risk mitigation instruments, and the impact of political risks.

Research question:

- How feasible is the project to absorb FX fluctuations in a three year time period?
- What is the value of contingent claims on RMI?

Research Objectives:

- To design a methodology to estimate the FX exposure in Public Private Partnership (PPP) infrastructure projects.
- To develop a method to simulate country risk on risk mitigation instruments (RMI) based on signals and proxies.
- To relate sensitivities to financial strategies.

The methodology used to analyse FX rate exposure is briefly discussed in the following sections. A case study illustrates the results on the commonly applied RMI of tariff adjustment mechanism. The methodology follows two different models. First, the project feasibility index beta is computed to simulate how much increase of market risk the project can absorb within a three year time period. Because of correlations between FX rates, interest rates and inflation rates, it is necessary to simulate the market risks and not FX rates independently. Input parameters of the feasibility index are the fitted distributions of FX rates, inflation rates, and interest rates as well as the covariance matrix of the defined variables during economic cycles. Secondly the CRR index is designed to estimate the value of contingent claims on RMI and to compute default probabilities. The results are illustrated in a case study.

Computation of the project feasibility index beta

The project feasibility index beta is modelled via an expanding dispersion ellipsoid. It reflects not only the effect of the mean values but also the covariances of the random variables influencing the non-investability domain. The second moment feasibility index β was first defined by Hasofer and Lind (1974). The index has been further treated in Rackwitz and Fiessler (1978), Ditlevsen (1981), Shinozuka (1983), Ang and Tang (1984), Madsen (1986) et al. and Tichy (1993). Low and Tang (1997a, 2004, 2007) presented a practical procedure of efficient feasibility evaluation for correlated non-normal variables with respect to the Hasofer-Lind index and first order feasibility method (FORM).
The matrix formulation of the Hasofer-Lind index for correlated normal random variables is defined in equation 1 as follow:

$$\beta = \min \sqrt{\left[\frac{x-\mu}{\sigma}\right]^T [R]^{-1} \left[\frac{x-\mu}{\sigma}\right]} \quad (1)$$

where x represents the set of random variables, μ represents the mean value, R represents the correlation matrix, and σ represents the standard deviation. The procedure to compute β is by varying x_i to minimize the quadratic form of the ellipsoid subject to the constraint that the ellipsoid just touches the surface of the non-investability domain. Low (2004) expanded the Hashofer-Lind ellipsoid perspective in Figure 1 for correlated non-normals by applying the Rackwith-Fiessler equivalent normal transformation.

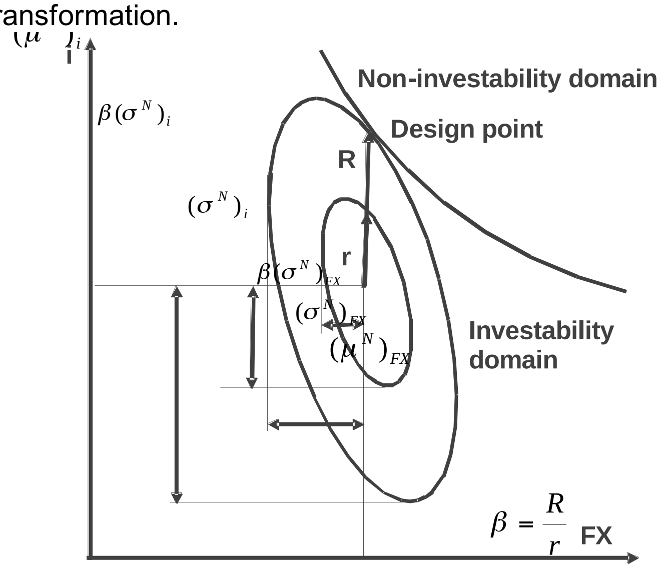

Fig. 1. Equivalent dispersion ellipses in the original space of the basic random variables; Source: Adjusted based on Low et all., 2007

Each axis of the ellipsoid is parallel to a corresponding coordinate axis if the variables are uncorrelated. The dispersion ellipsoid is tilted by consideration of correlation assumptions between the escalators.

Most of the market risk variables follow either lognormal or normal distributions. The transformation of lognormal μ and σ, to μ^N and σ^N is derived by applying Rackwitz-Fiessler normal transformation as follow:

$$\mu^N = x(1 - \ln(x) + \ln(\mu) - \frac{1}{2}\ln(1 + (\frac{\sigma}{\mu})^2) \quad (2)$$

$$\sigma^N = x * \sqrt{\ln(1 + (\frac{\mu}{\sigma})^2)} \quad (3)$$

The feasibility index β is the axis ratio (R/r) of the ellipse that touches the limit state surface of the non-investability domain and the one standard-deviation dispersion ellipse. The ratio is the same along any direction because of geometrical properties of the ellipsoid.

Computation of the CRR index

Factors influencing country reliability can be identified in the governments' ability to repay debt obligations. According to Ciarrapico, (1992) proxies for country risk regarding payment feasibility may be found in indicators like balance-of-payment difficulties, liquidity difficulties, and political difficulties.

To compute the CRR index it is important to transfer the proxies into dimensionless ratios. The proxies of the CRR index include (i) domestic debt to GDP, (ii) reserves to imports, (iii) debt service to exports, and (iv) M2 to foreign reserves. All ratios focus on the balance of payments risk caused by real or monetary disturbances. Ratio one and two are considered as solvency variables and ratio three and four as liquidity variables. The proxies help to easily generate and aggregate an opinion. The country reliability risk (CRR) index is computed as follows:

$$CRR = -(1/\sigma_{D/GDP})*(\frac{\Delta D/GDP_t}{D/GDP_t}) + (1/\sigma_{R/I})*(\frac{\Delta R/I_t}{R/I_t}) + + (1/\sigma_{DS/E})*(\frac{\Delta DS/E_t}{DS/E_t}) + (1/\sigma_{M2/FR})*(\frac{\Delta M2/FR_t}{M2/FR_t}) \quad (4)$$

where $\sigma_{D/GDP}$ is the standard deviation (SD) of domestic debt to GDP, $\sigma_{R/I}$ is the SD of reserves to imports, $\sigma_{DS/E}$ is the SD of debt service to exports, $\sigma_{M2/FR}$ is the SD of M2 to foreign reserves. All data can be obtained from the IMF-IFS database.

The probability that the country reliability grade is r_j at time $t+1$ (i.e., $R_{t+1} = r_j$) on the condition that at time t the grade is r_i (i.e. $R_t = r_i$) is labeled as $\lambda_{i,j}^t$:

$\lambda_{i,j}^t$ =Prob{ $R_{t+1} = r_j \mid R_t = r_i$ }

The Country Rating Transition Matrix Ω^t at time t, can thus be represented by elements of $\lambda_{i,j}^t$:

$$= \Omega^t = (\lambda_{i,j}^t)_{m,m} = \begin{pmatrix} \lambda_{1,1}^t & \lambda_{1,2}^t & .... & \lambda_{1,m}^t \\ \lambda_{2,1}^t & \lambda_{2,2}^t & .... & \lambda_{2,m}^t \\ .... & .... & .... & .... \\ \lambda_{m,1}^t & \lambda_{m,2}^t & .... & \lambda_{m,m}^t \end{pmatrix} \quad (5)$$

The one year migration matrix of S&P sovereign foreign currency ratings (1975-1999) is implemented as general country rating transition matrix (CRTM) (Claessens et al. 2003).
If the CRR index is positive, it is more possible to transit to higher reliability rating grade; if the index is negative, it is more possible to transit to lower reliability rating grade. Based on the CRTM probabilities, the z-value of the fitted normal density function of the CRR index is computed. With the z-value of the fitted normal distribution plus the CRR index, it is possible to derive the conditional country rating transition (CCRTM) matrix as shown in equation 6.

$$\lambda_{ij}^t = \begin{cases} \Phi(y_j - Z_t) & j = 1 \\ \Phi(y_j - Z_t) - \Phi(y_{j-1} - Z_t) & 1 < j = m-1 \\ 1 - \Phi(y_{m-1} - Z_t) & j = m \end{cases} \quad (6)$$

The y value is element of the CRTM and the z-value is substituting the annual CRR index. The CRR index is therefore used as country change indicator and a shift of the probability density function of ratings towards better or poorer country states.
The country reliability state α_t depends on the CCRTM and the distribution of the previous state vector (equation 7).

$$\alpha_t = \alpha_{t-1} \bullet \Omega^{t-1} \qquad (t = 1, 2, \ldots, n) \quad (7)$$

It also follows that:

$$\alpha_t = \alpha_0 \bullet (\prod_{k=0}^{t-1} \Omega^k) \qquad (1 \le t \le n) \quad (8)$$

Finally, the country reliability can be computed for every time period.

Case Study - Power Plant in South East Asia

The case study of a PPP power plant in South East Asia has been conducted under confidentiality agreements. Therefore project name and involved parties are not mentioned. The project has a concession period of 30 years, including a 5 years construction period. The project size is a capacity of 180 MW (gross) with a total estimated construction cost of USD 300 million. The project Debt/Equity ratio is assumed as 75%:25%. Financing is separated into local and foreign lending. The local lending is equal to USD 50 million. Foreign lending is equal to USD 250 million including equity. The foreign lender has senior status to the local lender. Both loans have a maturity of 22 years. The first loan repayment is in year 6. A subordinated working capital with assumed 10% interest rate will be drawn in case of shortcomings in interest rate payments and principal repayment.

The variables with exposure to market risks and impact on cost and revenue positions are listed in Table 1, where i_1 is the consumer price index (CPI) of IND, i_2 is the producer price index (PPI) of IND, i_3 is CPI of USA, and i_4 is the wholesale price index (WPI) of the USA. Interest rates are fixed over the whole concession period and therefore not relevant in the model. The data was obtained by the international financial statistics database. Figure 2 illustrates the curves of the selected variables. Furthermore, the graph illustrates the cycles before, during, and after the financial crises. Each variable covers 250 data points from 1988 to 2008.

Table 1. Fitted distributions

		Distributions	Para1	Para2
CPI IND	i1	Lognormal	11,15	8,57
WPI IND	i2	Lognormal	12,78	13,68
CPI US	i3	Lognormal	3,02	1,08
PPI US	i4	Normal	2,67	3,46
FX rate	FX	Normal	9000	482

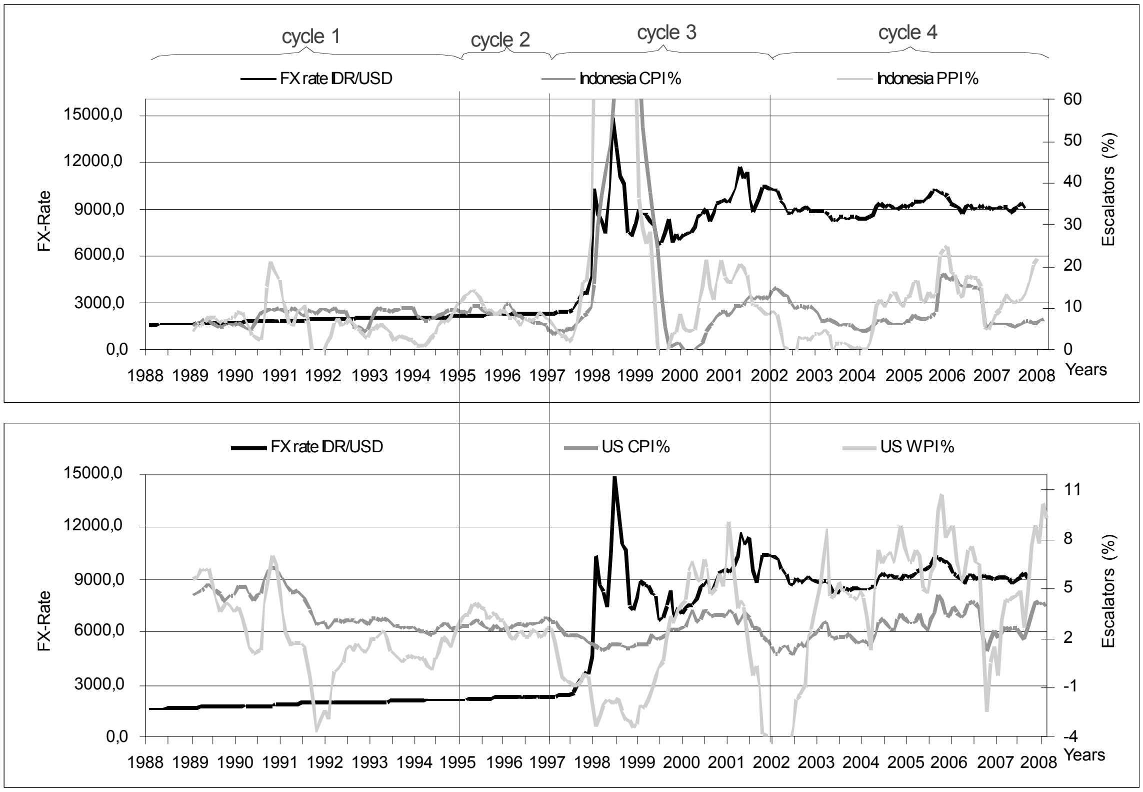

Fig. 2. Foreign exchange rate and escalators applied in the cash flow

The results of the fitted probability density functions are shown in Figure 3 for the whole cycle of 1988 to 2008. The random variables x_i are subject to the constraint that the ellipsoid just touches the surface of the non-investability domain. The variables μ^N and σ^N are derived by applying Rackwitz-Fiessler normal transformation in equation 2 and 3.

Assumptions

		Distributions	µ	_	x*	µ^N	_^N	nx
i_1	CPI IND	Lognormal	11,15	8,57	4,00	8,56	2,73	-1,67
i_2	WPI IND	Lognormal	12,78	13,68	3,00	10,98	2,62	1,14
i_3	CPI US	Lognormal	3,02	1,08	9,69	-1,71	3,36	3,39
i_4	PPI US	Normal	2,67	3,46	3,00	2,67	3,46	0,10
FX	FX rate	Normal	9000	482	1,00	8995	482	-18,66

Correlation Matrix

	i_1	i_2	i_3	i_4	FX
i_1	1	0,300	0,361	-0,432	0,000
i_2	0,300	1	0,846	-0,327	-0,396
i_3	0,361	0,846	1	-0,233	-0,234
i_4	-0,432	-0,327	-0,233	1	0,542
FX	0,000	-0,396	-0,234	0,542	1

Results

Feasibility index _	1,25
Feasibility function g(x)	0,00
Prob. (non-investability)	0,11

Fig. 3. Feasibility analysis via SOLVER in MS Excel

The touching point is obtained by using Microsoft Excel's build-in optimization routine SOLVER. The feasibility index β is computed by varying x_i to minimize the quadratic form of the ellipsoid. This is the case when the defined feasibility function g(x) becomes zero. Figure 3 illustrates the feasibility analysis via MS Excel by applying the constraint optimization of equation (1). The example shows an feasibility index of (1,25) by (0,11%) probability of reaching the non-investability domain. The correlations between the variables and the P-values are listed in Figure 4.

		CPI IND	PPI IND	CPI US	WPI US	FX rate
CPI IND	Pearson Correlation	1	0,300 **	0,361 **	-0,432 **	0,113
	Sig. (2-tailed)	.	0,000	0,000	0,000	0,091
	N	225	225	225	225	225
PPI IND	Pearson Correlation	0,300 **	1	0,846 **	-0,327 **	-0,396 **
	Sig. (2-tailed)	0,000	.	0,000	0,000	0,000
	N	225	225	225	225	225
CPI US	Pearson Correlation	0,361 **	0,846 **	1	-0,233 **	-0,234 **
	Sig. (2-tailed)	0,000	0,000	.	0,000	0,000
	N	225	225	225	225	225
WPI US	Pearson Correlation	-0,432 **	-0,327 **	-0,233 **	1	0,542 **
	Sig. (2-tailed)	0,000	0,000	0,000	.	0,000
	N	225	225	225	225	225
FX rate	Pearson Correlation	0,113	-0,396 **	-0,234 **	0,542 **	1
	Sig. (2-tailed)	0,091	0,000	0,000	0,000	.
	N	225	225	225	225	225

** Correlation is significant at the 0.01 level (2-tailed).

Fig. 4. Correlation matrix

The expected return of 18% project IRR and 16% equity IRR is included in the project costs. Therefore the limit state surface describes a non-investability domain.

Figure 5 illustrates the change on the feasibility index beta and the probability of reaching the non-investability domain. The feasibility index is below one until the year 2010 and increases to 3 in the later stages of the operation period. The feasibility index can be interpreted as the probability that the project will perform its requirements during the predetermined time period. The requirement is defined as minimum 1,8 debt service cover ratio (DSCR) within the feasibility function g(x). The time period is limited to three years. The beta increase during later stages of the operational phase can be explained by higher revenue escalation compared to the total costs escalation in the cash flow model. The expected dividend payments are also higher in the early and middle stage of the project. Therefore the limit state surface will be closer to the mean values of the hyperellipsoid and reduce the feasibility index beta. The second line in Figure 5 indicates the probability of reaching the non-investability domain. The probability is quite significant until 2010 and especially during the years 2003 and 2009. The fact can be explained by higher operation and maintenance costs during that period.

Figure 6 highlights the maximum possible change of escalators and FX rates by touching the non-investability domain in a three year time frame. Practitioners see this time frame sufficient to react on market conditions like refinancing the project or redeploy the assets.

Each combination fulfils the constraint of feasibility function g(x) = 0 and min beta. It is therefore a forward looking approach searching for the maximum values possible without reaching the non-investability domain. The possible combinations of the escalators and FX rates are based on the fitted distributions and the correlation assumptions. The input parameters are linked to the cash flow and reflect the different life cycle costs and revenues structures. Higher x-vales compared to the original μ illustrate the potential of increased inflation rates or FX rates without reaching the non-investability domain.

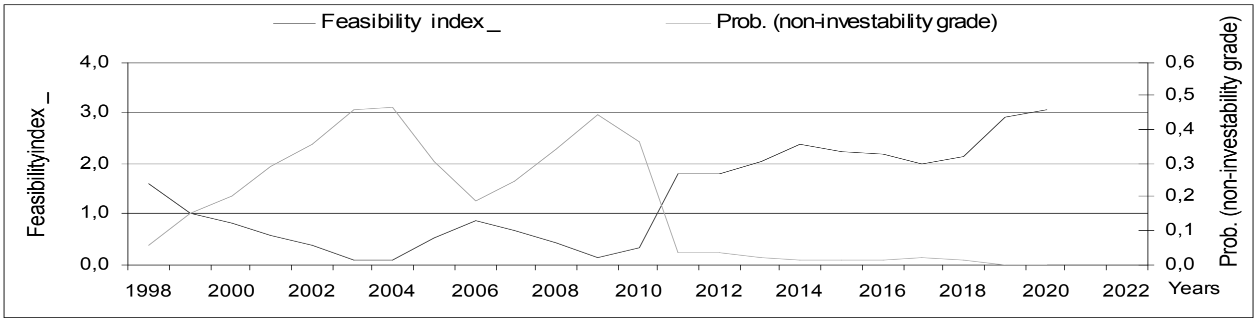

Fig. 5. Feasibility index beta versus probability of reaching non–investability grade

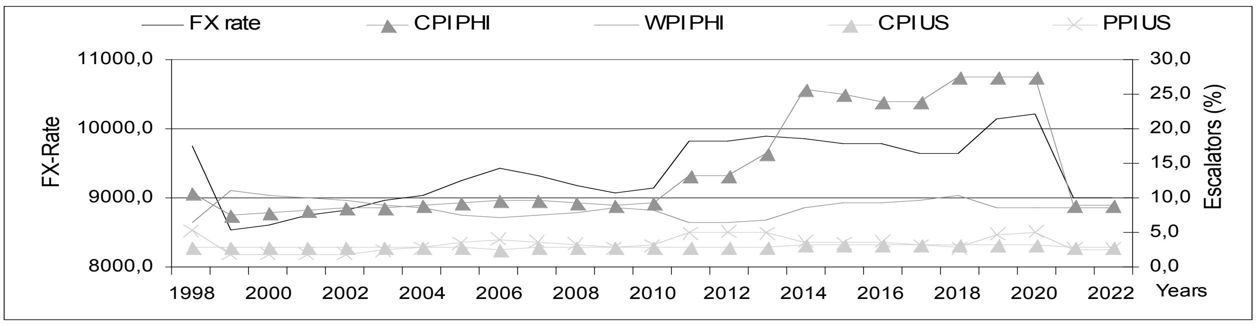

Fig. 6. Maximum possible change in escalators to touch the non-investability domain

Figures 7 and 8 illustrate a scenario with a tariff cap of 16 USc/Kwh on the tariff adjustment mechanism. The feasibility index beta is decreased by 10 to 20%. Until 2003 the model could not find a feasible solution. The tariff is always required to be higher than 16 USc/Kwh otherwise the return on equity would not be maintained on the same level of 16% ROE. Figure 8 shows significant lower combinations of the escalators compared to the base case.

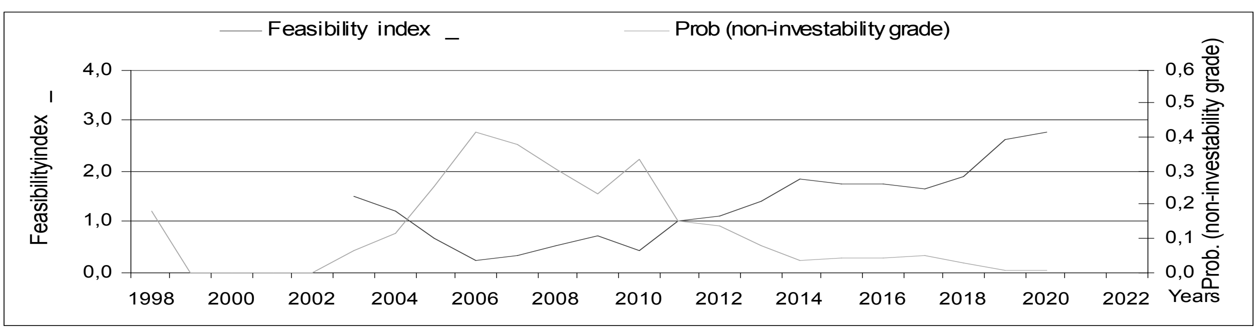

Fig. 7. Feasibility index beta with tariff adjustment mechanism

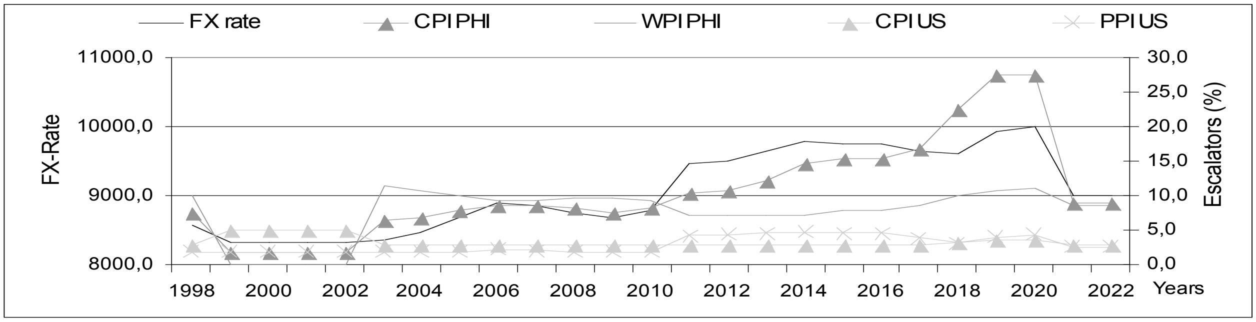

Fig. 8. Maximum possible change in escalators with tariff adjustment mechanism

Figure 9 illustrates the aggregated CRR index. Positive values illustrate a higher country reliability and strength, than negative values. The purpose of the index is to evaluate risk mitigation instruments. Therefore, the proxies chosen for the CRR index focus on the balance of payments risk caused by real or monetary disturbances. Figure 10 shows the fitted probability density function of the index.

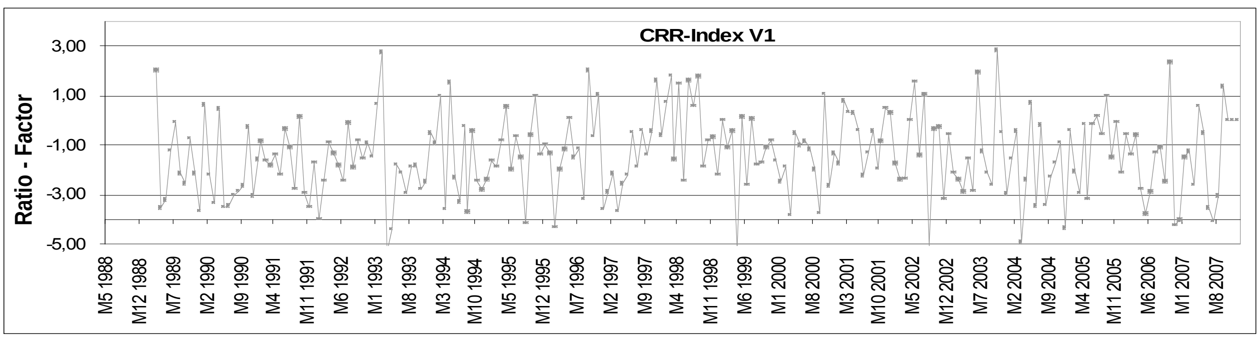

Fig. 9. CRR index

The normal distribution is fitted on the historical CRR index. The index covers 250 data points from 1988 to 2008.

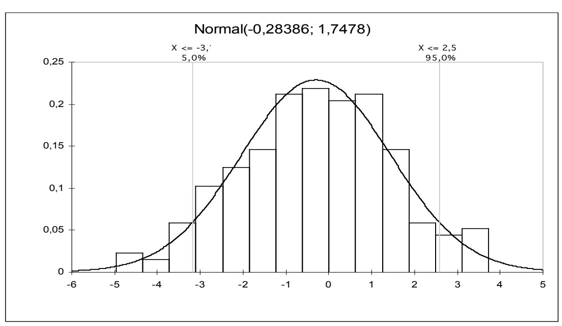

Fig. 10. Fitted CRR index

Figure 11 shows the default probability on RMI, the probability of reaching non-investability grade and the logarithmic trendline of the default probability on RMI. The critical time periods have been at the beginning of the concession period from 1996 to 1998. An additional overlapping exists between 2006 until 2011. From 2011 onwards the project has very low probability to reach the non-investability grade domain.

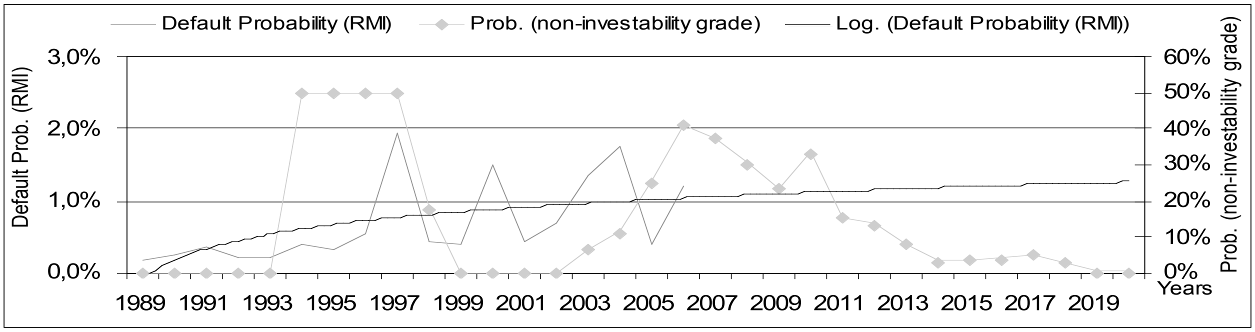

Fig. 11. Default probability of RMI

Discussion and conclusions

This research analyzes project feasibility on economic FX exposure and country reliability on RMI in PPP projects. The project feasibility model for PPP projects represents a strategic component of the set of quantitative tools. The model can be used as a monitoring tool for performing market risk and return analysis. The model has been designed to act as an assessment system to evaluate the project exposure to market risks by monitoring changes in the market condition. The CRR model can estimate the conditional transition matrix and improves the prediction of government reliability on RMI. The model has been designed to act as an assessment system and can be used as a monitoring tool for screening country reliability risk on RMI. The model has a dynamic framework which requires input data that are based on indicators and proxies. It can be applied to support financial strategies in funding PPP infrastructure. It helps investors to evaluate RMI and to estimate the necessary FX protection, and prevents underestimation of the risk that governments would refuse to readjust the contracts after or during a currency devaluation period. The model can be applied to infrastructure projects such as power, water or transportation.

Key Lessons Learned:

- The designed feasibility index beta allows estimating economic FX exposure in Public Private Partnership (PPP) infrastructure projects by considering distribution functions and correlations between the inflation, interest, and FX rates.
- The country risk has significant impact on risk mitigation instruments (RMI). The CRR index is based on signals and proxies, and transferred into a conditional credit rating transition matrix to estimate default probabilities.
- The CRR model is a flagging system and provides information of how good the project is prepared to absorb market fluctuations.

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