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A note on currency-hedging

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A note on currency-hedging*

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Abstract

In this note we analyze if currency hedging reduces the volatility of a portfolio. Based on historical data (2000m1-2018m12), we found that optimal levels of hedging will depend on the degree of risk of the underlying asset, being full-hedging for the case of high-quality sovereign bonds and very small hedging for equity indexes. Finding are consistent across both US and EU assets and different Latam currencies.

Resumen

En esta nota analizamos si es que la cobertura cambiaria reduce la volatilidad de un portafolio. Basado en datos históricos (2000m1-2018m12) encontramos que los niveles óptimos de cobertura dependen del nivel de riesgo del activo subyacente, siendo cobertura completa para el caso de bonos soberanos de alta calidad y relativamente baja cobertura para índices bursátiles. Los resultados son consistentes tanto para activos denominados en dólares como euros así como también para diferentes monedas de Latinoamérica.

Resumen no-técnico

La inversión en activos en moneda extranjera no solo implica una exposición al riesgo del activo sino que a los cambios en la paridad. Estos últimos podrían ser mitigados a través de la cobertura cambiaria. El objeto de esta nota es investigar si dicha estrategia es contingente al tipo de activo (e.g, acciones o bonos). Con datos efectivos de las últimas décadas se concluye que la estrategia de cobertura cambiaria contribuiría a mitigar el riesgo cambiario; pero los niveles óptimos dependen del tipo de activo.

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I. Introduction

With the purpose of taking exposure to a diversified set of risk-factors, investors have expanded their asset allocation to various asset classes across different regions and currencies. Investments in financial assets denominated in currencies different from a portfolio's base currency are exposed to currency-risk. Derivatives, such as foreign exchange forward contracts, are used to hedge currency-risk while maintaining exposure to other factors that drive assets' performance. In this paper we focus on the risk mitigation effectiveness of hedging currency risk for different asset classes. To do that, we define optimal currency-hedging (OCH) strategy as the one that minimizes the risk of a portfolio, the latter measured as the monthly volatility of log portfolio return. Thus, an OCH strategy exists if, according to the model, a given fraction of the portfolio should be hedged in order to minimize its volatility.

Our analysis is based on agents that invest in assets denominated in U.S. dollars (USD) or euro (EUR), but compute returns in a foreign currency. For both US and EU assets we consider equity, corporate bonds (investment-grade, and high-yield), and government bonds; meanwhile for foreign currencies we use Brazilian real (BRL), Chilean peso (CLP), Colombian peso (COP), and Mexican peso (MXN). Thus, this paper is an extension of our own previous research in the area, in which we discuss currency exposure of the Chilean institutional investors (Alfaro and Goldberger, 2012).

Based on a monthly sample of the two recent decades, we conclude that there are OCH strategies, but the level of hedging depends upon the credit risk of the underlying bonds. These results are consistent for all currencies (BRL, CLP, COP, and MXN). Thus, the sovereign debt portfolios require full hedging, the investment grade corporate bonds portfolios need about 80% of hedging, and for high-yield bonds and equities optimal levels are significantly lower. In the last two cases, that occurs because the reduction of risk by applying a hedging strategy is small.

II. Analytical Framework

In this section we introduce a hypothetical portfolio that is composed by one US/EU asset and it is partially hedged using forward contracts. A simplified formula is proposed and with that the optimal currency hedging (OCH) strategy is introduced. Finally, a brief discussion on the data is provided.

1. The Return of the Partially Hedged Portfolio

A portfolio's total return can be split in two components: the return based on the fluctuation of the security, and the return that comes from the fluctuation of the exchange rate. In other words, if P_t is the price of a security in foreign currency and Q_t is the exchange rate, both at time t, then the value of the non-hedged part of the portfolio is $P_{t+1}Q_{t+1}$, and if we hedge the portfolio by using forward contracts, its value would be $P_{t+1}F_t$, where F_t is the exchange rate agreed in the forward contract at time t. We assume that the price of the forward is equal to the value of the spot exchange rate adjusted by the interest rate differential between the domestic and foreign interest rates (x_t) i.e. $F_t = Q_t \exp(x_t)$.

Thus, if we consider λ as the portion of the portfolio that is hedged, then the portfolio return with partial hedging is:

$$1 + R_{t+1} = (1-\lambda)\frac{P_{t+1}Q_{t+1}}{P_tQ_t} + \lambda\frac{P_{t+1}F_t}{P_tQ_t}. \tag{1}$$

Following Campbell et al. (1997) we use a loglinear approximation of (1). In order to get that approximation, we use the following continuous growth rates: $g_t = \log P_t - \log P_{t-1}$, for the asset, and $d_t = \log Q_t - \log Q_{t-1}$, for the currency which implies that log portfolio return (r_{t+1}) is:

$$r_{t+1} = \log(1 + R_{t+1}) = g_{t+1} + \log[(1-\lambda)e^{d_{t+1}} + \lambda e^{x_t}]. \tag{2}$$

The log-term in the right-hand side of (2) is replaced with a first order Taylor approximation, centered at zero ($\bar{d} = \bar{x} = 0$):

$$r_{t+1} = g_{t+1} + (1 - \lambda)d_{t+1} + \lambda x_t + HOT, \qquad (3)$$

where HOT stands for higher order terms. It should be note that (3) could be also obtained by applying portfolio formula presented in Campbell et al. (2003). We discuss that alternative derivation in the Appendix. In any case, we are assuming that higher order terms in (3) are time-invariant and for that can be ignored in the following.

In this framework, forward contracts are settled to one-month, hence interest rate differentials play a role, but it is less relevant because interest rates are known in advance and they have a marginal empirical impact. Thus, we omit the interest rate differential component from the main analysis, having the following equation for characterizing the return of partially hedging portfolios, which is similar to the one used in Alfaro and Goldberger (2012)[1]:

$$h_{t+1} = g_{t+1} + (1 - \lambda)d_{t+1}. \qquad (4)$$

In the Appendix we provide a comparison analysis between equations (2), (3) and (4), showing that formulae are numerically similar for all currencies (BRL, CLP, COP and MXN).

[1] As we discussed in the text, the interest rate differential component is known in advance, therefore that figure is in the information set of investors, but cannot be used to change the decision regarding currency hedging when the objective function is the volatility of the portfolio.

2. Optimal Currency Hedging

Regarding optimal currency hedging (OCH) strategy, we consider the optimal hedging ratio (λ) in order that minimizes the volatility of log portfolio returns, in line with previous literature (Castillo and Aguila, 2005; Walker, 2006)[2]. Thus, the variance of log portfolio return is:

$$\sigma_h^2 = \sigma_g^2 + 2(1-\lambda)\rho\sigma_g\sigma_d + (1-\lambda)^2\sigma_d^2, \tag{5}$$

where ρ is the correlation between the asset —in foreign currency— and the exchange rate. It is clear that minimum variance is achieved under $\lambda = 1 + \rho\, \sigma_g/\sigma_d$. Therefore, OCH only exists when there is a negative correlation.

Given that OCH is based on second order moments that could be unstable over time, we analyze the stability of this strategy by conducting three procedures over portfolio returns: (i) bootstrapping of returns, (ii) conditional volatility to external variable (VIX) and (ii) bivariate GARCH model (BGARCH) for assets and currencies returns. In the first case, we simulate 500 datasets by resampling, with replacement, the returns of the original data. Then, for each simulated dataset, we compute the level of volatility under different level of hedging in order to build 90% confidence intervals. Given that, this procedure assumes that joint returns (asset and currency) are independent over time. In the second procedure we allow that variances of both asset and currency returns could be time-variant, in a way that they depend on an external factor: the implied volatility of the US stock market (VIX). With that estimates of historical variances are obtained for (4) at a giving hedging ratio. That is used to build alternative 90% confidence intervals. Finally, in the last procedure, a standard BGARCH model is fitted for joint returns (asset and currency) and then applied to (4) in a similar way than (ii).

[2] Castillo and Aguila (2005) propose a model that include an optimal level of hedging; their main conclusion is that the optimal level of hedging depends on the correlation between asset and currency. Walker (2006) compare gains of having zero-hedging versus full-hedging for some equity portfolios; he conclude in favor of zero-hedging introducing the concept of natural hedge.

3. Data

We use monthly data (from January 2000 to December 2018) of equity and bond indices. Table 1 shows the asset classes considered for the exercises, the name of the indices used for each asset class and a summary of basic statistics.

Table 1. Asset classes, indices and summary statistics
(January 2000 to December 2018, monthly returns)

Asset Class	Index Name	Average Annualized Return	Volatility of Annualized Returns
US Government	ICE BofAML US Treasury Index	4.44%	4.39%
US Corporate IG	ICE BofAML US Corporate Index	5.51%	5.26%
US Corporate High Yield	ICE BofAML US High Yield Index	6.42%	9.25%
German Government	ICE BofAML German Government Index	4.46%	3.85%
Europe Corporate IG	ICE BofAML Euro Corporate Index	4.10%	3.90%
Europe Corporate High Yield	ICE BofAML Euro High Yield Index	4.81%	11.91%
US Equities	S&P 500 Total Return Index	4.75%	14.69%
EU Equities	MSCI Europe Gross Total Return USD Index	3.08%	18.38%

We can see that sovereign and corporate investment grade (IG) bonds have similar levels of volatilities. In the case of corporate high-yield (HY) that measure is significantly higher than the one obtained in the others bonds. Finally for equity indexes, volatilities are also high. This feature will be relevant in the following analysis given than corporate high-yield bonds will behave more close to equity indexes than sovereign or corporate investment grade bonds.

For each US and EU asset we consider the cases of the following Latam currencies: BRL, CLP, COP, and MXN.

III. Main Results

In this section we discuss the results of our experiments considering that returns do not exhibit clustering over time; thus, resampling or bootstrapping procedure can be applied in order to build confidence interval. We start with the bonds portfolios and then move to equity portfolio. Exercises for each US/EU asset consider the cases of the following currencies: BRL, CLP, COP, and MXN.

1. Government Bonds

Figure 1 relates the volatility of the log portfolio return with the hedging ratio (λ). Each panel represents a different country/currency, and all of them consider the US Government bond index as the asset of interest. It is clear that for these fixed-income portfolios currency-hedging offers a consistent reduction in the level volatility. For all country/currency, moving from zero-hedging to full-hedging reduces volatility from the range 12%-16% to 4.5% (solid line).

Moreover, the 90% confidence interval (dash lines) shrinks as the hedging-ratio increases, which further supports the conclusion that full-hedging is the OCH strategy. Thus, by adopting such strategy, the volatility of the log portfolio returns will be centered at 4.5%, with a 90% confidence interval between 4% and 5%.

In addition, Figure 2 complements the results previously presented by considering the German Government Bond index as the relevant asset. Again, for all country/currency we have two main results for higher degrees of hedging: (i) a significant reduction in volatility, and (ii) a reduction in the confidence interval.

These results are consistent with previous research that uses high frequency data and expected shortfall as additional measure of risk (Alfaro and Goldberger, 2012). For high-quality foreign bonds, currency hedging does reduce the level of risk, which in this paper is measured by the volatility of the portfolio.

Figure 1. Volatility and Hedging Ratio, US Government

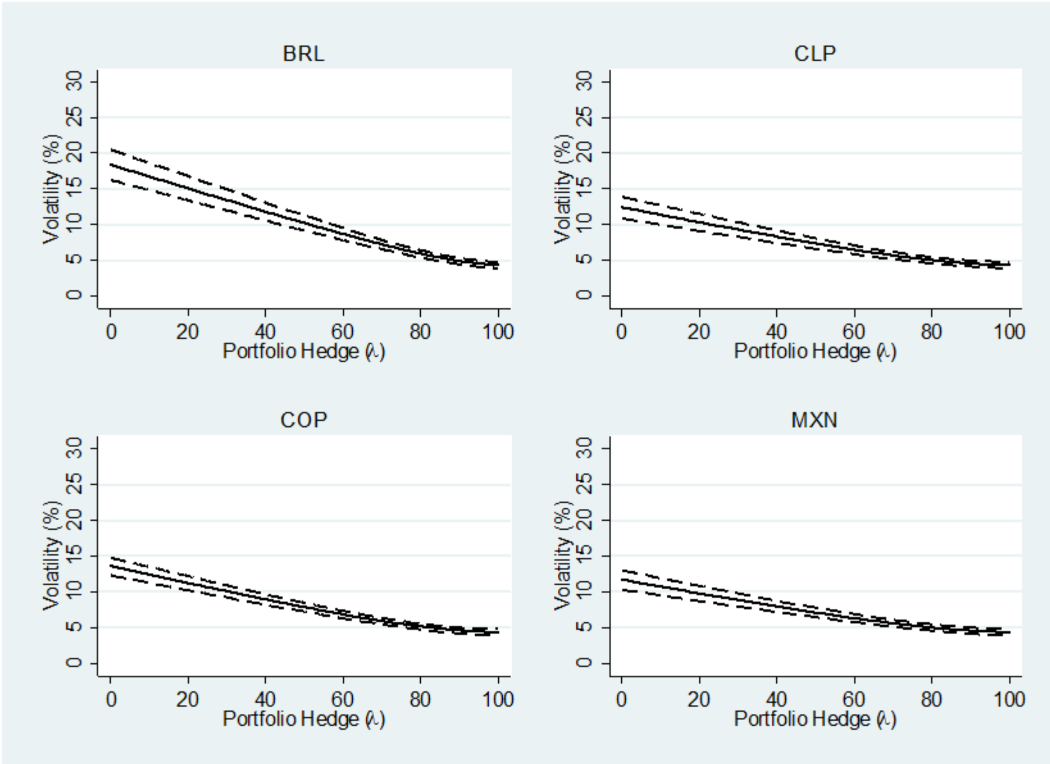
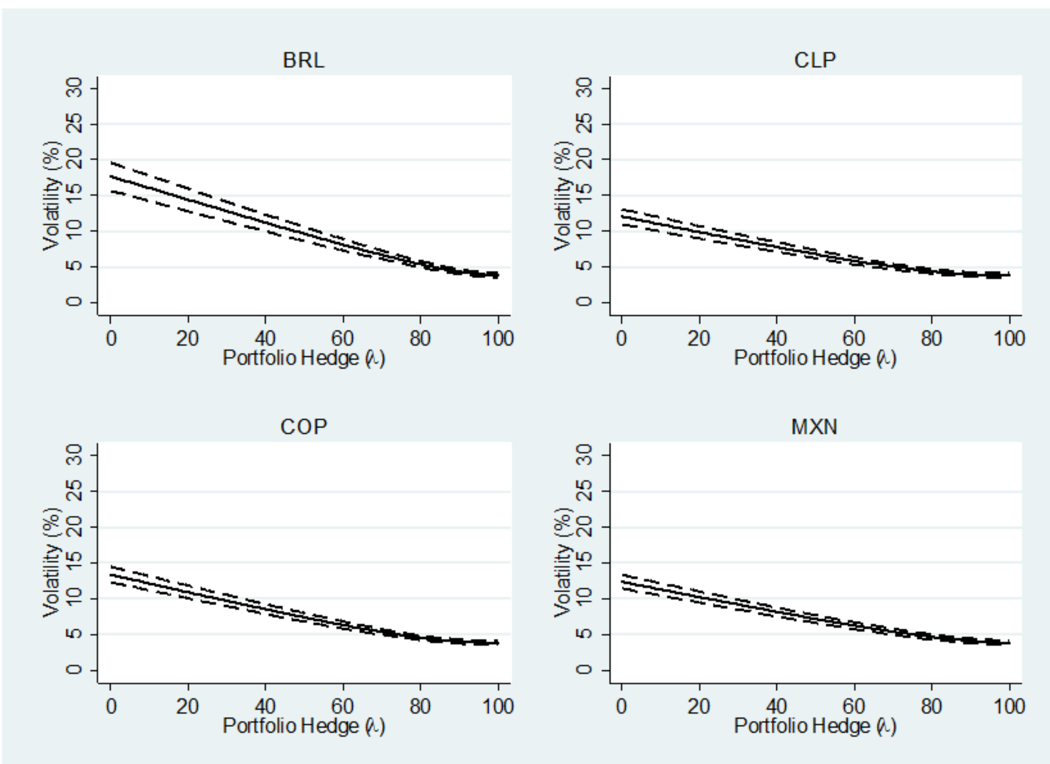


Figure 2. Volatility and Hedging Ratio, German Government



2. Corporate Bonds

Figure 3 shows the case of a portfolio of US corporate bonds classified as investment grade. The OCH is not 100%, but about 80% for all currencies (BRL, CLP, COP, and MXN). Also, there is a reduction in the size of the confidence interval around the level of OCH. Indeed, moving from zero-hedging to 80% the volatility decreases from the range 10%-12% to 5%.

Figure 4 shows the case of a portfolio of US corporate bonds classified as high yield. In contrast to government and corporate investment-grade bonds, the currency-hedging strategy has a lower impact on volatility which moves from 10%-12% when zero-hedging is considered to 8% under 60% of hedging. Results for EU corporate bonds are somehow similar (Figures 5 and 6).

3. Equity

Figure 7 shows results for the US equity portfolio and Figure 8 for the EU equity portfolio. Similar to the case of high-yield bonds, there is a small gain of using currency hedging to reduce the volatility of these portfolios. This is particularly clear for the case of US assets, in which the volatility of portfolio looks relatively flat when is graphed against the degree of currency hedging. Hence, for that kind of portfolio a small degree of currency hedging should be considered. For the case of BRL a 40% hedging seems reasonable, meanwhile for CLP that figure is about 20%. Interesting, for EU equity there is negative relationship that suggests a high degree of hedging that we will discuss later.

It is important to stress that our analysis is based on volatility, therefore a weak relationship between the volatility of the portfolio and the hedging ratio could be attributed to two factors: (i) unstable correlation measure and/or (ii) relatively large variance of the asset compared to the currency. The first factor is well documented in the literature and it is particularly relevant in the case of Latam currencies which are strongly related to commodity prices and not to the US or EU stock markets. Regarding the second factor, the volatility of US or EU equities tend to be 20%-40% greater than the volatilities of the Latam currencies, excluded BRL. Thus, for the extreme case of no-correlation, most of the volatility of the portfolio is due to the volatility of the foreign asset.

Figure 3. Volatility and Hedging Ratio, US Corporate IG

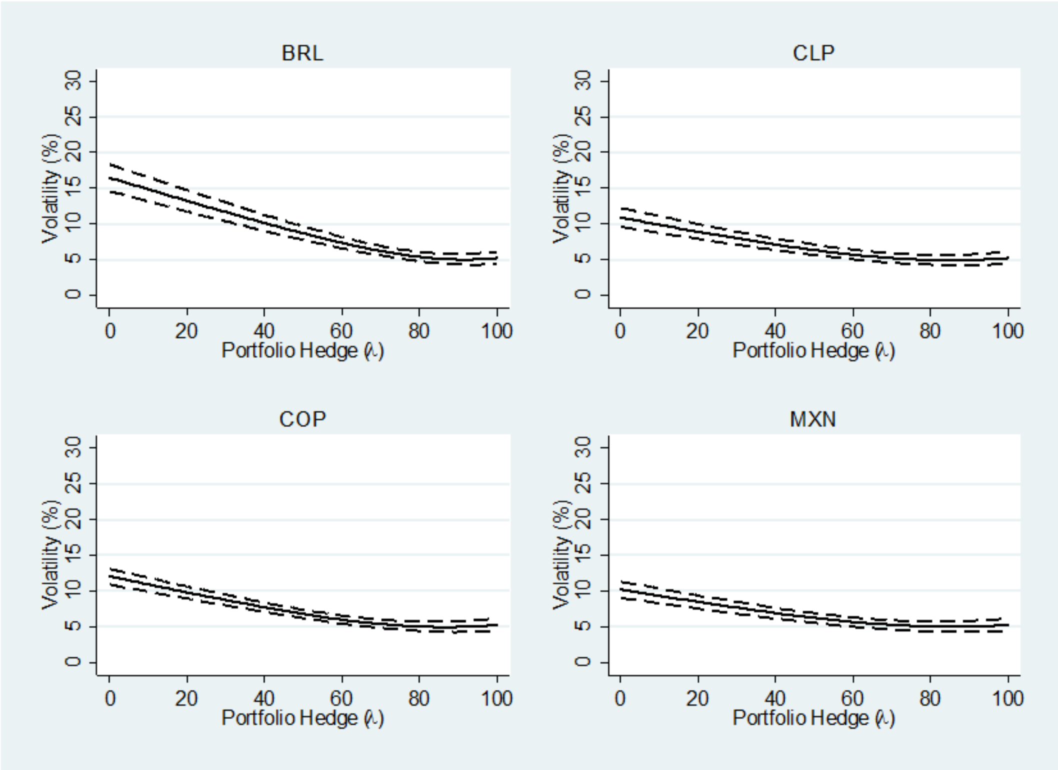


Figure 4. Volatility and Hedging Ratio, US Corporate HY

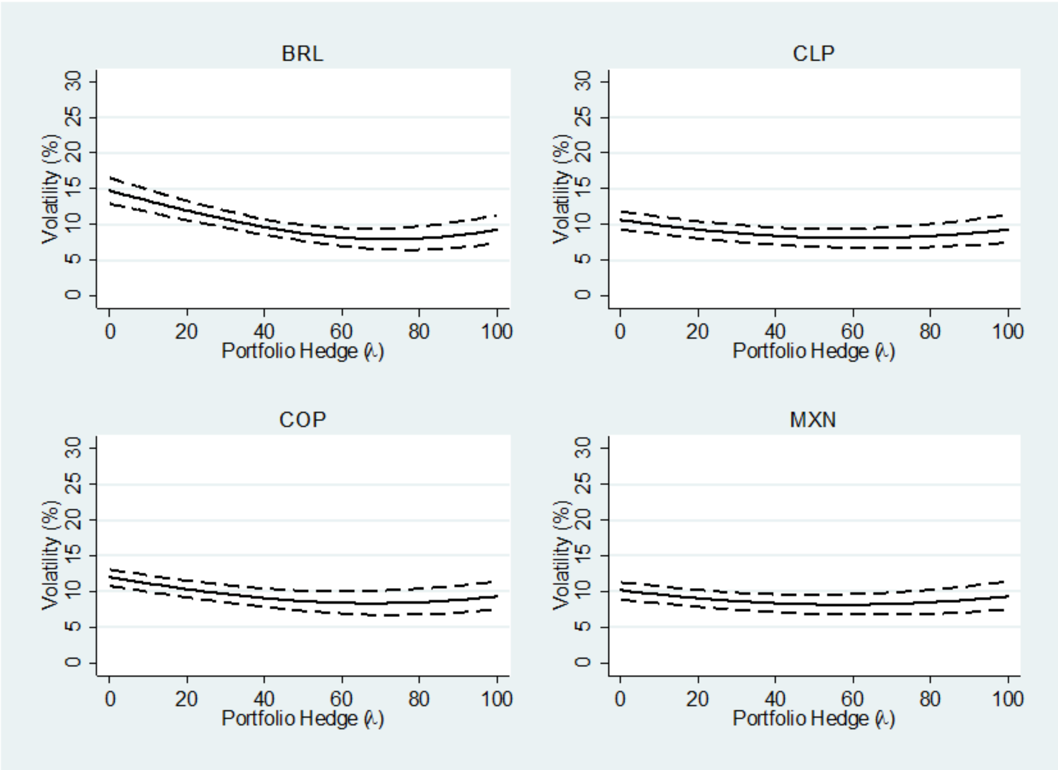


Figure 5. Volatility and Hedging Ratio, EU Corporate IG

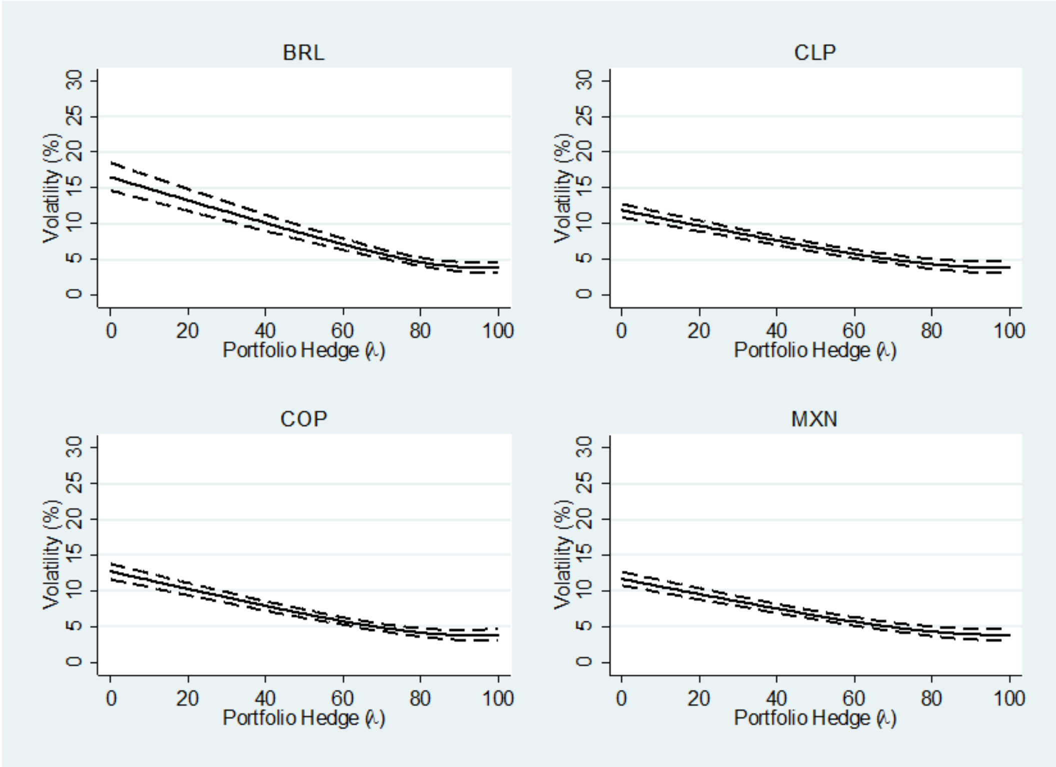


Figure 6. Volatility and Hedging Ratio, EU Corporate HY

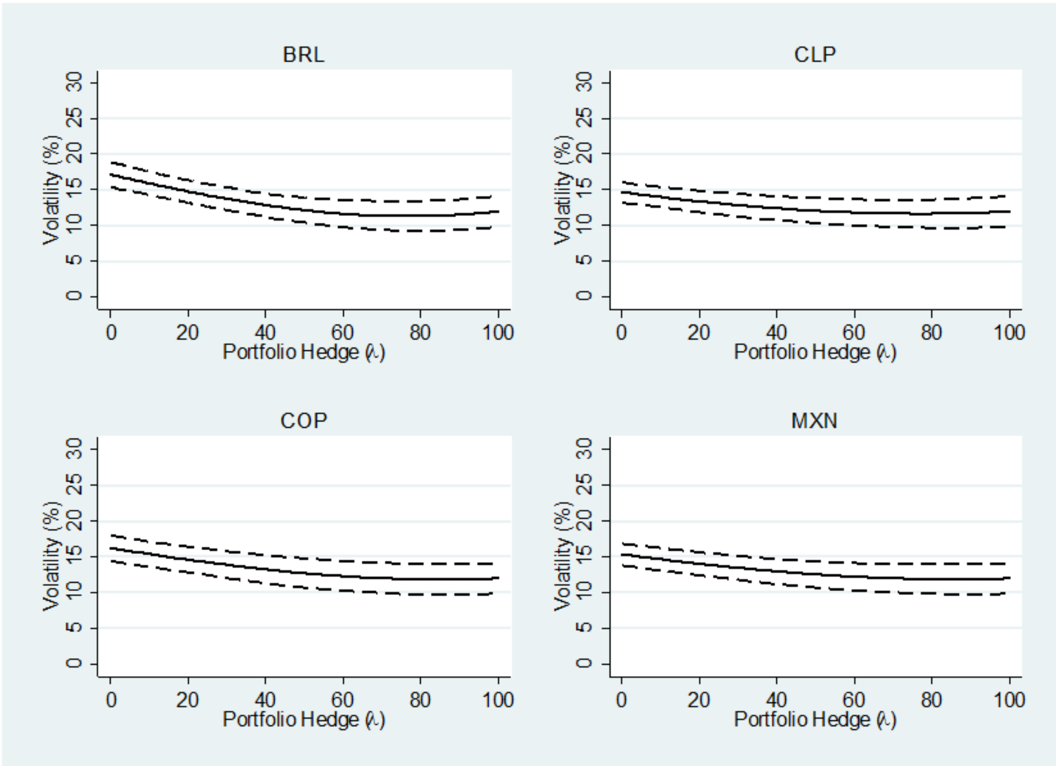


Figure 7. Volatility and Hedging Ratio, US Equity

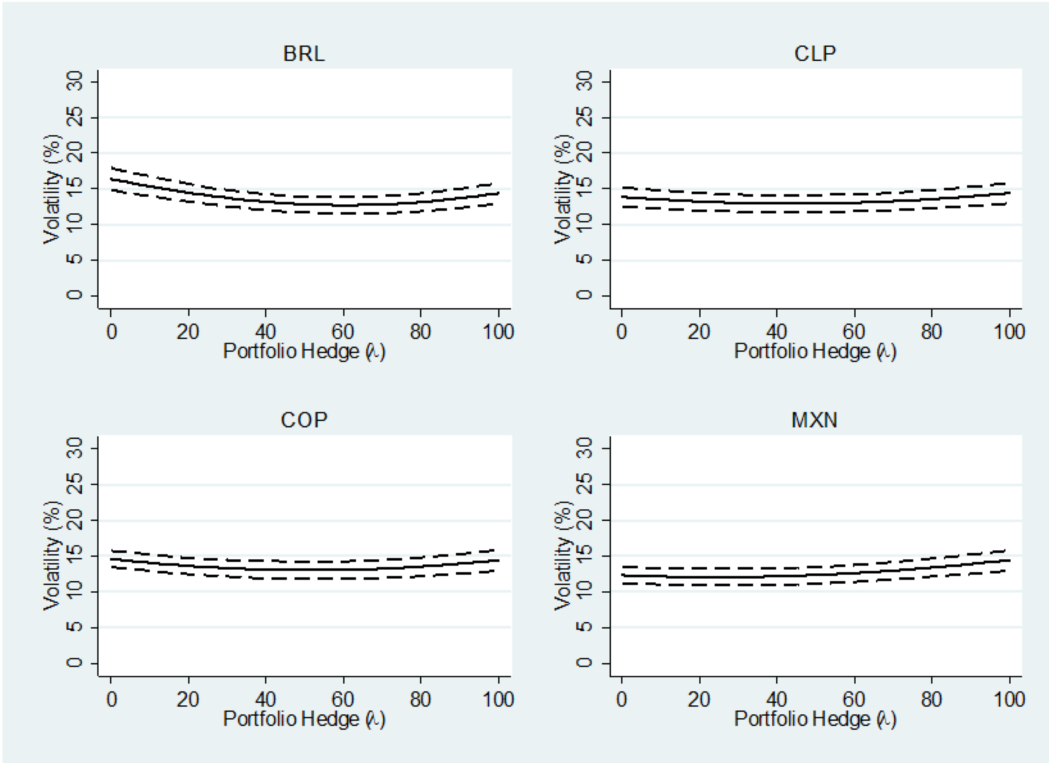
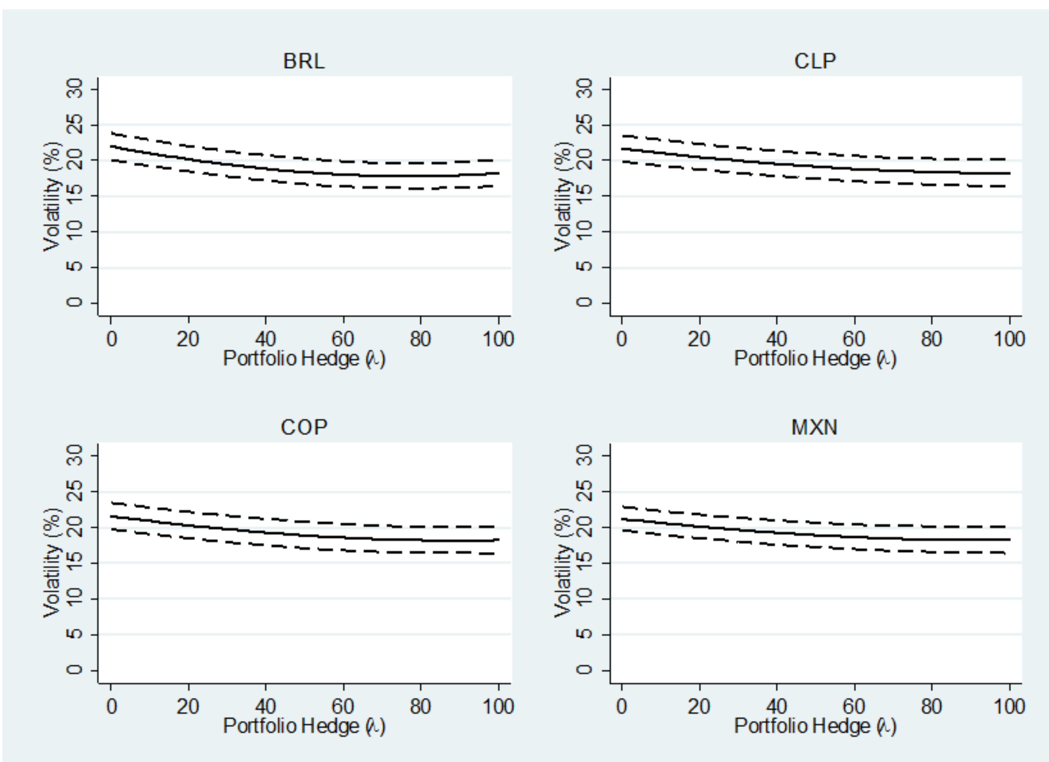


Figure 8. Volatility and Hedging Ratio, EU Equity



IV. Robustness

This section complements the previous one by considering that returns could exhibit some clustering over time and therefore confidence intervals should be adjusted to that. In the first set of exercises the variances of the two returns (asset and currency) is conditioned to the VIX. In the second set of exercises the variances are obtained by fitting a bivariate GARCH model. Results for the Euro assets are reported in the Appendix. As we discussed in the previous section, patterns are similar to the one obtained for the US assets.

1. Conditional variance

In previous section we consider that returns have time-invariant second order moments. That assumption could affect the relevance of the results obtained there. In order to stress that, this section includes an exogenous variable in the second order equation which is the implied volatility for the US equity index SP 500: VIX. The VIX is a well know volatility index that reflect the willingness of investors to take risk. It has been used in several academic papers as a metric of market risk or fear indicator. In our application, both the variance of the asset and the currency are conditional to the level of the logarithm of the VIX. After fitting the model for the entire sample (2000-2008), predicted variances are obtained and then used to build 90% confidence intervals.

Figure 9 considers the US sovereign bond having a similar result than Figure 1 which is full currency is preferred. Figure 10 considers the US corporate IG asset, it complements conclusion obtained in Figure 2: a high degree (80%) of currency hedging is optimal. Figure 11 also support the conclusion of medium level of hedging (60%) for this kind of bond, but it states that confidence intervals are wider. Figure 12 has the case of equity showing us the confidence interval are significantly larger than the ones obtained for bond assets. In any case, some small degree of currency hedging (20%) is suggested.

Figure 9. Volatility and Hedging Ratio, US Government

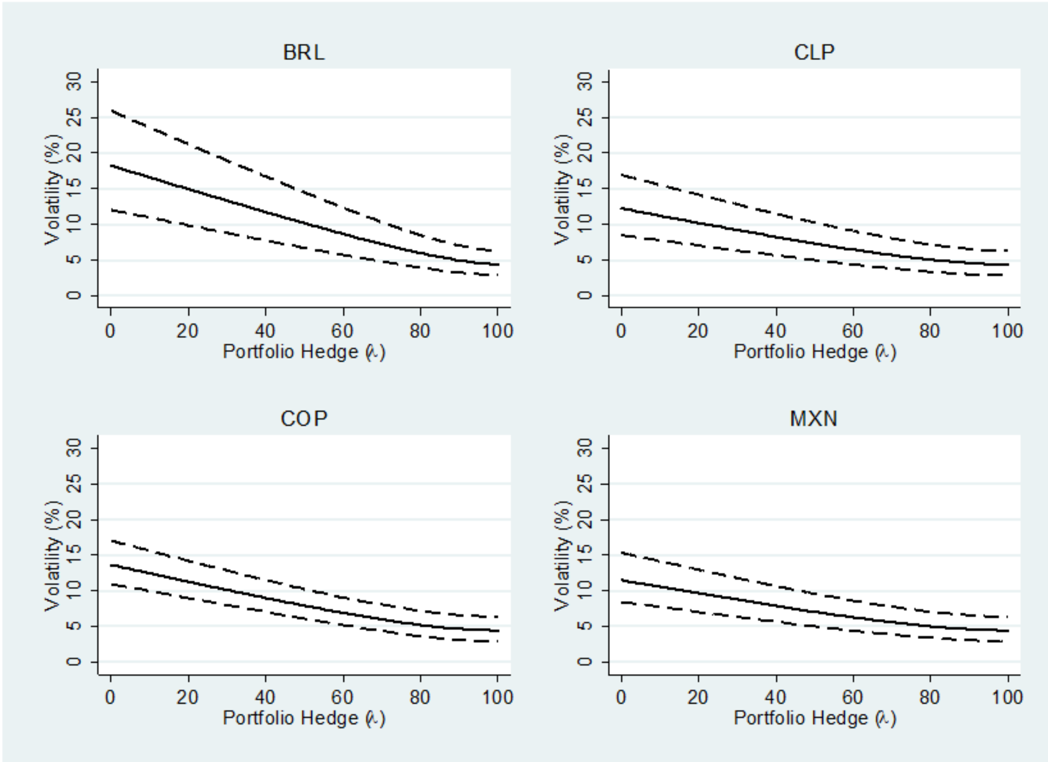


Figure 10. Volatility and Hedging Ratio, US Corporate IG

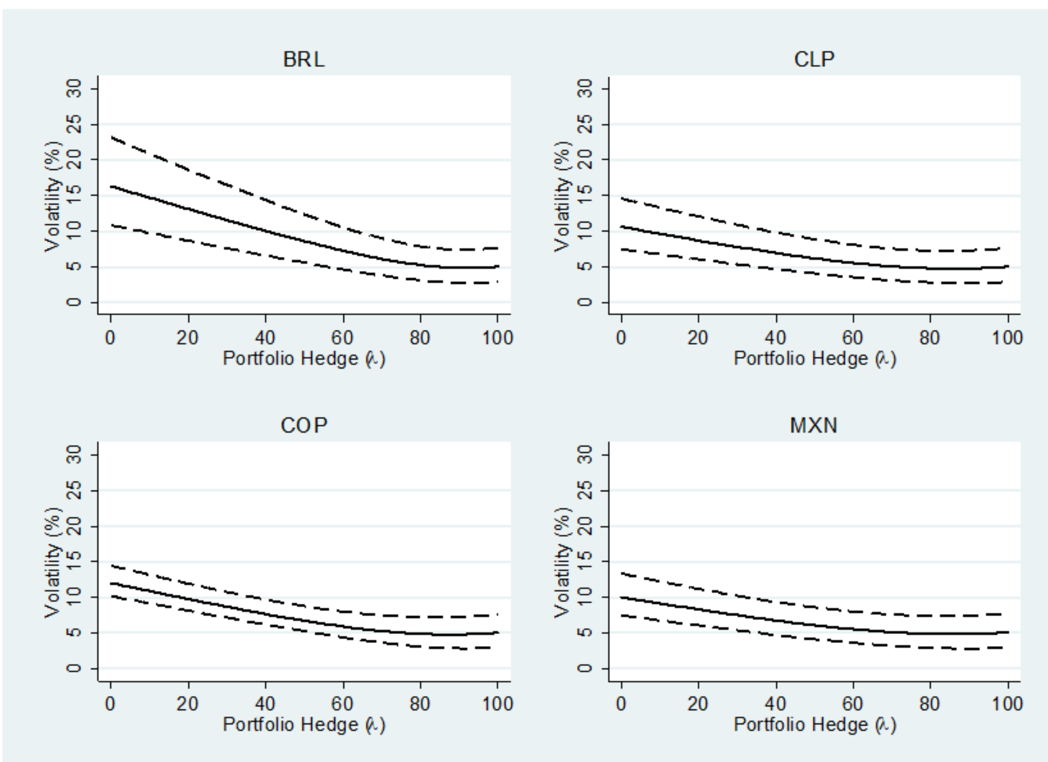


Figure 11. Volatility and Hedging Ratio, US Corporate HY

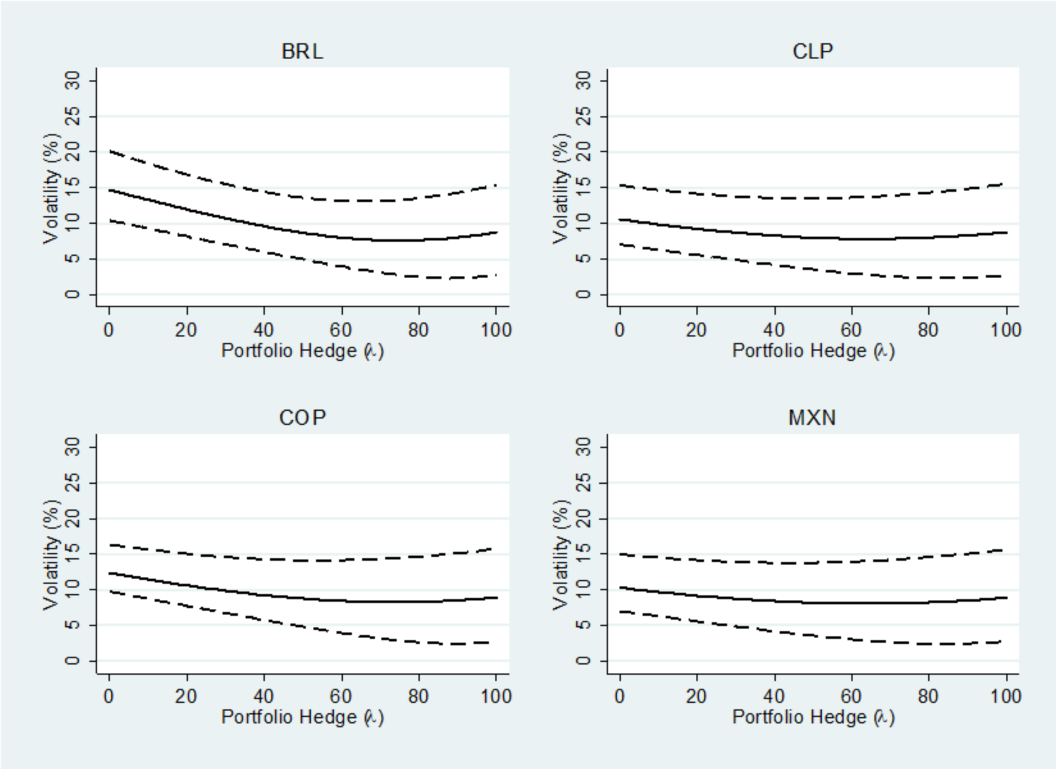
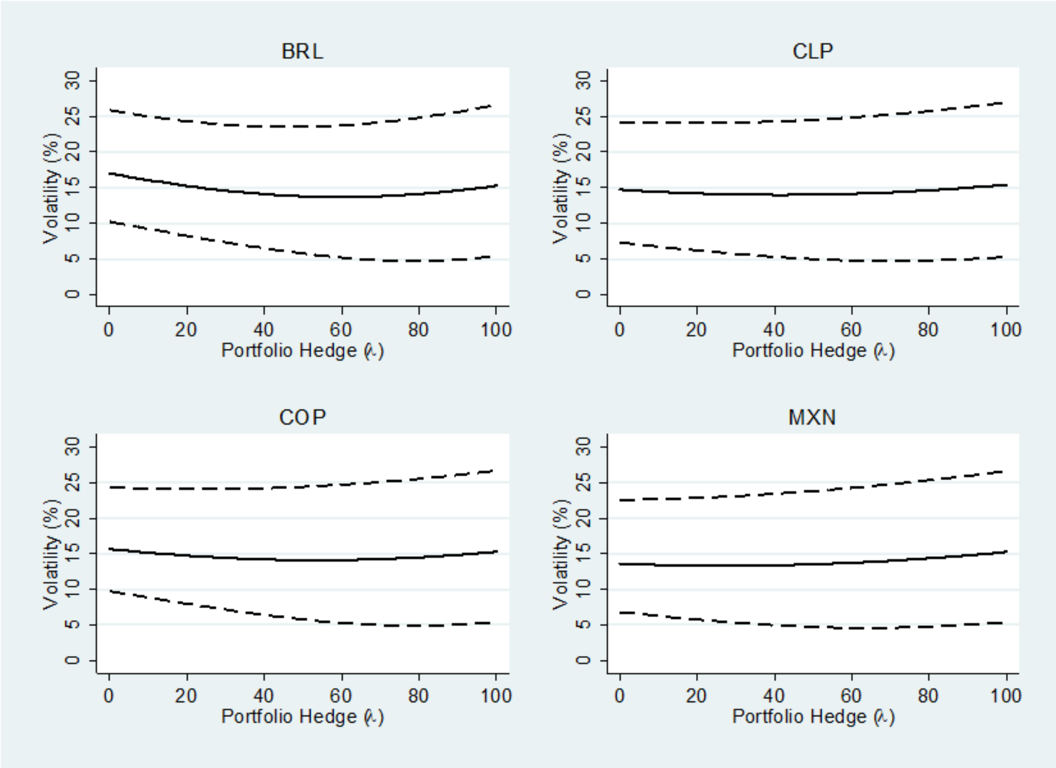


Figure 12. Volatility and Hedging Ratio, US Equity



2. Bivariate GARCH

In the case of univariate series, the GARCH(1,1) is a popular choice for fitting conditional variance for financial assets (Wilmott, 2006). That could be applied directly in the multivariate context by adding an assumption regarding correlation between errors. They are many cases of modeling that factor, but we use bivariate GARCH(1,1) with constant conditional correlation for each pair asset/currency[3]. After that, estimates of the variance of (4) are computed for each hedging ratio using the sample 2000-2018. Based on these historical estimates, 90% confidence intervals are calculated.

Figure 13 considers the US government asset. Similar to figures 1 and 9, results show that full currency hedging is optimal. Figure 14 considers the US corporate IG asset, having a similar conclusion than figures 3 and 10: a high degree of currency hedging (80%) is optimal. These are the main conclusions of this paper, in which we extend results obtained in Alfaro and Goldberger (2012) by adding different currencies as well as different procedures to achieve the OCH. Those provide a clear reduction of confidence intervals around the optimal level of hedging.

For the case of US corporate HY (Figure 15) the optimal degree of currency hedging is around 60%, which is consistent with results obtained in figures 4 and 11. It should be noted that confidence intervals under these statistical approaches tend to be significantly larger than the one obtained for high-quality bonds. The latter is also observed in the case of US equity (Figure 16). Again, as in Figure 7 and 12, a small degree of hedging is required for this kind of asset.

[3] Results using dynamic correlation models are similar for most of the pair asset/currency. Given that we decide to report the constant conditional correlation to be consistent with the previous section.

Figure 13. Volatility and Hedging Ratio, US Government

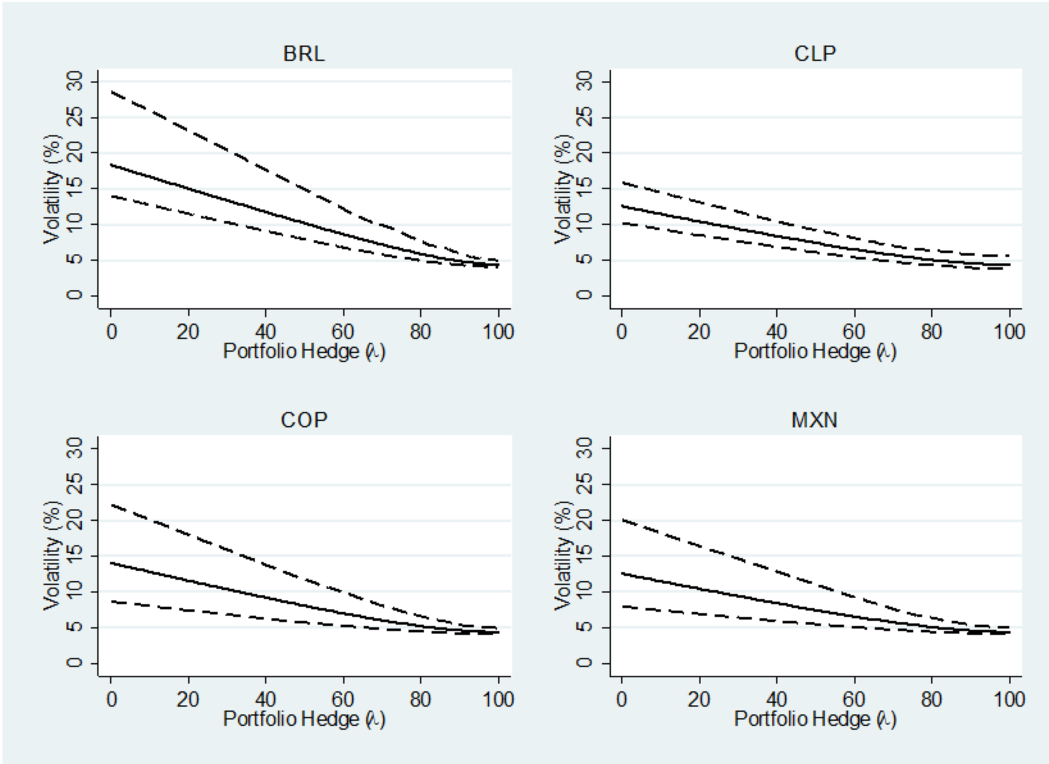


Figure 14. Volatility and Hedging Ratio, US Corporate IG

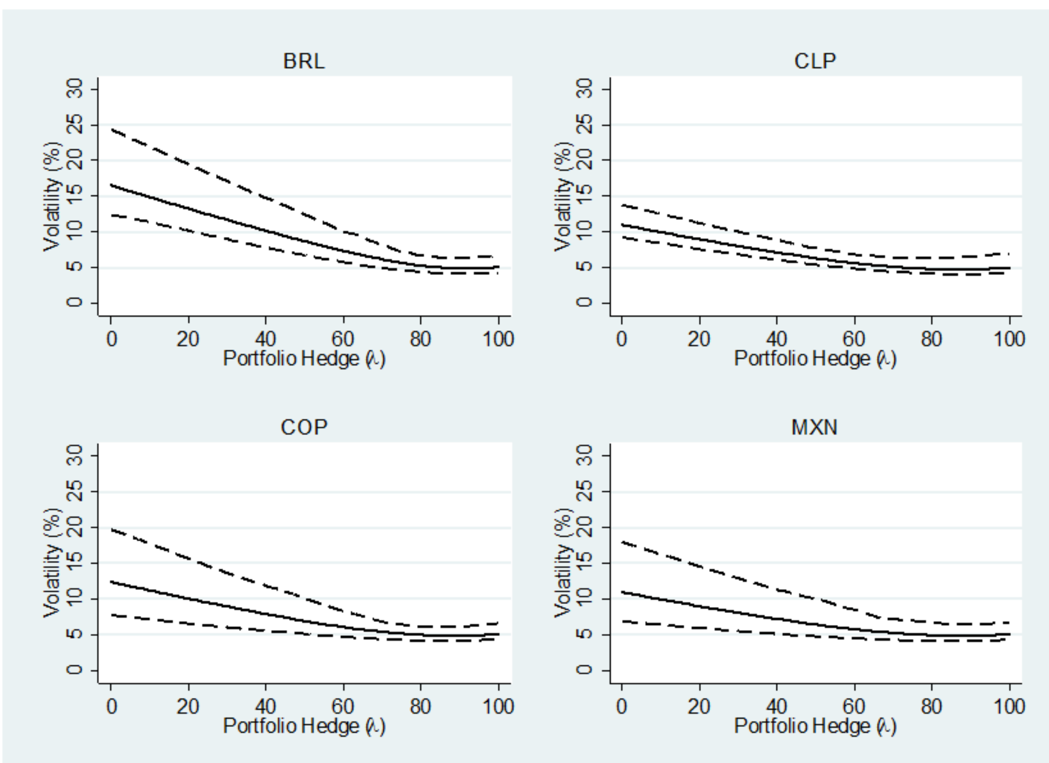


Figure 15. Volatility and Hedging Ratio, US Corporate HY

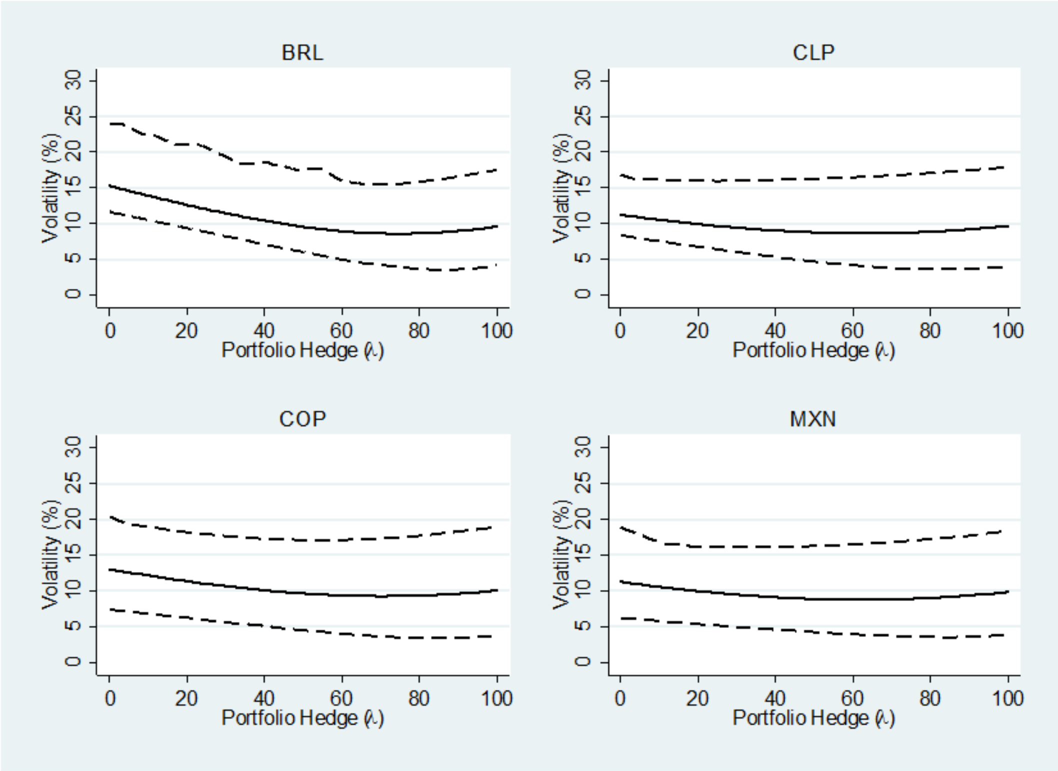
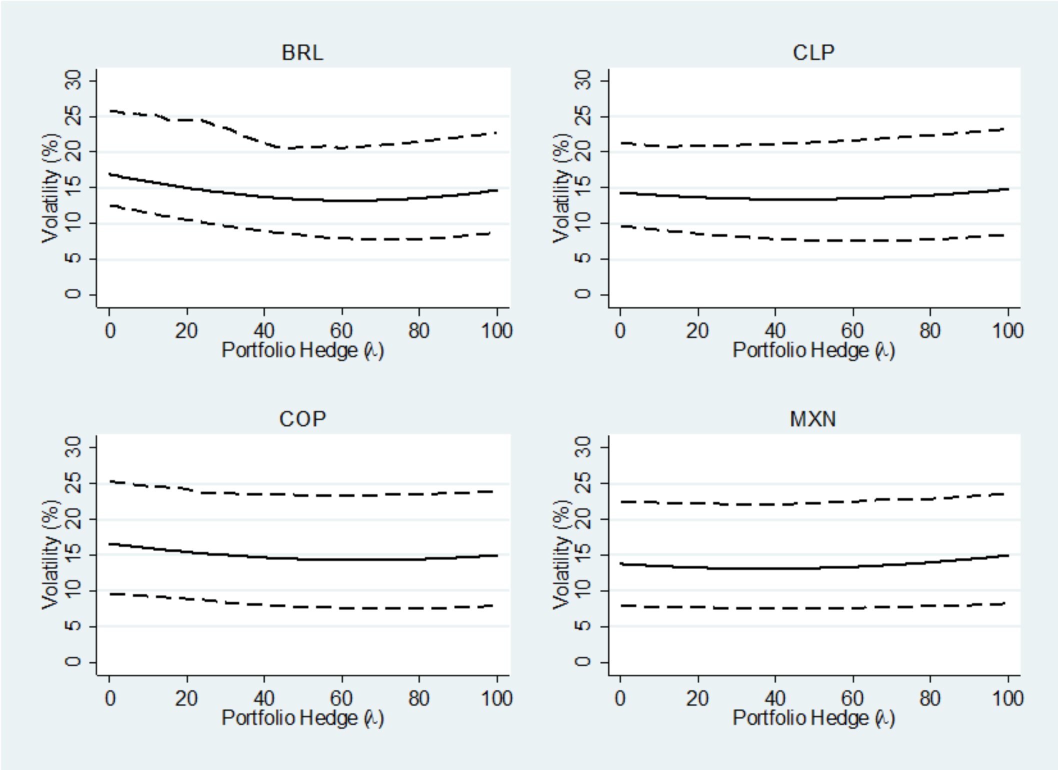


Figure 16. Volatility and Hedging Ratio, US Equity



V. Conclusions

In this note we analyze optimal currency-hedging strategies for portfolios that include US or EU assets (equity and bonds) but are managed by foreign investors. In particular, we consider the case of investor that could be based in Brazil, Chile, Colombia, and Mexico, and manage portfolios denominated in their respective local currencies.

We conclude that fixed-income portfolios require some degree of hedging to reduce the volatility. That degree depends on the credit risk of the underlying asset, implying full hedging for the case of government bonds and about 80% for investment grade bonds. For the case of high-yield bonds and equities, the optimal levels of hedging are lower, given that the reduction of risk doing this strategy is small. These conclusions remain under the case that returns are considered to have time-variant variances (conditional variances and GARCH models).

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Appendix

In this section, we relate (2) with previous research, document the numerical errors of equation (3) and provide additional figures for Euro assets computed under the BGARCH model.

1. Log return

Campbell et al. (2003) provide an alternative way to approximate equation (2). In particular, for the case of a portfolio of three assets the log return of the portfolio is approximate as a sum of the log returns of each component of the portfolio:

$$r_t = \log(1+R_t) = \log\left[\begin{pmatrix}\alpha_1 & \alpha_2 & \alpha_3\end{pmatrix}\begin{pmatrix}1+X_{1t}\\ 1+X_{2t}\\ 1+X_{3t}\end{pmatrix}\right] = \theta + \begin{pmatrix}\alpha_1 & \alpha_2 & \alpha_3\end{pmatrix}\begin{pmatrix}x_{1t}\\ x_{2t}\\ x_{3t}\end{pmatrix}.$$

where X_t is the return of a given asset, and θ is the Jensen term, which is time-invariant because it depends only on the second moment parameters of the log returns of assets:

$$\theta = \frac{1}{2}\begin{pmatrix}\alpha_1 & \alpha_2 & \alpha_3\end{pmatrix}\left[\begin{pmatrix}\sigma_1^2\\ \sigma_2^2\\ \sigma_3^2\end{pmatrix} - \begin{pmatrix}\sigma_1^2 & \sigma_{12} & \sigma_{13}\\ \sigma_{12} & \sigma_2^2 & \sigma_{23}\\ \sigma_{13} & \sigma_{23} & \sigma_3^2\end{pmatrix}\begin{pmatrix}\alpha_1\\ \alpha_2\\ \alpha_3\end{pmatrix}\right].$$

The relationship holds exactly in continuous time when asset prices are geometric Brownian motions. This means that asset prices are martingales with constant volatilities. Authors claim that the approximation is highly accurate for short-time intervals.

The equation (3) discussed in the text could be obtained from this approximation by considering the returns in two assets: (i) hedged and (ii) unhedged, then both the interest rate differential component and the Jensen term should be dropped.

2. Errors terms

Equation (2) presents the log portfolio return and (4) is a first order Taylor approximation in which the interest rate differential is also dropped. The purpose of this appendix is to show that (4) is a reasonable approximation of (2).

For this exercise, we examine the following degrees of hedging: 10%, 50%, and 90%. The metric adopted for comparison is the average absolute difference —in basis points (bp)— between the exact log return and one obtained by using (3):

$$|r_{t+1} - h_{t+1}| = |\log[(1-\lambda)e^{d_{t+1}} + \lambda e^{x_t}] - (1-\lambda)d_{t+1}|$$

Regarding Taylor approximation, results for BRL are 1.2, 3.3, and 1.2 bp for low (10%), medium (50%) and high (90%) degree of hedging. For CLP: 0.5, 1.4, and 0.5 bp. For COP: 0.8, 2.1, 0.8 bp. And for MXN: 0.4, 1.2, 0.4 bp. These relatively small errors are in line with Campbell et al. (1997).

In our analysis, formula (3) also omits the interest rate differential increasing the error term. Thus, for BRL: 10, 50, and 86 bp; for CLP: 2, 10, and 17 bp; for COP: 4, 19, and 32 bp; and for MXN: 5, 22, and 39 bp.

3. Results for Euro assets

In the following graphs, we include results for Euro assets that complement section IV. Results are consistent with the one obtained for US assets. Figures A.1 to A.4 are the BGARCH results, and figures A.5 to A.8 the one obtained with conditional variance (VIX).

Figure A.1. Volatility and Hedging Ratio, EU Government

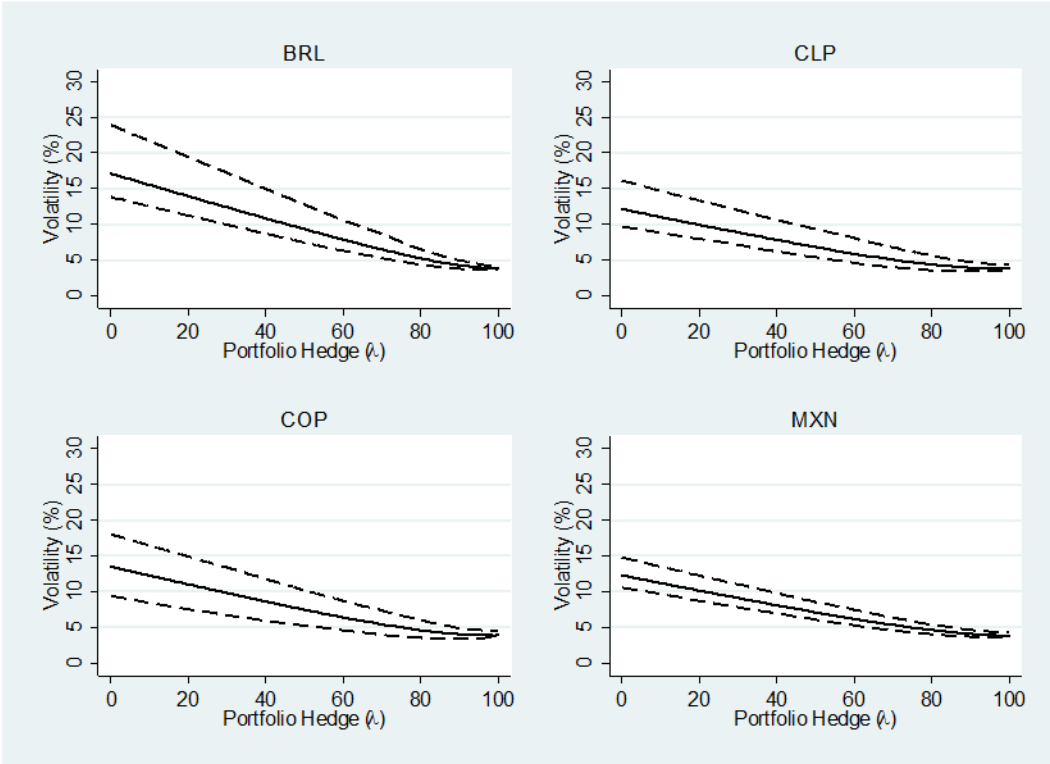


Figure A.2. Volatility and Hedging Ratio, EU Corporate IG

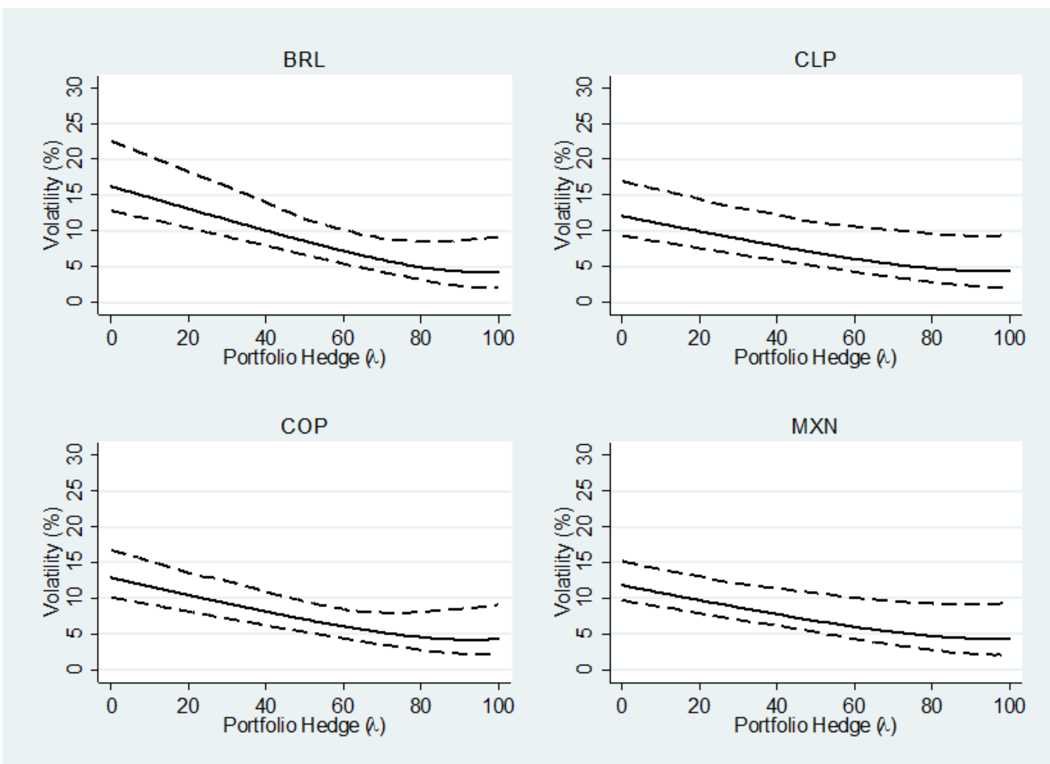


Figure A.3. Volatility and Hedging Ratio, EU Corporate HY

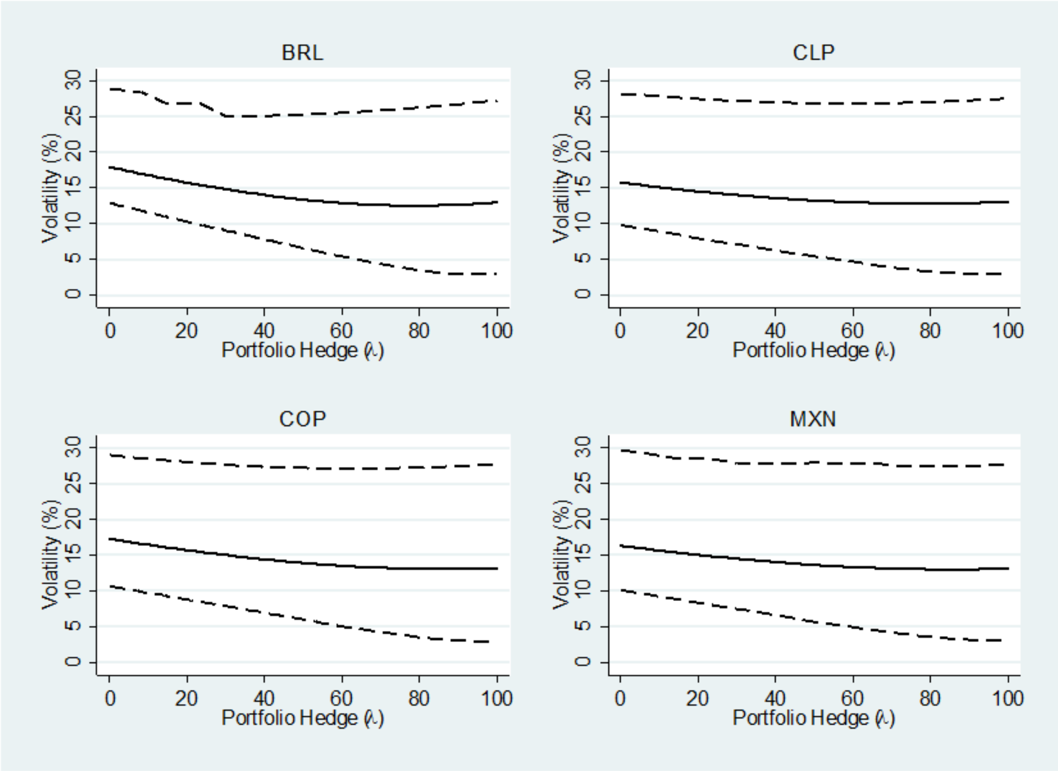


Figure A.4. Volatility and Hedging Ratio, EU Equity

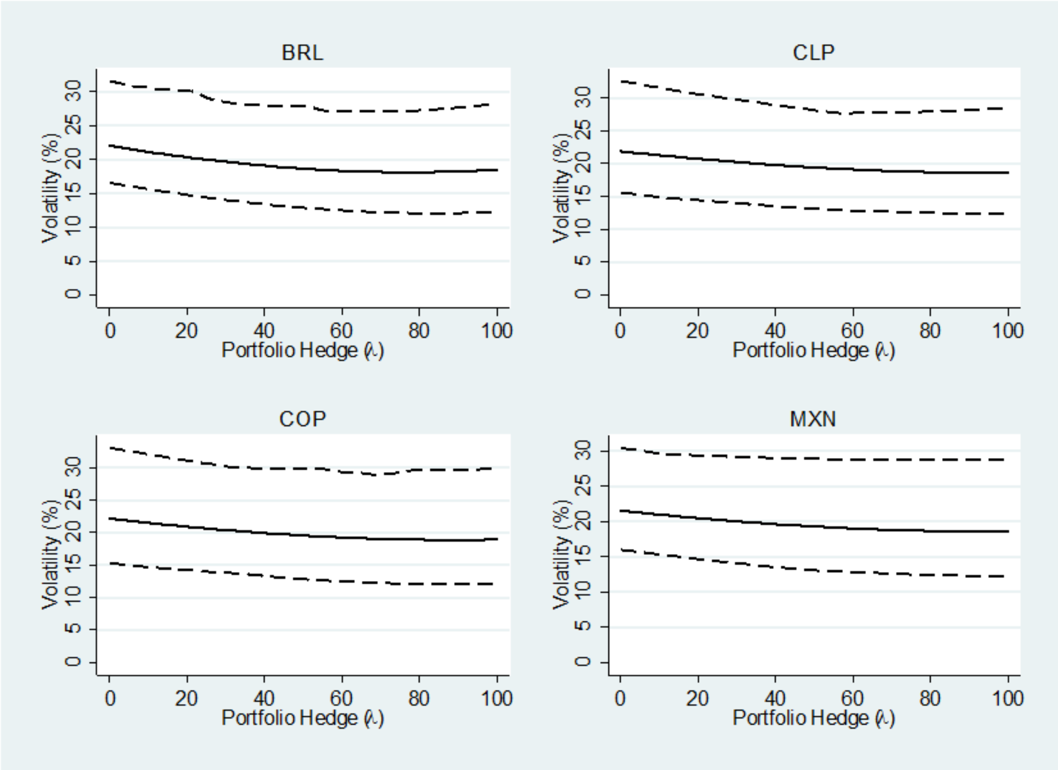


Figure A.5. Volatility and Hedging Ratio, EU Government

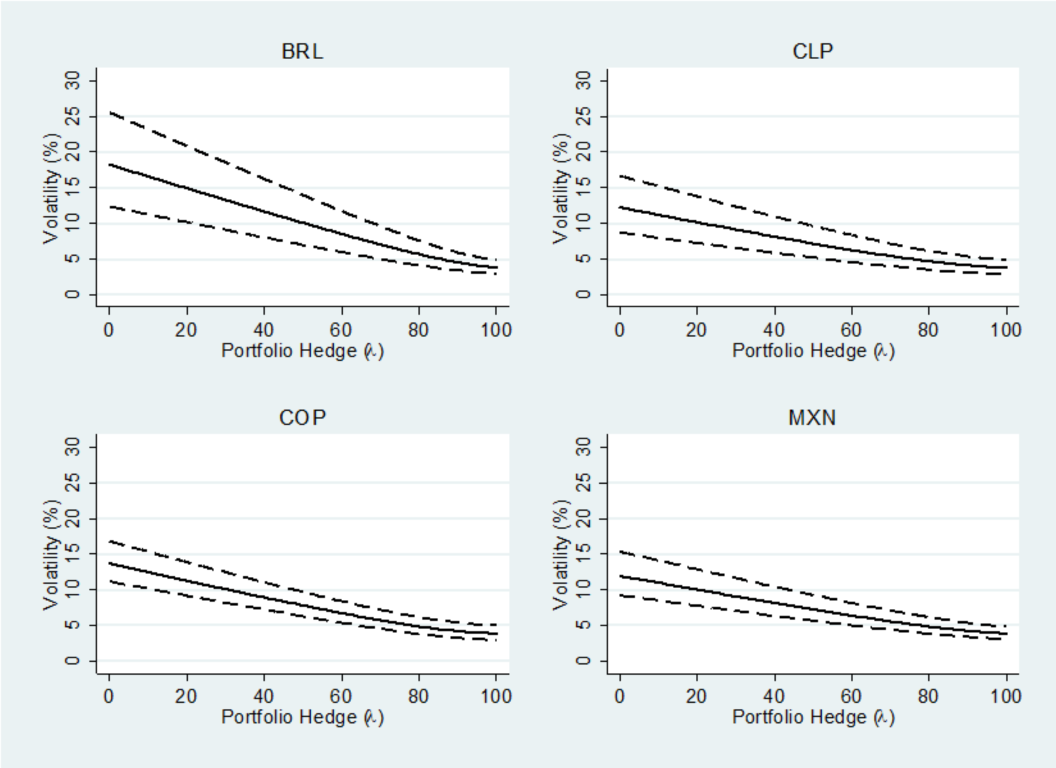


Figure A.6. Volatility and Hedging Ratio, EU Corporate IG

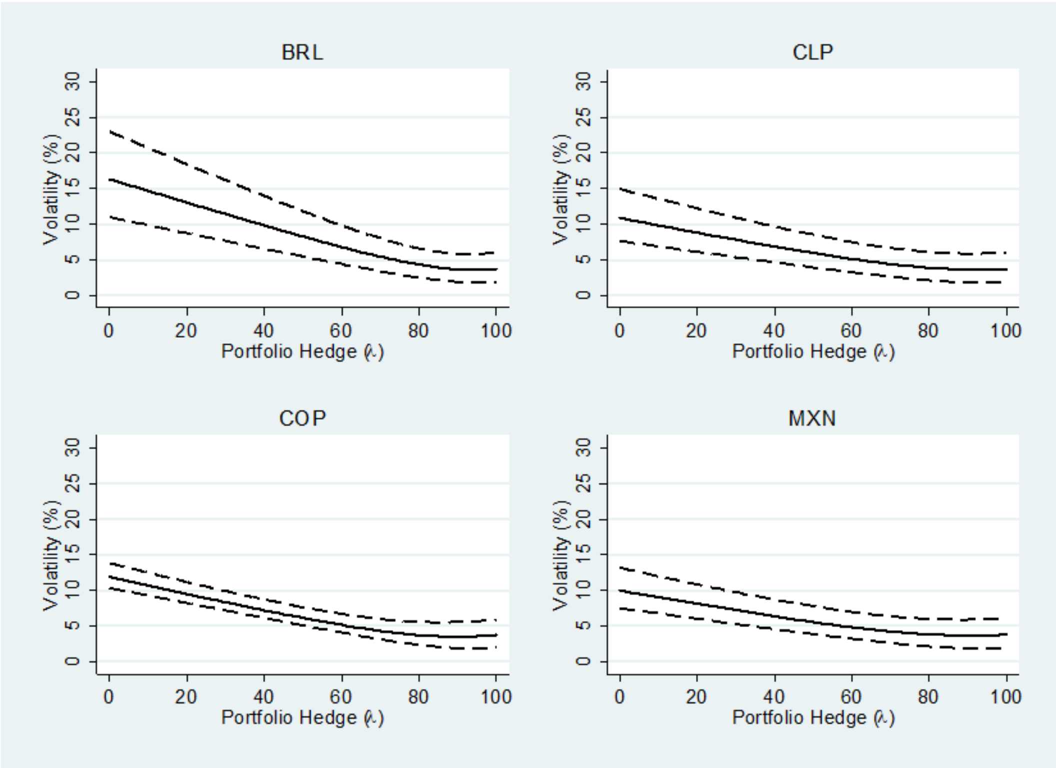


Figure A.7. Volatility and Hedging Ratio, EU Corporate HY

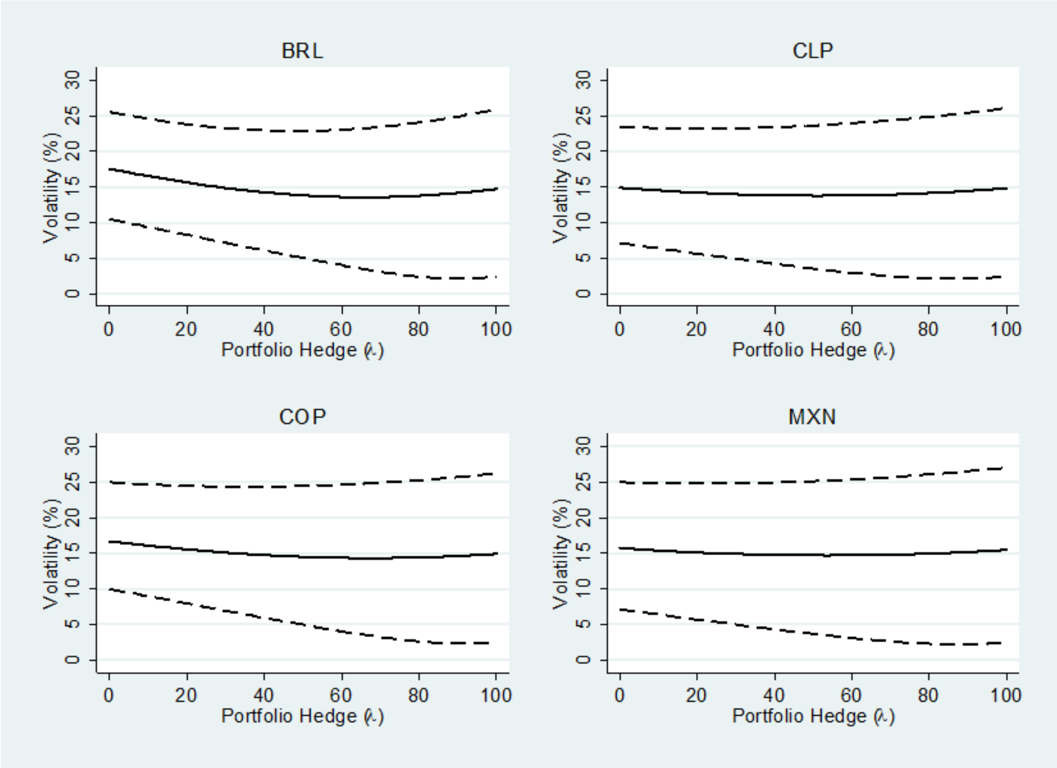
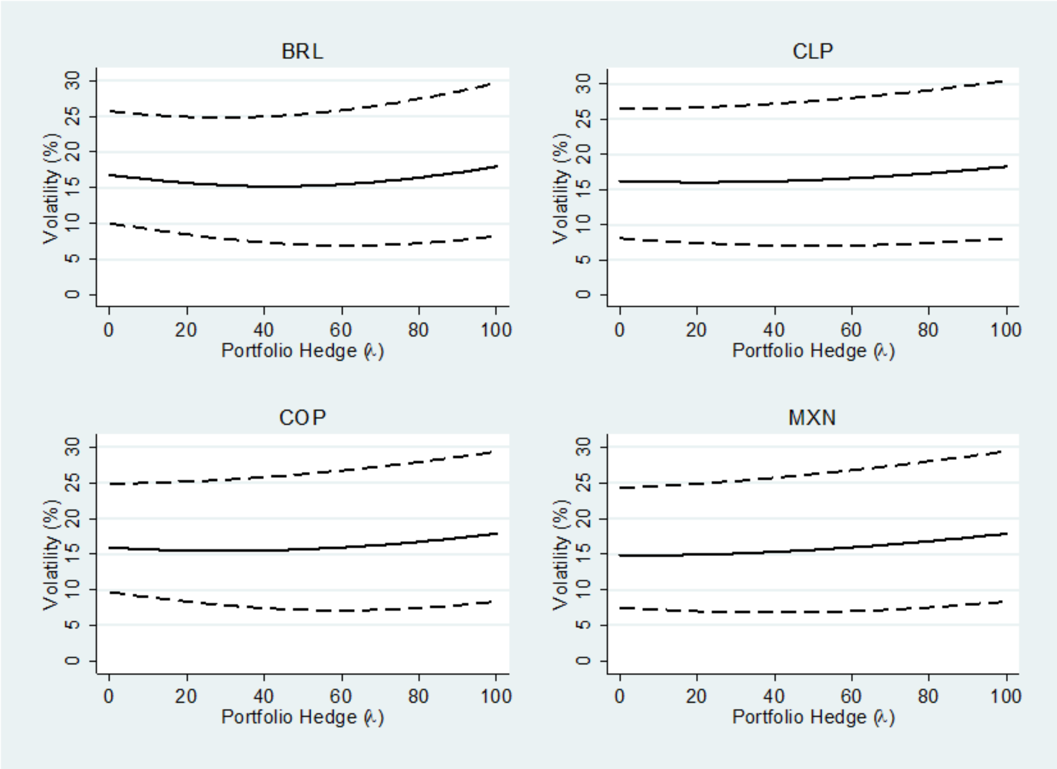


Figure A.8. Volatility and Hedging Ratio, EU Equity



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